7th INTERNATIONAL SYMPOSIUM ON INDUSTRIAL ENGINEERING

INDUSTRIAL ENGINEERING DEPARTMENT,
FACULTY OF MECHANICAL ENGINEERING,
UNIVERSITY OF BELGRADE, SERBIA
&
STEINBEIS ADVANCED RISK TECHNOLOGIES,
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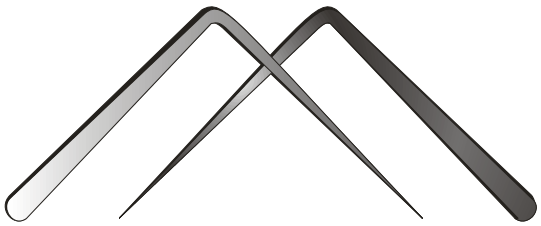

SIE 2018 PROCEEDINGS

Editors:

Vesna Spasojević-Brkić
Mirjana Misita
Dragan D. Milanović

27th-28th September 2018
Belgrade, Serbia

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PREFACE

Since the first symposium in Belgrade, Serbia more than two decades ago, in 1996, International Symposium on Industrial Engineering - SIE has been held regularly every 3 years. It represents an opportunity for researchers in the Industrial Engineering community to review and evaluate their scientific achievements over the period since the previous SIE, share their most recent results and ideas, and discuss possibilities for new directions in research, joint experiments and observing campaigns.

The aim of the 7th International Symposium on Industrial Engineering – SIE 2018 is to contribute to a better comprehension of the role and importance of Industrial Engineering and to point out to the future trends in the field of Industrial Engineering. The Symposium is also expected to foster networking, collaboration and joint effort among the conference participants to advance the theory and practice as well as to identify major trends in Industrial Engineering today. According to these goals the Symposium addresses itself to all experts in all fields of Industrial Engineering to make their contribution to success and show capabilities achieved in the work that has been done are very welcomed. SIE 2018 provides an international forum for the dissemination and exchange of scientific information in industrial engineering fields through the large number of multidisciplinary topics.

The book brought together 58 papers and more than 170 authors from 12 countries, namely from Serbia, Portugal, Finland, Switzerland, FR Macedonia, Italy, United Kingdom, Thailand, Slovakia, Canada, Poland and Bosnia and Herzegovina. The submitted full length manuscripts were peer-reviewed, and selected for publication by experts in their respective fields. The authors ranged from senior and renowned scientists to young researchers. Only unpublished papers were accepted and the first author is responsible for the originality of the paper. All papers are classified into six chapters, including opening and closing plenary lectures.

We expect that papers and discussions will contribute to better comprehension the role and importance of Industrial Engineering in this and other countries, both in domain of scientific work and everyday practice.

Our efforts in organizing would not succeed without the considerable help of the members of Scientific Program and the financial help of Ministry of Education, Science and Technological Development was greatly supportive for the success of the entire project.

At the end, the editors hope, and would like, that this book to be useful, meeting the expectation of the authors and wider readership and to incentive further scientific development and creation of new papers in the field of Industrial Engineering.

Welcome to the 7th International Symposium on Industrial Engineering – SIE 2018! We wish to all participants a pleasant stay in Belgrade and are looking forward to seeing you all together at the 8th Symposium on Industrial Engineering – SIE 2021.

Belgrade, September 2018

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Opening Plenary Session

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ECONOMIC ANALYSIS OF PROJECTS AT THE ASIAN DEVELOPMENT BANK

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1. INTRODUCTION

Since public sector projects involve scarce resources their economic efficiency must be tested. The standard test for project economic efficiency, project economic appraisal, is a version of discounted cash flow analysis which requires a with and without project comparison of benefits and costs in each year of a project's life. It differs from financial analysis in the scope of its definition of benefits and costs, which in principle should capture the impact of a project on the whole economy, not just on its financial stakeholders. In the context of low income countries Aid donors, whether multilateral, regional or bilateral, have used this methodology to assess the effectiveness of the projects they support. Project economic analysis is typically used alongside other assessments of project impact, like environmental or poverty impact assessments, so that it is not the only criteria by which a project is judged. However, in many organizations passing the economic test is a necessary, but not sufficient condition, for project acceptability.

Assessing the economic impact of projects is a potentially complex task. The practice of Aid donors has been guided by a substantial technical literature on how to assess costs and benefits in a development context. For a summary see Curry and Weiss (2000). [1] With some, often quite significant, simplifications this literature has formed the basis the practical appraisal of projects financed by organizations like the World Bank, regional development banks like the Asian Development Bank, the African Development Bank and the Inter-American Development Bank, as well as bilateral donors like the UK Department for International Development. In Europe the approach has also been applied in lending by the European Investment Bank and the European Commission (EIB 2013, European Commission 2014).[2] This paper focuses on practice in one regional bank the Asian Development Bank (ADB), which revised its Guidelines for the economic appraisal of projects in 2017 (ADB 2017).[3]

ADB lends throughout the Asian region, including to Central Asian Republics that were part of the Soviet Union. Its primary focus in terms of lending volume is hard infrastructure projects in transport, power, water and general urban development. However, it also lends for agriculture, financial sector and natural resource development as well as to the social sectors like education and health. It initially lent only to governments but now has a growing private sector window. All ADB projects require a form of 'economic due diligence' be applied. This requires setting out where a project fits in the wider sector and macro-economic context, ensuring a technically feasible and low-cost version of the project is selected for detailed analysis, testing for risks and financial sustainability and crucially where ever possible comparing project costs and benefits in a quantitative analysis to establish

[1] The development cost-benefit literature stems from the seminal works of Little Mirrlees (1969, 1974) and UNIDO (1972) and subsequent refinements in Squire and van der Tak (1975), UNIDO (1978, 1980) and Ray (1984) with some differences of emphasis in Harberger (1972).

[2] For a discussion of economic analysis at the World Bank see (World Bank 2010) and Jenkins (1997).

[3] The author was closely involved in this exercise as a consultant.

economic viability. This requires either a rate of return or exceptionally a cost effectiveness calculation. The Guidelines ADB (2017) sets out the preferred approach to this quantitative cost-benefit comparison.

The remainder of this paper is organized as follows. Section 2 discusses the general approach in the current Guidelines and section 3 sets out how it differs from earlier guidance in the Bank (ADB 1997). Section 4 highlights some difficulties in application and section 5 concludes.

2. GENERAL APPROACH

Where project outputs and inputs are sold on a market the starting point for valuation is their price on that market. However, the presence of taxation, lack of information or various regulatory controls means that in practice markets are 'imperfect,' so that market prices need not reflect the true worth of goods and services to the economy. Economic appraisal under these circumstances requires the adjustment of actual market prices to what are termed 'shadow prices' or alternatively 'economic prices', which are used to value outputs and inputs in an economic appraisal. Where no market exists for the goods or services used by a project, economic appraisal requires that a monetary value be assigned to these non-marketed transactions.

Application of economic analysis requires setting out the alternative with and without-project scenarios in each year of a projects life, estimating annual net benefits and costs, where without-project costs are subtracted from with-project costs and without-project benefits are subtracted from with-project benefits. Because the original development literature tried to quantify the effects of projects on several different objectives – short-term allocative efficiency, longer term-growth and income distribution- a numeraire or unit in which different project effects could be weighted and combined was necessary. In practice applications have largely focused on allocative efficiency, so that the unit or numeraire is consumption or income at either domestic or world prices.[4] The 1997 Guidelines gave analysts the choice of working in either a domestic or a world price unit.

In principle all effects created by a project, whether or not they worked through a market should be identified and valued. In ADB (1997) there was a detailed discussion of environmental impacts with possible ways of valuing these, although in practice environmental valuation was rarely done. The efficiency test to be applied was an internal rate of return above the test rate set by the Bank of 12% and a positive net present value at this discount rate. The 12% figure was used as a rationing rate for Bank projects and was intended as approximation to the opportunity cost of capital in borrower countries. The figure of 12% was not justified quantitatively and it was stated clearly that if in any particular economy a national rate had been calculated then this could be used as an alternative. Further where it was judged there were some benefits that it was not possible to quantify and value then a lower rate of return of 10% would be acceptable provided these were explained fully. There was an explanation of how the poverty effects of projects could be assessed through a distribution analysis and a poverty impact ratio – defined as the share of the poor in the economic net present value of the project- could be calculated. However, this was not mandatory for all projects and no minimum figure was set for the poverty impact ratio. The risks associated with a project had to be tested using sensitivity analysis and possible risk analysis for more complex projects.

3. CHANGES IN THE NEW GUIDELINES

ADB (2017) introduced changes to the earlier approach in three main areas relating to the decision criteria (that is the test discount rate), environmental valuation (principally the treatment of CO2 emissions) and the choice of numeraire (a domestic price unit was recommended). In terms of impact on practice the first two of these changes are potentially significant.

Discount rate

In terms of decision criteria, the key test rate of discount was revised downwards from 12% to 9%. It is still to be used as a rationing rate with the caveats that where a national rate is available this can be used and that a lower rate of 6% can be used for projects with unquantifiable benefits or for poverty-focussed projects. Several broad arguments were used to justify a lower rate – falling global rates, the fact that as countries get richer rates tend to fall as

[4] Apparent differences between the alternative approaches arose from the basic choice of numeraire - government income or investment measured at world prices in one (Little Mirrlees,1974) and domestic consumption at domestic prices in the other (UNIDO 1972). Subsequent work showed how the alternatives could be reconciled relatively easily (Curry and Weiss 1990, 2000, Potts 2002). In practice a distinction is rarely drawn between income that is saved and income that is consumed, or between government and private income.

financial intermediation improves and the fact that a lower rate places a higher value on long-run environmental effects. Unlike the earlier Guidelines in this case the choice of 9% was rationalized formally on the basis of some simple calculations implicitly estimating a time preference discount rate for the Asian region.

The calculations were based on the 'Ramsey model' which defines the declining value of consumption over time as

$$DR = g.n + \mu$$

Where DR is discount rate, g is per capita consumption growth, n is elasticity of marginal utility of consumption and μ is pure time preference. Average values for the region as a whole were used, so in other words, values for 'representative consumers' in each country were averaged.

Values of g = 5%, n = 1.5 and μ = 1.0 were used to give 8.5% which was then rounded up to 9%.

The selection of a 9% rate based on the Ramsey formula can be questioned on both theoretical and empirical grounds. Theoretically it is questionable whether it is meaningful to think of time preference for a region as large as Asia based on the average of preferences of 'representative consumers' in the different countries. Empirically the 9% rate is based on a set of assumptions, principally a high average rate of growth of regional per capita consumption of 5% and a relatively high elasticity of utility with respect to consumption growth of 1.5. Earlier empirical work suggested an elasticity of 1.0 and if this is combined with a more conservative projection of the growth of per capita consumption of say 3% plus the same pure time preference figure of 1%, the result is a much lower discount rate of 5%.[5] This is not say that a lower rate like 5% is more accurate than the 9% in ADB (2017), but simply to point out the uncertainty involved in this type of exercise and the extent to which it relies on assumptions and projections.

Environmental valuation

In relation to environmental valuation more practical guidance was given as compared with the earlier Guidelines. The net CO2 emissions from a project (or the CO2 equivalent for other gases) are to be estimated and valued at $36/ton in 2016 prices, escalated by 2% annually. The figure of $36/ton came from a review of marginal damage cost from the environmental literature. The effect of increasing the 2016 base value by 2% annually has the effect of discounting by a rate of approximately 7% as opposed to the standard rate of 9% and thus goes a modest way towards addressing the charge that discounting at rates like 9% places a low value on long-term environmental impact. The introduction of a value like this for emissions can have large impact on the appraisal of projects in sectors like energy and transport and can shift decisions towards more environmentally-friendly projects that reduce emissions since they will now be credited with a quantitative benefit. For other environmental impacts the suggestion is that as far as possible a 'benefit transfer' approach be applied whereby values estimated in the context of one project or location or drawn from the secondary literature are adapted for use on a new project.

Choice of numeraire

In relation to the choice of numeraire whilst the use of a world price unit is not ruled out, a preference is stated for a domestic price system and all examples in the text are given in domestic prices. This preference is on practical not conceptual grounds. It is relatively easy for confusion to arise with a world price system in relation to estimating willingness to pay for project output and in conducting distribution analysis. The former of these has been a significant practical problem. In sectors like power and water it is typically the case that an estimate is made of willingness to pay to reflect project benefits. This will be a value in prices faced by consumers, which are domestic prices. If the appraisal is in world price units all project effects both benefits and costs must be in world prices. This is done typically on the cost side by removing taxes and applying a Standard Conversion Factor (which is an economy-wide average ratio of world to domestic prices) to residual local costs.[6] However, there is a risk that the same adjustment (revaluing willingness to pay by a Standard Conversion Factor) is not applied to willingness to pay, creating an over-estimate of benefits as the Standard Conversion Factor as calculated is always below 1.0.

The problem with distribution analysis arises because the income effects from the financial arrangements of a project must be combined with the income effects measured at economic prices. It is

[5] For studies using an elasticity of 1.0, see Squire and van der Tak (1975) and UNIDO (1980).

[6] The Standard Conversion Factor is the inverse of the ratio of the Shadow Exchange Rate to the actual market rate. There is a further technical complication with this approach, which is discussed in Weiss (2018).

not always understood that if world price units are used in the economic analysis this requires adjusting the income changes from the financial arrangements, which will be at domestic prices, by the Standard Conversion Factor. If this is not done the full income changes created by a project will calculated incorrectly. This potential misunderstanding has been less significant in practice since most distribution analyses of projects have been done as part of an economic analysis at domestic prices, so the scope for error does not arise.

4. SOME PRACTICAL COMPLICATIONS

The changes highlighted here are intended to provide a more rigorous test of the economic viability of projects. None the less in practice economic analysis remains an approximate approach to the assessment of benefits and costs. Here two continuing practical difficulties in estimation are highlighted – one in relation to willingness to pay and the other in the treatment of foreign exchange.

Estimating willingness to pay

For projects in non-traded sectors benefits are typically specified in terms of willingness to pay for the additional goods or services the project makes available. [7] However despite the theoretical importance of this concept in practice it can be difficult to estimate with accuracy. ADB (2017) discusses the problem of estimation in more detail than in the previous Guidelines giving three main alternative approaches, each of which are subject to complications. The simplest is the 'rule of half' which values output at the average of with and without-project prices; this is the average of P1 and P2 in figure 1. The use of the average of with and without project prices is strictly only valid where the price-demand relationship is linear and will be misleading if the project offers a different quality of good or service (such as network electricity or piped water as compared with kerosene lamps or standpipes), since if the quality is sufficiently different with and without-project prices will be on different demand lines.

Where one of the two prices are not known, the shape of the demand -price line can be inferred based on the known price and a value for price elasticity of demand. Such a situation arises where the without-project price is controlled so the price charged is not a market-clearing price reflecting willingness to pay. Application of the rule of half requires that P2 in figure 1 be a market-clearing price, otherwise the average of P2 and P1 will understate average willingness to pay. This second approach requires an accurate estimate of price elasticity of demand for the good or service involved and is only strictly valid for small changes in price caused by a project.

The third approach involves asking consumers how much they are willing to pay for a good or service in a form of contingent valuation survey. Such surveys are both time-consuming and need to be implemented with considerable care in terms of sampling and the phrasing of questions.[8]

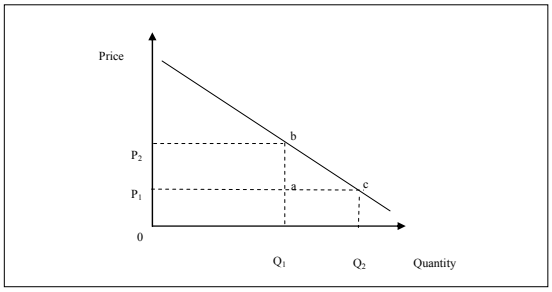

Figure 1. Demand-Price line

Foreign Exchange

In project economic analysis in domestic price units as set out in ADB (2017) foreign exchange is valued at a shadow exchange rate. The existence of policies that allow flexibility in the nominal exchange rate do not remove fully the need to make some adjustment for the economic value of foreign currency. The presence of taxes on trade mean that a wedge is created between domestic and world prices and the version of the shadow exchange rate used in virtually all Bank appraisals is given by the average tax and subsidy rate on foreign trade. As taxes and subsidies on trade are now low this means that in most countries the shadow exchange rate is very close to the nominal official rate, so that the ratio of the two (termed the Shadow Exchange Rate Factor) is close to unity. This means an adjustment for foreign exchange costs or benefits will have little impact on the results of many projects. The main difficulty with this approach is that it ignores any underlying disequilibrium in the foreign exchange market which will cause a change in the real

[7] ADB (2017) describes this as benefits from incremental (that is additional) output. For output that is non-incremental (that is replacing other goods or services) benefits will be in terms of cost savings.

[8] ADB (2013) describes applications of both the second and third approaches to valuation of willingness to pay and in particular highlights what it considers a best-practice approach to contingent valuation surveys in the water sector.

exchange rate over the life of a project. ADB (2017) also gives a second version of the shadow exchange rate formula which incorporates an exchange rate adjustment. Whilst this conforms with theory the practical problem is that estimating future real exchange rate changes accurately is very difficult.[9]

5. CONCLUSIONS

ADB as an organisation has consistently applied the technique of economic analysis to assess the viability of the projects it finances. Such appraisals are usually limited by the time and resources available, but within these constraints efforts are made to ensure that operational work keeps up with what can be considered good practice in the technical literature. The 2017 Guidelines aims to do this by incorporating concerns over time preference and the limitations of using high discount rates, as well as environmental issues. It omits some of the more complex adjustments that are considered in the academic literature such as a value for the marginal cost of public funds and the issues raised by a distinction between producer and consumer prices.[10] Further it ignores most second-round effects from projects, which can have important distributional effects. The Guidelines are intended as a practical operational document not an academic study and should be assessed by this criterion. They are a useful addition to the literature on appraisals by international organisations and reflect a renewed awareness of the importance assessing projects from a broad perspective.

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[9] There is an extensive literature on estimating equilibrium real exchange rates that generate external balance using econometric techniques; see for example Edwards (1988). A simpler approach, for example in Rodrik (2008), identifies exchange rate misalignment with the divergence of an actual real exchange rate from the purchasing power parity rate allowing for an economy's income level. This takes the ratio of the actual real exchange rate (RER) to the purchasing power parity exchange rate (PPER) and compares this with the ratio predicted by a regression which links the real exchange rate and GDP per capita.

Thus $RER_i = ER_i/PPER_i$

and $RER_i^* = a + b.GDPcap_{it} + d_{it}$

where ER and PPER are the nominal and purchasing power parity exchange rates respectively, GDP is per capita GDP, d is a fixed effects dummy and i and t are countries and years, respectively. Misalignment in the exchange rate is the difference between the actual RER and its predicted value R*, so that, for example, if RER>RER* undervaluation is greater than expected for a country's income and wage level and in the long-run the exchange rate will be expected to adjust.

[10] See Weiss (2018)

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THE ITALIAN EXPERIENCE IN DEALING WITH THE ISSUE OF AGEING MANAGEMENT IN THE PROCESS INDUSTRY

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Abstract
The paper discusses a method developed to assess the adequateness of equipment safe ageing management in the process industries. Basically it is an index method, which evaluate the factors that accelerate or slow down the equipment deterioration. Both physical and intangible factors, including management systems, have been considered. The method has been adopted by the Italian Competent Authority for the prevention of Major Accident. It will be used during the mandatory audit of industrial establishments, in the framework of Seveso III Directive for the control of Major Accident Hazard.
Key words:Ageing, Major Accident Hazard.

1.INTRODUCTION

The Ageing for industrial systems is defined as the effects of concurrent deterioration mechanisms, which cumulate in time and have the potential to reduce performances, increase hazards and jeopardize functions of the system. Ageing may be controlled by means of inspections and maintenance. In a large process plant, such as a refinery or a petrochemical plant, there are thousands of technical systems, which in turn are part of a more complex system, which includes people with their duties, skills and knowledge, organizations, regulations, procedures, instructions, documents, technical specification, as well as external stakeholders. The ageing issue is critical for the sites where a major loss of hazardous materials is possible, with severe consequences for people and environment. At these sites, the EU Seveso Directive for the control of Major Accident Hazard (MAH) has been enforced since thirty years. The issue of ageing is critical, because corrosion and other deterioration mechanism may be the cause of major accidents, as demonstrated by a few studies about accident in oil and chemical industry published by EU Commission and OECD [9; 11].

The European Directive 2012/18/UE (Seveso III), replacing the previous Seveso Directives, introduced a few requirements for the safe aging of critical equipment, which must be verified during mandatory audits. In Italy, most of the Seveso establishments are featuring aged plants, thus the issue of plant safe ageing is very important. The implementation of the new EU Seveso III Directive in the national legislation was a good chance for the Italian regulators to face this issue. According to the EU Directive, the operator of a Seveso establishment must have a monitoring plan to control equipment ageing and prevent losses due to corrosion and other deterioration mechanisms. During the inspections, which are organized by the Competent Authorities, it is essential to verify the adequateness of the monitoring plans adopted by the operators. The aim of the paper is to discuss how the Italian Competent Authorities are fulfilling these duties and what methods have been used for these purpose. In order to develop adequate methods research world was involved. At the end, Academia and Authorities Working together with Industry developed a cutting-edge solution, which may be interesting for many European Countries, facing the same problem.

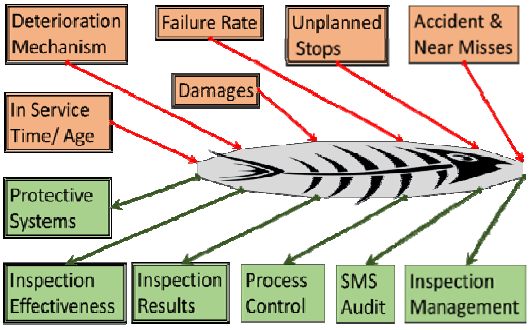
2. SCOPE & OBJECTIVES

The scope of the paper include the Seveso sites, which are the establishments that hold hazardous materials in quantity equal or higher of defined thresholds. The Seveso Legislation discriminates

establishments in upper tier and lower tier; but, for the ageing control, there are no differences.

The goal of the ageing management is to assure the longevity of the plants. Longevity may be defined, within the scope of the paper, as the capacity of control, by means of planned activities, the effects of ageing, avoiding the consequences, assuring the functions of the system, preventing the losses of materials and energy. In other words, Longevity is the Resistance to Ageing! An essential condition for longevity is to adopt and implement a plan to control all potential deterioration mechanisms. The paper discusses, in the detail an assessment method for the adequacy of the ageing management in the framework of the safety management system for the prevention of major accident hazard, as required by the Seveso legislation. The method has been initially proposed by the authors [4]. The method was improved in a further paper [8] and, at end it has been adopted, by the National Committee for the application of Seveso Legislation, which includes representatives of all Seveso stakeholders (Environmental Agencies, Fire Brigades, Civil Protection, Ministry of Industry). Before to be definitely approved, the method was tested in a few representative sites, chosen by the Industrial Association, namely Petrol Industrial Union and Chemical Industry Federation. The scope of the method, at now, includes just the primary containment systems. Machines and control systems are not included. Control systems and machines are relatively easier to replace than large containment systems. The replacement of large vessels, instead, requires major investments as well as difficult authorization processes, thus in Seveso establishment many containment systems have been in service for a time largely exceeding the initial design lifetime.

Figure 1 The fish-bone model for the ageing



3. THE METHOD

The three pillars to assure "longevity", as defined in the objectives, are

- Inspections, which provide data;
- Modeling, based on knowledge, which make data usable;
- Resilient Management, which use data and prognosis to make right decisions at the right time.

To face the problem of Ageing must be assessed both the "strength" of ageing factors and the "adequacy" of the longevity factors.

Table 1 Ageing and Longevity Factors to be averaged on all critical items

Factor	Score
Ageing (negative)	
In-service time/expected lifetime	(1) ≤ 90%; (2) 90 ÷ 100%; (3) 100 ÷ 120%; (4) > 120%
n. of **Unplanned Stop** / total number of stop	(1) ≤ 10%; (2) 10 ÷ 25%; (3) 25 ÷ 60%; (4) > 60%
actual /expected **FailureRates**	(1) $f \le 0{,}5 \cdot f_{rif}$; (2) $0{,}5 \cdot f_{rif} < f \le 1 \cdot f_{rif}$; (3) $0{,}5 \cdot f_{rif} < f \le 2 \cdot f_{rif}$; (4) $f > 2 \cdot f_{rif}$
Deterioration mechanisms	Details in tabel 2
Longevity (positive)	
Inspections planning and results	Include three sub-factors: a) percentage of positive function test, *(1)<90%; (2) 90-95% (3) 95-98% (4)>98%* b) percentage of positive integrity test, *(1)<98%; (2) 98-99% (3) 99-99.5% (4)>99.5%* c) percentage of the peformed of planned inspesctions *(1)<90%; (2) 90-95% (3) 95-99% (4)>99%*
Inspections efficiency	Include two sub-factors: (i) effectiveness of inspections, According to API 581:2016 (ii) trainer qualifications According ASTM or ISO 9712:2012
Specific **Protections**	Average evaluation sub-factors: (i) inspection intervals, (ii) protection's conditions

Ageing factors Include:

1. The Vulnerability of the equipment (deterioration mechanisms, detectability, potential effects)
2. The vulnerability of the overall systems (accidents, near misses, unexpected shutdown, inappropriate repairs and modifications in the past)

3. The Actual conditions, as revealed by inspection results and recorded failures and ruptures.

Longevity factors include:

1. The Capability of Manage information, as gathered along the plant life cycle.
2. The Capability of Monitoring, including sensors, instruments and skilled inspectors
3. The Prognostic Capability, including knowledge based modelling
4. The Capability of Recovering, including, protection, repair and maintenance.

The basic idea of the proposed method is to evaluate these points by a means of fishbone model, according the schema shown in figure 1. In the upper side of the fishbone, there are the ageing factors, in the lower one the longevity factors. Based on the fishbone model a scoring system has been developed. Scores range from 1 to 4 for all factors. Ageing factors, have a negative weight and longevity factors have a positive weight; thus for ageing factors the lower the better and for longevity factor the higher the better. A balance between negative and positive score is the necessary condition to have a positive evaluation of the system.

The very first step of the method is to have a list of critical containment systems, which are identified in the risk analysis and contains hazardous substances in quantities significant compared to the Seveso thresholds. The data required for any critical containment systems are summarized in table 1. Both negative (ageing) and positive (longevity) factors are shown. The score for ageing and longevity factors are calculated by averaging the score of individual containment systems.

There is no room in the paper to discuss in the detail all factors, but the factor *Deterioration mechanisms* is worthwhile of a little discussion.

Each deterioration mechanism has a score, ranging from 1 to 4. The higher the score the more aggressive the mechanism. The score derives from the combination of three partial scores, i.e. detectability, propagation velocity and consequence.

✓ *Detectability:* The score depends on the difficulties to detect and measure the phenomenon. They depend, in turn, on the instrumentation, its costs, the required skills, the repeatability and uncertainty of the measures.

✓ *Velocity:* The parameter considered is the temporal scale of the phenomenon, which is the mean time between the very beginning of the phenomenon and its occurrence in the form of failure or rupture.

✓ *Consequences:* The most serious consequences are the possible sudden structural failures. At the lower level there is the possible formation of more or less extended holes and lowest alterations of characteristics that do not compromise the containments (e.g. deformation).

Table 2 shows the scoring of for the main classes of deterioration mechanisms, but it is possible define further mechanisms. The score must be calculated using the three criteria above mentioned. The three criteria may be used also to customize the score, if the mechanism may be controlled by means of some innovative techniques. If a critical system has concurrent deterioration mechanisms, with different scores, the highest one must be selected.

Table 2 Types of deterioration mechanisms

Mechanism Type	***det.***	***vel.***	***cons.***	**score**
Long-term metallurgical	*4*	*1*	*4*	3
Short-term metallurgical	*4*	*4*	*4*	4
Localized thinning mechanisms	*4*	*3*	*4*	3
Uniform Thinning Mechanisms (corrosion and/or erosion)	*2*	*2*	*3*	2
Corrosion due to the environment (atmospheric, soil)	*1*	*1*	*2*	1
Tenso-corrosion with cracking	*4*	*2*	*4*	3
Damage from Hydrogen to High Temperature	*4*	*3*	*4*	4
Fatigue	*3*	*3*	*4*	3
Creep	*3*	*3*	*3*	3
Corrosion under insulation	*4*	*3*	*4*	4

A further point to stress is the certification of inspection personnel. The compliance with ISO 9712:2012 at different levels (1, 2 and 3) is recognized by the method, with higher score in the factor “Inspection Efficiency”.

Further factors (both negative and positive) are not specific of the individual systems and are valid for the whole establishment. They are shown in table 3. Neither for these factors, there is room for a complete discussion but it is essential to highlight the role of the standards for inspection programming. The policy of Competent Authority is clear on this point. Standard may be very useful for operators, but cannot become an obligation, because company are different each other and Seveso Directive impact also small establishments, where standard could result oversized.

Standard and Recommended Practices are, anyway, promoted by means of the scores. The following

documents are recognized as suitable for ageing management: API RP 580 [1], API RP [2]; EUUMA159 [6]; UNI TS 11325-8 [10], EN 16991:2018[5]. Just EN16991:2018 is a true "standard", which may be certified in all industries; the other ones are basically "guidelines" or "recommended practices", suitable just for specific industries, API for oil and gas, EUUMA for atmospheric tanks, UNI for pressure equipment. All these documents are aimed at a Risk Based Inspection Plan, which should assure safe operations for a fixed time interval. A more dynamic approach could be valuable, thus the highest score is reserved for the adoption of more innovative techniques, including Intelligent Prognostics and Health Management (PHM) and Condition-Based Probabilistic Safety Assessment (CB-PSA). A further example of a dynamic approach in oil&gas industry is API RP 584 [3]. It consider the ranges and limits of process parameters that may change in service time, so that to assure integrity and reliability of equipment within defined "operating windows".

Table 3 Ageing and Longevity Factors for the overall establishment.

Factor	Score
Ageing (negative)	
% of **near misses** due to deterioration	(1) ≤ 5%; (2) 5 ÷ 15%; (3) 15 ÷ 35%; (4) f > 35%
% of equipment with recorded **damages**	(1) ≤ 1%; (2) 1 ÷ 3%; (3) 3 ÷ 5%; (4) > 5%
Longevity (positive)	
Inspection Management System	(1) according to legislation; (2) risk-based and integrated (partially or totally) with the inspection planning; (3) according to Standards including API 581, EUUMA 159, EN 16991 UNI 11325.8 (4) periodically updated API 584
Safety Management System **SMS Audit**	Percentage of minor and major non conformance detected during saftey management system audits
Process control	(1) unregistered local control system; (2) control system with data recording; (3) data recording system with automatic blockage system; (4) control system with data recording + automatic blockage system + certified blockage system according to IEC 61511 or 61508

4. IN FIELD APPLICATION

In Italy, there are some 1000 Seveso sites, divided equally between upper tier and lower tier. There is a national plan of the National Competent Authority to visit all upper tier establishment at least once in three years. Thus, the National Competent Authority organizes every year an inspection campaign, involving 150 establishments and more. Similar plans are adopted by Regional Authorities to visit all lower tier sites. Thus, before to propose the method discussed in the previous section to such a large audience, a few experiments have been done. The sample included a large Petrol Tank Farm, a Refinery unit and a Medium sized Chemical Plant.

During the 2018 inspection campaign, which the method will be used to verify the adequateness of the ageing management at some 150 upper tier Seveso establishments. After the first year, a first revision of the method is planned, so that to include even machines and control systems. In next three yearly inspection campaigns will cover all establishments. The expected effect of such action is the promotion of innovative technical and organizational interventions for the safe management of all ageing Seveso plant.

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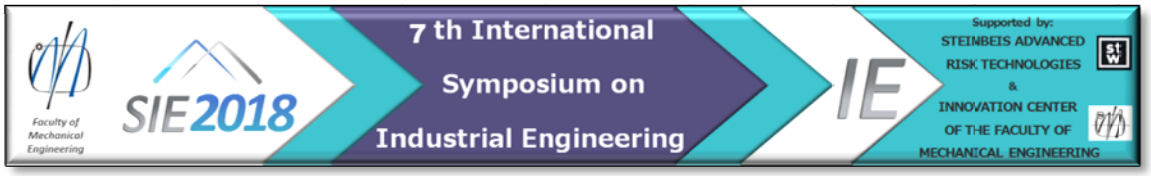

GOVERNMENTAL SUPPORT OF INSTITUTIONAL COOPERATION BETWEEN SCIENCE AND SMALL AND MEDIUM-SIZED BUSINESSES IN SERBIA

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Abstract. *Innovation and knowledge-based economy are key factors of competitiveness and sustainable development. One of the most important features of innovation is represented through linkage between science and small and medium-sized businesses. Institutional collaboration among these sectors in Serbia is reinforced through government supported programs implemented by the Innovation Fund. This paper will present three grant programs aiming to support commercialization of research and development activities, each of them using different mechanism. Furthermore, up-to-date funding statistics of these programs will be elaborated in order to understand the significance of public financing of joint innovative projects with the goal of creating new commercial value.*

Key words: *Innovation, Public funding, SMEs, R&D*

1.INTRODUCTION

One of the key challenges of transitional economy is proper development of competitiveness trough knowledge-based entrepreneurship and linkage of science with business. Establishing this liaison is very important and certain researches show that partnership with science sector is more important than the companies' customers for the introduction of new products to the market [7].

According to the **Global Competitiveness Report** for 2017-2018, Serbia's overall global competitiveness index is 78 out of 137, while the global competitiveness index for innovation ranks Serbia 95 out of 137. The Global Competitiveness Report 2017-2018 ranks Serbia 47th of 137 economies overall in R&D research, 107th in company spending on research and development (R&D), and 95th in university-industry collaboration [12], while according to the Global Competitiveness Report for 2010-2011 in university-industry collaboration 71st [11].

According to the **European Innovation Scoreboard** for 2018, Serbia is a Moderate Innovator with the strongest innovation dimensions in Company investments, Linkages (including SMEs collaboration with others), and Employment impacts, while Innovation-friendly environment and Intellectual assets are the weakest innovation dimensions [1].

Although technological entrepreneurs may be abundant with ideas, typically they lack the resources necessary to realize them, specifically operating capital required for activities such as intense research, development of prototype, and/or product commercialization. Government intervention in early stages of technological development can create the momentum necessary to launch the technology and to develop an industry [8].

Serbia was among the first countries in the region to adopt the so-called "innovation imperative", that is the notion that successful participation in the global knowledge economy requires the ability to adapt and advance new technological and research capabilities that involve public and private collaboration. Founded in 2005, operational since 2011, **the Innovation Fund (IF)** was a pioneering effort to institutionalize this endeavor – first by increasing the capacity of start-ups and resources available for their growth. The IF aims to promote links between research and technology development and economy, and support the development of innovative entrepreneurship.

In 2016, the Government adopted the Strategy for Science and Technology Development: Research for

Innovation 2016–2020 (Strategy), specifically calling for reforms in the public RDI sector and reinforcing the importance of enterprise innovation and technology transfer for the economy, including support for the activities carried out by the IF. The essential novelty of this Strategy is that it focuses around the "research for innovation", in the function of economic and overall social development of the country. One of the key objectives of the Strategy is strengthening the link between science, economy and society to encourage innovation. This objective implies that better connections between scientific research organizations and industry accelerates the development of technological innovation, and a connection between science, art and technology on one side with the new business models and practice on the other side, opens up new opportunities for the development of social innovation. For these reasons, the Strategy states that the establishment of these links will be supported, both in the process of creating new intellectual property and in different stages of development of new products, services and technologies. [9]

In the past few years, Serbia has made progress in this area by developing and implementing different support programs for innovative companies and researchers. However, in spite of positive developments in the field of entrepreneurial competitiveness, commercially applicable R&D activity and promoting collaboration between the academic research institutions and the private sector, still requires substantial efforts for repositioning Serbia's economy towards a knowledge-based profile. Furthermore, it has been established that the majority of Serbia's R&D is performed by higher education institutions, with estimates that innovation in business enterprise sector amounts to as low as 14% of Serbia's entire R&D. It has also been found that a mere 6% of researchers work in the business sector in Serbia, compared to the EU's 45%. [10]. These indicators being diametrically opposite when compared to the EU indicate a low level of competitiveness in Serbia's SME sector. In spite of Serbia's investment into R&D infrastructure in the period from 2010 to 2015, there is still none to very limited existence of and access to financial incentives and instruments that enable R&D collaboration between the academia and the private industry. Enhancing this model of cooperation would provide additional value and potential for increase in competitiveness of Serbian SMEs. Over 35% of all R&D projects financed under the Innovation Serbia Project (ISP) had at least some form of collaboration between private sector enterprises and RDIs, which indicates organic willingness to engage in this type of cooperation, especially when facilitated through financial incentives. Notable results have been observed under the ISP. Serbian research institutes have expressed interest in developing capacity for applied R&D, technology transfer and commercialization. [3]

2. PROGRAMS FOR SUPPORT OF COOPERATION BETWEEN PUBLIC R&D ORGANIZATIONS AND PRIVATE SECTOR

In order to establish cooperation between science and economy, since 2015 the IF has implemented the following programs: First, under the Direct Grant between the Department for Contracting and Financing of European Union Funded Programs of the Ministry of Finance of the Republic of Serbia and the IF, the IF has established the **Collaborative Grant Scheme Program** (CGS) to incentivize private-sector companies and public-sector R&D organizations to engage in joint scientific research and development projects with the goal of creating new commercially viable products and services, as well as innovative precompetitive technologies with significant future impact and market potential. CGS is implemented through a Direct Grant Agreement. The IF, with support from the World Bank, leverages international best practices in the design of the CGS that encourages stakeholders to increase collaborative R&D activities, as well as to utilize existing infrastructure in public sector R&D organizations. Under the CGS, the IF manages grants of up to EUR 300,000 per project for research and technology development projects in the duration of up to 24 months. The IF has been awarded the direct grant of EUR 2.4 million of EU contribution and EUR 1 million provided by the national public contribution of Ministry of Education, Science and Technology Development, covering a maximum of 70% of total eligible project costs with 30% minimum co-financing provided by the sub-grant beneficiaries. Public call for proposals for this program was opened in 2016. A total of 96 project proposals were submitted and the majority of proposals came from the fields of food and agriculture, ICT and energy and energy efficiency. Out of 96 submitted proposals, 74 applications satisfied all eligibility criteria and 28 were shortlisted. A total of 14 projects were approved for financing in this pilot public call, and again, food and agriculture dominate the selection (see Table 1.). These projects are currently in the development phase and it is expected that new products, services and technologies will be created as a result of this collaborative process in the following 6 months. [2] Second, the IF is implementing the Serbia Research, Innovation and Technology Transfer Project (SRITTP),which is financed by the IPA 2013 in the total amount of 2.5 million EUR. The objective of

Table 1. Collaborative Grant Scheme Program Funding

Total Budget (EUR)	Approved IF funding (EUR)	Approved IF funding %	Awardee co-financing (EUR)	Awardee co-financing %
4.376.276	3.000.000	68,55%	1.376.276	31,45%

SRITTP is to stimulate collaboration between public R&D sector and the private sector in order to commercialize R&D and promote technology transfer [5]. The centralized **Technology Transfer Facility (TTF)** established within the IF, as one of the components of SRITTP. The **TTF** has been operating with a dual mandate: to demonstrate that commercialization of inventions arising out of Serbian public research institutes and universities is possible and to help build capacity of the existing technology transfer facilities to consummate technology transfer transactions with private sector companies. Since its establishment, the TTF has designed support program as a combination of a technical support and funding and built a pipeline through which the evaluation of proposals coming from R&D organizations is evaluated and further supported up to the commercialization transaction with the private sector companies. The TTF deploys the following Service lines: Eliciting disclosures from researchers; Screening technology commercial readiness (Triage); Funding the proof of commercial readiness activities to move the technology closer to the required technology readiness levels (financial support in maximum amount of EUR 50.000); Determining commercialization strategy and tactics, including the need for additional commercial readiness funding either from IF funds or externally; Executing the commercialization strategy and tactics; Identifying potential commercialization partners; Negotiating and closing transactions (contracting) with such partners; Monitoring and follow-up of further commercialization tactics; Contract research, Service contracts for industry, IP landscape analysis; Support in applying for EU and other donors funds and Innovation voucher scheme. So far, under TTF total of 26 applications have been received: 21 disclosures and requests for funding and 4 applications under the service line contract research, and one application under service line Support in applying for EU and other donors' funds [6]. 15 projects have been approved financing, totaling 292.050 EUR as shown in Table 2.

Table 2. Technology Transfer Facility Program Funding

	Number of applications	Approved	Signed contracts	Licensed
Number	26	16	13/16	3/16
Total funding (RSD)	/	36.498.080	29.692.653	/

In 2017, the IF launched **Innovation Vouchers Scheme (IVS)**, part of the TTF Program, as additional service line for SMEs who want to use services of the public R&D organizations. The innovation vouchers scheme is a new financial support mechanism for small and medium-sized enterprises that use the services of the scientific research sector with the aim of raising the level of innovation of their products and becoming more competitive on the market. In the pilot phase, the IF has awarded 115 innovation vouchers in total amount of RSD 72 million [4]. Data presented in Table 3.

Table 3. Innovation Vouchers Scheme Funding

	Number of applications	Approved	Signed
Number	134	118	115
Total Amount of funding (RSD)	105.400.532	92.855.532,5	90.361.802,5
IF Amount of funding 80% (RSD)	84.320.426	74.284.426	72.289.442
Amount of co-financing by the firms 20% (RSD)	21.080.106	18.571.106	18.072.360

3. SECTORIAL DISTRIBUTION OF FUNDING

The funding support provided by the IF is sector-agnostic. The fund accepts applications from all sectors, revealing a capacity for firm-led innovation beyond the ever-dominant ICT sector. Beneficiary companies have demonstrated potential in sectors as diverse as agribusiness, construction, and bioengineering. Distribution per sectors for CGS, TTF, IVS is shown in Table 4., Table 5. and Table 6. respectively.

4. CONCLUSIONS

Presented programs are directly responsible for significant number of newly created liaisons between academia and private companies regardless of industry sector or funds available. As shown, potential for such collaboration in Serbia is high.

Number of applications for CGS exceeds available funding, and demand for the innovation vouchers greatly surpasses the allocated program budget. Considering that leading applicants in these two programs are from the private sector, it reflects willingness of private companies to seek partnership in public R&D sector, despite the belief that small and medium-sized enterprises are reluctant to cooperate with the academia. Although still pilot programs, CGS and TTF demonstrated good example of government involvement in building strong institutional collaboration between science and small and medium-sized businesses.

Table 4. Collaborative Grant Scheme Program Sectorial Distribution

Sector	Submitted		Eligible		Preselected		Approved	
Food and agriculture	16	16,67%	13	17,57%	4	14,29%	4	28,57%
Medical and therapeutical devices	5	5,21%	4	5,41%	2	7,14%	1	7,14%
ICT (Information and Communication Technologies)	15	15,63%	11	14,86%	3	10,71%	1	7,14%
Life sciences	8	8,33%	7	9,46%	3	10,71%	2	14,29%
Environmental and climate protection	8	8,33%	7	9,46%	5	17,86%	1	7,14%
Software and application development	7	7,29%	5	6,76%	2	7,14%	1	7,14%
Electrical engineering	9	9,38%	8	10,81%	3	10,71%	2	14,29%
Construction and civil engineering	2	2,08%	2	2,70%	0	0,00%	0	0,00%
Energy and energy efficiency	10	10,42%	10	13,51%	4	14,29%	1	7,14%
Machines and mechanical engineering	7	7,29%	6	8,11%	2	7,14%	1	7,14%
New materials and nano-technologies	3	3,13%	0	0,00%	0	0,00%	0	0,00%
Other industry	6	6,25%	1	1,35%	0	0,00%	0	0,00%
Total	**96**		**74**		**28**		**14**	

Table 5. Approved Technology Transfer Applications by sectors

Sector	Number of approved applications	%
Chemical engineering	5	31,25%
Mechanical engineering	5	31,25%
Medical and therapeutical devices	3	18,75%
Food and agriculture	1	6,25%
Software and application development	1	6,25%
Environmental and climate protection	1	6,25%
Total	**16**	**100**

Table 6. Approved Innovation Vouchers by Sectors

Sector	Number of approved innovation vouchers	%
Mechanical engineering	31	27,0%
Food and agriculture	29	25,2%
Electrical engineering	9	7,8%
Biotechnology	8	7,0%
ICT (Information and Communication Technologies)	7	6,1%
Software and application development	6	5,2%
Other industry	5	4,3%
Construction and civil engineering	4	3,5%
Energy and energy efficiency	4	3,5%
Chemical engineering	3	2,6%
New materials and nano-technologies	3	2,6%
Medical and therapeutical devices	3	2,6%
Environmental and climate protection	2	1,7%
Metallurgy	1	0,9%
Total	**115**	**100**

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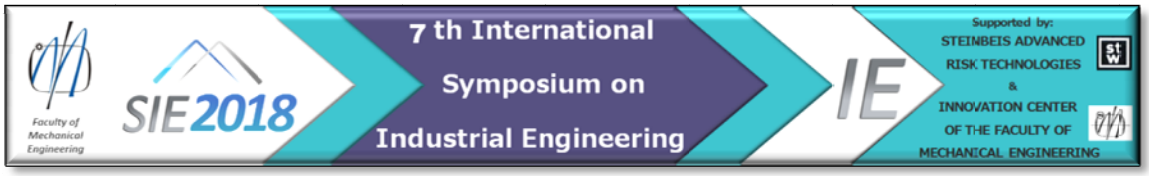

A SYSTEMATIC LITERATURE REVIEW IN THE DOMAIN OF ISO 9001 CERTIFICATION AND BUSINESS IMPROVEMENT

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Abstract. *In this systematic review the impact of ISO 9001 certification on business performance is addressed. A total of thirty (n=30) scientific articles in the domain of ISO 9001 certification are thoroughly analysed. The sum of samples of each analysed article is 9280. The findings indicate that almost half of the total sample size reported positive impact of certification. It is evident that ISO 9001 positively affects business performance. This paper can be used for further research as it provides a concise review on the effectiveness of quality management systems.*

Key words: *quality management systems, ISO 9001 certification, business performance, improvement*

1.INTRODUCTION

In this article the impact of ISO 9001 certification on business performance will be addressed. A thorough systematic literature review is conducted in the domain of ISO 9001 certification. In addition, business performance metrics will be analysed.ISO 9001 certification improves financial performance, and contributes to higher organizational efficiency [12]. This efficiency is the result of improved processes throughout the organization.It was suggested that ISO 9001 implementation positively affects customer satisfaction, operational performance, and financial performance [11]. This is manifested in the form stronger customer loyalty, and higher profit margins. Higher operational performance is achieved through more efficient processes. However, in other articles it was argued that ISO 9001 certified companies didn't acquire benefits from certification, and there was no evidence of financial, and business performance improvement [13]. In addition, it was described that ISO 9001implementationbrought noimprovements in business performance [3].

Furthermore, a more recent research suggested that ISO 9001 certified companies for more than three years are less prone to risks of failure [7]. In the same research it was noted that the certification process brought improvement to business performance. The metrics for business performance included productivity, cost-savings, customer satisfaction, process efficiency, and competitive market position.

It is evident that there are contradictions in the existing literature in the domain of ISO 9001 certification. The main objective of this systematic review is to concisely present various scientific articles in this domain, in order to determine the impact of ISO 9001 on financial performance, operational performance, and overall business performance. In the next section, a brief theoretical background is given. Further, the methodology is described,and the results are presented. Based on the findings, conclusions are drawn, and future research is recommended.

2. THEORETICAL BACKGROUND

The ISO 9001 defines the requirements for an effective quality management system. This standard has a positive impact on business performance, and brings improvements such as higher product quality; higher customer satisfaction; improved employee communication; improved internal, and external

processes; higher rates of employee training, and new skill learning; achieving economic goals; and improving financial performance. SMEs have to focus on internal organizational processes in order to effectively implement ISO 9001. This includes quality culture, reduction of risky behaviour towards the successful implementation of ISO 9001, readiness analysis, and a dynamic business environment [2]. It is evident that in order to maximize the potential of the ISO 9001 standard, the internal processes of an organization, have to be intensely supervised, and effectively managed. Management has to address the commitment, and awareness of workers regarding quality management systems, and its benefits to the organization. Employees play a key role in the implementation process.The main elements of ISO 9001 implementation include [4]:

- customer relationship development (developing strong relationships with customers is important for re-purchase of products and services, and overall for developing customer loyalty);
- research, and design of products, processes, and procedures (implementation of ISO 9001 often requires the redesign of processes, and procedures in order to synchronize them with the requirements of the quality management system);
- resource management(without adequate, and efficient resource allocation, the implementation process can be jeopardized);
- security of processes (the new ISO 9001:2015 standard focuses on risk management, and the security of processes play an important role in maintaining a safe environment where security risks are minimal).

The literature in the domain of ISO 9001 certification is dynamic, and the findings are often contradictory between each other. ISO 9001:2000 was described as a standard that improves business performance[10]**.**Contradictory to these findings it was argued that ISO 9001 certification didn't bring improvement to business performance or other business processes [1].When addressing business performance, it often means an integrated group of performance metrics that includes productivity, cost reduction, customer satisfaction, innovation intensity, waste reduction, and higher product quality. It was argued that the ISO 9001 certificate fulfils only 40% of the requirements of thehighly respected quality achievement, the Baldrige award.

The reasons are the following [6]:

- certification is easy to achieve if only the certificate is the goal, and not overall organic quality improvement in the organization;
- the ISO 9001 standard focuses on less important, minor problems rather than cardinal processes and procedures;
- often the quality of products before and after certification is similar, and companies don't see the point of certification;
- the total quality management concept bring better improvements in opposite to ISO 9001, thus certification is not conducted.

Some findings showed that implementing a quality management system doesn't affect business performance if the majority of the competitors on the market are also ISO 9001 certified. However, if the competitors are not ISO 9001 certified, then there is an advantage if a company possesses a certificate [8].Dynamic markets with volatile trends, are prone to higher risks when it comes to ISO 9001 certification. On markets where trends dictate product demand, and where customer loyalty is not developed, the percentage of ISO 9001 implementation failure, is higher. During the implementation process, companies often choose simple quality tools, while the more complex tools are used only in special situations. Human resources are often the main influential factor in quality tool usage. If the workers, or even worse, the managers, are not committed to the certification process, the advanced quality tools will not be used, thus the benefits of these tools will not be utilized. This way, a significant portion of the positive benefits of quality management systems, is excluded. It is important to address these issues before the implementation process. The commitment aspect of quality management systems is crucial for a successful certification [5].

This systematic review focuses on thorough analysis of various literature in order to determine the effect of ISO 9001 on overall business performance. In the next section the methodology of this research will be defined.

3. METHODOLOGY

Articles used in this systematic review were obtained through the Google Scholar, and KoBSON service. The main key words used to search for the adequate articles were the following: ISO 9001; ISO 9001 certification; ISO 9001 impact; ISO 9001,and business performance; ISO 9001, and

financial performance. Predatory conference papers and predatory journal articles were avoided. When a certain article was found it was downloaded and stored on the authors' personal computer. Duplicates were removed, and the eligible articles were further analysed. Irrelevant sources were excluded. Every article was thoroughly analysed, and key findings were noted. In every article the business performance metrics were addressed, and noted accordingly. This way, a useful insight is given regarding the type of positive, negative or neutral impact of ISO 9001.For the overall review process a defined protocol was used that included the following steps:

- Identifying, and obtaining articles through the Google Scholar and KoBSON services;
- Removing duplicates;
- First analysis of articles (ineligible articles were excluded);
- Second analysis of articles (articles excluded with reasons);
- Article selection for the systematic review, and qualitative analysis.

The review protocol was created according to the PRISMA protocol which was developed by Moher, Liberati, Tetzlaff, Altman, and the PRISMA Group, in 2010 [9]. This protocol is widely acknowledged as an effective tool for conducting systematic reviews in various scientific domains. The PRISMA protocol includes specific review steps that makes it easier, and more effective to analyse literature for a systematic review. In the next section the obtained results are presented.

4. RESULTS

Thirty (n=30) scientific articles in the domain of ISO 9001 certification were used for this systematic review. In Table 1, the sample size, and the impact of ISO 9001 certification on company performance (positive; negative; neutral), are presented. The labels in the "Impact of ISO 9001" column have the following meaning: Q-overall quality; FP-financial performance; PQ-product quality; OP-operational performance; PC- process control; CI-communication improvement; CS-customer satisfaction; IN-innovation; PM-process management; PR-production; BP-business performance; IE-internal efficiency; CP-competitiveness. The mentioned labels are the metrics that were analysed in individual articles. These metrics were used to determine the impact of ISO 9001 certification on overall business.

Table 1. Sample size, and impact of ISO 9001

Sample size	Impact of ISO 9001
131	Neutral
108	Positive – Q, BP
713	Negative – FP
872	Neutral
287	Positive – PQ, OP
120	Positive – PC
414	Neutral
239	Positive – IN
800	Neutral
133	Positive – PM, OP
20	Positive – CI
1000	Neutral
106	Positive – PR
27	Positive – FP
441	Positive – BP
352	Positive - PM
87	Positive – PQ, BP
168	Positive – FP, PQ, CS
143	Positive – FP, BP
209	Neutral
3	Positive – BP, FP, CS
N/A	Neutral
287	Positive – CS
138	Positive – CP
N/A	Positive – BP
255	Neutral
749	Positive – IE
200	Negative – IE
1150	Positive – OP
1000	Negative - FP

The sum of all samples of the analysed articles is 9280. The sum of samples where positive impact was reported is 3686 (39.72%). The sum of samples where negative impact was reported is 1913 (20.6%). Finally, the sum of samples where neutral impact of ISO 9001 certification was reported is 3681 (39.33%).It is important to note that these percentages are referred to the sum of samples in individual articles. Therefore the number of companies that reported positive, negative, or neutral ISO 9001 impact in each individual article is not presented.

To determine **apositive** impact of ISO 9001, the following metrics were analysed: improved business performance, financial performance, operational performance, improved quality, higher customer satisfaction, and increased productivity. For **the negative** impact, lower productivity, higher costs, difficulties in implementation, and lower financial performance were addressed.**Neutral** impact was noted where companies didn't report any improvement after ISO 9001 certification.

5. CONCLUSIONS

Based on the obtained results, it can be concluded that ISO 9001 certification can have a positive impact on business performance. However, the neutral impact also has a high percentage. Companies that had good business performance before ISO 9001 certification, didn't report dramatic improvement. Negative impact of ISO 9001 certification was reported when managers didn't get involved with the implementation process. This resulted in time miss-management, higher costs, and unachievable deadlines. Therefore, it is important for top managers to get involved, and to be committed to the implementation of the ISO 9001 standard. The results presented individual article samples sizes, and ISO 9001 impact on business performance. It is interesting to see the contradictory reports from companies regarding benefits, and improvements (if any) after ISO 9001 implementation.

Certainly, the findings of this research are moderately significant. It provides a solid base for future research in the domain of quality management systems. Practical implications of this paper may include use from companies, and managers who are thinking about ISO 9001 implementation. The limitation of this paper is the lack of detail in data presentation when it comes to individual articles. However, this could annul the concise nature of this paper, and could invite confusion to the readers. Therefore, for in-depth detail on this subject, it is recommended to conduct a similar research in the domain of ISO 9001, with the focus on specific business performance metrics, and statistical data.Additional conclusions can be drawn from the mentioned recommended research.

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SOME POSSIBILITIES OF THE IMPACT ON GrSCM

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Abstract: By the development of science, technique and technology, there is an increase in environmental awareness in all segments of modern business and life. Especially in the last decades, environmental issues have significantly increased on the list of priority issues, especially in the supply chain management (SCM), where increasing emphasis is focused on environmental sustainability. A literature analysis indicated that this led to the development of management of so-called Green Supply Chain (GrSC). However, the legal framework that formulates regulations for fulfilling especially ecological norms has a problem related to the lack of adequate literature in the field of management of the GrSC (GrSCM). This paper aims to demonstrate the importance of environmental sustainability for the SC in conditions of much harder competition in the market, in order to meet the needs of the end user. In this context, some of the possible ways to influence the improvement of GrSCM will be presented.
Keywords: SCM, GrSCM, logistics, environmental sustainability

1. INTRODUCTION

The concept of *supply chain* (SC) has been present in the literature in the 1980s, and its adopted precise definition still does not exist. It can be noted that within a number of definitions, the SC at the first includes the exchange of goods and information in logistic processes that begins with the procurement of raw materials until the delivery of finished products and/or services to the end user, including reverse flows; all suppliers, service providers and users must be linked to the efficient functioning of the SC (Chorpa and Mendl, (2004), Simchi-Levi, Kaminsky, and Simchi-Levi (2009) et al., Glossary of SCM Council…).
Previous researches in the SC domain have been mostly related to the analysis of its functioning at the global level from the aspect of the functioning of all its members. Bearing in mind the strengthening of competition on the market in order to maintain the SC's existence and its competitiveness, from the aspect of one, for example, production company, it is important to perceive at and improve internal processes (Marinagi, Trivellas and Sakas, 2014). Therefore, lately more and more attention has been focused to elementary logistics activities in the field of intralogistics, from the aspect of SC functioning. In addition, there are increasing demands for the integration / inclusion of SCM's environmental protection, both in the domain of research and practice.
The joining of ecology and SCM has led to the emergence of GrSCM, which implies the strengthening of environmental awareness in all SC segments. Having in mind that the complexity of environmental issues is a relatively great challenge for researchers, there are numerous aspects to enhance SC's competitiveness from an environmental point of view. This paper aims to show only some of the numerous tendencies and opportunities in the GrSCM domain. After the introduction, it was first given the definition of the term GrSCM, as well as some of the advantages that a company can achieve by its introduction. Then, in practice, some of the ways to improve the management of the GrSC are described. In the next part, the tendencies in the GrSCM were analyzed, with emphasis on some subsystems of logistics that may be of relevance to SC competitiveness.

2. GrSCM – DEFINITION AND POTENTIAL BENEFITS OF ITS IMPLEMENTATION

In today's business environment, competition is getting tougher, and companies have to choose their place in the market. In addition to increasing profits, lowering costs in various areas of the company's business, increasing attention is also focused on the impact on the environment. The negative impact on nature and natural resources is becoming more pronounced, and in recent times a special point has been put on reducing or even eliminating these negative impacts, if possible. One way to achieve

this goal is to introduce a green supply chain (GrSC).

GrSCM points to the relationship between SCM and environmental impacts *and aims to minimize or eliminate waste, harmful substances emissions* during the procurement, production, distribution of the final product, and to manage end-of-life products. Therefore, GrSCM *has an impact on every company that participates in the SC, and in that way contributes to sustainable development and thus to the living environment.*

In this way, opportunities have been created to *integrate environmental awareness* into the SC, beginning from supply, product design and production and also to the management of EoL (End of Life) products. GrSCM includes activities in the areas of ordering, production, distribution and reverse logistics, which create ***positive environmental effects*** (China, Tatb and Sulaimana, 2015). The basic components of GrSC are shown on figure 2.1. When compared to traditional SC, use of GrSC provides number of advantages:

Figure 2.1. Basic components of GrSC

- a healthy environment for life, - reducing the negative environmental impact of business entities,
- reducing:
  * costs of procurement, production,
  * the use of primary raw materials for production, the price of (certain) products (using recycling materials),
  * waste handling and disposal costs,,
- interruption / prohibition on the use of hazardous substances in SC.

Along with the above advantages, the impression that the company leaves on its users and society is better when it is noticed that it has awareness of environmental protection. In addition to the advantages achieved by the implementation of the GrSC, there are some shortcomings: insufficient acceptance or complete ignorance / rejection by management and other employees (as a rule as a result of insufficient information on the importance of ecology in business), high implementation costs, etc. However, in order to maintain and improve the competitive position of the market, it is necessary to be flexible from the aspect of satisfying the demands of the users, along with the respect of environmental sustainability in all its segments.

The imperative of successful business is reflected in the environmental sustainability of each entity in SC. According to the latest trends / regulations, each product must be made so that it (or its components) can almost (could) be reused (reusable, recyclable, etc).

Having that in mind, it is clear that the SC management process is more complex if one aspect is added - ecology, which is explained in more detail below.

3. MANAGING GrSCM FROM THE ASPECT OF ENVIRONMENTAL SUSTAINABILITY

Respecting environmental sustainability as one of the imperatives of successful business, in practice, most commonly encountered *two ways of managing* the GrSC. ***The first*** way is shown on Figure 3.1. (http://scmitc.com/ accessed on 30.03.2018)

Figure 3.1. Components of the first way of GrSCM

The Second way involves one of the most common practices of GrSCM that includes (Ninlawan et al., 2010):

- green procurement,
- green production,
- green distribution and
- green logistics

Due to spatial constraints, this paper focuses attention only on *green logistics*, whose components are shown in Figure 3.2.[1]

Green logistics involves shipping goods to the end user using alternative fuels, forming bulk consignments, investing in vehicles with reduced negative environmental impact, adequate routing of vehicles to reduce costs and time of transport, etc. As shown in the Figure 3.2, green logistics has its subsystems: transport, storage, information etc.

An indispensable process of particular importance for environmental sustainability is the reverse logistics - it refers to the taking of products from the end consumer in order to further its treatment (Ninlawan et al., 2010).

[1]https://www.oocllogistics.com/eng/ourcompany/aboutus/environmentcare/Pages/Environmental%20CARE%20Management.aspx (accessed on 19.03.2018)

Figure 3.2. Components of Green Logistics as a segment/part of the GrSC

Reverse logistics activities include, among others, the collection of used products, sorting, transport to the processing site, re-processing, etc. It can be said that these activities permeate all the listed subsystems of green logistics and will be considered in the next part of this paper, which deals with the analysis of some tendencies in improving the functioning of the GrSCM.

4. THE IMPORTANCE OF ECOLOGICAL PACKAGING IN GrSCM

None of the entities of SC doesn't function independent from the others, so environmental sustainability can't be analyzed in only one segment of SCM, without respecting others. So the packaging is present more SC entities, like production, storage, transport. One of the first tendencies from that aspect is that companies are reducing assortment and quantity of product packing, as well as reducing the expenses of transport, energy, etc. The most present in praxis and the aim are two aspects:

a) special attention is directed towards to higher ***use of used – reverse packing*** where it is used multiple times, which leads to reduce quantity of waste and there are big possibilities of saving when compared to production of „new“ packing;

Praxis shows there are two ways of *used packing* flow management (modified, taken from Tadić and Zečević, 2009):

1. Consumers sort materials from recycling packing and disposal; it is recommended that sorted materials are transported to place of their further treatment,
2. Manufacturers undertake to return the packaging of used products (and their parts) with the delivery of new products; this is the process of one part of the established reverse distribution/logistics system;

b) ***packaging materials*** should be biodegradable and not affect the eco-system (Gandhi and Sharma, 2014).

One of the present and significant tendencies in the development of *environmental packaging* is that materials that have already been used are used for packaging production. Thus, plastic bags in retail facilities are increasingly replaced with reusable bags, made of recyclable materials, easy to maintain. Furthermore, the developed countries the years ago instead plastics, have introduced the use of paper and bags from biodegradable plastics (so-called *eco bags*). Some of them favor bioplastics, whose production was expensive so far, but with the development of new technologies, biodegradable bags (and other products, such as glasses), are financially and functionally competitive with plastic ones (Figure 4.1)[2].

Figure 4.1. Bags/packages and other products made of biodegradable materials.

For example, scientists are even testing the production of bioplastics bags made of sugar and cereals, which can eventually be used for the production of compost. Compared to plastic bags, linen bags are a better solution. Their production requires far less energy, and moreover, their exploitation is longer than plastic and paper bags[3].

In the area of packaging and handling, there is an interesting trend in the range of pallets. A significant number of companies perform logistics activities using standard pool pallets (800mm x 1200mm); made of wood (material from nature), that is intended for multiple use, but when irreparable damage occurs, it is subject to write off and most often to thermal treatment.

The use of cardboard instead of a wooden pallet is thus one of the possible impact on the GrSC. Cardboard Pallet (*PalletKraft*) is a novelty in the field of palletization (see Figure 4.2.). This pallet is efficient and tolerates loads as well as wood and easily adapts to the requirements of the users. The lower weight, the ability to adapt and other advantages of the carton pallet reduce transport costs by up to 2%.[4]. The material is a paper hollow profile that proved to be extremely suitable material for the creation of this group of logistics units. This pallet was present at LogiMAT 2018[5] Logistic Fair. The first of the advantages of a cardboard pallet is its weight of 7 kg (unlike wood, weighing up to 28 kg).

It can be noted that carton pallets represent a logistics solution of the 21st century. There are numerous advantages of using this pallet in relation

[2] http://retaildesignblog.net/2012/11/21/brokulaz-packaging-by-bruketa-zinic/ (accessed on 23.03.2018)
[3] ibid
[4] http://www.palletkraft.si/hr/ (accessed on 31.03.2018)
[5] https://www.mm-logistik.vogel. de/ logimat/ articles/693905/ (accessed 23.03.2018)

to wood ones[6]: reduction of damage of goods in transport, better absorption of vibration (cca 80%), up to 75 % lighter than wooden one, high load capacity (up to 2.500 kg), more favorable for clients,

Figure 4.2. Cardboard pallet (*PalletKraft*)

savings in transport costs (for example, in a semi-trailer with 30 pallets, the pallet mass decreases by up to 0,6t, where lower fuel consumption results in a reduction in environmental pollution).
Additionally, they are resistant to insects and bacteria, comply with international regulations (export ready - ISPM 15), recyclables, etc. This trend is also present in mini-load units (see Figure 4.3) with all the positive effects that come from their application.

Figure 4.3. Cardboard mini-load unit

It is shown that this solution approach positively influences both environmental and economic effects, and experts from this field are engaged in testing various innovations in this field.

5. CONCLUSION

With the increase of number and assortment of user's demand, the complexity of SC also increases where one must have in mind that every member of SC directly or indirectly has the effect on the pollution of the environment. That is the reason why traditional SC gets environmental component which creates GrSCM. While in significant number of countries this is already praxis, in other it is in the early development (like Serbia).
GrSC implies lot of innovations in SCM, because from supply to fulfillment of user's demand his functionality is analyzed from the aspect of saving the environment. Therefore, it is very important that all SC members have awareness of environmental sustainability (Kumar, Teichman, Timpernagel, 2012). In order to function with success, GrSC must be accepted from all the participants. To maximize the positive effect of its functioning, the changes must be included in all the components of the SC. It is logical that there are numerous areas of researches in this area with the possibility of increase in environmental and economical efficiency, safety and other advantages that follows this trend.
So called „green praxis“ in this area are very significant, like decrease of usage of natural resources, re-usage of used products (and/or their parts), recycling of used and EoL products and materials in order to get new source of raw materials etc. This paper deals with one segment of GrSCM domain which shows some tendencies related to wrapping material focused on cardboard pallets and mini load logistics units.
Future researches should focus on product design/construction, material choice and acquisition, manufacturing processes, delivery of final product to customer, but also on product managing after expiration of expiry date, and all that in context of environmental sustainability of SCM.

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USING VALUE STREAM MAPPING AND FIVE FOCUSING STEPS FOR INCREASING CAPACITY IN CONFECTIONARY INDUSTRY

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Abstract. *The paper shows results of action research where Value Stream Mapping (VSM) and Five Focusing Steps (5FS) of Theory of Constraints (ToC) have been used together in order to increase the capacity of production line in confectionary industry. VSM has been used to define the scope of improvement and measure the process.5FS have been used in order to identify the constraint for the process, and decide on how exploit the system in order to maximize the capacity of the constraint and the system as a whole. The results show that this approach can lead to consequential increase in capacity of production line, and can prevent costs such as overtime, introduction of additional shifts of investments in new equipment.*

Key words: *Value Stream Mapping, Theory of Constraints, Five Focusing Steps, capacity increase, confectionary industry.*

1. INTRODUCTION

Theory of Constraints (ToC) is a manufacturing paradigm devised by Eliyahu Goldratt, which says that performance of any system is limited by relatively small number of constraints [4]. As such, it advocates that the performance of the system can be improved by improving the performance of the constraint, and that any improvement to the performance of non-constraints is merely an illusion. It also suggests that a system should be managed by managing the constraint of the system.

In order to improve the performance of the system, Goldratt & Cox proposed a methodology for continuous improvement based on the notion that the system is only as good as its constraint (the methodology is also known as Process of On-Going Improvement – POOGI) [4]. The methodology suggests that special attention (focus) should be given to constraint, and consists of five steps (hence the name Five Focusing Steps – 5FS) [4]:

1. Identify the constraint – identify the resource that limits throughput;
2. Exploit the constraint – maximize the utilization and performance of the constraint;
3. Subordinate everything else to the constraint – ensure the rest of the system supports the work of the constraint (also make sure to avoid producing more than constraint can handle, in order to limit WIP);
4. Elevate the constraint – expand the capacity of the constraint, possibly with new investments;
5. Prevent the inertia, and go to step 1 – constraint might persists, or if the constraint has been elevated, new constraint will emerge.

Constraints can be physical (resources), managerial (policies), and behavioral (paradigms). Physical constraints are most obvious, and will be the focus of this paper, as they are the ones requiring 5FS [2].

Food industry (and confectionary industry, as its part) is the type of industry that supplies customers with the food required. As a process type of industry, it is highly capital intensive (as opposed to discrete manufacturing that can be labor intensive, e.g. assembly), and as such it relies heavily on technology and equipment during manufacturing. Equipment can be quite expensive, which requires for it to be efficient and highly utilized. This is why ToC and 5FS might be good solution for continuous improvement in this type of industry, especially having in mind the focus on constraints and its maximal utilization.

Every system depends and a small set of constraints. However, identification of the system as a whole is often overlooked. Fredendall & Hill claim that it is important to define system before applying 5FS, in order to establish its boundaries, purpose, and a set of measures [3]. Value Stream Mapping (VSM) has been used extensively for providing the overview of the system. It shows a series of events that transform raw material to finished products, and it includes a set of measures used for diagnosing the state the system is currently in [6]. As such, VSM is a perfect candidate to define system in a pre-implementation phase of 5FS. However, some adaptations to specific manufacturing environment (process industry) is needed, given the fact that VSM has been developed primarily for discrete manufacturing. For example, in process manufacturing takt time is not as important as if the rate of production, buffers between processes don't play significant role (and they usually don't exist), focus is on resource utilization rather than labor utilization, which in turn requires specific set of measures, etc. [5].

This paper shows results of action research, where VSM and 5FS have been applied together in order to improve the capacity of the production line in confectionary industry. The remainder of the paper is organized as follows: second section gives a short overview of methodology used; third section gives brief examination of the results obtained, and is followed by conclusion.

2. METHODOLOGY

The research focuses on a single company. Using single company can be appropriate if it provides an opportunity to observe and analyze a phenomenon previously inaccessible to scientific investigation, and if longitudinal approach is taken, i.e. if functioning of case company is analyzed over a considerable period of time [9].

Company SUGAR (real name is obscured) is typical confectionary manufacturer. It produces a wide variety of confectionary products, such as chocolates, candy bars, cookies, waffles, and snacks. The company has stable but increasing demand, with high production volumes. Salty sticks are one of company's most recognizable products. They come in variety of tastes, all produced on the same production line. The demand for this product is on the rise, so the management has been seeking ways to increase capacity, while at the same time delaying the decision on investing in new equipment. The management was aware that current production line is constrained, but wanted to explore the possibilities of increasing the capacity.

The research involved cooperation between researchers, company managers and employees. Having that in mind, as well as the fact that research question 'relates to describing an unfolding series of actions over time in a given group, community or organization', the research can be further typified as action research, as a variant of case research [1]. A process consultation model was chosen. Here, researchers help the clients inquire into their own issues, and actively participate in the design and implementation of the solution [7]. A consistent approach was developed and well documented, so it can be followed by other researchers [8]. Researchers' subjectivity was mitigated by including management and employee representatives in the research team. All decisions were made by consensus. In turn, employee subjectivity was mitigated by the presence of researchers.

Research has been conducted in two phases: (i) VSM in order to define the system, identify its purpose, and decide on and set-up measurements; and (ii) implement 5FS in order to increase the systems' capacity, with special attention to first three steps of the procedure.

3. RESULTS

VSM for salty sticks production process is given in Figure 1. Being that procurement and delivery were out of focus of this research, only processing steps are shown on the map. Since production is scheduled on the first step of the process, and can be classified as "push" (which is often case in process industries), production control paths have been left out of the map as well.

The process consists of seven steps, with continuous flow between them and no buffers. Steps two, three, four and six are capital intensive, while steps five and seven are labor intensive. Step one is a combination of capital and labor intensive work. The production line works five days a week (also weekends if necessary), three shifts per day, 8 hours per shift (with one 30 minute break per shift). As for measures, maximum capacity (as defined by equipment manufacturer) and effective capacity (maximum achieved capacity) were measured. Required capacity is determined according to system bottleneck. i.e. baking and cooling. Utilization is calculated as ratio between effective capacity and required capacity. Changeover time is determined according to archival data.

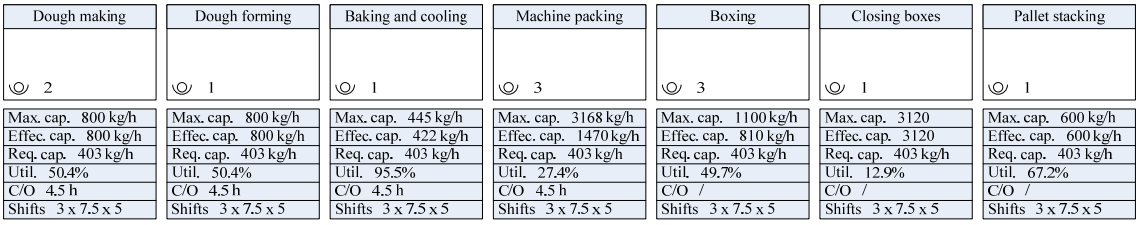

Figure 1. Value Stream Map for salty sticks production process

Baking and cooling process has been identified as a constraint, being it is a process with the lowest capacity. The process is performed in an automated oven fed by a conveyer belt. The existence of constraint was known even before the VSM. However, VSM introduced systems view of the entire process, where both managers and employees were able to grasp interdependences between different phases of the production. Besides that, VSM also helped to focus on the part of the process up to baking and cooling, being that performance of baking and cooling is directly influenced by preceding steps.

Next task was to decide how to exploit the constraint. One of the main issues were changeovers, which are complex, and require for the entire production line to stop for a certain amount of time in order for the production line to be thoroughly cleaned. Changeover and cleaning processes were unstructured, and organized and staffed in an *ad hoc* manner. This resulted with high variations in changeover time, where cleaning could last from 2 hours to more than 4 hours, which in turn resulted in great loss of capacity. As a countermeasure, new changeover and cleaning procedures have been designed, and small investment in new cleaning gear has been suggested. This resulted in changeovers being repeatable, manageable, and able to plan. SMED technique has been used extensively during this phase. Second issue were breaks, where the entire line stops for 30 minutes per shift and all of the workers go on a break, resulting in loss of 90 minutes of capacity per day on a constraint. The production line is largely automatic, requiring just monitoring most of the time (given that there are no disruptions to the process flow). Having this in mind, it has been decided that production line should work all the time, where one half of the workers go on break, leaving the other half to man the line, and switching after 30 minutes.

Exploiting the constraint, it became important for the baking and cooling process to be supplied with work all the time. Pareto analysis has been performed in order to identify major sources of disruptions to the flow. The analysis showed that the major issue is with the cutting knife, located on the end of dough forming station. The knife is covered with the Teflon foil, which gets depleted over time, sooner or later depending on the ingredients used in the dough, as well as the quality of the foil itself. When the foil gets depleted, it requires change, done by technical maintenance staff. The procedure itself is short, lasting about 10 minutes, followed by knife adjustment. However, depending on the availability of maintenance staff, the time between reporting the damage on the knife and replacing the foil could be as long as one hour or more. Moreover, the analysis showed that the production line loose 24 minutes per day on average, due to the issues with the cutting knife. Foil change is considered to be a problem with low significance by maintenance staff, since it usually prevents them to commit themselves to more serious technical issues. As a countermeasure, production line employees were empowered and trained to change the knife themselves when the issue occurs. Since foil change requires special care, it is still done by the maintenance staff. However, the system similar to two-bin Kanban has been introduced, with one backup knife being prepared for the production line to replace the damaged one. When the damage one has been replaced, it is sent to maintenance to change the Teflon foil.

3. RESULTS

New changeover procedures stabilized changeover and cleaning time, and resulted in decrease of changeover time of 49 minutes on average (depending on the type of the product). It has been estimated that this decrease will save approximately 1550€ of wasted capacity per month.

Having in mind the capacity of baking and cooling process (403 kg/h), it was possible to produce 9067 kg of products per day, in a situation where there are no disruptions to production process. Just by introducing new scheme for taking breaks, it was possible to increase daily production to 9672 kg.

This increase will lower the requirement for extra shifts and working on weekends, which are measures often used during periods of increased demand (summer and first half of the fall). Previous way of working required 26 extra days (weekends) per year, while new way requires 15 extra days of work per year. This means that this extra capacity can be utilized should the demand rise even more.

Subordination of the system to the requirements of the constraint resulted in the increase of the capacity of the oven. By maintaining uninterrupted flow of products (through autonomous maintenance) from the dough forming station, the average capacity was increased from 403 kg/h to 414 kg/h, meaning that daily production can be increased to 9936 kg, having in mind that available time for production is now 24 h per day. This increase can also be used to lower the need for extra days, or it can be utilized to follow the increase in demand when it occurs. Given the fact that the maximum observed capacity is 422 kg/h, this leaves the room for future improvements.

4. CONCLUSIONS

This paper presents the results of an action research, where VSM and 5FS were applied together to increase capacity of a production line in confectionary industry. VSM has been used in order to define the system that needs to be improved, including its purpose, boundaries and set of measures to be taken. After that, the 5FS approach has been applied in order to improve system's ability to continually obtain goals. Focus was on first three steps, where constraint was identified, later exploited, and the rest of the system was subordinated to the constraint. The application led to consequential increase in capacity of production line, and prevented additional costs such as overtime or introduction of additional shifts. In addition, the improvements did not require significant investments in new equipment.

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SMALL AND MEDIUM SIZED ENTERPRISES AND LEAN CONCEPT

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Abstract: *The authors analyze the importance of small and medium enterprises and the problems of managing their production and production cycles. One way of pursuing perfect production is a lean concept that aims to eliminate losses and wait in production. It is argued that SMEs who adopt Lean Manufacturing can benefit by improving competitiveness through faster innovation and production, increasing flexibility and reducing costs. The paper presents the results obtained by experimental application of the developed method in a small one from representative small and medium enterprises in Serbia. The goal is just to eliminate all losses and shorten non-production times in production cycles.*

Key words: *Lean concept, production cycle, elements of production cycle time, small and medium sized enterprises*

1. INTRODUCTION

Modern enterprise in new conditions, conditions of globalization, turbulence, the global market, numerous rapid and ever-increasing changes, has to adapt and change, in order to achieve competitiveness and survive in modern business. Companies that want to be successful and to advance in the marketplace must be innovative, flexible and ready to adopt and apply new knowledge, strategies and technologies. We need to strive for a perfect lean production, with as little loss as possible, with efficient production management to produce a quality product. The strategy of constant innovation and the dynamism of change is the response to the demands posed by the market struggle. Small and medium enterprises SMEs are generally characterized by below-average labour productivity because these enterprises are too small-sized to achieve economies of scale or economies of scope. In addition, they are less capital but more labour intensive. In developing countries, such as Serbia, technological profile of Serbia's industrial structure comprises 49.9% of low-tech and 25.6% of medium-low-tech companies [3]. Although enterprise resource planning - ERP implementation would be useful for SMEs in developing countries, it is usually restricted by knowledge and resources constraints [4].

Lean Production is an integrated set of activities designed to achieve high-volume production using minimal inventories. Lean thinking is applicable to all business processes within the process industries. The challenge, if we decide we want to be lean, is whether we know enough about our ways of working, what customers of the business processes truly value, and how our businesses operate and need to operate.

It can be concluded that the provision of rational production and deadlines required in the production of high-quality production planning and appropriate technical- technological calculation, which give modes machinery and duration of operation as well as activities in the production process. Particular emphasis is placed on small and medium enterprises as the bearers of economic growth and development and reducing production cycle in them as a means of improving productivity and achieving competitiveness.

Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs (products) having the requisite quality level. Production is defined as "the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user." Thus production is a value addition process. At each stage of processing, there will be value addition.

The PC time involves the time needed to make a unit or a series of units from putting them into production

until their storage, and aside from being significant as a technical indicator, it is also important as an economic indicator of freezing current assets, especially raw materials. There can hardly be any enterprise that does not monitor PC time through documentation and analytically, but rarely do they monitor the elements of work within the PC and by analyzing those elements affect their reduction and thereby PC time reduction.

For developing and transitional economies in particular, SME development holds the added allure of being a key component of wider economic development and poverty alleviation. The SME community is seen as a major and sustainable generator of employment and income (and therefore tax revenues) for citizens working outside of the State sector. In the case of transitional economies, although many State-owned enterprises can also be SMEs, SME development is broadly synonymous with private sector development. In developing countries, SMEs can also serve as a useful bridge between the informal economy of family enterprise and the formalized corporate sector. Some of a country's more able SMEs may also be a source of foreign exchange earnings, if they are able to meet the quality and quantity standards required to export their products or services overseas (ESCAP).

2. SMALL AND MEDIUM SIZED ENTERPRISES

In most theories is the notion that SMEs are at a disadvantage in participation in production networks compared with large firms. SMEs face, to a higher extent than large firms, resource constraints (in terms of finance, information, management capacity, and technological capability) [9, 6].

The probability of SMEs joining production networks (as direct exporters, indirect exporters, or overseas investors) is lower than that of large firms. Furthermore, justification exists for public policies to support the entry of SMEs in production networks. In the main, such support should be geared to an enabling environment that opens access to markets, reduces bureaucratic impediments against SMEs, and provides appropriate SME institutional support services.

Technological machine time t_{tm}, viewing production against machinery, is exclusively linked to machine performance and the quality of technological calculations, and is mainly a deterministic category. However, if the production cycle is viewed from the aspect of a serial sequence of operations, the elements of working time differ, depending on the automation level. If production is automated, then t_{tm} for a series will be simply a sum of individual n equal operations. However, if each part has to be manually or mechanically conveyed for processing from a joint crate or some other room where a certain series of parts is stored, manual placement on the machine is ancillary manual time – t_{pr} (in theory, this refers to individual pieces). Such time is not frequently encountered in literature (rear examples are papers [8] dealing with the division of working time elements.

According to Gits [5] production is one of the key and primary function of the organization. Huang et al. [7] argued this requires the companies to be efficient, work to optimize, and improve the productivity level. Muchiri & Pintelon [11] are of the view that production losses lead to decrease in productivity due to an inefficient manufacturing process.

Typically SMEs and especially small enterprises are not only adaptive and innovative in terms of the products but also their manufacturing practices. Recognizing the continuing competitive pressures, small organizations are becoming increasingly proactive in improving their business operations [1], which is a good starting point for introducing lean methods.

3. LEAN CONCEPT

The term lean is used to denote a modern, successful business philosophy, that is, production of a world class characteristic of the modern era of business. The goal of this philosophy is to enable the company to achieve a satisfactory, if not a leading, market position in conditions of rising competition, falling customers' loyalty, constant technological innovations, drastic cuts in the life of products. The secret or key to success of the concept of managing production operations lies in "... the tendency to eliminate all forms of loss and wastage of production resources, while improving the quality, flexibility and speed of response to the impulses that come from a turbulent environment."

Observing differences, traditional, or mass production, is considered an outdated paradigm, precisely because there is no direct link between production and demand. On the other hand, lean represents a new paradigm, since the production of different models in small series directly meets the needs of customers, and allows the company to adapt to market changes more easily and quickly. The smaller the series, the overall business process is easier and better run. Lean production takes place

continuously, from a single-phase flow, emphasizing the optimization and integration of machines, materials, people and objects [4].

Many companies have a very poor system of preventive maintenance, or because of cost reduction, they decide to buy cheaper and less reliable machines [3]. Practice shows that the costs that are caused by product congestion are much higher, because in this way the problem of delay in delivery is primarily a problem, which in today's conditions of intense competition can be a very serious problem, because the customer will be disappointed with the delay to choose another.

Lean is one of the most influential new paradigms in manufacturing, and has expanded beyond the original application on the shop floor of vehicle manufacturers and component suppliers in the auto industry, ranging from “heavy” industries such as primary metals (notably Alcoa’s production system see www.alcoa.com) to aerospace businesses [14]. In particular when applied to sectors outside the high-volume repetitive manufacturing environment, lean production has reached its limitations, and a range of other approaches to counter variability, volatility and variety have been suggested. Here, the often quoted lean-agile debate is applicable, discussing whether an agile or a lean strategy, or even a hybrid approach is most suitable [12, 13].

The ultimate goal of eliminating activities that do not add value is actually shortening the duration of the process. One of the most important measures for the success of lean implementation is the reduction of the time that elapses from the moment the company receives the order until the moment of delivery and lead time [10]. The basic assumption is that as little as possible the product takes time in the system, it will be less costly to join.

4. METHODOLOGY

The methods and techniques used in the function are the realization of the set goals and tasks of research, that is, for the development of the stochastic model of optimization of the production cycle in small and medium enterprises, as well as proving the set goals of the research.

The descriptive method of theoretical analysis provides an overview of relevant research and experiences in the field. The method of the study of the documentation and the methods of theoretical analysis were used in the study of the selected and available domestic and foreign literary sources. In order to realize the research, already known statistical methods were used, while analysis, synthesis, induction and deduction were used as rationalistic methods for logical conclusion. A modified instant observation method (record sheet) was used to collect data.

In the research, the stochastic method of optimizing the production cycle time in small and medium enterprises are experimentally proved. The method is graphically and mathematically checked in a multi-year study, and in this paper we present only the segment of the obtained results.

A modified work sampling method will enable the determination of the participation percentages of working time elements against the total duration of the production cycle and production. As this method is statistic and is based on a certain number of instantaneous observations of a certain activity, it is simpler to use and more efficient than the continual streaming method. Monitoring within the production cycle will involve technological time with lead time and manufacturing time, non-technological time with times for transport, control and packing, while non-production time includes stoppage due to poor production organization, lack of materials, lack of tools, including the failure or breakdown of machinery and other types of stoppage, their interdependence, as well as impact factors such as series size, organizational level and product characteristics pertaining to the factors mentioned.

5. RESULTS AND DISCUSSION

Representative screening time is related to the length of the production cycle time. Production and productivity are also related to the production dynamics which are planned at the operational level on a daily, weekly or monthly basis. Hence, the production cycle for the above mentioned periods is also provided for the purposes of monitoring and comparing.

Screening performance requires the precise definition not only of technological and mathematical problems, but also of the practical screening process and the establishment of working time elements. Thereafter, the elements of production cycle working time should be defined and, in particular, the difference against the elements of working time related to machinery, i.e. for the purpose of establishing the machine capacity only or within the production cycle, because these two are not the same.

In this paper we present some of the results obtained by surveying result in a medium-sized company. The company is family owned and has 20 employees. It deals with the production of school

and office materials. Products of school rucksacks, travel bags, business bags, duvets, agendas, leather products, rotating carriers and others. It is the general distributor of PENTEL and LUXOR products for Serbia. In addition to its own production, the company also has a retail and wholesale retail store. Research was conducted in the same period 2012, 2013 and 2014. for the purpose of monitoring and comparative presentation of results.

Monitoring included 47 cycles of different series sizes (4 – 10 units) and the time duration ranged from the shortest (240 min) to the longest (420 min), with 10 - 30 instantaneous observations. There were 932 observations in total, while the total time for all cycles amounts to 15,293 min. The average production cycle time - t_{pc} is 325 min and the average production cycle time per unit t_{pc} is 56.2 min. Figure 1. showing elements of working time in the production cycle.

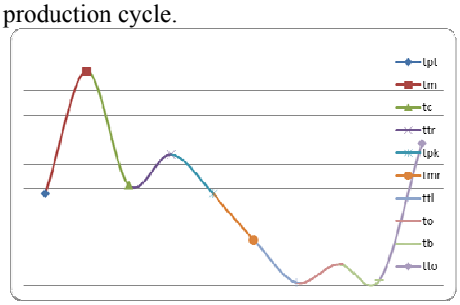

Figure 1. Elements of working time in the production cycle

Comparative results have been given in the table 1 for all three years.

	t_p						t_{np}							
Год.	t_{pt}	t_m	t_{pt} - t_m	t_c	t_{to}	t_{pk}	t_{pt}	t_{mr}	t_{tl}	t_{tr}	t_b	t_{ito}	t_p	t_{np}
2012	14,53	44,97	59,5	12,34	6,15	6,15	24,64	3,52	0,93	1,42	1,91	7,1	85,22	14,78
2013	21,18	40,11	61,29	61,29	11,66	6.11	5,79	3,54	1	1	0,13	8.9	87,3	12,7
2014	21,85	53.72	75,55	6.53	6.22	2.9	15,65	2,9	0,9	0,46	0.1	6.4	90.5	9,5
2012 - 2014	19,2	46,3	65,5	10,2	6,2	4,9	21,25	3,3	0,94	0,96	0,71	7,5	87,7	12,3

In 2013, all PC times with little difference, except for preparatory finishing time, where the increase was from 14.53% in 2012 to 21.18% in 2013. The average production time is t_p=87,7%, non-productive $t_{np=}$ 12,3%.

There are 11 groups that contain at least 9 pieces in the series, while the largest group is 115 in the series. The movement of all the elementary production cycle of the average productivity time t_p and control limits of company 3 for 2014 is shown in the diagram 1.

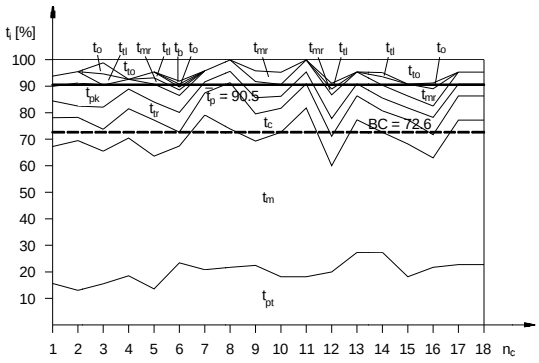

Diagram 1. Elements of the production cycle, average productivity time t_p and control limits for 2014

From the diagram 1, it can be seen that the total production time for the observed production cycles in percent for 2014 is t_p = 90.5%, and the non-production time is t_{np} = 9.5%.

CONCLUSIONS

The duration of the production cycle (PC) in domestic enterprises, especially in small and medium-sized enterprises (SMEs), which are undoubtedly the drivers of economic growth and development, has been very long, which greatly affects productivity and competitiveness in modern business conditions [2]. It is necessary to apply, modify the existing and develop new models that will enable efficient production management, shortening the production cycle and the tendency towards a lean concept both in large and small and medium-sized enterprises.

Reduced cycle time can be translated into increased customer satisfaction. Quick response companies are able to launch new products earlier, penetrate new markets faster, meet changing demand, and make rapid and timely deliveries. They can also offer their customers lower costs because quick response companies have streamlined processes with low inventory and less obsolete stock. The PC is the most significant technical-technological indicator in production and it is necessary to steadily monitor and reduce it: PC reduction is possible by influencing the factors related to the duration of individual working time elements.

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MODERN PRODUCTION CONCEPTS

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Abstract: *The authors analyze the conditions of modern production and the concepts that are increasingly applied in order to make the most efficient and competitive production. Competition is becoming more numerous, conditions inside and outside production are changing at a high speed, and buyers know exactly what they want and are not obliged or ready to pay for production and waiting errors. Some of the concepts that are available are Lean concept, Six Sigma. The term industry 4.0 is increasingly used.*

Key words: *Efficient production, Lean concept, Six Sigma, Industry 4.0.*

1. INTRODUCTION

In order to survive the company, in the growing competition in the world market, demands for rationalization of production are growing.

Today, in modern production conditions and increasing numbers of competitors, companies have at their disposal modern concepts that they can and should apply in the desire for survival and timely responses to customer demands.

Efficient and flexible production is a modern production with more difficult companies aware of the necessity of timely response and responds to market demands dictated by the customer who expects a quality, functional product. The buyer does not want to pay for production errors and should be minimized. A stock accumulation should be avoided, which creates costs and produces the "right" time.

With rapid development in the fields of information technology and hardware, the world is about to witness a fourth industrial revolution [14]. The concept of 'Industry 4.0' is going to change the way India manufactures, designs and refurbishes the products [13]. Driven by the power of big data, high computing capacity, artificial intelligence and analytics, Industry 4.0 aims to completely digitize the manufacturing sector.

2. PRODUCTION

The functions of enterprise management and production are the basic functions of companies that require constant monitoring, improvement and innovation. Research in these areas requires the application of scientific methods that are flexible; they must be based on methodologies that will maximally respect the specificities of particular parts. In order to rationalize production and business, exit from difficulties and enter into more stable business, enterprises are increasingly oriented towards the application of the latest scientific methods and technology. Determining the length of the product development process is an important step in designing a technological process for the production of products, as this is a requirement that the process can be planned and that production costs can be calculated. Since the process consists of several operations (which are performed in specific workplaces by certain executors), the total process time is, as a rule, determined through the accumulation of time for individual operations from the process [1].

Rationalization of production is achieved by: shortening the production cycle (increasing productivity), reducing production costs, and increasing the utilization of capacity and space. One way to reduce production costs is to optimize the

flow of materials. Optimizing the flow of materials is of particular importance in achieving the required level of efficiency of the production process.

The term "flow of value" is used to show that there is the right order (most optimal) for all business activities, how they are interconnected and how they all contribute to a successful business together. The flow of value is always viewed from the customer's side, observation begins on the one side where the flow stops (at the buyer) and is traced to the source, i.e. to the very beginning (to the supplier). This can be seen as a river with many tributaries, each of which adds a new flow to the main flow (values for the customer) [2].

3. EFFICIENT PRODUCTION

Optimization of production and business processes has become the target point for all companies to strive. Traditional analytical tools used to increase process efficiency and reduce costs have mostly focused on the physical processes involved in each stage of production, while alternative methods of increasing efficiency consider the process as a whole and optimize the integration of each stage of production [3].

Flexible production involves continuous and interrupted production flows, that is, the benefit and advantage of these flows, compensating for their shortcomings, with the aim of continuing the flows of materials within the production. This means that the system can respond to the requests of each individual customer in the shortest possible time, without stalling in the production, accumulation of unfinished products, and the like [4].

Pull production is the opposite of Push. This means that the products are made only when the buyer requests it or pulls it out, and not earlier. Accordingly, there is no production without the demands of customers. After the introduction of tactile production, single current flow of materials and reliable machines, the enterprise can introduce pull production, providing products at the moment when the customer needs them.

3. MODERN CONCEPTS AND TRENDS OF PRODUCTION

In the literature, industry 4.0, which is also called "the industry of the future" or "smart manufacturing", does not seem to refer to a single, common definition. Nevertheless, experts agree that digital technology will play an essential role: industry 4.0 production processes will incorporate autonomous technology and tools that will communicate with one another throughout the value chain, thereby disrupting the role of operators and managers [5].

A simple definition, proposed by Bidet-Mayer [6], describes "connected factories that are made flexible and smart through networks of machines, products and individuals." Schumacher et al. [7] provide a more detailed definition of Industry 4.0 by referring to recent technological developments where the internet and support technologies provide a backbone for incorporating physical objects, human beings, smart machines, product lines and processes across organizational boundaries in order to form a new sort of smart, networked, agile value chain. Industry 4.0 therefore implies constant communication with all of the parts of the value chain that are outside the company, especially suppliers and customers. Real-time sharing of information among 4 all the different stakeholders makes the supply chain more responsive [8]. In addition to this horizontal integration of the value chain, there is also vertical integration: all the operations carried out in the company may now be connected and optimised in an integrated network [5].

The advancement in the digitalisation within manufacturing and electronic data interchange linking supply chains has led to the emergence of Industry 4.0 [9]. It is critical to understand the role of Industry 4.0 in today's fast-changing and competitive business environment; where companies are facing challenges in dealing with big data and rapid decision making for the improved productivity [10]. Academic literature shows that the Industry 4.0 has remained as a cost-driven initiative and there is limited evidence of real business model transformations [11].

One of the modern concepts available to manufacturing companies that want to achieve a competitive edge is certainly a lean concept. This concept seeks to eliminate all losses in production, avoids scattering of materials, resources available, with the aim of achieving high quality, flexibility and price that the buyer is ready to pay. It strives for continuity, optimization and integration of machines, people and other resources in the production process.

The fundamental philosophy of LM of continuous improvement summarized in the Japanese word kaizen summarizes the emphasis of lean manufacturing on “ongoing improvement involving everyone”

The effectiveness of lean manufacturing (LM) in achieving individual worker well-being and operational outcomes has been largely debated in the operations management literature [11]. LM is a manufacturing system whose objective is to streamline the flow of production while continually seeking to reduce the resources (e.g., direct and indirect lab our, equipment, materials, space, etc.) required to produce a given set of items; any slack in the system is referred to as 'waste' [12].

Traditional methods such as Six Sigma 6σ focus more on quality than it does at speed.

All major six sigma problems are solved using the DMAIC methodology (Define - Defining or Determining, Measure - Measurement, Analyze - Analyzing, Improve - Improving or Improvement and Controle - control or management). This technique can be used to teach techniques: how collect data, how much to use, and how often they count and how to be flexible.

The Six Sigma concept is a system that combines tools for continuous improvements that are on to make it possible to draw attention on processes, analyze them and compare each other, and objectively determine resources for those processes that require that they pay more attention to them. Important it is to emphasize that the common bond between different the process in one organization is a defect. Because every process is immanent defects that cause repairs, fines, losses, in addition production time and increased costs. By focusing on these defects and concentrating Efforts to reduce them will reduce the norm production time and processing costs. System 6σ Measures the process in the process and normalizes them so that they are can make a comparison between the individual processes. And when a comparison is made between process can make objective decisions in a look at where and how to allocate resources for achieving better performance.

CONCLUSIONS

On the changes and demands of the market and customers, in the sea of competitors, companies can respond with the improvement and efficiency of their production and process, which can be enabled by the application of six sigma, lean concepts and modern methods and techniques.

The concept of continuous improvement, adaptation, monitoring of changes, reduction and elimination of losses is the only correct and the right way to achieve efficient production. By applying the modern, mentioned philosophies of the company, they can respond in a timely manner to the demands of customers who will be loyal and satisfied with the quality and price of the product.

We are witnessing a fast, dynamic development of technologies, especially information technologies that are increasingly being used in the production and changing the concept of the industry.

In the world, the concept is increasingly being applied, with the tendency to achieve efficient and so-called. fit production. Continuous, continuous improvements in the organization - Kaizen method, 5S method, job organization, are some of the easy methods that enable the desired efficient production.

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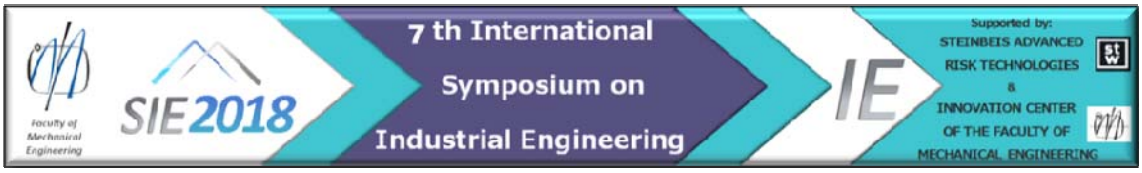

THE ROAD TO PERFECTION THROUGH CONTINUOUS IMPROVEMENT OF THE BUSINESS PROCESSES IN THE HOTEL A- ROSA

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Abstract. *In this study an analysis of hospitality services company - Hotel Resort "A-ROSA" in Germany was performed in order to identify whether it has an efficient quality system. The survey was done as an attempt to perceive the existing situation in this company in the domain of design and implementation of the quality system, analyzed through the four pillars of the house of quality at the top of which is the top management, while the base is consists of measuring, evaluating, analyzing and comparing quality / poor quality.*

The results of applying the Total Quality Management (TQM) methodology have shown that it is possible to achieve the company's vision and main goals towards meeting the needs of internal and external clients, right on time, while eliminating the processes which are not adding value or any promotion.

Key words: *House of quality, Internal standardization, TQM philosophy, Hotel industry, Customer satisfaction*

1.INTRODUCTION

Every organization should develop the activities of the quality system, which can be presented as a "house of quality". The pillars of the house of quality are: internal standardization, methods and techniques for operation with absence of faults, education, and motivation, and the cost of quality [1]. Top management is most responsible in the "house of quality" and it's "holding" the four pillars, which are subsystems of the system itself [2]. In the basis of the house of quality lies the measurement of the defined, collected business process data in order to understand and control them, as well as to gather important information about products and services for improving the quality and optimization of business processes. Monitoring does not only screen the quality of products/services, but also the adequacy of the entire TQM (Total Quality Management) system in the implementation of the quality functions [1][3]. Assuring quality of the company's activities is a key factor for its success, as well as its sustainability on the market. Total quality management requires full responsibility of all members of the company, as it is joint work of all [4]. In the process of implementation of the TQM philosophy, important aspect are the employees, processes and customers, as well as all interested parties in terms of protection, partnership, responsibility, guarantee, communication, service, security, support, as well as assistance and openness for cooperation [1][2][5].

This study was made to explain the importance of quality for hospitality services company - hotel resort "A-ROSA" in Germany. The survey is done by monitoring the way business processes are managed (identifying, documenting, and controlling) and whether documentation was put together for efficiency of the system.

In the hospitality industry, it is necessary to respect the standards for production, service and safety of people and products [6]. Adequate control is also required in order to achieve the goals set. The opportunities provided by the ISO 9000 series of standards enable definition and activation of control points, which will prevent defects, complaints, delays[7][8]. But a good quality system does not only mean a system that will provide projected

quality, but management and optimization of processes [7][9][10].

2. METHODOLOGY

2.1. Application of total quality management methodology in the hotel complex A-ROSA

The hotel complex A-ROSA was built on to the existing building infrastructure of the previous hotel "Kempinski", built after the Second World War in Eastern Berlin at that time. The hotel welcomes guests with the new brand from the distant 2004 with a tendency of continuous development. It is a chain of hotels under the brand A-ROSA and it's certain that this hotel stands out from the others with the ideal location, situated in a nature rich in forest, along the shore of Lake Scharmützelsee. Throughout the years, although the ownership structure changes, the management of the hotel manages clearly defined goals. The greatest achievement of the management was to get the coastal part of the local lake - for summering from the local government, as well as the few hectares of land in which, with a small investment, they got wonderful golf courses for recreation. Today, the A-ROSA Hotel is a place for recreation, leisure, entertainment and enjoyment of elite guests from all over Germany. The dedication of management and employees is intense, 24 hours a day, seven days a week. The hotel complex serves its clients with experienced and cordial staff from the parking lot to the reception, from the hotel rooms to the cafes, to the spa center, swimming pools, beaches. The company is the main artery for domestic tourists, and the management is proud that A-ROSA is a brand that gives satisfaction to customers, and ensures profit.

The structure of the company constitutes the management team as the highest body, while the report for the operation is received from the General Manager. The workload requires a structural division in six sectors, each with its own share of the operation. Dividing the operation into sectors enables independence in finding ways to facilitate the operation in the process of fulfilling hotel's services. All sectors are in interdependent horizontal communication and their processes are connected, Figure 1. Overall services are carried out with the coordination and collaboration of teams for all business processes.

2.2. Creating a business culture in a hospitality service company

The business world creates new values in the society [11]. The value consists of the well being created by the business world, business opportunities and the quality of the services. One of the company's missions is to advance the society in which they operate [1].

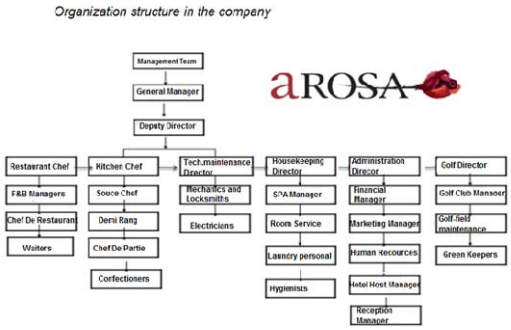

Figure 1: Organization structure in the company

In all projects implemented by A-ROSA hotel, the world's quality standards are at the top of each stage of development. By applying professional knowledge, experienced personnel, modern technology, care is taken to meet the needs and expectations of all clients with whom they cooperate in the society on the domestic and international market, in order to offer continuous quality. In all projects that have been implemented so far, A-ROSA always respects ethical values. For this purpose, the management team is working to improve issues related to quality, environment, occupational safety and health of employees, and for this purpose they organize continuous training for raising awareness among employees, following technological innovations and establishing relevant systems in the areas of project activities. In accordance with the current valid domestic and international rules and regulations, the main principle of managers is to provide quality assets and equipment for protection of human health and the environment. The goal is to use natural resources at an optimum level and to support and provide conditions for "sustainable development" of natural, social and economic resources.

When talking about the service in the hotel industry, it is essential that at the first visit guest's expectations are meet and exceeded [3]. The quality of the services includes all the parameters that will result in guests' satisfaction. One of the principled ways in which A-ROSA Hotel differs from other hotel industry companies is the quality policy of services, through consistent delivery of higher quality in relation to the competitors.

3.2 Defining the business processes in the hotel "A-ROSA"

In defining business processes, a person is a key factor in the quality of services, since he is the carrier of all activities in the hotel industry [1][11].

The company invests in the development and education of employees for successful execution of the business processes in the hotel. Proper performance of the work responsibilities of each sector individually is an important component of the hotel so that it can offer quality services, figure 2.

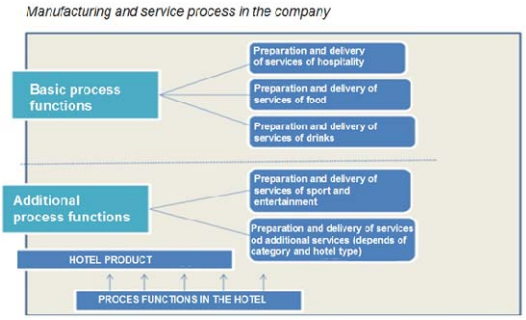

Figure 2: A schematic representation of the standard operational procedure during the preparation and provision of services at the hotel

Information is the basis for business management, i.e. the basis for decision making, organizing, forecasting, etc [4]. They are a key resource that hotel existence is dependent on, because depending on the way and the speed of collecting all relevant customer information will depend on the success in their work.

3.3 Standard operating procedure of one of the business processes in the hotel "A-ROSA"

The description of one of the business processes in the hotel "A-ROSA" is a series of logically related activities that use the resources of the hotel, whose ultimate goal is to services the guests with appropriate quality and prices, in an adequate timeframe, with simultaneous realization of values from the process of functioning, Figure 3.

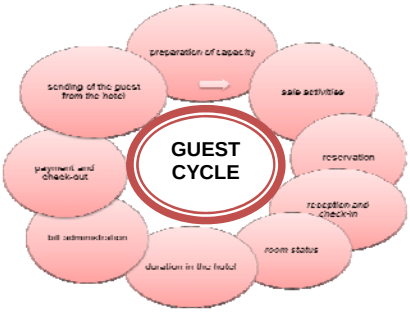

Figure 3: Production-service process in the company

Aside from the use of general documents in the realization of the processes local documents are also created for a more detailed explanation of the process and allocation of responsibilities, as well as the need for adjusting the process to the local state laws. Business documents can be work instructions, forms, databases, standards, list of instructions and specifications. Figure 4 provides a standard operating procedure for the business process - Preparation and provision of food services at the Marktrestaurant restaurant. The standard operating procedure specifies the documents used in the process, participation of the employees, as well as the possibility of comments with further explanations or guidance on instructions that are defining the sub-process. The sub-process is the main buffet breakfast and dinner, allowing guests to enjoy a fun cooking display.

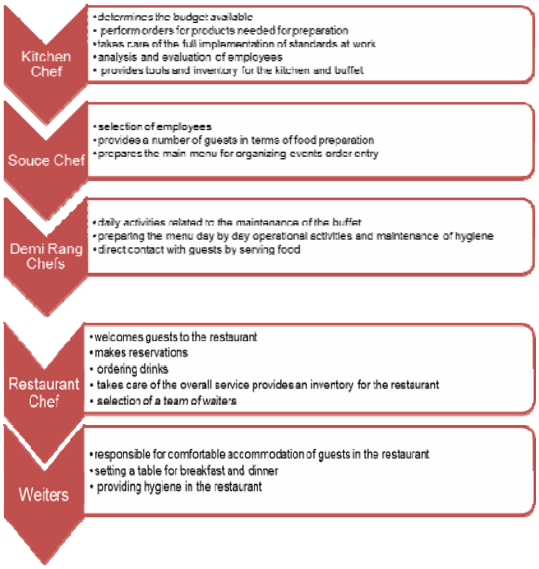

Figure 4: Schematic representation of the standard operating procedure in the hotel's kitchen and restaurant

The application of internal standardization improves the responsibility of employees in the realization of business processes. The application of the TQM system methodology means the design of a good documented quality system that is covering all business processes of the company and is an indispensable basis for the successful application of SPC (statistical process control) and efficient teamwork that otherwise could not be set up in case of a bad quality system [2]. Errors are recorded in tables and diagrams and are subject to analysis by managers. Based on the information obtained from the daily reports, the responsible manager can identify the oversights or complaints made by the clients, and depending on the type of problem, they are recognized, defined and recorded in the checklist. Based on the total operational errors, as well as criticisms and complaints from the clients, the **Pareto diagram** is being prepared from the **checklists**. This diagram should show which objections are of the highest frequency and

importance and in which direction the management team should pay attention and seek a solution to overcome the problem, Figure 5.

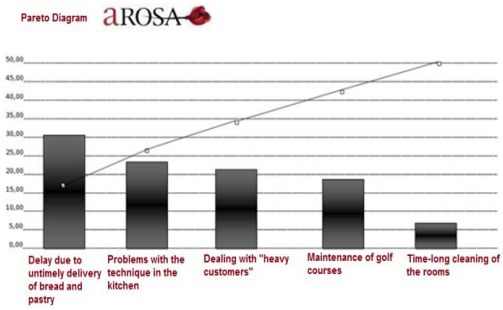

Figure 5. Pareto diagram in regards to the frequency of irregularities in operation

From Figure 5 it can be seen that the number of complaints is the highest in delays by deliverer's of bread and other bakery products. The first pillar of the diagram shows the delays of bread and other bakery products for the use in the hotel. The hotel complex does not produce its own and depends on the delivery by the suppliers. The proposal of the management team is to employ people with the necessary skills and to supply equipment for their own production for internal use. The second pillar of the diagram shows complaints due to frequent break-down of the kitchen equipment (malfunction of the ice machine, refrigerators, and stoves). The proposal of the management team is solving the problem by replacing existing ones with new technical equipment. The third pillar of the diagram gives the frequency of complaints by "VIP" clients in relation to hotel services, especially during the seasonal months or holidays when the hotel operates at full capacity. The guests' revolt arises as a consequence of the strict rules and regulations of the hotel regarding the code of conduct of the guests. The fourth pillar of the diagram gives the frequency of problems related to the current maintenance of golf courses as a result of the widespread area and the need for daily maintenance and irrigation. The proposal for a management solution is to increase the number of staff for horticulture (especially in the golf course and for organizing golf tournaments) and purchase of more mowers. The fifth pillar of the diagram gives the frequency of problems related to the equipment and cleaning of the rooms due to lack of necessary staff (housekeeping attendants). The management solved this problem by employing seasonal workers. After determining the causes of the problem, the actions to be taken are defined, the person responsible for the implementation of the actions and the deadlines for the implementation of the corrective measures.

3. CONCLUSIONS

The hospitality services company - hotel resort "A-ROSA" in Germany sees the benefits of applying the methodology for designing and implementing the TQM system in:

- the application of internal standardization which improves the responsibility of employees in the realization of business processes;
- the use of statistical methods and techniques reduces defects in operation and is a significant benefit, especially when requiring specified quality at the lowest operating costs;
- the application of software packages increases the efficiency in the application of statistical methods and techniques;
- by analyzing the cost of quality, losses can be controlled and minimized in terms of material and energy consumption.

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IMPLEMENTATION OF SIX SIGMA AND LEAN PRODUCTION CONCEPTS IN ORGANIZATIONS: A REVIEW OF CONCEPTS

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Abstract. *The six sigma concept represents an advanced function of the level of knowledge for advancement in managing the organization's business, with the aim of avoiding mistakes and malfunctions in technological and business processes. The six sigma system introduces tools and techniques to improve the organization's process in terms of quality systems and reduce the number of defect products. The implementation of the six sigma concept is an approach that influences the increase in the level of quality and profit of the organization. Lean concept has long been a competitive advantage. The concept of lean production aims to reduce the number of product errors and reduce the size of the warehouse, without reducing productivity. This paper presents the criteria for successful implementation and use of the concept, six sigma and lean production in different areas of the organization.*

Key words: *Six sigma, LEAN production, implementation.*

1.INTRODUCTION

The concept of six sigma and lean production has an important role in the implementation of these two models in organizations in recent decades. For any business enterprise it is important to achieve business excellence, which is based on meeting customers´ demands, improving the business productivity and corporative social responsibility [4]. Constant maintenance of high quality in the organization is significant as well.. There are many models of advanced systems: ISO 9001, Malcolm Baldrige Award, Continuous Improvement/Quality Management (QI/QM). SixSigma is a business model, which is oriented towards quality and profits [12].

The Six Sigma concept is a management approach which is focused on project development, continuous improvement of products, services and processes in the organization. These improvements are achieved through the reduction of defect products, lower maintenance costs, and higher production efficiency [3]. In addition, Six Sigma is oriented towards the understanding and satisfaction of customer needs; improving business systems; improving productivity, and financial performance [9]. Implementing Six Sigma has reported significant financial gains from their deployment efforts. For example, in 1999 General Electric (GE) reported $2 billion of net income benefits from Six Sigma initiatives [13].

Lean management represents a set of production management procedures designed for the customer to improve quality and reduce costs and production time [17]. To be successful, Lean implementation for competitive advantage requires organisations to apply Lean principles in all organisational functions, including accounting, sales and marketing, and human resources [7]. Lean production is a concept that tends towards reduction of defect products; waste reduction; higher value for customers; higher satisfaction of customers; robust production; cost reduction; quality improvement; and higher productivity [15]. Toyota Motor Company's high productivity and quality performance is routinely attributed to practices associated with Lean production [13].

In this paper some of the successful factors of implementation of the Six Sigma and Lean production mode will be presentedl. The main goal is to explore the successful implementation of these two concepts. Critical factors for the success of these two concepts have been presented.

2.IMPLEMENTATION OF THE CONCEPT SIX SIGMA AND LEAN PRODUCTION

Concept Six Sigma

Six Sigma is a set of techniques and tools used to improve the process, at the advanced level of knowledge in mathematics, probability, statistics and organization management [12]. Successful implementation of the Six Sigma concept includes quality integration in the company' main functions; spreading and utilization of the concept in all business processes; management support for putting quality as a top priority; and focus on well defined, and measureable goals [16]. In order to successfully implement the Six Sigma concept, companies have to focus on process variation reduction and to view projects as tools through which cost reductions can be made and higher customer satisfaction achieved [3]. The goal of Six Sigma is value creation through quality improvement [8]. Many organizations worldwide have implemented Six Sigma and achieved remarkable improvements in their market share, customer satisfaction, reliability and performance of products and services with impressive financial savings [5].

The concept of Six Sigma is a strategy of business development, which aims to identify and eliminate possible errors and deficiencies in business processes directing the activities that are reliable for customers. The key components to the success of implementing Six Sigma are related to the commitment of top management, the supporting infrastructure, training and statistical tools [6].

Six Sigma implementation involves the following characteristics [6]:

- An understanding of project expectations from the shop floor,
- Leadership of top management,
- Disciplined application of DMAIC,
- Fast application of the project (3–6 months),
- Clear definition of results to be reached,
- Supplying of infrastructure to implement improvements,
- Focus on the consumer and the process,
- Focus on the statistical approach to improvement.

Six concepts or constructs related to Six Sigma [14]:

- Top management leadership,
- Customer requirements,
- Focus on financial and non-financial results,
- Structured method of process improvement,
- Strategic process selection, and
- Full-time specialist.

In fact, the term 'Six Sigma' refers to a performance target of operating within 3.4 defects per million opportunities [13]. It is normal that this minimal error cannot be achieved immediately, it takes many years, but it is very important to achieve a certain goal.

Concept lean production

Lean has become a widely recognised philosophy that aims to reduce waste and non-value activities to improve performance in cost-efficiency, conformance quality, productivity, and reduced inventory levels and throughput times [10]. Lean production, evolved from the Toyota Production System (TPS) over a period of several decades, is considered to improve firm performance through elimination of waste. Lean production can be described at different levels of abstraction: it can be defined as a philosophy, as a set of principles and as bundles of practices [13].

Lean aims to reduce human effort, stocks, delivery time and production space to meet the demands of the market while delivering high-quality products at the lowest price. The gains from implementing Lean can be seen in the productivity results reach [6]. Lean concept implementation has considerable significance for effective and efficient production whose aim is less resources usage and lower production costs. Using both practical and project-based perspectives, a key strategy is the elimination of waste [11].

The critical success factors of Lean production include leadership; finances; organizational culture; and employee skills [1]. The organization should have a strong and competent leader who has the power to improve knowledge and skills of employees. Organizations that have failed to develop a certain level of leadership may be confronted with small process flexibility, risks of possible failure, irregular and inefficient allocation of resources. As one of the most important factors of Lean production, finance is the basis of stable business development [15].

The role of organizational culture is to create support for business processes, as an imperative for further creation of a sustainable and proactive company. Organizational culture has a role to create a strong and powerful management approach, in a dynamic and diverse business environment, with an overarching view of goals and accepting change. Knowledge and skills of employees represent an important role in business development and implementation of Lean production. Employees without adequate knowledge and skills have a more difficult time to accept new technologies, innovation, and overall development [2]. Lean management implementation can provide product differentiation and help the enterprise to operate with less risk in the selected market [17].

3. CONCLUSIONS

After carrying out the theoretical analysis in Six Sigma and Lean production, one can conclude that the goal of each of these concepts is to improve the organization's business performance. In order to improve the organization it has to achieve different business goals such as finance, cost reduction, waste reduction, customer satisfaction, product, and service quality and productivity. Lean production concept focuses on reducing production, warehouse and higher productivity. Six Sigma concept focuses on the minimum amount of manufacturing defects. The concept of Lean and Six Sigma plays an important role in management and employee engagement in order to improve business performance. In these two concepts, the nature of organizational engagement varies considerably in two approaches. Lean is a bottom up approach where management plays a supportive and facilitating role in engaging shop-floor workers to form cross-functional self-directed work teams and apply Lean tools. Six Sigma management plays a more active role, often selecting improvement projects based on financial and strategic goals, and championing and monitoring them as well [13].

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LEAN APPROACH TO RECURMENT STRATEGY – CASE STUDY

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Abstract. *In this paper, the application and advantages of the lean approach to start-up business is presented through a practical example how to correctly do employment of new workforce. Splunk was an example of innovate and creative approach to start-up and that will be shown in this paper. The focus of this paper is on taking various aspects into account when recruiting employees in order to ensure the success of a startup business.*

Key words: *Lean management, start-up business, employment, software*

1.INTRODUCTION

In order to properly introduce the Lean Start-up (Figure1) to a company, it needs to have an organization structure, culture and discipline to properly execute the search for growth and at the same time maintain the operational activity level [1]. Hence, applying this type of methodology on processes that already exist requires the adopting company to adapt the practices to the current culture and processes [2].

Figure 1: *Basic Lean Start-up scheme*

The Lean Start-up defines the team structure as self-autonomous and full-time cross-functional teams that have secured small capital, the necessary authority for not slowing down learning and accountability by unnecessary approvals and the recognition of the innovation success [1, 3]. When its organizational structure is in question, Lean Start-up suggests developing a "platform for innovation" that has self-imposed rules, i.e. within pre-determined and settled limits that promote and boost the start-up impact in the company itself without restricting its start-up met–hods [1]. Another curtail requirement is the necessity to change the company culture. In his works, Alange [4] states that top management should install a more innovative culture that is open to change amongst its employees to foster creativity, commitment and passion to innovate in a continuous learning environ–ment. Another essential part of making great impact on early Lean Startup is to not be blindsided, as very often happens to managers around critical processes like recruiting, hiring, and training and development.

In this paper, Splunk's approach to this field and how to successfully these blind spots can be avoided will be presented.

Splunk is a software firm from San Francisco; it's a perfect case that will be used to illustrate this point. Founded somewhere during 2003 with around $40 million in venture capital funding, Splunk was one of the pioneering companies that have been solely focused on so-called "big data" space. Splunk was a small company with no previous track record to use as a reference, so for this reason they needed to be clever and creative when it came to recruiting, hiring and training their team members.

2. METHODOLOGY

Shown in this paper are the insights on how Splunk preventet the blind spots as it scaled and how they succesfully recruited the right members.

When it comes to recruiting (Figure2), the saying goes „business process is only as good as the people involved". This is one of most crucial parts, it is most notable for the type of sales that is dependend from individual performance. Salespeople that are the best in their jobs generate astoundingly more than their average colleagues: the difference can be even up to ten times more, depending on what they are selling. To quote Bart Fanelli, Vice Presedent of the Spunk „For recruitment, we set our sights on talent from companies already operating at the level we want to operate at." This is a long and hard process and demands time and resources from company's leadership. The biggest part of making company constantly grow is recruitment and hiring as a continuous part of the management culture.

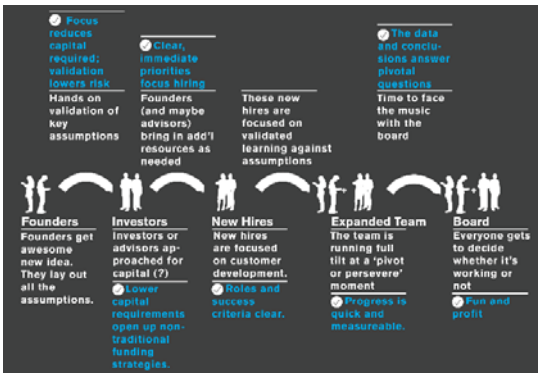

Figure 2: The Lean employment pattern

Next important part of successful recruitment is the process of interviewing and hiring. Problem starts here - managers are often too much self-assured about their ability to judge and estimate candidates based only on personal interviews. From experience, there is no parallel between performance on the interview and on-the-job performance. In studies that had been done, it was clearly shown that performing the hiring process solely by this way can be hurtful to the company in selection decisions: there is almost no difference between choosing randomly or solely by interviews. This danger is most evident in sales. When employees are chosen in departments where talent varies a lot, this usually leads to a so to say cloning: that managers hire as many as they see fit and are taking control of the interviews by themself. In companies where a manager's assessment is complemented with multiple interviews involving diverse people, much better results have been observed. As a consequence, a process that is structured, and emphasizes behavioural criteria was established.

Management's commitment to communicating, establishing, and keeping of an up-to-date hiring process remains a real constraint. The company Splunk created profiles that state certain skills and ability to perform each role appropriately. They also made certain behavioural elements in management's view, which are valuable across roles.

Another vital aspect that will be considered in this paper is training and development. Modern trends in most modern companies is that they don't train salespeople constantly and the usual practice is that training budgets increase following good sales and decrease when sales are tough. This is not a useful practice because it wastes time, and on top of that it's almost impossible to determine cause and effect.

Naturally, people need support and upgrading of the skills from time to time and motivational help. Here, the focus is of crustal importance - learning and development on an analysis of sales needs to be performed on site and with quality employees. This is a process that provides good and accurate feedback on time to managers and leaders of company.

To be more clear, it is of key importance to know what you can control and control it. In Splunk's case, as Fanelli notes, "we kept a certain leader-to-contributor ratio in mind to make sure the first-line sales leader can train contributors on the desired skills. We track this quarterly, looking at training and coaching with the same attention that we use to review 'the numbers' because the effectiveness of our first-line leaders is the gateway to the performance we want to see in sales outcomes."

Any work environment has a wide variety of people with different capabilities, learning styles and temperaments. To have the best effect, development and coaching needs to have capability to reach to any employee and be constantly updated and renewed. Review made on time in the sales organization can push the process up the chain and successfully create a constantly developmental tool. "The first-line review process," says Fanelli, "connects quarterly to every manager in the field. The second-line review (a review of those who manage and review the first-line managers) focuses

on a broader set of skills, happens annually, and goes into more depth than the quarterly process."

In this paper it can be seen that Splunk mixes a lot of good practices that in the long term are helpin to them avoid common blind spots in sales as it grows. Of course, not all companies need to do what Splunk does, but is highly recommended. In every company, placement and strategies are different, and because of that practices need to vary. What this paper is trying to show is that any company must acquire talent by making core processes like recruiting, interviewing, and development a real priority in daily practice. To quote Aristotle "Excellence is a habit."

3. CONCLUSIONS

Splunk had in plan to increase their capital from a $50 million company worth $250 million during a five-year cycle, but it should always be kept in mind that targeted figures are different form company to company. They successfully did this, allowing their company to grow to a desired level. Also, don't forget that this was possible due to considering the recruitment and hiring process as a continuous part of the management culture, not only an HR responsibility, this was Splunk's approach and it was very fruitful.

All of the recruitment concepts mentioned in the example presented in this paper are the same ones which make up the lean startup methodologies. They are based on careful selection of employees, taking into account various personal aspects, while ensuring that the future employees will receive all of the necessary training. In addition, the lean approach suggests that employee motivation is of great importance for a successful business.

Therefore, the success of Splunk's strategy was largely influenced by their decision to integrate the lean aspects into their recruitment method.

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LEAN START-UP APPROACH TO SALES – A CASE STUDY

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Abstract. *In this paper, the application and advantages of the lean approach to start-up business is presented, through an example involving the sales of personal energy appliances intended for outdoor use. By using a thoroughly developed step-by-step approach, BioLite company was able to come up with a way to sell their equipment to even the most remote of markets (in this case, towns in India that do not have access to large retail stores) by carefully analysing all of the key factors and problems involved. In addition, this paper contains the explanation of how specific lean principles were applied in achieving of the company's goal.*

Key words: *Lean management, start-up business, personal energy appliance, build-learn-measure (BLM), Get out of the building (GOOB)*

1. INTRODUCTION

In the recent years, the lean management concept was developed and found application in numerous areas. Lean management is based on the principles according to which entrepreneurs are everywhere, entrepreneurship is management and that validated learning is of great importance [1]. It also involves more specific principles, such as Build-measure-learn, Get out of the building and innovative accounting [2,3]. Due to its nature, which relies on quick and efficient production of small batches of products, as well as on systematic and detailed approach to target market analysis, the lean principles works exceptionally well when combined with start-up businesses, since the purpose of start-ups is to sell simpler, smaller and cheaper products, as the first step towards large-scale entrepreneurship.

The practical application of the build-measure-learn and Get out of the building principles, hereinafter referred to as BLM and GOOB was, is illustrated with an example involving BioLite, a company which manufactures personal energy appliances, such as cookstoves, mainly for outdoor use. Their products are typically bought from retail stores, however, the company attempted to sell them to more remote markets, including sub-Saharan Africa and certain locations in India. BioLite was faced with a number of problems, including the lack of retail stores and means of advertising and transportation of their products.

2. METHODOLOGY

In this part of the paper, the two aforementioned lean methodologies will be briefly described, along with the step-by-step process that BioLite had undertaken in order to ensure efficient and profitable distribution of their product to a remote town in India.

The build-measure-learn cycle represents an iterative lean methodology and consists of the following stages:

1. **Plan** – idea development, defining of hypo–theses and adequate metrics for measuring them.
2. **Build** – creating of a minimum viable product, on which the final product will be based.
3. **Measure** – analyse the results obtained by the previous stages.
4. **Learn** – Compare these results with the initial hypothesis and use the newly acquired knowledge to improve the cycle.

Once the BLM cycle is complete, additional itera–tions are performed (if necessary), until a satisfying solution is obtained. It can be seen that this

methodology strongly relies on experience gained during the iteration, which is used as the base for improvement (Figure 1).

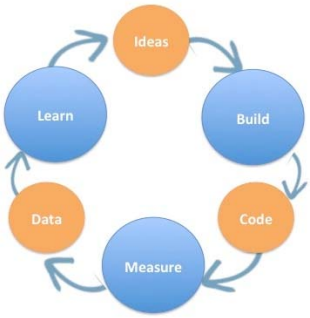

Figure 1. The Build-Measure-Learn cycle

The Get out of the building methodology was devised by Steve Blank [3], and represents an important step before the actual start-up business is initiated. It sug–gests that entrepreneurs should first establish contacts with interested partners and customers, in order to ensure a reliable source of valuable feedback about their needs regarding the product, and aids the process of improving of following iterations. In this way, a solid base for future start-up related work is created.

The case study presented here involves BioLite, accompany that manufactures personal energy appliances (such as portable cookstoves) both online and in major retail stores, while providing all of the necessary information to their customers.

In the case of certain markets, even a combination of online and retail presence could not reach the custo–mers and in order to solve this problem, BioLite had to adapt their approach to selling in accordance with the new, completely different market that they have discovered in India [4].

In order to solve this issue, their team in charge of emerging markets developed a series of experiments, for the purpose of determining the best way for their products to reach their intended users. The product in question (HomeStove) can be seen in Figure 2.

Figure 2. The HomeStove, manufactured by BioLite

2.1 Experiment 1: The Handi shop

Since BioLite's target customers in India don't have access to large retail shops, an alternative was found in the so-called Handi shops. BioLite attempted to sell their product (the HomeStove) through these shops.

This experiment failed due to lack of information available to buyers, and it was conclude that a more proactive approach is required.

2.2 Experiment 2: The Chaiwala

The next experiment involved the supplying of Chaiwalas, (tea sellers in India), with both the product and the appropriate training on how to use it. Even though the promotion was successful, it still failed in terms of sales, since the customers were more focused on getting their tea as quickly and as cheap as possible, without considering the technology behind it.

Thus, this experiment failed due to an inadequate target market and this was the next factor to consider.

2.3 Experiment 3: BioLite flagship store

The next experiment aimed to set up a business in a busy market in the town of Bhubaneswar, India. BioLite's local team would distribute promotional materials and demonstrate the product to anyone interested in a quick and comprehensive manner.

Although this approach attracted a large number of customers quickly, it turned out that it could not retain these costumers for longer periods of time.

This was due to the fact that the users who needed the cookstove the most, lived outside of town, and it was complicated for them to reach the flagship store.

Hence, the next issue that needed to be resolved was the distribution of products to the target market.

2.4 Experiment 4: Avon calling

Based on the previously revealed issues, it was concluded that there is a need for a partner that would distribute the product. BioLite partnered with the Greenlight Planet company in India, who were already in the business of distributing energy products to remote locations through local sales representatives.

This process involved the training of Greenlight Planet employees in terms of demonstrating value of the BioLite cookstoves. On the other hand, BioLite had to adapt their cookstoves to make it easier to transport them from one demonstration location to the other.

Insight gained from Greenlight Planet salesmen aided BioLite in searching for their own team of salespeople which would go from door to door to demonstrate the stoves and gain the attention of potential customers.

With this approach, the only remaining issue was related to the affordability of the product. In other words, BioLite needed to ensure that their target customers can actually buy the cookstove.

2.5 Experiment 5: Microfinance institutions

Microfinance is an economic engine used to aid low-income households by allowing customers to take loans, arrange payments and monitor their finances. BioLite's partnerships with microfinance institution (MFI), allowed their employees to present the cookstove using real-time demos, along with the possibility of showing the interested customers their finance programmes.

The programmes in question would immediately enable the customers to purchase the cookstoves, relying on the fact that their efficiency will make the stoves pay for themselves after a couple of months, by saving both fuel and energy.

This experiment managed to solve the final issues preventing people from becoming BioLite's customers, thus completing the experimental process of determining the best way to sell cookstoves in remote locations.

3. DISCUSSION

As can be seen by the flow of the experiments, the process of determining the optimal way for BioLite to sell their product under the given circumstances was iterative. Each unsuccessful iteration provided valuable knowledge and information about the problems which needed to be solved in the steps that would follow. In addition, every experiment mana–ged to solve some of the previously encountered issues.

The experiments started with a simple concept of selling the product through the available stores, continuing with educating of the customers, deter–mining of the distribution channels and finally offe–ring financial plans that would allow said customers to afford the product.

It can be seen that the approach undertaken by BioLite is based on the principles of the aforementioned Build-Measure-Learn cycle and the Get out of the Building methodology. The BLM is reflected in the iterative approach wherein the results of each experiments were analysed and conclusions were made about what can be improved, before moving onto the next stage.

However, this alone was not enough to obtain satisfying results, and there was the need to communicate with the target market, and provide clear and straightforward information about the product to the customers. For this purpose, BioLite employees and their partners in India personally demonstrated the product to the buyers. In this way, they were able to educate their buyers about the product, as well as the ways in which they can afford to buy it. Establishing and maintaining direct communication with the customers is the basic concept of the GOOB approach.

4. CONCLUSION

The case study presented in this paper, involving the selling of cookstoves in remote parts of India, confirmed that not succeeding on your first attempt at establishing a business is not necessarily a failure and that it can have its advantages, if approached in the correct manner. It can be seen how combining different lean management approaches can contribute to developing of a successful business model.

By using the BLM and GOOB principles, BioLite company was able to ensure efficient product distribution to their target market, despite the numerous problems related to selling, transportation and finances, wherein the product in question was a cookstove (a personal energy appliance for outdoor use). The experiments that were carried out allowed the company to obtain valuable information which was then used as a base for further improvements, and with each following experiment, one of the issues was eliminated. In addition, the BLM approach allowed BioLite to identify problems that were not taken into consideration previously.

Another well-known lean methodology, the GOOB approach, also played an important part in these experiments. Direct and adequate communication with the target market allowed BioLite to understand their customers' needs, and react to them accor–dingly. This manner of communication, which included training of employees in the best ways to demonstrate the advantages and capabilities of their product, ensured that the target buyers would be interested in the product itself. Additionally, direct communication with the locals aided BioLite in solving the issues related to transportation of their product to the target location, which was further away from the town where the stores are.

Hence, it can be seen that applying the lean approach to start-up businesses represents a reliable and effective long-term strategy, mainly due to one of the essential lean principles – the iterative learning based on previous unsuccessful attempts. It also emphasises the importance of direct communication with the target market, in order to fully understand and adequately take into account the customers' needs and potential problems related to the product aimed at them.

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LEAN APPROACH IN THEORY AND PRACTICE

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Abstract. *In this paper, the basic of lean approach will be briefly described, along with the examples of implementation of lean, benefits of lean production and challenges accounted in the empirical researches of lean system application. The paper presents the philosophy of "Lean" production which aims to make it easier, more effective and efficient through continuous improvement and to produce high quality and low-cost products.*
Keywords: *Lean approach, waste, benefits of lean.*

1.INTRODUCTION

The philosophy of "Lean" production and management is to create a lean enterprise, which aims to make this company more effective and efficient through continuous improvement and to produce high quality and low-cost products.

Business environment today is characterized with fast economic, political, institutional, technological, demographic and ecological changes. Development of information and communication technology is rapid, digitization has affected all spheres of activities and enabled new forms of business. Networking become an imperative of business development.

The phenomenon of globalization and competition at the global level include global marketplace, and environmental issues, creation of global supply chains. International trade barriers have fallen and new trade agreements have been created. It is increasing awareness of the need to preserve the environment and sustainable development. It is dominant a new "customer in focus" approach.

Lean production is a production system developed by Toyota Motor Corporation to provide the best quality, lowest prices, efficient use of resources during production through the elimination of unnecessary costs. Objectives of lean enterprise transformation are: less waste, less design and production time, continuous flow, less costs, more employee empowerment, fewer organizational layers, fewer suppliers, more flexibility and capability, more productivity, improved quality, higher level of customer satisfaction and long-term competitive success.

2. MEANING OF WASTE IN LEAN APPROACH

In their Toyota Production system (TPS), Toyota has defined 3 negative phenomena to be eliminated: MUDA or waste - loss, unnecessary cost; MURA or unevenness, irregularity, inconsistency - imbalance, unevenness, and MURI or overburden, unreasonableness - overload, unreasonableness. The lean system focuses on the elimination of waste which represent any action in a process that is not required to complete a process successfully. It strives to eliminate seven kinds of wastes often named “deadly wastes”: overproduction, waste of waiting time, transportation waste, processing waste, inventory waste, waste of motion and waste from product defects, Fig. 1. When waste is removed, only the activities that add values in aim to deliver a satisfactory product/ service to the customer remain in the process (process became “lean”). To do it Value stream mapping (VSM) can be used, as an extremely powerful tool, combining material

processing steps with information flow as well as other important related data.

Toyota achieved the substantial reduction of the production time and therefore reduction of the waiting time for the car to go to the market.

James P. Womack (1992) is considered to be the first to use the term "lean thinking" as a set of practices related to Toyota production system. Western world was presented the philosophy of TPS through his book "The Machine that changed the world" (Womack & Jones 1990).

Figure 1 The 7 Wastes

From that time to the present days, the popularity of lean thinking has spread in the business world. The lean thinking philosophy quickly moved to new areas such as IT sector, services, public sector, trade. It can be considered that the lean paradigm is:

„use less of everything – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering working hours to develop a new product in half the time. Also, it requires keeping far less than half the inventory on site, results in fewer defects, and produces a greater and ever-growing quality of products", [2] . (Womack, Jones, and Ross 1990).

According to Tanasic [3], „by identifying and eliminating unnecessary and wasteful activities inside the business process and by focusing attention exclusively on what, from the customer's standpoint appears to create value, lean production system makes it possible to achieve maximum quality of production processes in order to establish and maintain balance between good and timely services to customers and service providers' profitability in the modern business environment". Here, value is determined by the customers who want to buy the right product with the right capabilities at the right price.

3. DESCRIPTION OF LEAN APPROACH

Key pillars of Lean are physical workplace, process and people.

Principles of lean production are:

- Continuous Improvement (kaizen) which means- promoting constant changes which can be big or small but must lend itself toward improvement.
- Respect for people - good communication, listening to their ideas and helping out when necessary.
- Leveled Production (Heijunka) – it means utilization of a pull system which is the concept of basically building in response to actual customer demand or restocking inventories in a controlled way based on the customer's consumption of products. This enables possibility to reduce overhead and optimize storage costs.
- Just In Time (JIT) Production - to build what is required, when it is required and, in the quantity, required. It works well with Kanban. (Kanban is a tool for implementing of synchronized production and lean production. One of the main benefits of Kanban system is to establish an upper limit to the work in progress inventory, avoiding overloading of the manufacturing system.)
- Quality Built In (JIDOKA) - design of the part, into the manufacturing process, into the packaging, shipping. Quality is a major consideration.

3.1. House of Lean

House of lean, Fig.2, is a diagram that provides a visual representation of the elements in which lean tools and methods should be implemented.

Basic of the house is stability which means strong leadership, clear purpose, employee engagement and development. Creativity and knowledge became important source of sustainable competitive advantage. It requires empowerment of employees, ethical behavior and social responsibility which is cost-effective in the long run.

Standardization means commitment to continuous improvement of the work process and standardized work.

The first pillar is optimization of production using Just in time (JIT) which represent flow, usage of lean tools 5S and visual workplace, pull and levelling. The second pillar is about optimization of quality and Built in Quality (Jidoka) with autonomation, error proofing and visual control.

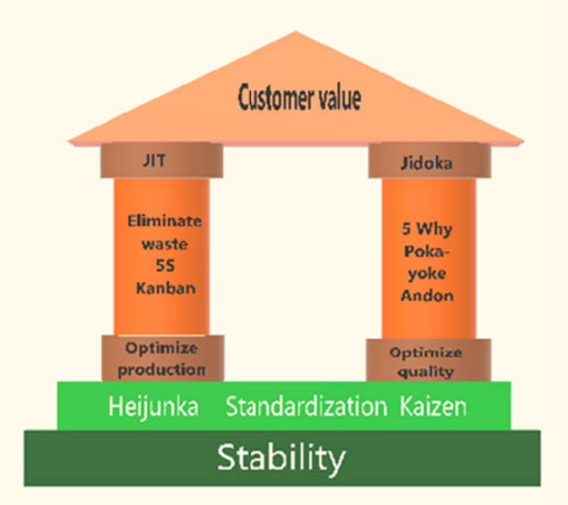

Figure 2. House of lean

Roof of the diagram represent customer values expressed through best quality, lowest cost and shortest lead time through shortening the production flow by eliminating waste and variation.

4. SPREAD OF LEAN IN THE WORLD

The practical application versus the theoretical aspects of "Lean Enterprise Transformation" continues to be topic of many debates around the world both on university campuses and business environment. In spite of that, Lean has arrived in many companies.

For example, the National "Jump Production" program was launched in Sweden in 2007, to support and strengthen the production capacities of small and medium enterprises through the implementation of Lean production.

SKODA AUTO has the Lean center in Mlada Boleslav. The training center train employees and suppliers to optimize processes in production and management. At Lean Center, associates and suppliers will receive comprehensive education for Lean Manufacturing and Lean Management.

The Fraunhofer Material and Logistics Institute in Germany developed a simulation for training Lean methods in their warehouses. The Lean Innovation Project for Small and Medium Enterprises, implemented in Germany in the period 2013-2015, was supposed to enable project partners to implement Lean Concept and thus innovate their management system, [5].

Some famous companies in the field of mechanical engineering, e.g. Bosch, Trumpf or Grob have already successfully introduced Lean's management concept, [5].

The "Automotive Lean Production 2012" in the Excellent Value Chain category has been assigned to the Fiat Plant in Bielsko Biala, after the analysis and evaluation process from a panel of experts selected by the German magazine "Automobil Produktion" and from the consulting firm "Agamus Consult ", [6].

In the period 1992-1998 through lean initiatives Nippon Steel Corporation (NSC) has improved the quality of the products by bringing down defect levels from 15.2% to 10.8% and energy consumption had reduced from 4.2% to 4.6% level. Cost of maintenance was brought down at NSC from 29.1% to 24.3% (Adam Paul Brunet and Steve New 2003), [5].

4.1. Lean in Serbia

Lean, as a new approach to production, appeared in Serbia at the beginning of the 21st century. From 2010 until today, more and more training courses about Lean approach have been realized. Lean is practically present mainly in foreign-owned companies. For example in Hofast Holding AG from Switzerland, realized the project of spatial arrangement of equipment, tools and materials in the existing production hall in Backi Jarak. The project envisages the alignment of materials, semi-products and products with LEAN principles of optimum production. ZF group in Pancevo strategically implementing the lean production, actively designing and supporting complex change processes. Fiat is already mentioned as company which uses lean production philosophy.

There were some projects in non-production areas, also. For example, in 2012 the implementation of Lean projects has started: "Improvement of the process of care of newborn babies in the Clinical Center Nis" and "Improving the process of clinical-biochemical laboratory diagnostics", [7].

Chamber of Commerce of Serbia organized 5-day seminars with topic" Lean business – introduction and basic tools", [8].

A Tempus project has been implemented, [9], and there are sites that deal with Lean, like [10]. Some Lean tools, such as the 5S, are also used in companies owned by domestic firms, such as EPS.

5. BENEFITS AND CHALLENGES OF IMPLEMENTING LEAN

According to Natarajan at all, [4], lean implementation in Micro, Small and Medium Enterprises (MSME) has resulted in vast

improvements in labor productivity, throughput, customer delivery, quality and changeover time.

Association of Manufacturing Excellence (AME), [5], indicated outcomes normally associated with lean implementation could be

1. 70-90% reduction in setup time
2. 20-60% improvement in productivity
3. 40-80% reduction in process time
4. 30-70% reduction in inventory
5. 40-90% reduction in walking time (distance travelled)

In literature, there are many studies demonstrating that lean manufacturing implementation has a positive influence on company performance.

Involving supplier management lean practices in company strategy improves raw material quality conformance, thus reducing the time dedicated to quality inspections, [10] and rework.

Lean manufacturing positively influences overall the firm's financial performance (returns on investments) through improving efficiency of organizational processes, cost reduction, [11] and labor and asset productivity, [12].

Although many firms have reported large benefits from lean implementation, a lot of skepticism still remains regarding attainable results and the possibility to apply Lean approach outside high-volume manufacturing and stable context, [13]. According to Bevilacqua and all, [14], the lean practices implementations are negatively influenced by product mix variety and innovation, while positively influenced by time effectiveness variables.

Implementing and sustaining lean processes are easier in some organizations than in others. There may be national and societal culture differences which should be researched more deeply.

6. CONCLUSIONS

Lean approach is an ever more present response to the challenges of the modern business environment. New rules have been developed for inventory policies, plant floor layout, optimal flow patterns of products through the plant, supplier relations, and cost constraints. These new rules have led to new competitive strategies fueled by quantum improvements in throughput, effectiveness, and responsiveness. By Eliminating unnecessary steps, aligning all steps in an activity in a continuous flow, recombining labor into cross-functional teams dedicated to that activity, and continually striving for improvement, companies can develop, produce, and distribute products with less of the human effort, space, tools, time, and overall expense.

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THE COMPARISON OF THE USE OF E-BUSINESS AND E-COMMERCE IN COMPANIES IN SERBIA AND IN EUROPEAN UNION COUNTRIES

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Abstract. *The aim of this paper is to present the review of the use of e-business and e-commerce in companies in Serbia for the period from 2013 to 2017 and to compare the identified trends with the currently possessed information technology development by the companies in European Union (EU) countries. The data are used from the freely available reports of the National Bureau of Statistics of Serbia and Eurostat. The presented results show that companies in Serbia lags for the companies in EU countries regarding adaptation and usage levels of e-government, social networks and cloud computing. However, Serbian companies can boast with the similar adaptation and usage levels of the Internet and website as the companies in EU countries.*

Key words: *e-business, e-commerce, companies in Serbia, companies in EU countries.*

1. INTRODUCTION

The influence of e-business on the transformation of business processes through increased productivity and reduced transportation costs was observed in the 1980s [5]. Transformation of business processes is reflected through the implementation of appropriate Internet technologies with the aim of full integration of business processes in the company, their automation and more efficient realization. E-commerce can be viewed as a subset of e-business. It is the activity of buying or selling of products on online services or over the Internet. E-commerce has transformed traditional trade by enabling the simultaneous realization of a large number of transactions.

According to Eurostat statistics [2] the following e-business trends are identified within the European Union (EU): an increasing number of firms have Internet access and use websites, and an increasing number of firms use Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) software solutions. The trend of e-business development is also identified in Serbia [4]. In 2010, Serbia developed the strategy for the development of an information society [6] with the objective of being capable of obtaining the adaptation and usage levels that are currently possessed by the European Union (EU) countries. The Serbian IT strategy [6] reveals that the development of e-business, including e-commerce, e-health, e-education and e-government, is the basis for the progress of an information society. Furthermore, in 2014, Serbia developed the project 'E-business development' [1] with the support of EU funds. The focus of the 'E-business development' project is on e-business development in firms, particularly in SMEs.

This paper has two objectives. The first one is to present the review of the use of e-business and e-commerce in companies in Serbia for the period from 2013 to 2017. The second objective is to perform comparison of the use of e-business and e-commerce in companies in Serbia and in European Union countries.

The rest of the paper is organized as follows. The considered methodology is described in Section 2. Section 3 shows the statistical results of the use of e-business and e-commerce in companies in Serbia and in EU countries. Concluding remarks and future work are given in the last section.

2. METHODOLOGY

We used the data from the following sources:

1. reports of the National Bureau of Statistics of Serbia, available at: http://www.stat.gov.rs/sr-Latn/oblasti/upotreba-ikt;
2. reports of Eurostat, available at: http://ec.europa.eu/eurostat.

The reports of the National Bureau of Statistics of Serbia are based on the following data: 1112 surveyed companies in 2013, 1112 surveyed companies in 2014, 1261 surveyed companies in 2015, 1548 surveyed companies in 2016, and 1538 surveyed companies in 2017.

The reports of Eurostat statistics are based on the data obtained from the each of 28 EU countries.

The research was conducted between June 2018 and July 2018.

3. RESULTS

The use of the Internet in companies in Serbia and in EU countries are presented in Figure 1 and Figure 2, respectively.

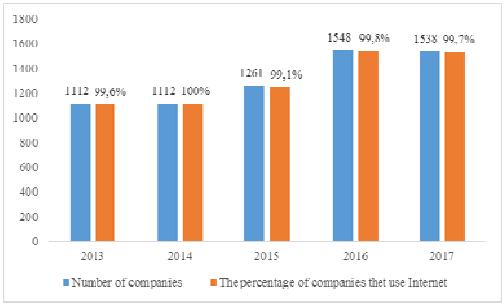

Figure 1. The use of the Internet in companies in Serbia for the period from 2013 to 2017

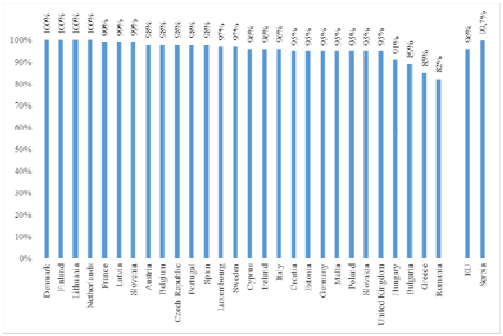

Figure 2. The use of the Internet in companies in EU countries in 2017

The use of e-government in companies in Serbia and in EU countries are presented in Figure 3 and Figure 4, respectively.

Figure 3. The use of e-government in companies in Serbia for the period from 2013 to 2017

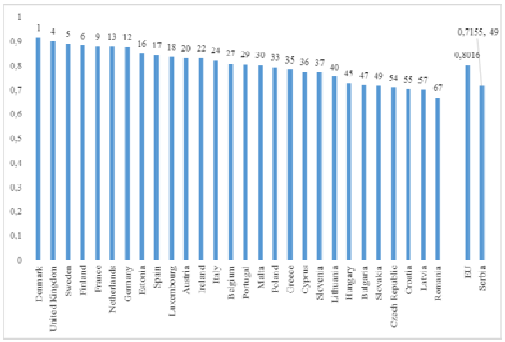

Figure 4. The e-government development index of EU countries and Serbia in 2018

The use of website in companies in Serbia and in EU countries are presented in Figure 5 and Figure 6, respectively.

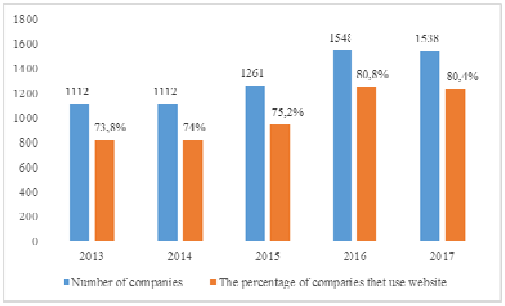

Figure 5. The use of website in companies in Serbia for the period from 2013 to 2017

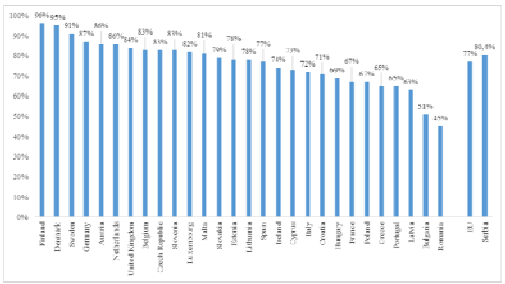

Figure 6. The use of website in companies in EU countries in 2017

The use of social networks in companies in Serbia and in EU countries are presented in Figure 7 and Figure 8, respectively.

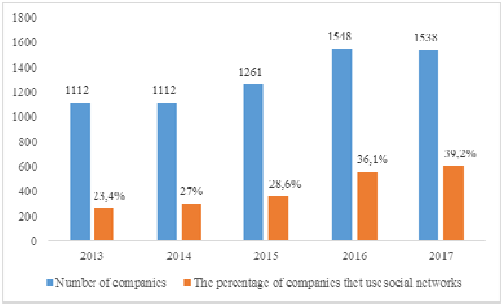

Figure 7. The use of social networks in companies in Serbia for the period from 2013 to 2017

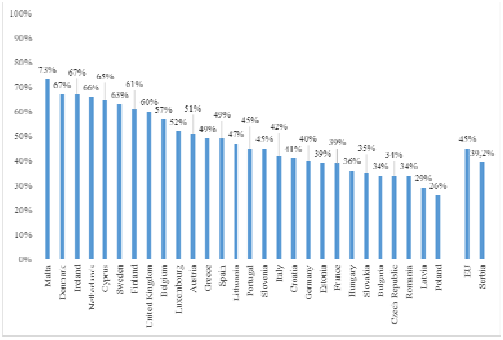

Figure 8. The use of social networks in companies in EU countries in 2017

The use of e-commerce in companies in Serbia and in EU countries are presented in Figure 9 and Table 1, respectively.

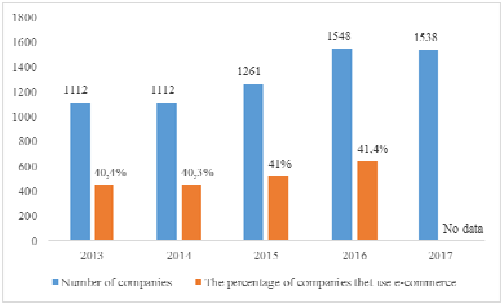

Figure 9. The use of e-commerce in companies in Serbia for the period from 2013 to 2017

According to the report of Eurostat [3], e-commerce refers to the trading of goods or services over computer networks such as the Internet. E-commerce can be divided into e-commerce sales (e-sales) and e-commerce purchases (e-purchases) depending on the way in which an enterprise receives or places orders.

Table 1. The use of e-sales in companies in EU countries for the period from 2012 to 2016

	Companies with e-sales (%)		
	2012	2014	2016
Large companies	40	43	44
Medium-sized companies	25	28	29
Small companies	15	17	18
All companies	17	19	20

The use of cloud computing in companies in Serbia and in EU countries are presented in Figure 10 and Figure 11, respectively.

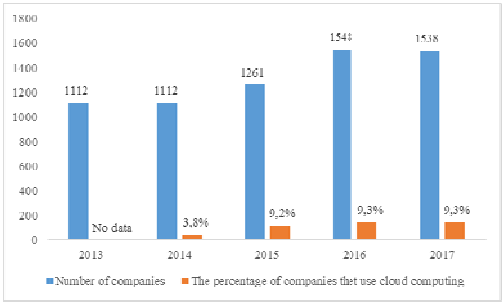

Figure 10. The use of cloud computing in companies in Serbia for the period from 2013 to 2017

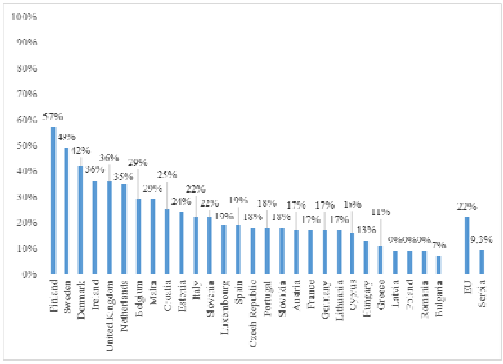

Figure 11. The use of cloud computing in companies in EU countries in 2016

4. CONCLUSIONS AND FUTURE WORK

It can be noticed that the average use of:

- the Internet in companies in Serbia is higher than the average use of the Internet in companies in EU countries (Figure 2);
- e-government in companies in Serbia is lower than the average use of e-government in companies in EU countries (Figure 4);
- website in companies in Serbia is higher than the average use of website in companies in EU countries (Figure 6);

- social networks in companies in Serbia is lower than the average use of social networks in companies in EU countries (Figure 8);
- cloud computing in companies in Serbia is lower than the average use of cloud computing in companies in EU countries (Figure 11).

According to the report of Eurostat [3], e-commerce is observed as e-sales and e-purchase, separately. Therefore, direct comparison between the use of e-commerce in companies in Serbia and in EU countries cannot be performed. However, it can be noticed that the use of e-commerce in companies in Serbia is in constant growth (Figure 9).

Future research can be focused on the use of some other IT in companies in Serbia and in EU countries. First, the use of radio-frequency identification and barcode technologies as well as ERP and CRM information systems can be explored. Second, the awareness of new IT paradigms, such as the internet of things and big data, among companies from different industry sectors can be examined.

ACKNOWLEDGMENT

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COLLABORATIVE PARTNERSHIP FOR VOCATIONAL TEACHERS' PROFESSIONAL DEVELOPMENT IN MECHATRONICS

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Abstract. *The purpose of the research presented in this paper was to investigate possibilities of collaborative partnership between industry partners and vocational teachers for development professional experiences in mechatronics. Research was conducted on a sample of 25 industry representatives. The results have shown that there was considerable number of training and training courses that industry representatives can offer as a professional development for teachers in mechatronics. The research suggests that a significant improvement of professional competencies of mechatronics teachers with the ultimate goal of obtaining competent workforce, can be achieved. These results could be used for building a new foundation upon which new type of collaborative partnership between vocational schools and industry partners could be built.*

Key words: *Mechatronics, Vocational teachers, Continuing professional development, Partnership, Industry*

1. INTRODUCTION

Mechatronics combines the disciplines of electronics, mechanics and information and communication technologies. There are many different interpretations of mechatronics. The most frequently used definition explains mechatronics as a synergy of engineering, electronics, computer science and technical control [2]. Mechatronics is a relatively new scientific field that is developing very quickly, and which is greatly influenced by technological development. These influences have been stimulated by many factors including developments in microprocessor industry, new and improved sensors and actuators, advances in design and analysis methods, simulation tools and novel software techniques [10], [9], [7], [6].

Mechatronics is studied at a theoretical and practical level, as a balance between theory and practice, with emphasizes on hardware implementation [5]. The principles of mechatronics education can be applied successfully to all teaching levels flexible, global thinking, as a trans disciplinary approach to the educational process [1], [8], [4].

Teaching mechatronics is complex due to its multi disciplinarity. The teacher should develop students' professional competence, understanding of technical and theoretical principles, as well as interpersonal and communication skills. Solving problems in mechatronics requires cognitive and operational knowledge and practical experience in the field of diagnostics, installation, and maintenance of mechatronic systems. Therefore, teachers are expected to implement a new pedagogical approach to teaching practices, intensive cooperation with colleagues and employers and the use of new technologies in the field of mechatronics.

Continuing professional development is important for improving and maintaining teacher quality as well as contributing to improving students learning outcomes. Expected effects of teachers' professional development in the field of mechatronics, among others, are:

- development and implementation of new teaching methods;
- improving cooperation with colleagues and all stakeholders (companies, national employment service, faculty, parents, local community, etc.);
- developing partnerships with industry;
- support for the dissemination of successful initiatives;
- improving the quality of education;
- support the development and implementation of educational policies.

Previous research suggests that there is considerable diversity of activities that encourage teachers' professional development in a field of mechatronics. These activities include: [3]

- visits to other schools in order to share knowledge;
- visits to companies in order to stay in touch with new methods and technologies;
- professional training courses in companies (training centers) with emphasize on specific sectors and areas of mechatronics, such as medical equipment, office equipment, kitchen equipment, car industry, etc.;
- participation in projects, etc.;
- various teaching training courses that will help the teacher to implement: project work, real problem solving, digital access and create teaching material.

In order to maintain the high quality of professional identity, teachers of mechatronics need to be in touch with new technological developments in the field of mechatronics. Formal education cannot provide teachers the necessary knowledge and skills required for teaching in the field of mechatronics for longer period of time. The knowledge economy requires new teacher competencies and implementation of new technologies in the teaching process. Teacher competencies have become an integral part of education policy. These competencies are developed through the permanent professional development of teachers.

2. PARTNERSHIP BETWEEN VOCATIONAL SCHOOLS AND INDUSTRY REPRESENTATIVES

A collaborative partnership between vocational schools and industry representatives could result in aligning curriculum with industrial needs and bringing more realistic examples to the classroom. Such collaboration could be beneficial not only for mechatronics teachers and students but also for their future employers. Teachers of vocational subjects could gain more technical experience through cooperation with industrial representative and improve their teaching practice. As a result, whole learning process would become more interesting and clearer, and students would easily understand learning lessons. That could have a positive effect on students, motivating them to learn and acquire new skills as a crucial feature that employers demand. It also opens the possibility for the students to develop entrepreneurial skills. On the other hand industry representatives have the opportunity to present their work and collaborate with potential trainees.

As a conclusion cooperation through partnership and bilateral dialog between vocational schools and companies is the must. The main research questions are:

- what are the attitude and expectations of mechatronics teachers regarding their professional development in companies;
- what are the attitude of companies regarding delivering trainings to the mechatronics teachers.

3. METHODOLOGY

The purpose of this study was to conduct willingness of industrial representatives for a collaborative partnership with vocational schools in terms of mechatronics teacher professional development. Possibilities of a collaborative partnership with industry representatives were conducted on a sample of 25 industry representatives who are employing students that have been completed vocational schools.

This study has been developed through a quantitative and qualitative methodology in which willingness of industrial representatives for a collaborative partnership with schools in terms of mechatronics teacher professional development were researched. Interview with representatives of the industry was structured and consisted of 11 questions grouped into three categories. The first category contained questions that are related to general information about the company. The second category contained questions about the type of training that are organized in the company, and the third category is related to the forms of cooperation with vocational schools. Statistical analysis included basic descriptive statistical measures.

The interview with industry representatives was conducted on a sample of 25 companies with a very long tradition in the field of mechatronics.

Companies differ in size and they are from various sectors such as: thermo technics, energy, food production, sales, distribution and service of mechatronic machines and equipment. The structure of industry representatives in relation to sector and size are presented in Table 1.

Table 1. Structure of Industrial Representatives in Relation to Sector and Size

General information		**No**
Name of sector	Thermo technics	8
	Energy	2
	Food production	9
	Sales, distribution, and service of mechatronic machines and equipment	6
Number of employees	< 10	4
	10 - 50	7
	50 - 100	9
	>100	5

General information about the company and the results are presented in Table I. The sample consisted of five companies with more than 100 workers, four micro companies with the number of employed up to 10, while the other companies are in the category employed from 10 to 50 (7), and from 50 to 100 (9). The most common profiles of jobs in these companies are mechanical and electrical engineers, a considerable number of experts from the fields of economics and management. All surveyed companies have organized the professional development of their employees.

4. RESEARCH RESULTS

This research was oriented towards examination if there was the willingness of industrial representatives for a collaborative partnership with vocational schools in terms of mechatronics teacher professional development and what companies could offer regarding teachers' professional needs.

The most of the companies that were interviewed have collaboration partnership with universities and faculties but rarely with high schools. Results show that industry representatives have a very positive attitude towards cooperation with vocational schools because being closer to the schools could help teachers to be more focus on subjects relevant to them. Such approach could result in getting more knowledgeable trainee. It also could focus teachers' attention on changes in labor market and economic realities.

One category of interview questions was related to the forms of cooperation with vocational schools. Topics and areas of professional training which industry representatives may offer to mechatronics teachers are shown in Table II. There are also shown how industrial representatives assessed the extent to which training topics that companies may offer, contribute to the development of professional competencies in mechatronics.

Table 2. Topics and areas of professional training in companies and its contribution

Topics and areas of professional training	**Contribution**
Choosing the right tools for assembly and disassembly	83%
Computer skills and specializes software	85%
Updates knowledge or increases qualifications	85%
Compliance with safety rules	92%
Making measurements	65%
Company presentation	80%
Environmental protection	57%
Independence and creativity	58%
Communicativeness	60%
Working in a group	70%

Analyzing training that the company can offer, it can be seen that even eight topics/areas of professional development of teachers could be implemented through various training in companies (Table II). They are: Choosing the right tools for assembly and disassembly; Computer skills and specializes software; Updates knowledge or increases qualifications; Company presentation; Independence and creativity; Communicativeness; Working in a group; Making measurements.

An important task of this study was also to determine the difficulties and limitations in the process of professional development of teachers from industry representatives' perspective. The industry representatives emphasized the importance of collaborative partnerships with vocational schools and point out to some difficulties regards teacher's professional development: „... our company has its own training programs for employees and trainer,

regardless of schools, we have our own criteria, procedures, and standards; it is simply impossible to directly involve teachers in the process of our work; it is necessary to establish closer cooperation with schools in the form of partnerships; teachers can attend students' practice, monitor their performance and to familiarize themselves with new technologies and develop their knowledge...".

These research results indicate that could be possibility for developing partnerships between vocational schools and employers with the goal of obtaining competent workforce in mechatronics.

5. CONCLUSIONS

Industries representatives suggested in an interview that cooperation and partnership with vocational schools can offer advantages for both employers and teachers. From their point of view, such cooperation could lead to modernization of curriculum and developing students' professional competencies required by the labor market. Another advantage that industry representatives recognize is the ability to introduce themselves to the potential trainee, to bring closer their standards, the way they doing their business and above all new technologies in mechatronics. On the other hand through such collaboration mechatronics teachers would be able to acquire knowledge of specific skills that are valuable for the field of mechatronics, to incorporate more realistic examples in their teaching practice and teach students how to solve certain mechatronics problems they may face in the future working environment.

These results could be used for building a new foundation upon which new type of collaborative partnership between vocational schools and industry partners could be built. The finding in this research suggests that it can be achieved a significant improvement of students' professional competencies in mechatronics with the ultimate goal of obtaining competent workforce.

Finally, as recommendations for overcoming difficulties and limitations in the process of professional development of teachers the following steps are proposed:

- encouraging closer cooperation between vocational schools and businesses for the purpose of introducing new mechatronics technologies and standards;
- involve the teacher in companies training practice and adjusted those training to the teacher's professional needs;
- find an appropriate way to engage industrial representatives in mechatronics teachers professional development.

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CAD/CAM TOOLS IN RISK ANALYSIS DURING DESIGNING PROCESS

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Abstract. *By definition, the risk represents suspense in relation to the desired outcomes. According to that, this project includes the algorithm which with the help of the tool CAD/CAM provides step analysis in the process of projecting to realization of the finished product. As well, algorithm points out the possible risks when presenting element or finished product.*

Key words: *designing, risk, CAD/CAM*

1.INTRODUCTION

Due to lack of communication in management, there are numerous weaknesses in the process of product development because the final product wasn't what customer's initial thought was.

The reason why risky management exists is because customers are often ambiguous and they have different perspective in visioning certain things, therefore, there is a problem for a designer on how to translate customer language into measurable characteristics of products or services [1].

The risk represents suspense in relation to the desired outcomes. Risk-based designing provides designers to establish factors which could be influencing certain processes to deviate from the desired result. Risk management implies that negative factors of designing should be reduced to the lowest measure and opportunies be taken to the maximum so that there are no negative occurrences.

The goal of this business is to find a solution and to avoid risks in the earliest phases of management. Presented algorithm with application CAD/CAM tools, provides elimination of potential risks during element designing or entire product.

2. RISK IN DESIGNING

In the process of realization grand engineering projects, Miller and Lessard[2] pointed out that understanding and managing risks represents challenging tasks for designers in the early stages. As well, failure of large engineering projects could lead to serious damages that could appear due to not taking risks in consideration [3].

Nowadays, all of the attention is given to technical risk [4] that implies to: 1) impossibility of determination interpersonal relations between key processes, 2) lack of access to technical expertise, 3) lack of agreement about analysis, tools and designing techniques, 4) lack of knowledge about technology application, 5) wrong technology choice, 6) limit in existing technologyapplication.

Designing is information process of transformation in which low level informations (estimates, analysis, stimulations, graphic display) are transforming in higher level informations. Generally, life cycle of a product from an idea to realization is going through following stages: designing, production, usage (exploitation) and recycling, look at the picture 2

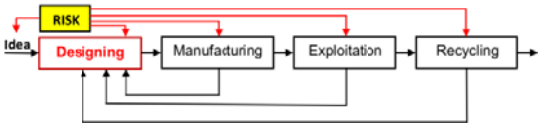

Fig 1. Stages in product life cycle

During the process of designing in an early stage of product development, the quality of a product is generated, but there is also a big number of errors. If errors do not become detected and eliminated in

initial development, the progressive growth of total expenses and qualities will show up. Errors detection in later stages in the life span of the product leads to higher costs of their remediation. A large number of errors arise in the product development phase and technology design. However, in the product development phase and technology design, the errors are the most difficult to detect.

As it was already mentioned, it is considered as technical risk which should be estimated cautiously when making decisions about the project [5]. Due to the same source, considering technical risk the processes are improving with described procedures and the expenses of defective product are being reduced (Corrections, warranties and additional services).

According to ISO 31010 standard [6], possibilities for risks inclusion could be: 1) avoiding risks and taking to consideration risks as a possibility, 2) taking over risks to take opportunities, 3) elimination of a risk cause/source, 4) change of probability or consequences of risk sharing, 5) risk retention based on the information

As well, the process of managing the risk implies following activities [7]:

- Risk identification: certain occasions, acts or occurrence can lead to risk. In this case, the main question is who to recognize it and how to proactively participate in these scenarios. In this category various sorts of abruptions, defects, poor production of finished pieces and low product quality could be included.
- Risk assessment: Estimation of risks and priorities are needed to determine compatible acts of management for identifying risk factors in accordance to the situation at the design levels.

As well, risk identification and estimation could be observed and indicators in which direction should activities go. Some risks could be reduced through common action in the designing team, as with the other risks, every designer has to deal with the problem individually. Generally, every designer that resorts to apply the strategy for risk managing, should include following [8]: risk transfer, risk taking, risk elimination, risk reduction, further analysis of individual risks

3. CAD/CAM TOOLS IN RISK ANALYSIS

Nowadays, CAD programs possess in their own libraries large number of standard parts and elements, where by calling from the base and inserting them, the elements are easily placed on the drawing.Also, all these elements can be corrected in the drawing.

By development of powerful hardware solutions, a completely new approach to 3D model analysis has been developed. This approach is reflected in the formation of a detailed model and its use in virtual experiments, in a similar way as it would have been in reality with a physical model. This means that it is no longer necessary to wait for months to create a physical model in order to carry out tests, and later expensive procedures and modifications with the final goal of achieving the required characteristics [9].

The goal of 3D modeling at the design stage is to eliminate risk through: timely problem solving, the development of more creative and reliable products, reduction of post-war costs, modification of the real model or the flow of the production process itself. CAD programs allow for certain changes of a constructive nature to be made. Advantages in the model domain allow the introduction of all changes, where each change is automatically implemented on all drawings where this phenomenon occurs. Nowadays, some industry branches can't even be imagined without the use of CAD tools in 3D modeling and drawing.A typical example for something like that is the air and automotive industry that uses many CAD programs for the basic tool to model various parts. which later, with the help of special methods, examine and simulate various external physical influences.

In its foundation, the platform for testing and realization of 3D models includes programs CAD, CAM, FEA. The CAD system is used in the process of product design.It represents developed computer hardware and the corresponding software that is that is used for designing and constructing [10]. In the preparation of technology, a computer is used in the computer (Computer Aided Manufacturing) or computer assisted technology development, or computer development of a technological process.

FEA programs are used to model elastic components, which takes into account the influence of elasticity during simulation in order to predict results with greater accuracy, as well as to determine the strain of the most critical parts and define their load bearing capacity in order to finalize the mass of the components.

4. METHODOLOGY- ALGORITHM

In this project, the design process will be explained with the analysis of risk occurrence in all its stages. As an example,we will use a model for mechanical

forks in the automotive industry (see picture 2). On this example, CAD application software was used in order to reduce the risks involved in designing, but also to avoid poor communication in relation to marketing - design - the manufacturing process.
The algorithm of the new product design process is given in the picture 2.

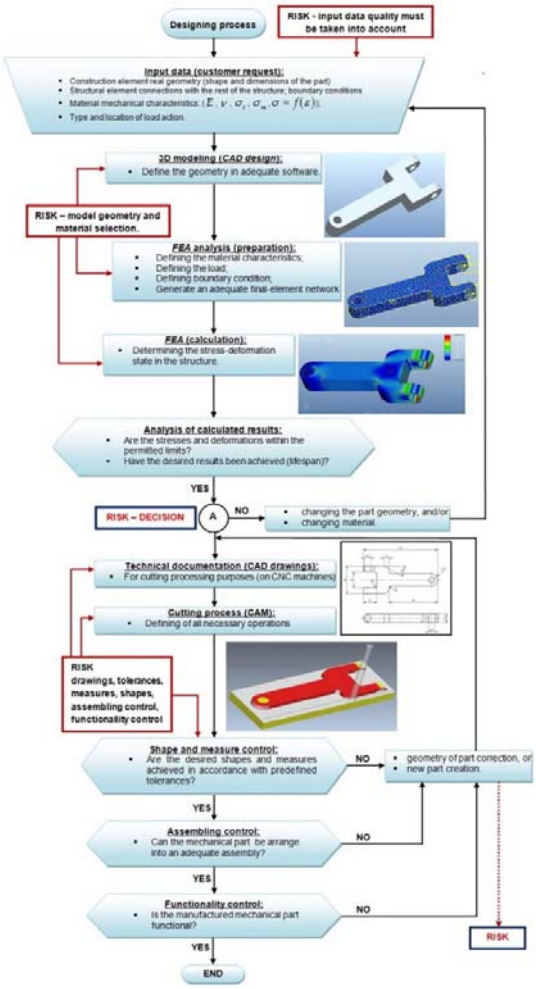

Fig 2. Designing process algorithm

The first step is defining the input data necessary for the entire process of conquering a new machine part and setting up technical and technological requirements. Here the risk can be involved if the input data not considered high-quality.
The second step is the 3D modeling of the machine part (in some of the available CAD software). Then, the preparation of the 3D model for the FEA - Finite Element Analysis and the calculation of the strength of the projected work is carried out. After the budget has been executed, the obtained results are analyzed from two aspects:

1. Are the stresses and deformations within the permitted limits?
2. Have the desired results been achieved (lifespan)?

The analysis of these results represents a step where the risk elements regarding the geometry of the set model and selection of materials are considered. If satisfactory results are not achieved, it is necessary to make certain corrections in terms of changing the material, and/or the geometry.The procedure is done iteratively, until the set requirements are met from the aspect of the strength of the structure, the planned (designed) working life of the construction.
Then, the planning and part realization on the CNC machine is done, with the previous drawingslaunching. In order to eliminate the risks, it is necessary to define in the drawing the appropriate measures tolerances, shapes and positions, which are determined in advance by the function of the projected machine part within a certain sub-assembly.
Finally, the realized geometric measures control, shapes and positions within the previously defined tolerances is carried out.
In order to eliminate the occurrence of risks, part assembly control, as well as control of its functionality within the sub-assembly, is of great importance. If these conditions are not satisfied, it is necessary to correct the geometry of the work, if it's possible. Otherwise, the new part is being developed.
The stream designing, i.e. the development of a new product indicates an obvious link between CAD and CAM tools. Changes on the 3D model are automatically manifested in the remaining modules (phases) within the overall design process. This greatly saves resources: people, resources and time, and therefore, money.
Based on the presented algorithm, the principle of functional characteristics and application of reference technology in the realization of the product has been respected. By its very nature, the functional characteristic refers to an existing product on the market, which has the same function and / or almost the same functional value for the user. The purpose of the functional characteristic is comparison with the new product, which will lead to improvement.
After completion of the project / product, most designers want a new opportunity to start all over again in order to do the right thing and for everyone to understand it. Unfortunately, a small number of them get an opportunity to do this. Solutions to the problem and potential solutions are obtained through

the knowledge of individuals, which indicates the loss of freedom in design.

5. CONCLUSIONS

The development of information technology enabled designers to present a new product or more combinations to obtain a sustainable production concept in a short period of time and with low costs, especially through the application of the 3D modeling program.

Product design is a risky activity in the production process. Success at the design level also determines the product price.

In the analysis of the demonstration model, it was tried to satisfy all conditions with the maximum exclusion of all predictable and unpredictable risk factors:

- the designing process should enable accurate and transparent steps in terms of providing solutions,
- the model should be neutral in the first consideration, and then the conditions of concretization,
- the elements of the model must be precisely defined,
- the proposed steps have to be accurately described and explained,
- analyzes and results obtained with other models should be carried out,
- the model should be understood by designers in practice,
- the model should be applicable.

This work shows the importance of CAD application software in the new product development. The application of software accelerates the development, analysis and decision-making of acceptable and solutions. With CAD application software it is possible to execute: static size calculations, stability and vibration calculations, multi-criteria optimization and determination of thermal changes in the design.

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SMARTPHONE SOFTWARE FOR URBAN NOISE MEASUREMENT

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Abstract. *The paper tries to analyse the aspects of using smartphone apps as a low-cost option for creating noise maps, as required by European legislative. Using smartphones as noise measuring instruments opens a number of questions related to the quality, reliability and integrity of data collected. A special attention is given to calibration and software quality. The research is accompanied by a real-world example, where results from different apps were compared to a professional instrument, in an outdoor environment. Results revealed that the discrepancy between the measurements are larger than the possible noise reduction interventions, indicating that smartphones used as measuring instruments should be questioned and thoroughly tested before making any decisions based on measurement results.*

Key words: *Urban noise measurement, Smartphone Apps, Software Quality.*

1.INTRODUCTION

Some studies show that about 40% of the population in the European Union is exposed to road traffic noise with an equivalent daytime sound pressure level exceeding 55 dB(A) and 20% is exposed to levels exceeding 65 dB(A) [10]. Therefore, environmental noise emerged as a major issue in environmental legislation and policy, which lead to the adoption of the European Noise Directive [4], often being used as a reference, even outside the EU. The Directive [4] focuses on three main action areas: the determination of exposure to environmental noise; ensuring that information on environmental noise and its effects is made available to the public; preventing and reducing environmental noise where necessary and preserving environmental noise quality where it is good.

According to this Directive, noise mapping is the main tool for the assessment of human exposure to environmental noise pollution. The noise mapping can be realized by computer simulations based on models of sound field propagation, and studies carried out with field measurements, performed either by professional instruments or smartphone apps. All these methods require validation and calibration, in order to stay within the acceptable error margins. The standard ISO 1996-2:2017 estimates a minimum uncertainty of 2 dB for measured noise levels, which is associated with factors such as instrumentation, operating conditions (repeatability), weather and terrain conditions and residual sound [10].

Maisonneuve et al. in [9] presented an approach to monitor noise pollution using smartphones as noise sensors. Worldwide users created the noise maps by sharing their geo-localized measurements with the community, which are now publicly available online at http://www.noisetube.net. However, the vast variety of smartphones can lead to poor measurement results, and some of the sources of these measurement errors are discussed in this paper.

2. SMARTPHONE AS A NOISE SENSOR

The expansion of smartphone usage worldwide, along with hardware improvements and the variety of software apps available today, bring some new issues related to the quality of measurement data. A number of researches was performed in order to estimate the data quality, and/or to relate it with smartphone brands. Most users today use either Android or Apple smartphones, and these two are the most common subject of testing in the literature.

Kardous and Shaw examined 14 iOS and Android apps in [7] in a controlled noise environment to test

whether they can be used for occupational noise measurements. Satoh et al. in [13] used smartphones with acoustic measurement apps to make sound maps in an university course for environmental acoustics, and validated the measurement results with white noise signal in anechoic chamber. Nesaratnam and Taherzadeh in their research [12] concluded that the smartphone microphone usually has a low frequency filter, as the device is primarily intended for speech (frequency range: 350 Hz - 4.8 kHz), and that this has to be taken into account when measuring noise with significant low frequency components.

Murphy and King in [11] took smartphone apps from controlled laboratory environment out to the field, in order to test their performance in a more realistic and more varied sound environment. Due to limited microphone frequency range, the apps performed worse than in laboratory, because the real-world sounds cover wider spectrum of frequencies. Hawley and McClain in [6] claim that measurement accuracy is hindered because smartphones use omnidirectional microphones, tailored to detect voices, instead of professional metering equipment which employ directional ambient microphones spanning over broader ranges of frequencies.

3. SOURCES OF MEASUREMENT ERRORS

Urban noise reduction interventions, such as low-noise pavement, speed reduction, mixed traffic flow reduction, and traffic calming measures can reduce the traffic noise up to 6 dB, and significantly more expensive noise barriers can reduce the noise for as much as 25 dB [16]. Therefore, the measurement uncertainty of noise sensors should be below these values, otherwise the effects of these interventions could not be measured precise enough.

Brown and Evans in [2] analysed the limitations of smartphones being used as noise sensors. They doubted the accuracy of these devices, due to hardware and software limitations, most notably the frequency range these devices are capable to capture. Maisonneuve et al. in [8] explained the calibration of mobile phones. They used pink noise 30 to 105 dB (by 5 dB steps) and obtained results with a final precision of ±4 dB on the Nokia N95 8GB.

Contrary to the controlled laboratory measurements, the field measurement results may vary greatly due to the effect of temperature, humidity, long-term use, object interference, and overall stability of the microphone and electronics in measuring devices [7]. González DM et al. in [5] have found that it is necessary even to make corrections of the standard measurements for the distance to the source if there are parking lanes. That only points out that field measurements are subjected to a number of various influence factors that could change the measured noise levels more than the effect of noise reduction measures implemented.

The influence factors for the quality of measurements performed by smartphone apps include:

- microphone type (e.g. Apple moved to a new supplier of microphones with the introduction of the iPhone 5 [7], which changed their performance),
- microphone quality (almost all smartphone manufacturers use MEMS microphones in their devices, which typically have a sensitivity between 5 and 17.8 mV/Pa and can capture signals as low as 30 dB SPL and as high as 120 to 130 dB SPL with signal-to-noise ratio >60dB. MEMS microphones also have a flat frequency response similar to ceramic and condenser microphones in type 2 noise dosimeters [7]),
- calibration method (smartphone apps often enable only a "calibration" using single sound frequency/ intensity. The real calibration should cover a wider range of frequencies and intensity levels to check the calibration curve)
- measurement technique (the newest Brüel&Kjaer professional sound level meters suggest Bluetooth remote operation to avoid influences of sounds such as clicking the instrument buttons. Smartphones, on the other side, use built-in microphones with limited sound capturing capacity, and can be influenced by a number of obstacles such as phone protection covers, microphone openings clogged by dust, or bizarre situations such as incoming phone call notification during the measurement)
- operating system features (e.g. Apple iOS6 allows app developers to bypass speech filters and input gain control on older devices [7]).
- sound measurement software features and capabilities (how software can be adjusted, which external influences are taken into account, is data integrity well taken care of, are there time delays in data processing, etc.).

Android devices are built by several different manufacturers and that there is a lack of conformity for using similar microphones and other audio components in their devices [7]. Results from [13]

also showed that variations of the data are more significant in Android than in iOS devices.

4. SOFTWARE QUALITY

The term "software quality" may refer to desirable characteristics of software products, and to processes, tools, and techniques used to achieve them [5]. Software quality is also defined as the "capability of software product to satisfy stated and implied needs under specified conditions" and as "the degree to which a software product meets established require-ments; however, quality depends upon the degree to which those established requirements accurately represent stakeholder needs and expectations" [1].

The hidden complexity within the software in measu-rement systems is a potential source of errors that could remain undetected, thus inducing measurement errors or increasing uncertainty.

Western European Legal Metrology Cooperation (WELMEC) issued a technical guidance for the application of the Measuring Instruments Directive (MID) 2004/22/EC, especially for software-equipped measuring instruments [14]. However, this guidance does not refer to sound level meters, and other instruments covered by this guidance (water meters, thermal energy meters, exhaust gas analysers etc.) could be used as a template to derive the specific software requirements for sound level meters, such as indication suitability, inhibit resetting of cumulative measurement values, or fault recovery.

Another software validation guidance document was developed by the National Physical Laboratory [15]. It covers much more issues than WELMEC Guide, such as software non-linearity, numerical instability, structural decay, code review etc.

Smartphone apps are usually rated according to customers opinion polls, but the real software quality, as defined in [1], is rarely tested. Since more and more apps are used to encompass the Internet of Things (IoT), there is an urgent need to define the software quality requirements for smartphone apps used for purposes such as environmental monitoring, pollution or noise mapping. Making decisions according to these data makes it even more important.

5. EXPERIMENTAL SETUP

In order to test the usability of smartphones as noise level detectors, three free Android apps (*SoundMeter* v.3.2.6 by Abc Apps, *Sound Meter & Noise Detector* v.2.4 by Tools Dev and *NoiseCapture* v.1.1.3 by Ifsttar) were installed on two smartphones (Samsung Galaxy SM-J510FN with Android v.7.1.1 and Samsung Galaxy SM-A500FU with Android v.6.0.1).

Simultaneous measurements were performed by Brüel&Kjaer hand-held Analyzer Type 2250 [2] and low-cost sound-level meter UT353 made by Uni Trend Technology.

Figure 1 shows how measurement results can vary significantly and it was very hard to obtain the same readings on different measuring instruments.

Figure 1. Different readings of the same noise level measured by different instruments

Tables 1 and 2 contain measurement results of noise levels captured by different devices in an urban environment (next to the busy street) during the day (15:00-15:15), and during the night (22:00-22:15). The frequency of large trucks (making the highest levels of noise passing by the measurement location within 15 minutes was 40-50 during the day and up to 10 during the night. Maximum noise levels recorded in the daytime and the night-time were 96 and 51 dB, respectively.

All measurements were performed at the height of 1.2 meters above the ground to avoid the sound reflection, and the measurement results are averaged over the 15-minute periods.

Table 1. Daytime noise measurements

Noise level (dB) / Device	Application: Sound-Meter	Sound Meter & Noise Detector	Noise-Capture
Galaxy J5	69.5	67.0	74.5
Galaxy A5	71.2	68.4	75.2
B&K 2250	72.9		
UT353	72.6		

Table 2. Night-time noise measurements

Noise level (dB) / Device	Application: Sound-Meter	Sound Meter & Noise Detector	Noise-Capture
Galaxy J5	62.5	62.1	68.7
Galaxy A5	64.3	63.3	69.3
B&K 2250	67.5		
UT353	67.3		

The measurement results show that the difference between the professional and low-cost measurement devices are within ±0.3 dB, the difference between the smartphones using same application ±5.9 dB, and the difference between the applications on the same smartphone ±6.2 dB.

6. CONCLUSIONS

Having in mind that regular urban noise reduction interventions (other than sound barriers) can reduce traffic noise levels only by 2-5 dB, which means that using smartphones as noise measuring instruments should be questioned and thoroughly tested before making any decisions based on measurement results. It is not feasible to perform expensive measures if the results are lower than the measurement uncertainty.

Even though smartphone apps can be used for detection of noise hot spots, indicative measurements, and creation of low resolution noise maps, the serious noise maps, as requested by the regulations, should be performed only by calibrated measuring instruments.

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METHODOLOGY FOR IMPLEMENTATION OF ISO 9001:2015

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Abstract. *The 2015 edition of standard ISO 9001 has replaced the 2008 version, and over one million organizations all over the world had to update their quality management systems to fit the new version. Every organization is different, so the steps needed to adjust the management system are likely to be unique to every single situation. This paper shows research on practical issues concerning the methodology of transition from ISO 9001:2008 to ISO 9001:2015 in Serbia. The crucial changes in ISO 9001:2015 standard have been highlighted, and methodology for transition has been presented. The practical experiences in implementation of standard requirements have been showed and commented in the context of Serbian transitional economy.*

Key words: *ISO 9001, Quality management system, transition*

1.INTRODUCTION

ISO 9001 is an International Standard of Quality Management System (QMS). This Standard describes the requirements for organizations to help them promote continual improvements and achieve customer satisfaction. Standard ISO 9001 has been revised several times [1, 2].

The new version of the standard ISO 9001 [3] was published to bring the user a number of benefits. For example, ISO 9001:2015 should [4]:

- put greater emphasis on leadership engagement
- help address organizational risks and opportunities in a structured manner
- use simplified language and a common structure and terms, which are particularly helpful to organizations using multiple management systems, such as those for the environment, health & safety, or business continuity
- address supply chain management more effectively and
- be more user-friendly for service and knowledge-based organizations

The urgencies of the QMS certified companies to adjust their QMS were revealed by [5, 6].

The most noticeable change to the standard is its new structure. ISO 9001:2015 now follows the same overall structure as other ISO management system standards (known as the High-Level Structure), making it easier for anyone using multiple management systems [7].

The new version of ISO 9001 has 10 clauses and a brief comparison of clauses between both versions is presented in Table 1.

Table 1. The comparison of clauses between two latest versions of ISO 9001

ISO 9001:2008	ISO 9001:2015
Clause 1: Scope	Clause 1: Scope
Clause 2: Normative References	Clause 2: Normative References
Clause 3: Terms and Definitions	Clause 3: Terms and Definitions
Clause 4: Quality Management System	Clause 4: Organizational context
Clause 5: Management Responsibility	Clause 5: Leadership
Clause 6: Resource Management	Clause 6: Planning
Clause 7: Product Realizations	Clause 7: Support
Clause 8: Measurement Analysis and Improvements	Clause 8: Operation
	Clause 9: Performance Evaluation
	Clause 10: Improvement

Apart from different structure shown on Table 1, other major differences in ISO 9001:2015 are listed in further text.

RISK-BASED THINKING

While this has always been part of the standard, the new version gives it increased prominence. Formal risk analysis of processes that could endanger intended results of a system is now standard for every organization that implies ISO 9001 requirements. The addition of risk-based thinking set the principle of prevention in the focus of Quality Management System, and thus made the "preventive measures" of ISO 9001:2008 redundant, so the term "preventive measures" no longer exists in ISO 9001:2015.

CONTEXT OF THE ORGANISATION

ISO 9001:2015 requires an organization to define the specific context within which it is active. This means that organizations have to deal with internal and external strategic questions and to take into account and evaluate the needs and expectations of all significant interested parties.

MORE FOCUS ON INPUT AND OUTPUT

ISO 9001:2015 puts more emphasis on needed input and output of processes. According to ISO 9001:2015, organization should monitor which matter, energy and information are involved in the production process in order to have adequate products in the output. The basic elements of a single process are shown on Figure 1.

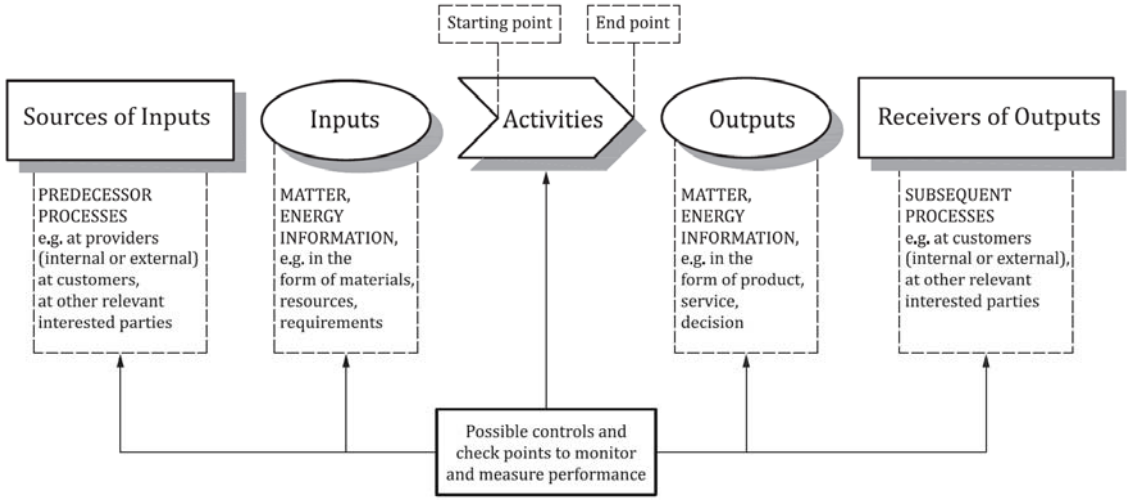

Figure 1. The schematic representation of the elements of a single process

THE INTERESTED PARTIES

In ISO 9001:2015 customers are not the only recognized interested party, as it was in 9001:2018. Suppliers, personnel, shareholders, legislative bodies, society, etc. are now included as interested parties, in addition to customers. Every organization, should anticipate requirements and expectations of important interested parties in order to deliver a desired product or service

LEADERSHIP

ISO 9001:2015 also puts more emphasis on leadership and management commitment. It requires greater involvement of top managers in the functioning of Quality Management System. In this way ISO 9001:2015 encourages integration of QMS with business processes and business strategies. Risk-based thinking enables top managers to steer the quality management system along the right lines.

DOCUMENTED INFORMATION

ISO 9001:2015 no longer requires obligatory documented procedures or a quality manual. All documents, including records, are now referred to as "documented information" in all clauses of ISO 9001:2015. The information can be in any format and come from various sources and media. This encourages organizations to find their own "best way" of system documenting.

ROLES AND RESPONSIBILITIES

The "management representative" required in ISO 9001:2008 was a member of the management committee who had the overall responsibility and authority for the organization, coordination, maintenance and improvement of the system. ISO 9001:2015 does not mention this aspect any more, which implies that quality should be a matter for everyone within the organization.

2. METHODOLOGY FOR IMPLEMENTATION OF ISO 9001:2015 REQUIREMENTS

The changes in ISO 9001:2015 triggered off some changes in approach of standard requirements implementation, although the authors suggest that all existing documents (Quality Manual, Procedures, Instructions and records) should be retained if they are effectively applied in the organization.

The engagement of the authors as consultants on improvement of Quality Management Systems in accordance with ISO 9001 standard requirements in numerous organizations was crucial for the creation of this paper. The experience of the authors shows that regardless of the size and activities of company, the project of transition from ISO 9001:2008 to ISO 9001:2015 requirements can be accomplished by 13 phases described below:

Phase 1 – The observation, analysis and estimation of system efficacy

In this phase the Consultants should be acquainted with an accurate management system status of the organization by observation and analysis of the system state and efficacy.

Consultants should get to know all relevant functions and documentation of the enterprise.

Phase 2 – The improvement program

According to the system efficacy estimation accomplished in the Phase 1, consultants should define the improvement program and assess the duration of activities, with expected duration of the whole Project.

Phase 3 - The informative seminar

The Seminar is intended to provide basic information to organization top managers on standard ISO 9001:2015 requirements. The Seminar should explain the way for the implementation of ISO 9001:2015 requirements according to the detailed Improvement program, which covers all requirements of the standard.

Phase 4 – Defining the context of an organization

Consultants in cooperation with the project team of the organization define the context of the organization, as well as the needs and expectations of stakeholders. Established elements should be documented in Quality Manual.

Phase 5 – The instructive seminar for the risk management process

This seminar is designed for participants from the organization, and it should include provision of basic instructions and principles for risk assessment of QMS processes. The proposed methodology for risk assessment process that will be used in the organization should be precisely explained. The starting point for risk assessment should be recognition of key performance indicators for all important processes. This process should be defined in a new procedure.

Phase 6 – Defining Quality policy and objectives

The existing Quality policy should be harmonized with the context of the organization, assessed risk levels and other changes according to the new requirements of ISO 9001. All the objectives of the quality management system should be aligned with the Quality policy and every objective should have documented program for its realization.

Phase 7 – Harmonization of existing documents

In order to meet all the requirements of the ISO 9001:2015, the development of new and changes in existing documents should be carried out according to the performed risk assessment.

Phase 8 – Distribution and application of documented information

After the distribution of new and revised documents, the project team should monitor their application and give instructions to the users of documented information.

Phase 9 - The instructive seminar for internal auditors

This phase covers the training of internal auditors from the organization, according to the ISO 9001:2015 requirements. Candidates for internal auditors will be determined by management. Seminar includes the examination and certificates are issued to all participants that pass the exam.

Phase 10 – The internal audit

Internal audits should be conducted by trained auditors. Findings of the audit with observed nonconformities should be documented and corrective actions defined.

Phase 11 – Corrective actions after internal audit

Consultants should check the implementation and effectiveness of corrective actions defined after the internal audit.

Phase 12 – Management review

Consultants should provide assistance in quality management system review. The management review records report the readiness of QMS for the certification audit.

Phase 13 – Corrective actions after certification
Consultants should provide assistance in application of corrective actions on eventual nonconformities noted by the certification body.

The order and duration of listed activities are crucial for the quality realization of the project of standard requirements implementation. Approximate Gantt chart for project realization is presented in Table 2.

Table 2. Approximate Gantt chart for project realization

THE IMPROVEMENT PROGRAM		PLANNED TIME OF PROGRAM REALIZATION ⇒ Weeks													
No.	PHASE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	The observation, analysis and estimation of system efficacy														
2.	The improvement program														
3.	The informative seminar														
4.	Defining the context of an organization														
5.	The instructive seminar for the risk management process														
6.	Defining Quality policy and objectives														
7.	Harmonization of existing documents														
8.	Distribution and application of documented information														
9.	The instructive seminar for internal auditors														
10.	The internal audit														
11.	Corrective actions after internal audit														
12.	Management review														
13.	Corrective actions after certification														

3. CONCLUSIONS

As it can be seen in Table 2, the project of ISO 9001 transition can be roughly terminated in 14 weeks, but this period of time can be reduced or extended according to complexity of activities of the organization, and it primarily depends on engagement of consultants and project team.

The phases of the project are adjusted to those organizations that have already implemented standard ISO 9001:2008 and it covers all the changes that standard ISO 9001:2015 has brought out.

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UNDERSTANDING HUMAN ERROR IN INDUSTRY

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Abstract. *It is proved that most of industrial accidents are related to some kind of human failure, sometimes with catastrophic consequences. The present paper refers to human error probability in industrial activities. The paper intends to make a literature revision referring important concepts about human behaviour and human reliability. It is fundamental to identify tasks, actions or activities that depend on human behaviour or even determine the conditions that influence human error and thus increasing risk. With this goal, the most important methods, techniques and tools to assess human failure (error) are referred showing their potential applicability.*

Key words: *Human Reliability, Human Error, Man-machine interaction.*

1. INTRODUCTION

It is known that human reliability analysis (HRA) is one of the most difficult issues when dealing with risk analysis. Human and organizational factors (HOFs) set a huge challenge to risk analysts despite several methodologies that appeared in the last years. Several accidents are reported referring a straight relationship with human error on maintenance and operation (M&O) activities. Industry is searching and investing in developing new methods and strategies, in order to mitigate or decrease the probability of a human failure.

The paper is structured into 5 sections. Section 1 refers to an introduction to describe the scope and importance of the theme. Section 2 is related to HRA and makes reference to some methods, techniques and tools currently applied. The behaviour of humans when performing an activity is referred in section 3. Section 4 refers some details of the most common methods and tools and finally in section 5 some conclusions are stated.

2. HUMAN RELIABILITY

Reliability is strictly related to the probability of success. In fact, reliability is defined as "*the ability of an item to perform a required function under given conditions for a given time interval and may also be defined as a probability*" [1]. This definition is mainly focused on physical assets regarding their probability of survival upon a given time. Human reliability is frequently described as a wider and more complex concept. The probability of someone make an error is directly influenced by several factors such as the ability, the training, the experience, the personal correctness and the aging.

There is not a universal definition for human reliability. However, several authors try to define it in accordance with their point of view. Meister [10] states that "*human reliability is linked to the probability of a work or task to be accomplished with success in a given time*". Kirwan [7] says that "*human reliability is a discipline of Ergonomics based on the knowledge of reliability and risk analysis*". A more complete definition of human reliability is mentioned by Pallerosi [13] saying that "*it is the probability of a person not to fail on the accomplishment of a required task (action), when demanded, in a given period of time, under adequate*

environmental conditions and with available resources to perform it".

Human reliability is an issue that started with a study in the 50's at Sandia National Laboratories (USA) to determine the feasibility of a defensive armed system operated by persons [16]. More recently the concept of HRA emerged in the literature as the way to identify the error, quantify human reliability (probability) and find how to mitigate or reduce human error [7].

The first methods were essentially based on the person's behaviour and not on cognitive factors and thus were considered as "first generation methods". It was a mechanical approach and the persons were identified as mechanisms or components. Later, with the introduction of cognitive factors as the skills, knowledge and rules appeared the "second generation methods" [14]. Nowadays, some methods are already referred as "third generation methods". More than thirty methods, techniques and tools can be described.

Several works in distinct areas can also be referred, as for example in the aviation field [15], medicine [11], nuclear field [5], transportation [2] or petrochemical facilities [9], among others.

3. HUMAN FAILURE

As stated before, most of HRA relies on human error events. In accordance to Pallerosi [13] human failures can be classified into different categories, as represented in Figure 1.

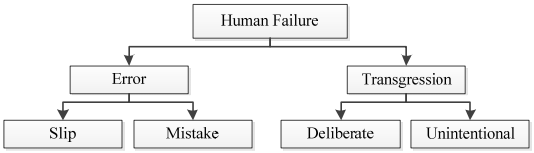

Figure 1 - Human failure classification.

According to Pallerosi the most common cause of human failures is error. These errors are dependent of operator capability, stress factors, motivation and environmental conditions. Mistakes usually happen due to fatigue or stress or even bad environmental conditions or person's aging but the main reason is due to lack of training for a specific activity. Deliberate transgressions are linked to behavioural procedures and are not related to capabilities, training of physical characteristics but lack of responsibility or impunity. The unintentional ones are often related to lack of knowledge of procedures or rules. Other classification of human error is done by Swain and Guttmann [17], as shown in Figure 2.

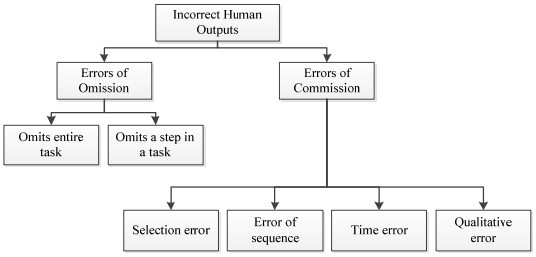

Figure 2 - Categories of incorrect human outputs in HRA (adapted from [17]).

It is also relevant to refer the relationship or interaction between man and machine and point out how it can affect human error.

Machine controls should be adapted, taking into account human physical, mental and sensorial capabilities. The machine must have an adequate design of controls and panels and environmental conditions should be supervised and controllable. All these aspects are very important if one wants to decrease the probability of human failure (error) and thus improve safety and production in industrial activities.

The emergence of new technological concepts leads to new interfaces man-machine. CPS systems (Cyber-physical systems) are a new generation of integrated computational (software) and physical (hardware) systems that can interact with humans through many new modalities [8].

The hardware and software must be highly dependable, reconfigurable and, where required, certifiable, from components to fully integrated systems. This can give rise to new types of human errors, as there must be total reliance on software to control processes and operations [8].

4. METHODS, TECHNIQUES AND TOOLS

In the present section it will be presented a brief description of the most known methods, techniques and tools for HRA.

4.1 Technique for Human Error Rate Prediction (THERP)

First developments of this methodology started in the 50s with military purposes in a way to diagnose the probability of occurrence of human error and evaluate the degradation of man-machine due to these errors in high risk industrial facilities.

Although thought at the beginning for application in the nuclear field, THERP can be used in several industries with credible results [6]. However, some disadvantages are pointed out to the method as the

high need of resources, excessive detail found in some evaluations and the absence of enough instructions for the determination of PSFs (Performance Shaping Factors) impact on operator's performance.

4.2 Accident Sequence Evaluation Program (ASEP)

ASEP method was developed in 1987 by Swain (the same author of THERP) also for the U.S. Nuclear Regulatory Commission due to the necessity to have a method that could estimate human error probabilities (HEPs) and response times for tasks performed during normal operating conditions and post-accident operating conditions, being sufficiently accurate for probabilistic risk assessment (PRA) and requiring only a minimal expenditure of time and other resources [18]. On the contrary of THERP methodology, ASEP was specifically developed for nuclear industry and thus not applicable to other sectors.

4.3 Human Error Assessment and Reduction Technique (HEART)

HEART was developed with the aim to be a simple and quick method to quantify risk related to human error and to give suggestions on how to proceed to reduce such error. The first presentation of this technique was done by Williams at a conference in UK, in 1985 [19], being developed and detailed in further works done by the same author [20] [21]. It is a general technique, recognized as a successful and cost-effective tool for predicting human reliability and identifying ways of reducing human error. It can be also applied to any industrial operation due to its methodology being centred upon the human operator rather than the technical process.

4.4 Standardized Plant Analysis Risk - Human (SPAR-H)

This methodology was also developed by the Idaho National Laboratory for the U.S. Nuclear Research Commission in 1994 with the aim to build an approach and development of probabilistic models to assess human reliability in NPPs. Various combinations of contributory factors were examined and given a rating based on their combined effect on dependency among tasks. The ratings of the various combinations correspond to zero, low, moderate, high, or complete dependency among tasks. A more detailed explanation of each factor and the relationship analysis between factors can be analysed in the reference document [3]. The methodology is mostly directed to the nuclear industry.

4.5 Cognitive Reliability and Error Analysis Method (CREAM)

This method was developed by Hollnagel in the 90s and presented in a scientific paper in 1998 [4]. It is described as a bidirectional method and is based on the distinction between competence and control. The method classifies human error into causes (genotypes) and manifestations or effects (phenotypes), regardless of whether it is for a retrospective or a predictive purpose.

4.6 A Technique for Human Event Analysis (ATHEANA)

ATHEANA is an assessment technique that provides a useful structure for understanding and improving human performance in operational events. It is the result from a study of operational events and from an attempt to reconcile observed human performance in the most serious of these events with existing theories of human cognition and human reliability models, within the context of plant design, operation, and safety [12]. This technique is concerned with identifying and estimating the likelihood of a situation in which operators take actions that render a plant unsafe. ATHEANA differs from other methods because it attempts to identify and determine the probability of a situation that can trigger an unsecure or unsafe action in plant personnel.

5. CONCLUSIONS

It is fundamental to assume that the impact of human reliability is as important as the impact of physical asset's reliability when performing an industrial risk assessment or a generic risk analysis. As it can be observed from the previous paragraphs, the estimation of the probability of human error is a complex task, once it can be influenced by several factors. Despite all the factors to be considered, it is also important to recognize how sensorial and cognitive processes work in humans.

In the last two decades there is a notorious effort in a way to create methods, techniques and tools that help analysts to understand and reduce human failures when performing an activity. For obvious reasons the nuclear industry has been all over the years the motor for investigating and developing new models. Some of these models can be applied in other fields of industry, being possible to incorporate this new paradigm into traditional analysis. It was

briefly presented a set of methods, techniques and tools and their main characteristics showing a variety of concepts and concerns around the human reliability. Whatever the method used for determining HEP, the most important is to assure that human failures are effectively considered in any HRA and PSAs.

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MEASURING THE EFFICIENCY OF AN INDUSTRIAL CONDITION MONITORING SERVICE

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Abstract. *The mode how industrial physical assets are maintained is very important to assure high equipment availability. It is important to find a metric or a key indicator that will point out the effectiveness of such function. Once condition based maintenance is widely assumed to be one of the most important maintenance strategies, it is fundamental to observe how assets are being monitored. The purpose of this paper is to observe the performance of the condition monitoring service within all maintenance activities. With this goal it is possible to determine the efficiency of this service and identify the gaps regarding the maximum achievable efficiency. The methodology or approach used called Overall Service Efficiency (OSE) refers to the Organization of the condition monitoring service, the Competencies and abilities of human resources affected to the service and the Interface between condition monitoring and other services inside the organization.*

Key words: *Condition monitoring, Efficiency, Gap, Maintenance.*

1. INTRODUCTION

It is very important for the top management of a company or a department to know how their industrial physical assets are maintained. It is fundamental to have a metric or some information or value to better understand the performance of maintenance function regarding the overall objectives. The objective of this paper is to observe the performance of the condition monitoring service within all maintenance activities, once it is very common in the industrial field, gaining a huge importance in the last two decades. It is possible to determine the efficiency level of this service and identify the gaps regarding the maximum achievable efficiency.

The paper is structured into six sections. Section 2 defines condition monitoring under the scope of condition-based maintenance (CBM), refers its importance and points out recent developments in the area. Section 3 refers to audit processes and in particular on the maintenance field. Section 3 presents a proposal for an innovative methodology directed towards condition monitoring service audit. In Section 4 a demonstrative example of the methodology based on a real case study is presented and in Section 5 some conclusions are stated.

2. CONDITION MONITORING

Maintenance plays a key role in industry competitiveness. Maintenance activities such as in military equipment, transportation, manufacturing systems, electric power generation, transmission, and distribution often incur high costs and thus demand high service quality [10].

Maintenance involves preventive and corrective actions carried out to retain a system in or restore it to an operating condition. In accordance to BS EN

13306 [3] maintenance can be performed before or after a failure occurrence. The former corresponds to preventive maintenance and the later one to corrective maintenance. Preventive maintenance can be classified into two categories:

- Scheduled Maintenance (SM) (also known as time-based maintenance or hard time maintenance);
- Condition-based maintenance (CBM) (or predictive maintenance).

Condition-based maintenance has been proven effective in reducing unexpected failures with minimum operational costs. Therefore, the use of condition monitoring techniques and CBM has increased rapidly over recent years [5].

The heart of CBM is condition monitoring which, in principle, involves periodic or continuous (online) data acquisition, processing, analysis, interpretation and extracting useful information from it. The information helps to identify if the asset health has diverged from the normal. If so, then fault diagnosis and prognosis often follow. Finally, a decision regarding when and what maintenance tasks are to be performed, is taken [4]. Fig. 1 illustrates the CBM process, including the condition monitoring.

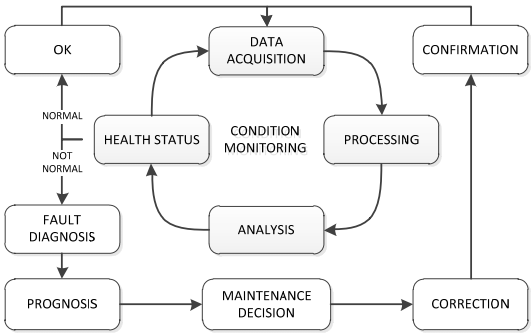

Figure 1 – Condition-based Maintenance process

Condition-based maintenance has been used in a large variety of applications. Regarding the published literature it is possible to observe the usage of CBM and reference to condition monitoring in several works [8] [13].

Concerning the energy sector it is also possible to find some works using condition monitoring techniques as for example for condition monitoring and fault diagnosis for hydropower plants [11] or wind farms [1] [12] [6].

Recently huge developments on the field of condition monitoring were achieved using information and communication technologies (ICT) with online and wireless techniques, providing reliable and continuous information with lower costs [4] [7] [14].

Condition monitoring refers to maintenance tasks performed on physical assets that includes collect data, process all the information gathered, perform a data analysis and decide the current asset status. This process must be reliable once a good or bad decision to perform subsequent maintenance activities could have a huge impact on safety, production or environment, with inherent costs and resource allocation.

3. AUDITING MAINTENANCE SERVICES

Maintenance quality in industry means to achieve the maximum availability of physical assets at minimum cost. This is somehow ambitious and ambiguous once we are facing contradictory objectives. One way to improve maintenance quality is to produce regular audits to this function or service.

The measurement of maintenance performance through audits can be observed in several papers on the area [9] [2]. Usually an audit process is based on inquiries, interviews and data analysis (when available). Condition monitoring service is one of the most audited services due to its importance inside a common maintenance department. Usually it uses high technological equipment that requires high investment on hardware, software and human competencies. Thus, it is important to be efficient in all activities performed under the scope of condition monitoring.

4. PROPOSED METHODOLOGY

Following the previous explanations and theoretical approaches concerning maintenance services and auditing, it is presented in the following paragraphs a methodology to evaluate the efficiency of the condition monitoring service in an organization.

The main objective of the implementation of such methodology is to determine the efficiency of the condition monitoring service comparing the actual situation of the service with one considered as ideal, and thus performing a gap analysis between these two situations. Fig. 2 shows a schematic representation of the proposed methodology, explained in the following paragraphs.

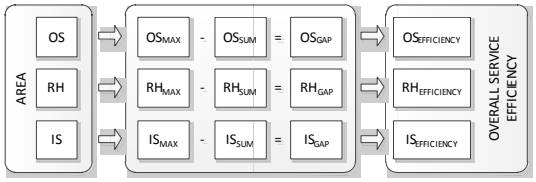

Figure 2 – Methodology proposed

The method analyses three main areas: the Organization of the condition monitoring Service (OS), the Human Resources affected to condition monitoring service (RH) and the Interface between condition monitoring service and other Services (IS). These three main areas resume most of the aspects related to a condition monitoring service once they cover fundamental issues that could have impact on the efficiency of the referred service. Each question of the inquiry has four possible answers and a fifth alternative if the question is not applicable. For each answer there is a specific punctuation in accordance to the matrix represented in Table 1.

Table 1 – Classification of the answers

Punctuation	Answers
3	Highly positive
2	Acceptable, but with recommendations
1	Not favourable, needing changes
0	Highly negative, unacceptable

Each question will be weighted in accordance to its level of importance for the condition monitoring service. In this way they will be evaluated in one of the four levels presented in Table 2.

Table 2 – Classification of question importance

Punctuation	Answers
1	Very Low
2	Low
3	High
4	Very High

Then, the efficiency value of each area under analysis will be determined considering the value achieved and the gap to the maximum possible punctuation. For example, the efficiency of RH is given by:

$$RH_{EFF} = \frac{RH_{SUM}}{RH_{MAX}} \quad (1)$$

Where the maximum punctuation is given by:

$$RH_{MAX} = \sum_{i=1}^{n} (RH)_{max}.(Wp)_i \quad (2)$$

And the punctuation achieved by the answers given by:

$$RH_{SUM} = \sum_{i=1}^{n} (RH)_i.(Wp)_i \quad (3)$$

The last step of the methodology refers to the determination of the Overall Service Efficiency (OSE) taking into account the punctuation of each area under analysis and the weight allocated to them in accordance to the following expression:

$$OSE = \frac{3.RH_{EFF}+2.OS_{EFF}+IS_{EFF}}{6} \quad (4)$$

Now, it is possible to make a qualitative evaluation of the condition monitoring service based on the achieved OSE and on the following criteria:

- OSE<40% - Highly Negative
- 40%<OSE<60% - Acceptable, with recommend.
- 60%<OSE<75% - Good
- 75%<OSE<90% - Very Good
- OSE>90% - Excellent (world class)

Based on the qualitative evaluation and on the gap analysis of each area it is time to establish a strategic plan. This plan is performed trying to fill up the identified gaps.

5. DEMONSTRATIVE EXAMPLE

The demonstrative example presented in this section is based on a real auditing process made to the condition monitoring service in a huge petrochemical installation. In this particular aspect this service plays an important role inside the maintenance department once more than 3000 assets are under condition monitoring.

Based on the weight of the person answering to enquiry and on the weight of the question for the condition monitoring service the efficiency value in each area was determined. The gap between these values and the maximum possible ones can be observed in Fig. 3.

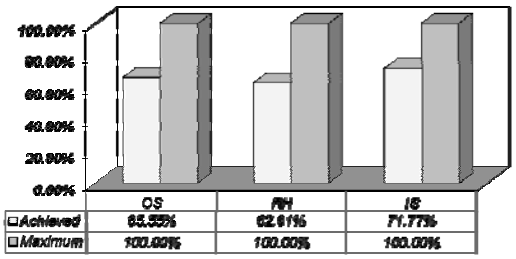

Figure 3 – Gap analysis

In a first sight it is possible to observe that RH is the weakest area with 62.61% of efficiency, followed by

the OS with an efficiency of 65.55%. The higher value of efficiency is achieved in the IS area with 71.77% of efficiency. Based on these values it is time to determine the Overall Service Efficiency (OSE), as stated on the proposed methodology in section 4. Applying the weight on each area a value of 65.12% was determined for the OSE.

According to the qualitative scale for OSE it can be said that we have a "*Good Condition Monitoring Service*" in this facility. Although this positive result it is clear that condition monitoring service is far from a "Very Good" or "Excellent" qualification. Making a deeper analysis at the identified gaps and on the consistency of the answers it is possible to point out some actions or recommendations in a way to improve the referred service. Based on a preliminary analysis of the final report it was established a calendar to implement the top priority recommendations and responsibilities were defined for each activity.

6. CONCLUSIONS

In the present work it was proposed a new methodology to determine the Overall Service Efficiency (OSE). To achieve the value of the OSE there are three main areas under observation: the organization of the condition monitoring service (OS), the human resources affected to condition monitoring service (RH) and the interface between condition monitoring service and other services within the organization (IS). It was presented a real case study where the referred methodology was applied with results.

The originality of the work developed is centred on an innovative methodology that can be easily applied in a huge number of industrial fields, although its simplicity.

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ANALYSIS AND CRITICAL ASSESMENT OF MARKS AND SPENSER FAILRUE IN CHINA

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Abstract. *The distinctiveness of the Chinese culture and market has for many years proven as resilient to Western business models. The British food and clothes chain Marks and Spencer has specifically shown what happens when the rules of international marketing are being ignored. This paper will examine the reasons for the failure of the British retailer on Chinese mainland and offer suggestions for future improvement. The paper will offer analyses varying from the mode of entry chosen, to the STP model regarding segmentation, targeting and positioning of the brand. Finally, suggestions will be provided that will help in further improvement and making of strategic decisions.*

Key words: *Marks and Spencer, British retailer, Chinese mainland, failure, international marketing..*

1.INTRODUCTION

The primary aim of this paper is to critically examine the ways in which the British retailer Marks & Spencer has failed to adapt to local needs and demands and therefore flunk to capture the Chinese consumers attention. China represents the fastest-growing market with $10 trillion and rapidly growing at 7 percent annually and is one for the key markets companies consider when expanding internationally. (McKinsey & Company,2018). Understanding the complexity of uniqueness of the Chinese culture and the dynamics of the market is vitally important for foreign companies. These are amongst the most important elements for reaching success in the Chinese market (McKinsey &Company, 2018). Over the past decade, there has been a number of different Western companies from various industries that have failed to succeed on the Chinese market (Chung, 2011). Marks & Spencer entered the Chinese market by opening wholly-owned stores in Hong Kong, Shanghai and slowly expanded its presence in Beijing and Guangzhou.
After a decade of struggles, finally, the British retailer officially exited China.

2. IDENTIFICATION OF THE PROBLEM

According to a research by Leelapanyalert and Gauri, the Chinese emerging middle class, spending power and size, represented 25–30% of the total number of customers the company has.

This paper will investigate the factors that determined the failure of the British retailer and propose solutions for re-entering the Chinese market. Specifically, the following issues will be addressed: absence of proper market research, failure to understand the culture and local preferences, underestimating the power of the industry rivals and lack of clear segmentation, targeting and positioning.

The issues investigated are news that have been published worldwide by numerous newspapers, journal articles and social networks, and represent a major disrupt of the future strategy of Marks and Spencer.

3. ANALYSIS IF THE BUSINESS PROBLEM

The first set of analyses will be regarding Marks and Spencer's international marketing strategy. According to the Uppsala model, they export their goods to foreign countries, however they do not adapt the products according to the needs of the foreign market.
The key strategic choice companies need to take when operating internationally is either standardization or adaptation of their products. Research has shown that Marks and Spencer uses

the standardization approach, not considering the regional differences. The company states that "our clothing products are the same in London, Madrid or Hong Kong" (Financial Times, 1994).

The second set of analyses is concerning the lack primary data marketing research (Leelapanyalert et al. 2015). The market strategy is mostly based on secondary research and regular visits, while implementing a global strategy without proper adaptation to the local market needs and demands. The product development and supply chain are highly centralized in the United Kingdom. (Whitehead, 1994)

Furthermore, Marks and Spencer lacked clear positioning and brand image. The clothes offered were neither traditional, business wear neither street fashion style which is popular amongst young Chinese consumers. (Financial Times, 2017). Considering that the Chinese youth tends to be fashion oriented, always experimenting with their style and preferences.

4. DID MARKS AND SPENSER CHOOSE THE RIGHT ENTRY MODE FOR CHINESE MARKET

Marks and Spencer international operations are usually through wholly owned stores, franchising or joint venture (Marks and Spencer, 2016). The entry to Hong Kong was followed by launching wholly-owned stores (Jackson & Sparks,2005) and then proceeded to compete on the Chinese mainland market via wholly owned stores in various locations. (Vrontis & Vronti 2000)

After years of poor performance, the company has decided to close five stores in the greater Shanghai region, followed by gradually closing a large number of wholly-owned stores from different locations. Instead, the retailer has decided to sell the merchandise through third party e-commerce platforms such as TMall.com and JD.com.

According to a 2017 report from Mintel, Marks and Spencer has announced to close its owned store property and will instead focus the efforts on joint venture and franchise partnerships in China. (Mintel, 2017). Closure relates to the low profitability, but the company has decided to trade with a reduced intensity of distribution or via resellers. (Burt et al. 2003)

Eventually, Marks and Spencer has confirmed that Al-Futtaim will become the new sole franchise owner for the stores in Hong Kong. (Marks and Spencer,2018)

5. HAS MARK AND SPENSER SLEPT WHEN CONDUSTING THEIR SLEPTS ANALYSIS

A thorough analysis of the environment is at the heart of understanding a certain marketplace. In recent years, there has been an increasing interest in developing a SLEPT analysis prior to entering a foreign market. The acronym SLEPT stands for social, legal, economic, political and technological factors, that might influence the company's operations.

When it comes to Marks and Spencer, and the Chinese marketplace, it can be noticed that they have failed to conduct a proper scanning of the market they entered to.

Social and cultural attributes include "language, religion, aesthetics, values, social organizations, etc." (Schlegelmilch, p.23,2016) As the demographics are constantly changing, the Chinese social factor is of crucial importance for companies who want to reach success. According to Geert Hofstede value dimensions, China is considered to be a collectivist culture (Hofstede Insights, 2018).

Of particular concern is Marks and Spencer's improper market research. The lack of market research and misinterpretation of the market's needs and demands, have led to disregarding the local customs and style preferences. They have proved as unable to keep track with the changing demand of the fashion in China. and most important of all, they have failed in understanding and targeting Chinese consumers. By offering clothes in sizes that didn't fit the local body shapes M&S has encountered "shortages of the smaller-sized clothes demanded by mainland consumers have depressed trade." (Financial Times, 2009). Additionally, they have showed culturally insensitive merchandise by having labels in British and European sizes. According to an article by Jiangsu Commercial Daily the sizes of the clothing was classified "by European metrics – 6, 8,10,12, not 'small,' 'medium, 'large' – which is what Chinese shoppers are familiar with".

In a recent article published by McKinsey and Company argues that the Chinese consumers have been embracing new products, services and retail experience at rates unseen in developed markets. For example, the mobile payment penetration went from 0% in 2011 to 25% of the population in 2015.

Additionally, the e-commerce sector has been rapidly growing with having more than 35% of the population in Greater Shanghai area to have purchased apparel online in the past six months. (McKinsey & Company, 2018)

The legal framework still in its early stage, as the country is going through a rapid development. For international companies that would to pursue business in China, there is a catalogue guidance issued by PRC National Development and Reform Commission (NDRC) and MOFCOM which indicates the type of licenses needed to operate in China. A separate guidance is available for companies that want to pursue a joint venture with a Chinese company.

Over the past five years, China's economy experienced significant GDP growth rate. Any

economic development could have a major impact on the international enterprises and their actions. China's GDP rate suggests that each citizen is increasingly adding more values to the society.
The political factors such as governmental regulations represent the biggest risk for international companies. Since 2001, the Chinese market has been open to foreign MNE due to China's entry in the WTO which removed trade barriers for foreign investors. This has encouraged foreign companies to invest and settle their operations in the Chinese mainland. Additionally, the government has been increasingly paying attention to further development of the e-commerce.
China has an advanced and innovative technological infrastructure and the government is increasingly investing in high-tech development. This contributes to retailers in the ways in which they can communicate with their target audience as well as provides to opportunity to include high-tech inside their stores.
The last element of the SLEPTS analysis is the sustainability. China's fast development has cause a lot of negative environmental issues. That is the reason the government is now paying increased attention to preserving the environment. Therefore, companies who operate on Chinese mainland should cooperate and include corporate social responsibility in their core strategy in order to have a successful integration in the Chinese market.

6. SEGMENTATION TARGETING POSITIONING – WHAT WENT WRONG?

The Chinese retail sector is being engaged by fierce competition, as well as the places of contact with the consumers has seen a great increase in the past decade which is one of the main causes for a powerful battle between retailers for market share. Proper segmentation, targeting and positioning are now more important than ever for marketing professionals in order to identify opportunities for growth.
With a middle class of more than half a billion people, the Chinese retail market is the largest in the world, valued at $4.886 trillion in 2016. eMarketer estimates to surpass $7 billion by 2020.
The behavioral segmentation proposes that Chinese consumers are prone to buying good quality products by reasonable prices. The purchase occasion is most likely to be for either special occasions to casual wear. The Chinese youth is more likely to experiment with their style and clothing design. This is where Marks and Spencer slipped in China, as they couldn't adapt fast enough to the changes in the fashion world and the style preferences of the local consumers.
The psychographic segmentation of Marks and Spencer's consumers are middle aged women, educated, with a dynamic lifestyle. They have failed to target the younger age groups which have high purchasing power.
The demographic segmentation of the consumers is 35-54 years of age. Their customers are family-oriented with active lifestyle.
Geographically, Marks and Spencer didn't have a clear segmentation, as they were present in different cities across the Chinese mainland.
Marks and Spencer adopted a "global segments as target markets", targeting middle aged women from different countries, conversely targeting younger generations.
They pursued a mixture of undifferentiated and differentiated targeting rather than a concentrated targeting approach. Middle aged women were seen as the prime revenue generator however they tried to target young individuals, both male and female.
The evidences provided have shown that Marks and Spencer didn't have a clear positioning in the Chinese mainland. The company was seen stuck in the middle of the spectrum between retailers such as H&M and Zara, and high-end retailers such as Prada, Balenciaga etc.

7. PROPOSAL OF SOLUTION FOR RE-ENTRY TO CHINESE MARKET

The data presented throughout this paper illustrates the need for Marks and Spencer to change their core marketing strategy and adapt it to the market they wish to target.
The past decade has seen the rapid development of the international marketplace in many ways. The inability of Marks and Spencer to adapt to these new developments, has been the main reason for their continuous struggle.
In order to recover their brand loyalty on the Chinese market, I would recommend that they try to capture the diversity of the wealthy Chinese consumers. Young Chinese have high purchasing power. Chinese youth has shifted to prioritizing luxury products and living a more balanced, healthy and family-centric life (McKinsey&Company, 2018). The changing shape of Chinese consumption and their spending powers are decisive in determining the companies that win or lose on Chinese mainland. The middle-class and affluent consumer households will continue to expand and is expected to reach 140 million in 2020 (Deloitte,2012). Providing a wider product offerings range as well as following the fast-seasonal pace of the fashion.
Connecting with customers through social networking: 75% of potential consumers are living outside the top 15 cities in China. (McKinsey&Company, 2016) Staying in touch with their customers virtually will help the company better understand the needs and wants of customers as well as increase their shopping experience by offering online shopping and shipping to many big

and smaller cities in China, as the population is highly dispersed across the country.

Further, I would recommend that the company should choose to localize with a partner. This will help the company to know the market directly which will help the company to optimize their expertise, as well as gain insight of the local authorities, business practices, retail market regulations, consumer laws, understand cultural differences etc. (Global times, 2014)

The final recommendation would be that beside using TMall.com and JD.com for selling their clothes, Marks and Spencer should offer online shopping and shipping directly from their website.

8. CONCLUSIONS

This paper has discussed the reasons for the failure of Marks and Spencer in China. Using a critical analysis and assessment of the reasons behind the unsuccessful exit from this market.

Taken together, the results indicate that prior to entering a foreign market, and especially a market as unique and complex as China, companies should conduct a thorough analysis of the environment in terms of social, technological, political, legal and environmental opportunities and risks.

Additionally, a study regarding the consumer segmentation and proper targeting will help companies to deliver a clear positioning. Perhaps, the most important consideration of all, is that companies learn how communicate their core value well with the consumers whether they are from the domestic or international marketplace.

Assumed the growth of the Chinese market both economically and demographically, there is still a chance for Marks and Spencer to achieve success and win over market share, however this would require essential changes in their organizational structure and overall strategy.

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ANALYSIS OF DIFFERENCES IN ANTHROPOMETRIC MEASUREMENTS BETWEEN PASSENGER CAR DRIVERS AND CRANE OPERATORS - PART 1: LIBYAN MALES DATA

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Abstract: *This paper is a part of ongoing research on ergonomic characteristics, specifically anthropometric measurements, for passenger car drivers and crane operators, in order to achieve better working conditions and improve safety. It represents one of the rare explorations containing the Libyan male drivers and crane operators data, and accordingly it is one of the first serious researches on Libyan population. In this paper anthropometric measurements and weight data have been compared between different occupations in Libya - male drivers and crane operators. Statistical analysis on 300 male drivers and 50 crane operators collected data are resulting with conclusion that male drivers have slightly higher value of weight, are taller, and have higher sitting height as well as upper leg length values, while crane operators have slightly wider shoulders and hips. Both groups have the same arm and foot lengths.*

Key Words: *Libyan male drivers, Libyan crane operators, anthropometric measurements, weight, comparison*

1. INTRODUCTION

Ergonomic adaptation results in better users` accommodation and their better performances when executing certain tasks. Therefore, anthropometric measurements, together with ergonomic principles are essential and required to achieve effective ergonomic adoption of the workplace.

Anthropometric measurements for Libyan population, up to date is till today rarely considered [1], [2], [3] and it is concentrated only on drivers [4]. In most cases crane operators are considered only from economic aspect, as side part of the other research [5], or from aspects of migration and wider research on workforce in Asian region [6].

This paper presents one of the first seriously conducted researches concerning Libyan male passenger car drivers and crane operators, comparing their anthropometric characteristics and statistically testing their similarities and differences, together with our surveys given in [4], [7].

One of the purposes of the research is to emphases significance of the anthropometric measurements examination for crane operators in order to enable initial framework for design of the safe and comfortable work space [7], [8], which is one of the major problems since they remain in the cabins all work day - 6 to 8 hours [9], [10], [11]. Also work in crane cabin, especially in extreme climate conditions is difficult, while cabin and seat design is comfortable only for 18.5% operators [8]. Those data still should to be confirmed for Libyan crane operators [7]. Also, passenger vehicle interior if ergonomically adapted enhances traffic safety. In previous research [12] difference has been found in preferred driving posture between two different nationalities - Koreans and Caucasian. Such differences justify the need for continual evaluation of interior vehicle space design and modeling.

2. DATA ANALYSIS

In order to compare anthropometric measurements characteristics of the Libyan male drivers and crane operators data for samples of 300 male drivers and 50 crane operators were randomly gathered. All crane operators are male, thus the comparison. Anthropometric measures include standing height - *STH*, sitting height - *SIH*, lower leg length - *LLL*, upper leg length - *ULL*, shoulder width *SHW*, hip breadth - *HIB*, arm length - *ARL* and foot length - *FOL*. Also weight - *WEI* of all subject were measured. For those data basic statistic and their comparison for subjected groups were conducted and shown is this paper.

Statistical data analysis includes:

- Descriptive statistic and
- Hypothesis testing of difference between anthropometric measurements.

2.1. Descriptive statistics for variables measured for Libyan male drivers and crane operators

In the first step of the research, descriptive statistics were conducted. It includes number of subjects, mean, median, standard deviation, coefficient of variation, Kolmogorov test for normality significance for normal distribution and type of variable of measurement subjects and their anthropometric measurements. Calculated data for Libyan male drivers are presented at Tab. 1, while for crane operators data are shown at Tab. 2.

Table 1. *Descriptive statistics for Libyan male drivers*

Dimension	*N*	Mean	*Me*	*SD*	c_v(%)	*D*	*p*	*SIG.*	*VT*
WEI LMD	300	82.910	83.000	14.149	17.07	0.1907	1	*n.s.*	parameter
STH LMD	300	1749.517	1750.000	63.104	3.61	0.1871	1	*n.s.*	parameter
SIH LMD	300	855.483	860.000	43.493	5.08	0.1919	1	*n.s.*	parameter
LLL LMD	300	543.050	540.000	34.425	6.34	0.1516	1	*n.s.*	parameter
ULL LMD	300	582.767	580.000	37.166	6.38	0.2407	1	*n.s.*	parameter
SHW LMD	300	471.350	470.000	45.440	9.64	0.1661	1	*n.s.*	parameter
HIB LMD	300	365.620	360.000	59.192	16.19	0.2018	1	*n.s.*	parameter
ARL LMD	300	633.053	610.000	72.291	11.42	0.2220	1	*n.s.*	parameter
FOL LMD	300	275.833	275.000	9.115	3.30	0.2126	1	*n.s.*	parameter

Table 2 *Descriptive statistics for Libyan crane operators*

Dimension	*N*	Mean	*Me*	*SD*	c_v(%)	*D*	*p*	*SIG.*	*VT*
WEI LCO	50	78.70	80	10.428	13.25	0.2799	1	*n.s.*	parameter
STH LCO	50	1701.40	1700	58.554	3.44	0.3050	1	*n.s.*	parameter
SIH LCO	50	829.40	840	47.827	5.77	0.1812	1	*n.s.*	parameter
LLL LCO	50	534.60	530	36.545	6.84	0.2222	1	*n.s.*	parameter
ULL LCO	50	559.00	560	32.779	5.86	0.1908	1	*n.s.*	parameter
SHW LCO	50	489.00	470	53.918	11.03	0.1590	1	*n.s.*	parameter
HIB LCO	50	382.00	370	49.652	13.00	0.2375	1	*n.s.*	parameter
ARL LCO	50	642.40	650	82.054	12.77	0.1565	1	*n.s.*	parameter
FOL LCO	50	273.70	270	9.248	3.38	0.1901	1	*n.s.*	parameter

First criteria for determination of type of data is coefficient of variation, that shows that data for all groups (Tab. 1 and Tab. 2 are homogeneous. Further more differences between mean and median are small, which indicate that distribution of data is symmetrical. In next step Kolmogorov test for normality were conducted. Results of this test show that all data for all measurements are normally distributed, meaning that variables are parametric, thus adequate statistic comparisons could be conducted.

2.2. Comparisons of anthropometric measurements between Libyan male drivers and crane operators

From descriptive statistics, based on conclusion that all variables are parameters type, further decision on comparisons were drawn, i.e. it enables use of *z* test for comparisons for difference of means Conclusions from this comparisons are based on the following criteria, with adequate annotations [13]:

If $p>0.05$ no significant difference (*n.s.*)
If $p<0.05$ low difference (>)
If $p<0.01$ strong difference (>>)
If $p<0.001$ absolute difference (>>>)

Table 3. *Comparisons of anthropometric measurements between Libyan male drivers and crane operators*

	z	*p*-value	*significance*
WEI LMD > WEI LCO	2.497	0.0125	<0.05
STH LMD >>> STH LCO	5.319	0	<0.001
SIH LMD >>> SIH LCO	3.615	0.0003	<0.001
LLL LMD = LLL LCO	1.526	0.127	*n.s.*
ULL LMD >>> ULL LCO	4.653	0	<0.001
SHW LMD < SHW LCO	-2.189	0.0286	<0.05
HIB LMD < HIB LCO	-2.097	0.0359	<0.05
ARL LMD = ARL LCO	-0.758	0.4485	*n.s.*
FOL LMD = FOL LCO	1.513	0.1303	*n.s.*

Detailed comparisons were further presented at Fig. 1-4.

Fig. 1 presents difference in weight between measured groups, since it has different units than anthropometric measurements. Although test shows (Tab. 3) that there is slight statistical difference, graph results show that Libyan male drivers are 5.53% heavier than crane operators.

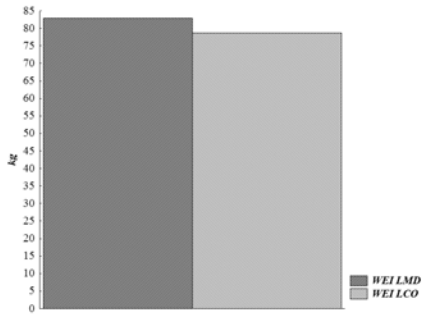

Figure 1. *Differences in WEI between Libyan male drivers and crane operators*

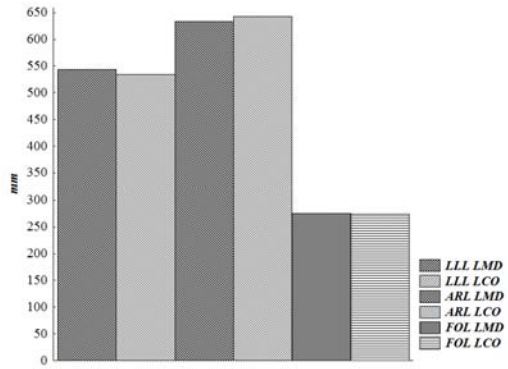

Figure 2. *Anthropometric measurements with same values for Libyan male drivers and crane operators*

Fig. 2, as well as tests from Tab. 3 shows that there no statistically significant differences between lower leg lengths, arm lengths an foot lengths between Libyan male drivers and crane operators. Differences in mean values vary between 0.78% and 1.53%.

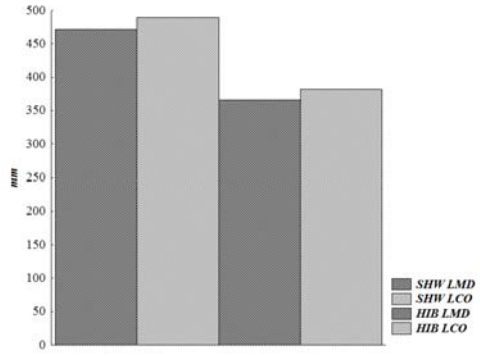

Figure 3. *Anthropometric measurements which are larger for Libyan crane operators than male drivers*

Tab. 3 and Fig. 3 shows that there exists small statistical difference between shoulder width and hip breadth in favor of crane operators, where difference of means for shoulder width is 3.61% larger for crane operators, while hip breadth is 4.29% larger for crane operators then for male drivers.

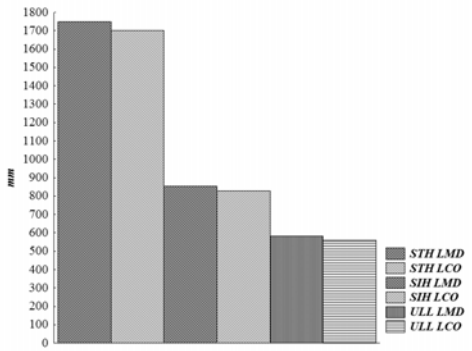

Figure 4. *Anthropometric measurements for Libyans, where male drivers have larger values then crane operators*

The rest of the anthropometric measurements are statistically absolutely larger for male drivers comparing to crane operators (Tab. 3, Fig. 4). Standing height is 2.83% larger, sitting height is 3.14% higher, while upper leg length is 4.25% longer for Libyan male drivers than for crane operators.

3. CONCLUSIONS

Comparison between Libyan male passenger car drivers and crane operators leads to the following conclusions:

- drivers are slightly heavier then crane operators;
- drivers have significantly heigher standing and sitting sitting hight, as well as upper leg length than crane operators;
- shoulder width and hip breath are slighter smaller for male drivers and
- drivers and crane operators have the same arm length and foot length (there are no statistically significant differences).

This paper is only one of the first steps in studies on anthropometric measurements for insufficiently examined data for Libyan drivers and crane operators. Those presented data should be further research on larger sample.

4. NOMENCLATURE

Abbreviation	Definition	unit
WEI	Weight	kg
STH	standing height	mm
SIH	sitting height	mm
LLL	lower leg length	mm
ULL	upper leg length	mm
SHW	shoulder width	mm
HIB	hip breadth	mm
ARL	arm length	mm
LMD	Libyan male drivers	
LCO	Libyan crane operators	
N	sample size	
Med.	Median	
SD	standard deviation	
D	Kolmogorov statistics	
p	*p*-value	

SIG.	Significance
n.s.	not significant
VT	variable type
z	*z* test for difference of means

5. ACKNOWLEDGEMENTS The work is supported by grant TR35017 – MESTD.

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ANALYSIS OF DIFFERENCES IN ANTHROPOMETRIC MEASUREMENTS BETWEEN PASSENGER CAR DRIVERS AND CRANE OPERATORS - PART 2: SERBIAN MALES DATA

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Abstract: *This paper presents a part of several active researches of anthropometric measurements – long-term investigation of Serbian passenger car drivers, Serbian crane operators, that started in recent years, as well as comparison of those measurements with Libyan drivers and crane operators. In this paper, similar to part 1, comparison of anthropometric measurements was presented, but in this case instead of Libyan measurements (given in part 1) for Serbian male drivers and crane operators. Collected data were statistically examined and compared resulting with the same weights, sitting heights, lower leg lengths, shoulder widths, hip breadths and arm lengths. Research included samples of 921 Serbian male drivers and 83 crane operators. Serbian drivers compared with crane operators have significantly larger standing height and upper leg length values, while foot length is significantly smaller for drivers than for crane operators.*

Key Words: *Serbian male drivers, Serbian crane operators, anthropometric measurements, weight, comparison*

1. INTRODUCTION

Anthropometric measurements differ between nationalities, gender, age, race, occupation and nutrition [1], [2], [3]. They also change over time, thus there is a constant need for their updating in order to achieve comfortable and safe vehicles or cabins interior design [2], [4], [5], [6], [7]. The work place design depends on anthropometric characteristics of users, and nationalities have significant effect on workplace design and modeling due to the differences in anthropometric characteristics [5].

Crane cabins have their use in the wide industrial spectrum [8], [9],[10], [11], [12], but crane operators still have one of the most hazardous jobs with high values of occupational fatalities and injuries [13] and with great losses of life and property [14].

Adding to that an occupational diseases for crane operators due to long operating hours - 6 to 8, in uncomfortable static sitting conditions, and mostly located highly above ground [15], [16], [17], [18], [19]. Thus understanding and implementing anthropometric measurements is one of the goals for improvement safety and contentment in working conditions for crane operators via alternate crane cabin designs [20], [21], [22].

In Serbia research of the impact of the ergonomics on the crane cabin design, and influence of the anthropometric measurements of crane operators started in recent years via participation in several EU financed projects, with main goal to improve ergonomic characteristics of crane cabins in order to increase crane operators safety and improve of their working conditions [7], [8], [9], [22], [23], [24], [25].

Similarly, driving can cause large number of musculoskeletal disorders while almost all drivers feel repetitive driving injuries [2], [3], [4], [5], [6], [7]. Previous research, such as [1], [2], [3], [4], [5], [6], [7], also show that further studies are needed since the field of interior space of a passenger car that till today still is not adapted enough for a human being.

2. DATA ANALYSIS

Second part of analysis of differences between passenger car drivers and crane operators include Serbian drivers` data. Since all examined crane operators were male, their anthropometric measurements and weights are compared with Serbian male drivers. Research included samples of 921 Serbian male drivers and 83 crane operators.

As in Part 1 anthropometric measures include standing height - *STH*, sitting height - *SIH*, lower leg length - *LLL*, upper leg length - *ULL*, shoulder width *SHW*, hip breadth - *HIB*, arm length - *ARL* and foot length - *FOL*, as well as weight of the subjects. This paper includes descriptive statistic of the subjects

groups and their comparison using hypothesis testing.

2.1. Descriptive statistics

First step includes basic descriptive statistics such are number of subjects, mean, median, standard deviation and coefficient of variation for Serbian male drivers (Tab. 1) and Serbian crane operators (Tab. 2).

Table 1. *Descriptive statistics for Serbian male drivers*

Dimension	*N*	*Mean*	*Med.*	*SD*	c_v(%)	*D*	*p*	*SIG.*	*VT*
WEI	921	86.617	86	11.693	13.70	0.1498	1	*n.s.*	parameter
STH	921	1811.26	1800	74.657	3.86	0.1668	1	*n.s.*	parameter
SIH	921	917.218	920	47.064	6.25	0.1551	1	*n.s.*	parameter
LLL	921	593.613	600	35.754	6.84	0.1615	1	*n.s.*	parameter
ULL	921	636.228	635	45.544	5.88	0.204	1	*n.s.*	parameter
SHW	921	471.356	470	46.728	10.14	0.1535	1	*n.s.*	parameter
HIB	921	391.097	390	43.749	14.61	0.2434	1	*n.s.*	parameter
ARL	921	706.488	700	46.213	7.22	0.1882	1	*n.s.*	parameter
FOL	921	281.612	275	12.577	4.21	0.1765	1	*n.s.*	parameter

Table 2. *Descriptive statistics for Serbian crane operators*

Dimension	*N*	Mean	*Me*	*SD*	c_v(%)	*D*	*p*	Significance	VT
WEI	83	84.916	82	11.636	13.70	0.2862	1	n.s.	parameter
STH	83	1768.193	1765	68.210	3.86	0.2694	1	n.s.	parameter
SIH	83	907.313	910	56.749	6.25	0.2134	1	n.s.	parameter
LLL	83	587.169	585	40.176	6.84	0.2441	1	n.s.	parameter
ULL	83	618.229	615	36.350	5.88	0.1894	1	n.s.	parameter
SHW	83	478.349	480	48.520	10.14	0.2718	1	n.s.	parameter
HIB	83	401.313	395	58.629	14.61	0.2785	1	n.s.	parameter
ARL	83	704.554	700	50.892	7.22	0.1843	1	n.s.	parameter
FOL	83	297.422	296	12.524	4.21	0.3668	1	n.s.	parameter

According to descriptive statistics for all measurements, it can be seen that values of mean are near values of median, indicating symmetrical distributions. Also coefficients of variation are small (<30%) - therefore data are homogeneous. This enables conduction of Kolmogorov tests for normality which proved that variables are parametric.

2.2. Comparisons of anthropometric measurements between Serbian male drivers and crane operators

Results of Kolmogorov test for normality, i.e. parametric variables enable conduction of z tests for difference of means (Tab. 3). Annotations for significance levels are [26]:

for $p>0.05$ no significant difference (*n.s.*)
for $p<0.05$ low difference (>)
for $p<0.01$ strong difference (>>)
for $p<0.001$ absolute difference (>>>)

Table 3. *Comparisons of anthropometric measurements between Serbian male drivers and crane operators*

	z	*p*-value	Significance
WEI SMD = WEI SCO	1.275	0.202	*n.s.*
STH SMD >>> STH SCO	5.465	0	<0.001
SIH SMD = SIH SCO	1.543	0.1228	*n.s.*
LLL SMD = LLL SCO	1.412	0.1589	*n.s.*
ULL SMD >>> ULL SCO	4.222	0	<0.001
SHW SMD = SHW SCO	-1.261	0.2072	*n.s.*
HIB SMD = HIB SCO	-1.549	0.1214	*n.s.*
ARL SMD = ARL SCO	0.334	0.738	*n.s.*
FOL SMD <<< FOL SCO	-11.011	0	<0.001

Visual comparisons and their relations are presented at Fig. 1-4.

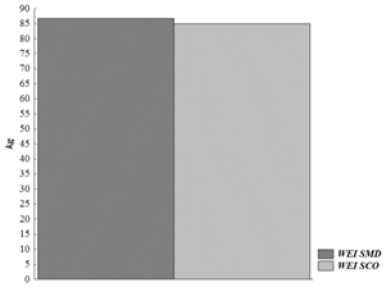

Figure 1. *Differences in weight between Serbian male drivers and crane operators*

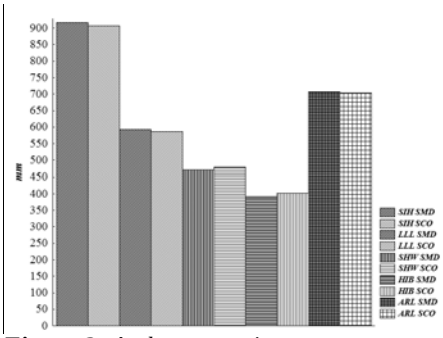

Figure 2. *Anthropometric measurements with same values for Serbian male drivers and crane operators*

Fig. 1 and 2 present measurements which are the same for Serbian male drivers and crane operators (Tab. 3). They shows that weight, sitting height, lower leg length, shoulder width, hip breadth and arm length have statistically same values with difference ranking from 0.29% for arm length to 2.54% for hip breath.

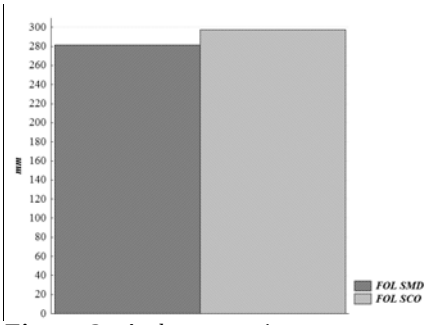

Figure 3. *Anthropometric measurements for foot length where Serbian crane operators have larger values than male drivers*

Only measure larger for Serbian crane operators then for drivers is the foot length, and it is statistically highly larger (Tab. 3, Fig. 3), with 5.32%.

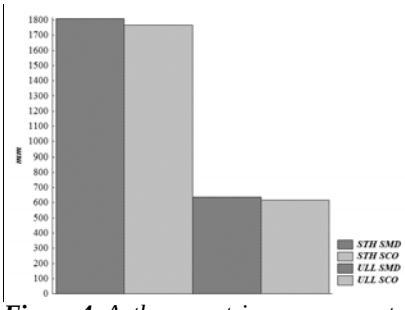

Figure 4. *Anthropometric measurements for Serbians, where male drivers have larger values then crane operators*

Two measures that are absolutely statistically higher for Serbian male drivers than for crane operators are standing height and upper leg length (Tab. 2, Fig. 4), with 2.44 and 2.91% respectfully.

3. CONCLUSIONS

From comparison between anthropometric measurements between Serbian male drivers and crane operators the following conclusions can be drawn:

- there no differences between weights, sitting heights, lower leg lengths, shoulders width, hip breadths and arm lengths between analyzed populations;
- standing height and upper leg length are significantly larger for passenger car drivers then for crane operators and
- foot length is significantly larger for crane operators then for passenger car drivers.

This paper is a part of several ongoing investigations on anthropometric measurements in Serbian population including passenger car drivers and crane operators with aim to improve design of vehicle and crane cabin interior.

4. NOMENCLATURE

Abbreviation	Definition	unit
WEI	Weight	kg
STH	standing height	mm
SIH	sitting height	mm
LLL	lower leg length	mm
ULL	upper leg length	mm
SHW	shoulder width	mm
HIB	hip breadth	mm
ARL	arm length	mm
SMD	Serbian male drivers	
SCO	Serbian crane operators	
N	sample size	
Med.	Median	
SD	standard deviation	
D	Kolmogorov statistics	
p	*p*-value	
SIG.	Significance	
n.s.	not significant	
VT	variable type	
z	z test for difference of means	

5. ACKNOWLEDGEMENTS

The work is supported by grant TR35017 – MESTD.

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THE IMPORTANCE OF ERGONOMIC PRINCIPLES IN DESIGN OF THE TRAFFIC SIGNS FOR CHILDREN

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Abstract. *Children represent a vulnerable population from the standpoint of traffic safety. A modern traffic poses complex and high requirements to all its participants, and among them, particularly to young children. Children have a higher risk of pedestrian injuries. Children experience traffic differently from adults. How do children view the world? What helps them to link with their environment? How do children imagine traffic signs? To address these questions, this study examines how fast the children (between 6 and 10 years of age) react to traffic signs mounted at different heights. The analysis of the results indicated that there were differences in mean reaction time for traffic signs of different heights. Children best perceive a traffic sign when it is mounted at 1.9 m. The research highlights the importance of ergonomic principles in choosing the appropriate height of traffic signs for children.*

Key words: *Ergonomic design, Traffic signs, Children.*

1.INTRODUCTION

In modern times, it's hard to imagine a world without traffic signs, and it's even more difficult to imagine the world before there was a need for them. They did not always exist because traffic was not like as it is nowadays. In one form or another, traffic signs have been in use since the time of the Roman Empire. Traffic signs provide important information, guidelines, and warnings on the road; they are designed and placed to assist drivers and pedestrians [6]. Despite their importance, they are not always understood correctly [7] and they are not perceived in the same way nor equally fast. Many studies have also shown that signs are often wrongly perceived by drivers and pedestrians [1, 6]. Some findings indicate that the comprehension level of some traffic signs is very low, and some are misinterpreted [6]. Ben-Bassat and Shinar (2006) tested if these differences in comprehension of signs could be explained by the signs' compliance with ergonomic design principles [3]. They found that signs that comply with three basic ergonomic principles – physical and conceptual compatibility, standardization, and familiarity – are generally better understood than signs that do not comply with these principles [6]. Symbols and colors on traffic signs significantly affected both the correctness of the answers and reaction time [8, 4]. Many studies have proposed various changes to the traffic signs [2, 9, 10, 11]. Besides, the speed of the response plays an important role in the perceptual judgments made by all participants in traffic situations and thus it is one of the critical components in the design of traffic signs of highways and streets. Age-related differences in the processing speed have been observed in a great variety of tasks involving visual search and response selection. In spite of the great number of researches in this area, these differences are still rarely reported although they are an indicator of the neural maturity of children's information processing system.

For the above reasons, the aim of this paper is to examine how children react to different heights of traffic signs.

2. METHODOLOGY

2.1. Participants and Experiment Procedure

Educational institutions from rural and urban environments providing state-funded preschool education programs were chosen as venues for this experiment. Of the total number of 60 respondents, 29 (48.3%) were females and 31 males (51.7%). In this study, simple RTs to presented targets - traffic signs (TS) of different heights were measured. Traffic signs were placed at 3 heights - 1.6m, 1.9m and 2.2m (2.2m is lawfully defined height of traffic signs in the populated place). For the sake of simplicity, these three TS heights will, in the rest of the manuscript be denoted as lower, middle and upper TS, respectively. The subjects (children aged between 6-10 years) were instructed to depress the response button immediately he/she recognized the stimulus - certain traffic sign, the response button terminated the clock counter. All subjects were tested under all three different conditions.

2.2. Data Analyses

Statistical analysis was performed using the statistical software package IBM SPSS Statistics v. 22. Normality distribution was tested by inspection of histograms and the Kolmogorov-Smirnov test. As the Kolmogorov-Smirnov test has determined that results do not significantly deviate from a normal distribution, the decision was to use Student's T-test and ANOVA. Dunnett's T3 Post Hoc test has been undertaken for additional comparisons. All tests were carried out on the basis of the recommendations from the textbook "SPSS Survival Manual" [5]. The threshold of statistical significance (α) is set at 5%.

3. RESULTS AND DISCUSSION

The rest of the paper presents the results of the children's reaction times for different heights of traffic signs.

The analysis of the results indicated that there were differences in mean reaction time for traffic signs of different heights (Figure 1). Generally, children showed the shortest reaction time for the Middle TS (0.259 s), then for the Lower TS (0.268), while the slowest reaction time was for the Upper TS (0.336). The series of performed paired Student's T-tests show statistically significant differences between RT for the lower TS and RT for the middle TS (t=7.291; p<0.001), RT for the lower TS and RT for the upper TS (t=6.681; p<0.001), as well as between RT for the upper TS and RT for the middle TS (t=2.068; p=0.043).

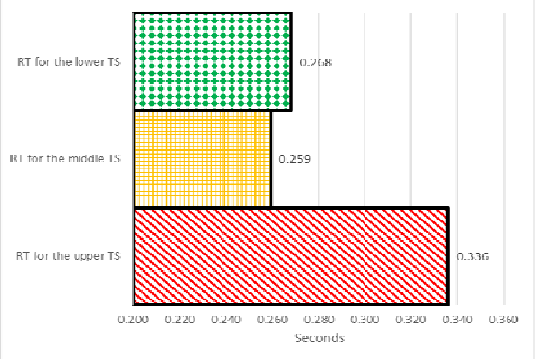

Figure 1. Mean reaction times for different heights of traffic signs

3.1. Age differences

One-way ANOVA indicated significant age group-related differences in RT. The results showed statistically significant differences between the first and fourth-grade children in RT for traffic signs of all three heights: for lower TS (F=9.969; p<0.001), for middle TS (F=9.978; p<0.001), as well as for upper TS (F=4.093; p=0.011). Figure 2 shows age differences in the mean values of reaction times for different heights of traffic signs.

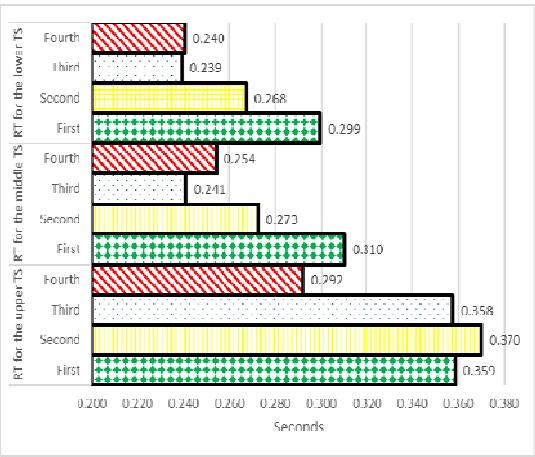

Figure 2. Age differences in mean reaction times for different heights of traffic signs.

3.2. Urban and Rural Areas

Reaction time data was also compared between urban and rural children. Figure 3 shows urban-rural differences in the mean values of the children's reaction times for different heights of traffic signs. The results of T-Test showed statistically significant

differences for the children's reaction time according to area: Lower TS (t = 9.762; p = 0.003), Middle TS (t = 8.187; p = 0.006) and Upper TS (t = 12.928; p = 0.001). Children from the urban area react faster than children from the rural area, for all three heights of the traffic signal.

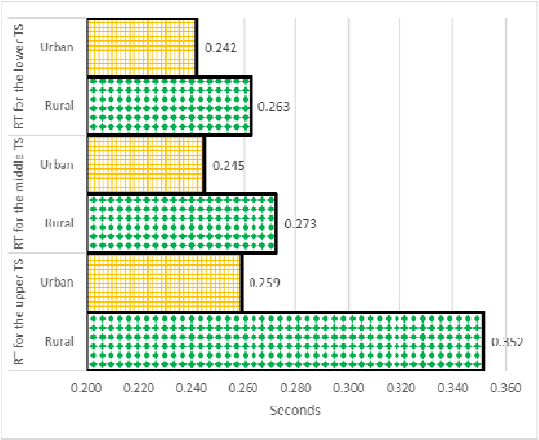

Figure 3. Urban-rural differences in mean reaction times for different heights of traffic signs.

4. CONCLUSIONS

Based on the data collected and analyzed in this research, some general conclusions can be derived:

- Children showed the shortest reaction time for TS mounted at 1.9 m (0.259 s), then for TS at the middle height (0.268), and the slowest reaction was for Upper TS (0.336);
- There are statistically significant age-related differences in children's RT for all three heights of the traffic signs;
- Children from the urban area react faster than children from the rural area, for all three heights of the traffic signs.

Taking into account the above mentioned, children best perceive a traffic sign when it is mounted at 1.9 m. Hence follows the conclusion and practical recommendation that, at least in school areas, traffic signs need to be placed at lower heights than defined by the rules (2.2 m). Ergonomic principles of design should be involved to improve traffic signs recognition and further behavior of traffic participants. It can be concluded that it is important to incorporate ergonomics in the design of road signs to ensure driver and road safety.

Future research should include all types of road signs, as well as more age groups of respondents.

Acknowledgements

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RESEARCH OF UNDOCUMENTED INJURIES OF PASSENGERS IN BUSES FOR CITY TRANSPORT

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Abstract. *Today, buses for public transport are used by a large number of people around the world. Passenger safety is one of the primary goals that needs to be provided. In this regard, the design of the interior of buses is one of the primary factors which affects the safety of passengers. In addition, passenger injuries are one of the basic indicators of bus safety. However, when it comes to injuries of passengers on buses for urban transport, the conclusions about safety are primarily based on documented injuries in some of the official institutions, such as for example hospitals. The basic assumption in this paper is that there are also undocumented passenger injuries, which may indicate some failure in the design of the bus. This paper presents a research related to undocumented passenger injuries in city buses.*

Key words: *City buses, safety, injuries, passengers, bus interior design.*

1.INTRODUCTION

In case of serious injuries in buses, the usual practice is to provide first aid to passengers on the spot, and then passengers are transported to a medical facility for further examination and medical treatment if necessary. In such cases, the injuries are recorded and archived. However, there are situations where, due to different circumstances, the passengers suffered physical pain and were subjected to minor injuries. In these situations, passengers usually do not opt to go to a medical facility for treatment. These injuries are usually easier in nature, whereby travelers assume on the basis of a personal assessment that such injuries do not have more serious consequences for their health and that they can not be compensated by an insurance company for such a type of injuries.

However, from the point of view of bus safety, such injuries may also be significant because they potentially point to the lacks in the interior design of the buses for urban passenger transport. An insight into the literature dealing with this issue [1-10] has shown that this aspect of bus safety has not been adequately treated before. It is difficult to find any research that has been focused on this topic.

Bearing in mind the foregoing, the aim of the research in this paper is to examine the possibility of the existence of formally unreported injuries in buses for city passenger transport. The basic hypothesis is that there are formally unreported injuries in buses for city transport of passengers on the territory of the city of Belgrade.

2. METHOD

On the basis of insights into the literature dealing with injuries of passengers in buses [1-10], it was not possible to find a methodology dealing with the problem of systematically collecting information about the unrecorded passenger injuries in urban transport. In view of this, it was necessary to develop a tool that would enable the collection of the said data. Bearing in mind that this information can be collected only from passengers, a questionnaire has been developed, which enables the recording of the necessary data.

The questionnaire was filled by 140 people. The criterion for completing the questionnaire was that all people at some time during a lifetime used public bus transport. The survey was conducted in the territory of the city of Belgrade. The questionnaire was primarily given to the respondents when they were sitting on the bus during the driving. Basic data on the structure of respondents are given in Table 1.

3. RESULTS AND ANALYSIS OF RESULTS

The average age of the respondents was 41 years (M=40,85; SD=15,29). Half of the respondents had up to 39 years, and a half had more (M_e=39). The age of respondents ranged from 19 to 73 years. Among the respondents the most frequent were respondents with 21 years of age (M_o=21). Quantitatively measurable data from the questionnaires were analyzed and summarized in Table 1.

Table 1. Analysis of the answers to the questions from the questionnaire on unreported injuries on the bus.

An ordinal number of the question from the questionnaire		Frequency	Percent	N
1. Respondents who have suffered an injury in a city bus		5	3,6	140
2. Unreported injuries to a health institution		2	40,0	5
3. The reason for the failure to report the injury is the initial		2	100,0	2
5. Respondents who did not report the injury to the driver		4	80,0	5
6. Respondents who did not report the injury to the company		4	80,0	5
7. Respondents who did not report the injury to the insurance		4	80,0	5
8. Respondents who did not report the injury to any other		5	100,0	5
10. The presence of the consequences of an injury		4	80,0	5
Gender	Male	81	57,9	140
	Female	59	42,1	

The frequency of injuries per individual parts of the body is shown in Figure 1.

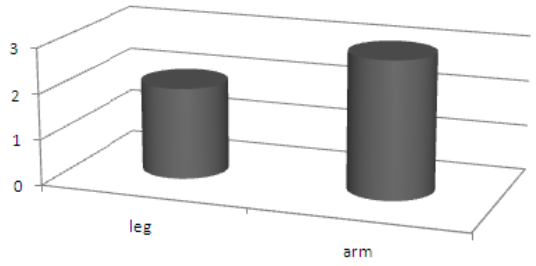

Figure 1. Parts of the body of passengers who were injured and the number of such injuries obtained in buses for the city transport of passengers in Belgrade on a sample of 140 respondents.

Figure 2 shows the types of injuries and the frequency of their occurrence.

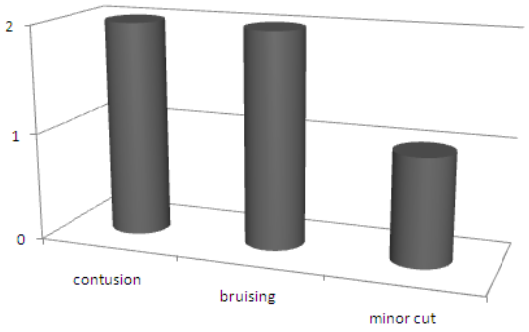

Figure 2. Types of injuries of passengers and the number of such injuries that travelers obtained in buses for city transport of passengers in Belgrade on a sample of 140 respondents.

Figure 3 shows the situations that resulted in passenger injuries and their frequencies.

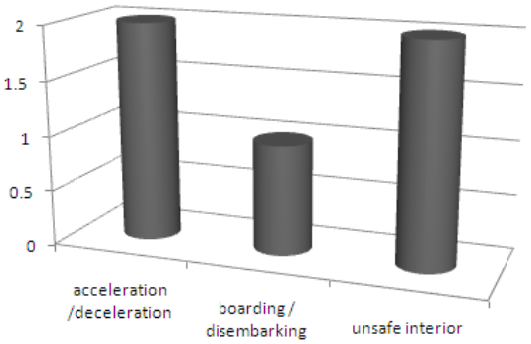

Figure 3. Causes of injuries of passengers in buses for city transport in Belgrade and the frequency of their appearance on a sample of 140 respondents.

4. CONCLUSION

This study confirmed the starting hypothesis that there is a certain percentage of undocumented injuries in buses intended for city passenger transport. This percent is relatively small and in this study, it is 1.42% of the total number of respondents. Of the total number of injuries, 40% constitute unregistered injuries. However, this survey was done on a sample of 140 respondents, which is a relatively small percentage relative to the number of inhabitants in Belgrade. Taking into account the number of inhabitants in Belgrade and the resulting percentage of injuries, a considerable number of people who have suffered some kind of injuries during driving around the city will be obtained. As can be seen from the analysis, these injuries are milder in their character. Nevertheless, they indicate that should be given additional attention to certain

aspects of interior design, in order to further reduce the percentage of injuries of passengers in city buses.

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THE DISTRICT HEATING PROJECT IN BELGRADE AREA: AN APPRAISAL IN THREE DIFFERENT STUDIES

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Abstract. *The paper presents a review of the financial assessments of a district heating project in Belgrade area in three different studies. Sensitivity analysis shows that the Project's most critical parameter is the price of natural gas. In addition, the results of these studies indicate that the project is acceptable only if the ratio between the electricity price and the price of natural gas is higher than 1:5.*
Key words: *district heating, financial assessment, sensitivity, Belgrade area.*

1. INTRODUCTION

Bearing in mind significant energy, economic and environmental effects it has for the development of the economy and society, the system of combined electricity and heat production outside of city area is being used increasingly, even in the countries with relatively moderate climates such as Serbia.

Combined electricity and heat production outside of Belgrade area provides:

- Increased security of energy supply and increase in energy efficiency in energy transformation and consumption, as well as
- Mitigating the negative effect of production and energy use on the environment.

The existing local district water-heating system in the Belgrade area is the largest in the Balkans. The system was formed as a series of independent heating systems that developed around individual settlements and followed their development. Today, there are 14 local heating plants in the city of Belgrade. Each heating plant supplies its own independent heating area with heat energy.

The problem of developing a district heating system for Belgrade outside of Belgrade area has been a topic of discussion for several decades. So far, three feasibility studies have been conducted dealing with the construction of a district heating system in Belgrade from a technical, energy and environmental point of view (1995, 2004 and 2018) [1, 6, 7]. The proposed district heating project in the Belgrade area is based on converting condensed water into stream in the thermal plant, first passing it through a pumping system via a pipe (radius 1000 mm), transporting it to local heating plants and then through a heating network to a heat exchanger station [2]. The main objective of the investment is to ensure the substitution of imported natural gas by domestic lignite coal and a more efficient use of domestic energy sources. In addition, connecting a larger number of consumers to one source of thermal energy supply is a more favourable solution from the aspect of environmental protection. The combined source is usually dislocated from the city, which practically eliminates the pollution of the city environment.

The district heating system in Belgrade includes: a thermal power plant, a system for transporting heat energy to Belgrade and two heating areas that would be connected to the system first (the heating plant "Novi Beograd" and the heating plant "Dunav"), which account for more than half of the total consumption of the district heating system of Belgrade. The base source in the system for the district supply of Belgrade with thermal energy is the thermal power plant ("Nikola Tesla A", hereinafter TENT A) located 28 km from Belgrade, which uses domestic lignite for the production of heat energy. The thermal power plant has six blocks with the total installed electrical power of

1,650 MW. Blocks 1 and 2 have already been reconstructed, while the reconstruction of other blocks would be carried out during the realization of the project. Heating area "Obrenovac" is already supplied with thermal energy from TENT A. In all feasibility studies of the project which have been carried out so far the economic life of the project has been estimated at 20 years. The total consumption of the district heating system was estimated at 2,681 MW at the beginning and at 3,215 MW in the final year of the project. During the period of project exploitation, the share of heat energy in the supply of the heating district of Belgrade would amount to an average of 83%. This percentage also represents the share of the substituted natural gas quantities from the total required in the period prior to the realization of the project.

The paper is divided into five sections. After an introduction, section two provides an explanation of the used methodology for the financial analysis of the district heating project in Belgrade area. In section three, we present the results of the financial analysis of three different feasibility studies of a district heating project. In section four, the sensitivity analysis was performed in order to test the impact of possible errors in the projection of the key parameters of the project on the results of the financial analysis. The conclusions are presented in the fifth section.

2. METHODOLOGY

As a rule, the assessment of economic and financial effectiveness of a particular project is based on a comparison of the revenue and costs generated by the project. However, the district heating project in Belgrade area requires a different approach in accordance with its specific characteristics. The economic and financial analyses of this project must take into account the fact that the revenue from the energy sold to the final consumers is the same in the situation "With" and "Without" the Project. The district heating project serves as the replacement of the existing capacities (the replacement of the costs of the existing system with the costs of the new system).

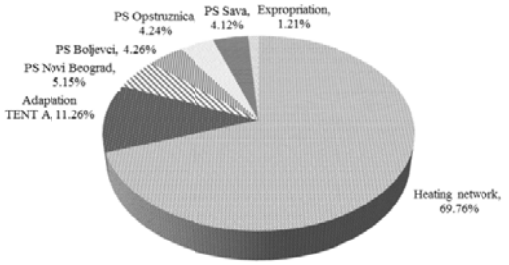
The methodology of the financial analyses of the project which will be presented in this paper is based on a comparison of the benefits of the project (in regard to the "Without" the Project situation) and the costs of building the district heating system. The objective of the financial analysis is to provide an answer to the question: *Is the district heating project in Belgrade area financially profitable to the project owner*? The project profitability will be measured, based on the projected cash flow, by three key dynamic indicators: *the financial net present value of the investment (NPV)*, *the financial rate of return on the investment (IRR)* and *the payback period of the investment* [5].

3. FINANCIAL ANALYSIS

Investment and investment dynamics

The realization of the district heating project of Belgrade from TENT A started in the mid-1990s. However, the implementation was soon terminated due to the lack of financial resources and the inability to achieve the originally conceived financing structure. When comparing the situation "Without" the Project and the situation "With" the Project, from the standpoint of economic and financial analysis, only unrealized investments are relevant.

Besides the investment cost in the district heating system, financial analysis also takes into account investments in boiler plants at Belgrade heating plants which would be necessary if the project is not undertaken. These investments are treated as the benefit of the project, not the cost.



* PS – Pump station

Figure 1. The structure of the investment cost in the district heating system

Benefits and operating costs of the project

The profitability of investment is analysed by comparing the cost which will be substituted and the new costs. If the project of the district heating system in Belgrade is undertaken, one part of the costs of the existing system would be substituted. These costs are treated as the benefit of the project and refer to (Figure 2):

- the costs of fuel procurement – natural gas in heating plants (fuel substitution);
- the reduction of operating costs, which refers to maintenance costs of the existing production plants;

- the depreciation and the financial costs of new boiler plants that should be built if the district heating project is not undertaken.

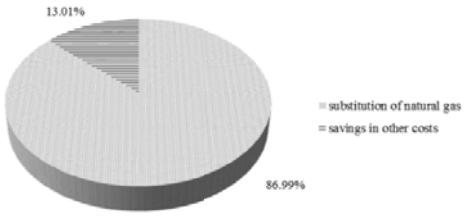


Figure 2. Benefits of the district heating project

The "With" the Project situation implies the substitution of one part of the costs of the existing water-heating system and the operating costs of the new system. The operating costs of the new system include (Figure 3):

- the costs of the delivered heat energy (valued through unproduced electricity: the amount of electric power which will be lost as a consequence of heat energy production);
- maintenance costs;
- insurance costs;
- depreciation costs;
- the financial costs of the new system, and
- the cost of electricity consumption of pump stations.

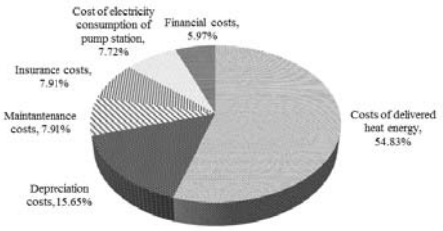


Figure 3. The cost structure of the district heating project

The costs of the delivered heat energy are valued through unproduced electricity as an amount of electric power which will be lost as a consequence of the heat energy production. To estimate these costs, we used the information about the annual amount of electricity that is lost (determined based on energy balance) and the European economic price of electricity for long-term investments.

Financial analysis

The objective of financial analysis is to determine whether the project provides a return on the investment and an appropriate profitability rate. It is important to point out that the financial analysis is carried out in order to assess the project profitability, regardless of the possible positive or negative effects that the project can have on the wider community. In order to measure profitability of the project, it is necessary to project cash inflows and cash outflows and then to discount the net-cash flow for the entire economic lifetime of the project [3].

The projected cash flow, based on which the dynamic indicators of financial analysis are calculated, contains:

- *On the benefits side (cash inflows)*: fuel savings, the reduction in the operating costs, the investments in the new boiler plants and the residual value of the project.
- *On the costs side (cash outflows)*: the investment in a district heating system, the maintenance costs, the insurance costs, the costs of delivered heat energy and the costs of electricity consumption of the pump station.

The results of the financial analysis of the district heating project are presented in Table 1.

Table 1. Financial analysis of the district heating project

Input values	*Feasibility study 1995*	*Feasibility study 2004*	*Feasibility study 2018*
Investment (EUR)	161364600	136970000	165091078
Substitution of fuel (average per year)	183072 t	219921580 m^3	188013678 m^3
Unproduced electricity (average per year, kWh)	375120290	435928000	397230000
Price of natural gas	137.4 EUR/t*	0.13 EUR/m^3	0.33 EUR/m^3
Price of electricity (EUR/kWh)	0.041	0.045	0.045
Loan financing/repayment period	100%/10 years	100%/15 years	65%/15 years
Indicators of financial profitability			
NPV (EUR)	-52353000	-55809011	125040849
IRR (%)	2.84	3.26	19.68
Payback period (Years)	19	16	3.6
The cost on the threshold of Belgrade heating plant (EUR/MWht)	21.93	19.55	21.56

* average price of natural gas and fuel oil

Based on the presented results of the financial analysis of the project, we can conclude that, according to the used criterion for the evaluation of investment justification, the project is only acceptable in the case of the last feasibility study from 2018. The Project's net present value is positive. The discounted value of the net profit at the rate of 10% is EUR 125,040,849. Apart from the positive net present value, the Project also achieves a positive rate of return of 19.68. The payback period is 3.6 years, which is acceptable for this type of project. According to the results of the financial analyses of the feasibility studies from 1995 and 2004, the Project is not acceptable (the net present value is negative and the rate of return is lower than 10%).

In addition to investment costs, two types of costs determine the results of the presented financial analysis. These are *the costs of thermal energy at the threshold of the Belgrade power plant*, which depend on the quantity and the price of unproduced electricity and *lower fuel (natural gas) costs*, which represent the benefit of the project according to the applied methodology. The amount of electric power which would be lost as a consequence of the heat power production, as well as the substituted amount of fuel, are calculated from clear energy budgets that are roughly the same in all three feasibility studies. Considering that the prices are generally the most uncertain part of all projections, we can conclude that only the unit prices of the natural gas and electricity can be the topic of a more serious discussion. In the next section, we will present the sensitivity analysis of profitability indicators to price changes.

4. SENSITIVITY ANALYSIS

The results of the financial analysis which have been presented in the previous section refer to the most likely input values. However, during the implementation of the project, there can be a deviation from the projected sizes in both directions. The value of investment, electricity price and the natural gas price are the parameters that can be changed during the implementation of the project. The change in the values of these parameters certainly affects the values of relevant parameters for the evaluation of project justification.

If a parameter of the project is not well predicted, then the real profitability of the project will be different. In the case of the district heating project in Belgrade area, the three parameters that may have a significant effect on the results of the financial analyses include:

- the investment costs of the project;
- the price of electricity through which the price of the delivered heat energy is valorised;
- the price of fuel (natural gas) that is substituted.

The profitability of the project will increase if the volume of investment is overestimated and if there is a decrease in the price of electricity and an increase in the price of natural gas. On the other hand, the profitability of the project will decrease if the volume of investment is underestimated and if there is an increase in the price of electricity and a decrease in the price of natural gas. From the above, we can conclude that the effects of the change in the price of electricity on the profitability of the project are contrary to the effects of the change in the price of natural gas. Therefore, we carried out the sensitivity analysis in order to test the impact of possible errors in the projection of the key project parameters on the results of the financial analysis.

Sensitivity analysis was performed by changing one of three key input parameters (*the volume of investment, the electricity price* and *the price of natural gas*) in the range ±10%, while keeping other input parameters constant. This analysis does not include simultaneous changes of input parameters.

Sensitivity analysis in three different feasibility studies (1995, 2004, 2018) of the district heating project shows that the Project's most critical parameter is the price of natural gas. The switching value indicates a percentage change of the value of the key input parameter of the Project which equalizes the financial net present value of the investment to zero and the financial rate of return on the investment to the discount rate of 10% [4].

In the last two feasibility studies (2004 and 2018), the price of electricity has remained the same (0.045 EUR/kWh), while the price of natural gas has risen (from 0.130 EUR/m^3 in the 2004 study to 0.330 EUR/m^3 in the 2018 study). Table 2 shows the results of the sensitivity analysis.

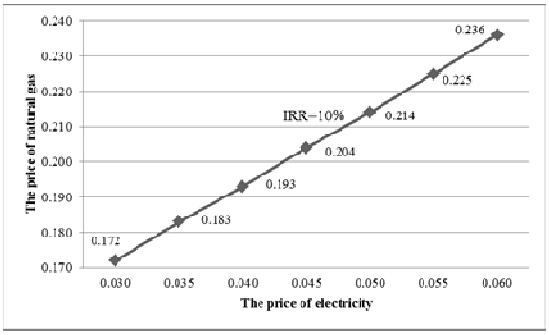
Table 2. Sensitivity Analysis

Variable	Changes (%)	*Feasibility study 1995*	*Feasibility study 2004*			*Feasibility study 2018*		
		IRR (%)	NPV (€)	IRR (%)	Payback (Years)	NPV (€)	IRR (%)	Payback (Years)
Investment costs	0%	2.84	-55809011	3.26	16	125040849	19.68	3.6
	-10%	3.73	-43724728	4.27	14.5	137123432	21.39	3.1
	10%	2.10	-67858616	2.39	17.7	112958266	18.19	3,9
Switching values (NPV=0, IRR=10%)		-40%	-44.8			100.3%		
	Changes (%)	IRR (%)	NPV (€)	IRR (%)	Payback (Years)	NPV (€)	IRR (%)	Payback (Years)
Electricity price	0%	2.84	-55809011	3.26	16	125040849	19.68	3.6
	-10%	4.26	-41532148	5.16	13	134490212	20.29	3.2
	10%	1.37	-70085873	1.19	/*	115591486	19.05	4
Switching values (NPV=0, IRR=10%)		-45%	-40%			132%		
	Changes (%)	IRR (%)	NPV (€)	IRR (%)	Payback (Years)	NPV (€)	IRR (%)	Payback (Years)
Natural gas price	0%	2.84	-55809011	3.26	16	125040849	19.68	3.6
	-10%	0.50	-75758413	0.31	/*	92242548	17.45	4.6
	10%	5.05	-35859609	5.87	11.8	157839150	21.74	3.2
Switching values (NPV=0, IRR=10%)		35%	27%			-38%		

* The payback period is not provided within the economic life of the project.

Figure 4 presents the relative relation between the price of natural gas and the price of electricity.

Figure 4. The relative relation between the price of natural gas and the price of electricity for the IRR=10%



The price of electricity varies from 0.03 EUR/kWh to 0.06 EUR/kWh, with a discrete step of 0.005. For these values, the corresponding prices of natural gas are also shown. The increase in the natural gas price over the boundary value improves the profitability of the project, and vice versa. These results are based on the projected cash flow in the last feasibility study of the project from 2018. At a price of electricity of 0.045 EUR/kWh, the Project is acceptable only if the price of natural gas is not lower than 0.204.

5. CONCLUSIONS

The district heating project in Belgrade area should serve as the replacement of the existing capacities (the replacement of the costs of the existing system with the costs of the new system). The economic appraisal of the financial analysis of the project presented in this paper has been applied according to its specific characteristics. The financial profitability of the project has been estimated via the difference in costs between the situation "With" and the situation "Without" the Project. Based on the presented results of the financial analysis of three different studies of a district heating project in Belgrade area, we can conclude that, according to the used criterion for the evaluation of investment justification, the project is only acceptable in the case of the last feasibility study from 2018.

The sensitivity to changes in the volume of investments does not impair the viability of the

project for any of the three feasibility studies. In the case of variations in the price of fuel which is substituted – the natural gas and the price of electricity – significant sensitivity was observed, but in the opposite direction. An increase in the price of natural gas improves the results of the analysis, and the increase in the price of electricity makes them worse.

The financial profitability of the project depends exclusively on the price of the natural gas and on the price of electricity. The problem is that these prices are unpredictable in the long term. If we look at the last two feasibility studies (2004 and 2018), the relative ratio ranged from 1:3 to 1:7 in favour of the natural gas. The result of the sensitivity analysis shows that, besides the slightly different technical and economic parameters used in the study of 2018, with the prices of gas and electricity from the 2004 study the project would not be financially acceptable. We can conclude that at the current prices of gas and electricity and under the assumption that the relative trends of these prices would continue, the district heating project in Belgrade area is financially acceptable.

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THE CONCEPT OF ENTREPRENEURSHIP AND ECONOMIC GROWTH: EXAMPLE OF RURAL AREAS IN SERBIA

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Abstract. *The current paper focuses on the analysis of the role of the concept of entrepreneurship in economic growth, with a special emphasis on rural areas with different outdoor amenities in Serbia. The paper has two aims. The first aim is to provide theoretical explanations for linking entrepreneurship to economic growth and to highlight the factors that influence the regional variations in entrepreneurial activity. The second aim is to measure and compare entrepreneurial activity across rural areas with different outdoor amenities in Serbia.*
Key words: *Entrepreneurship, economic growth, rural areas, Serbia.*

1. INTRODUCTION

There are two dominant approaches in the literature which feature an understanding of the significance of the concept of entrepreneurship for the economic growth. *The first approach* focuses on entrepreneurs and the factors which determine the decision of an individual to become an entrepreneur and start one's own business. *The second approach* analyses the factors that influence the regional variations in entrepreneurial activity.

Regional variations in entrepreneurial activity can be explained by various factors: income growth, human capital (measured by formal education as the share of people with a college degree or by creative occupations as the share of employees in creative occupations), change in the industry structure (the shift from manufacturing to services and an increasing role of entrepreneurship and SMEs), tax rates, unemployment rate, outdoor amenities as the quality of life indicators, institutions, training and education, population density and growth, etc.

The main research questions in this paper are the following:

- What are the factors that influence the regional variations in entrepreneurial activity?
- How big are the differences regarding the degree of entrepreneurial activity across rural areas with different outdoor amenities in Serbia?

The paper is divided into five sections. After an introduction, section two provides a brief theoretical and empirical background of the role of the concept of entrepreneurship for economic growth on the national and regional level. In section three, we present the endogenous growth model with entrepreneurship. In section four, we explain the alternative approaches for measuring entrepreneurship and analyse the entrepreneurial activity (level and growth) on the example of rural areas with different outdoor amenities in Serbia. The conclusions are presented in the fifth section.

2. LITERATURE REVIEW

Empirical studies carried out in the USA and the EU countries confirmed the hypothesis about the significant impact of entrepreneurship on economic performance at the national [3] and regional level [1, 2, 5, 7]. The contribution of [3] is reflected in the confirmation of the link between the degree of entrepreneurial activity and economic performance on the macroeconomic level. The results of empirical evidence for a panel of the OECD countries pointed out that countries that have experienced an increase in entrepreneurial activity also have higher rates of economic growth and greater reduction in unemployment. In order to test the positive link between self-employment and overall employment at the regional level, [7] used the pooled time-series cross-section data set on the sample of 24 Swedish counties. According to the results of this empirical study, increased self-

employment has a positive effect on economic growth.

However, there is a gap in the empirical studies which analyse the link between entrepreneurship and economic growth by using rural areas as a geographic unit of observation. A small number of empirical studies examined the role of the concept of entrepreneurship in rural economic growth and analysed the factors that stimulate entrepreneurial activity in rural areas [8, 10, 11, 12, 17]. One of the reasons for this gap is the lack of appropriate data.

Generating and promoting new company formation at the local level can have a considerable positive effect on employment. In the developed economies, human and entrepreneurship capital are strongly associated with economic growth, especially in rural areas with high outdoor amenities. According to [11], outdoors amenities as the quality of life indicators, human capital (measured as a share of the workforce employed in the creative occupations) and entrepreneurial context had a synergistic effect on the US rural county growth (growth in the number of new establishments and employment) in the 1990s.

If a rural area with attractive outdoor amenities has a high level of human capital (high level of college graduates and/or high level of employment in creative occupations), then it should have more entrepreneurship capital. Entrepreneurship capital can be defined as specific type of the social capital which refers to the ability of a society to generate new enterprises due to creative and highly educated individuals who are able to:

- recognize a potential market opportunity,
- provide the necessary resources, and
- in a short time period, transform the new ideas into products and services for which there is a market demand.

The results of an empirical analysis, based on panel data for 24 rural areas in Serbia from 2009 to 2013, suggest that human capital, employment growth and growth of young population have a significant positive effect on the growth of entrepreneurial activity [10]. Furthermore, the growth of entrepreneurial activity in rural areas can be explained by the high level of unemployment. Entrepreneurship is recognized as an important instrument for reducing local unemployment. When workers are unemployed they might be more likely to start their own businesses [1].

3. ENDOGENOUS GROWTH MODEL WITH ENTREPRENEURSHIP

According to the endogenous growth models, three factors are the most important for improving economic performance:

1. *Investments in research and development,*
2. *Human capital* and
3. *Entrepreneurship capital*.

The first generation of endogenous growth models links technology with human capital and economic growth. Knowledge externalities and the creation of clusters of talented and creative individuals have a strong impact on economic growth. The second generation of endogenous growth models highlighted that investments in research and development contribute to economic growth by creating new knowledge and innovations.

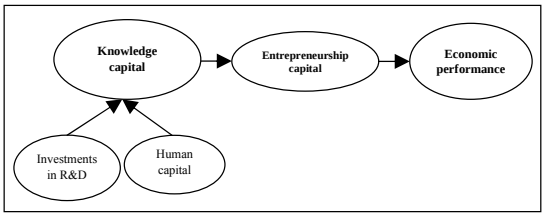

Figure 1. Entrepreneurship in endogenous growth models

The disadvantage of the first and second generation of the endogenous growth models is that they have not provided a precise explanation as to how new knowledge is converted into economic knowledge. The third endogenous growth models identified entrepreneurship (start-up and growth of new enterprises) as a spillover mechanism which reduces the filter between knowledge and economic knowledge, and which has direct effect on economic growth. Knowledge capital (investments in R&D and human capital) has an indirect effect on economic performance through entrepreneurship (Figure 1). The knowledge-based entrepreneurial activity facilities knowledge spillovers, and is therefore conductive to regional economic performance [4]. Entrepreneurship is tends to be higher in the local economy that poses a high share of human capital in the work force.

On the national and regional level, a high rate of economic growth depends on the resources for the creation of new knowledge (investments in research and development) and on the development of entrepreneurial culture (an orientation of the working population towards entrepreneurship and the existence of local educational and financial institutions that will support entrepreneurial initiatives). In a knowledge-based economy, entrepreneurship becomes an increasingly important factor in shaping economic growth.

In rural areas, outdoor amenities are identified as an attractor of the "entrepreneurship human capital" (knowledge and skills). Outdoor amenities refer to two types of amenities: *natural amenities* (which include the physical rural environment: climate, topography, forest land and water areas) and *build amenities* (comprising the development of infrastructure for various recreational activities in rural areas) [9]. In the developed economies, rural areas most attractive to highly educated or/and creative individuals are the areas with high outdoor

amenities. According to empirical results [12, 18] entrepreneurial activity in these areas is higher than in rural areas with lower outdoor amenities due to significant human capital.

4. MEASURING THE ENTREPRENEURIAL ACTIVITY IN RURAL AREAS IN SERBIA

In the literature, there is no generally accepted method of measuring entrepreneurship for the purpose of testing the hypotheses about the positive link between changes in entrepreneurship and changes in economic growth. The used measure of entrepreneurship usually depends on the available data. Since rural areas are not homogeneous with respect to their size, many empirical studies, in order to compare entrepreneurial activity between different geographical units of observations, standardize the number of entrepreneurs.

In empirical research two alternative approaches are used most frequently for developing a proxy measure for entrepreneurial activity:

- The *first approach* standardizes the number of entrepreneurs through the number of existing enterprises.
- The *second approach* standardizes the number of entrepreneurs through total employment.

The latter approach, the "labour approach", is often interpreted as the propensity of a member of the regional workforce to start his/her own business [5].

The analyses of entrepreneurial activity presented in this section are based on the 2009-2016 data [13, 14, 15, 16] for 24 rural areas in Serbia (6 significant rural or intermediate and 18 predominantly rural areas).

Table 1. Measuring entrepreneurial activity in rural areas in Serbia

Rural area	Outdoor amenity index	Level		Growth (%)	Area share	
		2009	2016	2016-09	2009	2016
Zlatibor	8.201	0.167	0.152	-9.328	0.062	0.059
Raska	7.486	0.141	0.157	11.064	0.054	0.057
Moravica	3.773	0.162	0.155	-4.109	0.047	0.050
Pcinja	2.575	0.113	0.134	18.677	0.027	0.030
Bor	2.512	0.111	0.106	-4.178	0.018	0.017
Rasina	1.288	0.166	0.154	-7.642	0.045	0.047
Branicevo	1.201	0.138	0.131	-5.321	0.031	0.031
Macva	1.114	0.165	0.142	-14.045	0.054	0.053
Nisava	0.946	0.107	0.116	8.017	0.057	0.063
Kolubara	0.663	0.146	0.161	10.502	0.037	0.040
Pirot	0.389	0.089	0.103	15.830	0.013	0.012
Jablanica	0.239	0.141	0.149	5.546	0.028	0.035
Toplica	-0.095	0.143	0.115	-19.114	0.013	0.012
Zajecar	-0.135	0.121	0.119	-1.887	0.018	0.016
Sumadija	-0.317	0.160	0.128	-19.829	0.058	0.054
South Backa	-1.086	0.107	0.124	16.504	0.127	0.138
Pomoravlje	-1.473	0.122	0.142	16.155	0.040	0.038
Srem	-2.945	0.167	0.130	-22.190	0.061	0.058
South Banat	-2.966	0.167	0.158	-5.395	0.064	0.056
Central Banat	-3.724	0.121	0.110	-9.001	0.028	0.027
North Backa	-3.910	0.101	0.085	-15.528	0.031	0.026
Podunavlje	-3.914	0.135	0.135	-0.554	0.033	0.031
West Backa	-4.035	0.137	0.128	-7.022	0.033	0.029
North Banat	-5.788	0.100	0.096	-4.230	0.020	0.019
Average	0.000	0.134	0.130			
Total number of entrepreneurs					170,134	176,740

In Table 1, all rural areas are ranked according to the developed index of outdoor amenities for rural areas in Serbia [10]. Rural areas with the lowest rates of entrepreneurship (below 11%) in 2009 and 2016 are North Backa, North Banat and Pirot. In six areas entrepreneurship rate is higher than 15% (Kolubara, South Banat, Raska, Moravica, Rasina and Zlatibor). Zlatibor, Raska and Moravica are also the rural areas with high outdoor amenities (the outdoor amenity index for these rural areas is higher than 2). South Backa is a rural area with the highest number of entrepreneurs. Nearly 13.8% of the total 176,740 entrepreneurs in the 24 rural areas in 2016 come from this area. The areas which are characterized by

a growth of entrepreneurial activity in the period from 2009 through 2016 are: Pcinja, South Backa, Pomoravlje, Pirot, Raska, Kolubara, Nisava and Jablanica. There are 16 areas suffering a decline in entrepreneurial activity during the observed period.

On the example of 24 rural areas in Serbia we cannot confirm the hypothesis that entrepreneurial activity in the rural areas with high outdoor amenities is higher than in the rural areas with low outdoor amenities. The Raska area is the only one of six rural areas with high outdoor amenities in Serbia that has the above average level and growth of entrepreneurial activity during the observed period.

The concept of rural entrepreneurship is relevant for the economic growth of rural areas with high outdoor amenities. The concept involves an intimate relation between entrepreneurial activity and rural environment (unique factors that a certain rural area possesses as necessary inputs for entrepreneurial activity: natural, historical, cultural, human, social, etc.). The concept of rural entrepreneurship refers to the combination of locally specific resources in order to create added value not only for entrepreneurs, but also for rural economy.

5. CONCLUSIONS

The creation of new knowledge through increasing investments in research and development and the growth of human capital are two necessary, but not sufficient factors for generating local economic growth. On the national and regional level, a high rate of economic growth depends on the resources for the creation of new knowledge, human capital and on the development of entrepreneurial culture.

In order to measure entrepreneurial activity across rural areas in Serbia, we calculate "the rate of entrepreneurship" by using the labour approach (the number of entrepreneurs divided by the total number of employees). The Raska area is the only one of six rural areas with high outdoor amenities in Serbia that has the above-average level and growth of entrepreneurial activity.

Bearing in mind the afore-said, the main focus of rural development strategies should be on attractive outdoor amenities and entrepreneurships as the preconditions for sustainable rural development of Serbia. The results presented in this paper can serve as a useful basis for future research on the link between entrepreneurship and rural economic growth.

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MISTAKES IN APPLICATION OF TAGUCHI'S EXPERIMENTAL DESIGNS: CASE STUDIES

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Abstract: *Paper considers case studies of parts of optical fiber hub produced by plastic injection molding process. This is process is in detail described in previous research [1], [2], [3], [4]. Unlike in the previous research this paper are centered on the mistakes in experimental assumptions and settings. Those mistakes had consequences on experimental results and furthermore to conclusions that can be obtained from experiments regarding their quantity and quality. Thus, it is shown that simulation results are unreliable comparing with real experimental results, in cases when technology used in production is outdated, but it is still in use. Second considered problem is the factors that influence of parts with produced from different materials and with dimensions. It was noticed and presented that the same initial experimental conditions, regarding chosen factors and their levels do not produce the same outcomes.*

Key words: *Taguchi's experiment, plastic injection molding, simulation and real experiment, housing, lid, geometric deformations*

1 INTRODUCTION

Process of plastic injection molding is categorized as one of most economical and widespread processes in industry of polymer plastic, since there is great increase in its use in modern products [5], [6].

In process of injection molding of plastic, main problem for quality of finished products are occurrence of geometric deformations during the production, such are warpage and rarely shrinkage. In order to eliminate those problems great number of research were conducted during the years. In their research most authors mostly apply simulation methods or other numerical methods (computing, fuzzy logic, response surface methodology etc.) using computer packages such are MoldFlow Plastic Insight, Moldex 3D, PRO/Engineer, C-Mold [7], [8], [9], [10], [11], [12]. Some authors use experiments conducted in laboratory conditions or from manufacturer databases [13], [14]. Experiments conducted in real productions are sparsely used [1], [9], [13], [15].

Therefore analyzed case studies are related to examination of potentially influential factors on geometric deformations (warpage and shrinkage) which occurs during process of plastic injection molding [1], [2], [3], [4], [11], [16], [17].

2 CASE STUDIES

Two types Taguchi's experiments for production optical fiber hub were conducted in order to obtain geometrical deformations during the process of plastic injection molding for housing and lid. For both parts two types of experiments were conducted simulation with L_8 orthogonal array (OA) on two levels and real experimentation with L_{27} OA, with three levels. Main factors for both types of experimentation and parts are the same. Also lowest and highest factor levels in L_{27} OA are corresponding to L_8 OA. This paper considers only main factor effects. Those factors are presented at Table 1. In further discussion factors are enumerated not by their abbreviations, but by alphabet, since their real physical influence is not the subject of this paper [1].

Table 1. *Main factorial effects in experiments*

Factors	unit
A - Holding pressure (HP)	[bar]
B - Injection time (IT)	[s]
C - Cooling time (CT)	[s]
D - Injection temperature (TMP)	[^{o}C]
E - Holding pressure time (HPT)	[s]

Allocation of main effects in simulation experiment are presented at Tab. 2, while for real experiment are shown at Tab. 3 [18].

Table 2. *Main factorial allocation in OA for simulation*

factor	A	B	C	D	E
column	1	2	3	4	5

Table 3. *Main factorial allocation in OA for real experiment*

factor	A	B	D	E	C
column	1	2	4	8	11

For both parts geometrical deformations were measured in five places, i.e. points from injection point to the furthest. Those points are presented for housing at Fig. 1 and for lid at Fig. 2.

Housing is constructed from Cycoloy PC/ABC Grade C2800, compound of polycarbonate and acrylonitrile-butadiene-syrane (PC/ABC) with weight 26 g and dimensions 155x92x9 mm. Lid is constructed from Terluran, GP 35, ABS copolymer, weighting 21 g, width dimensions 151x91x1.6 mm [19], [20]. There is 17.53% difference in mass and 5.84% difference in dimensions in favor on housing.

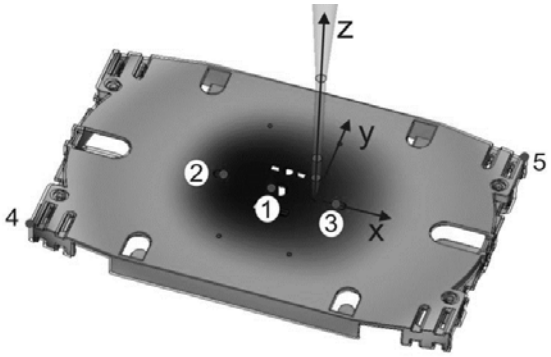

Figure 1. *Measurement points for housing*

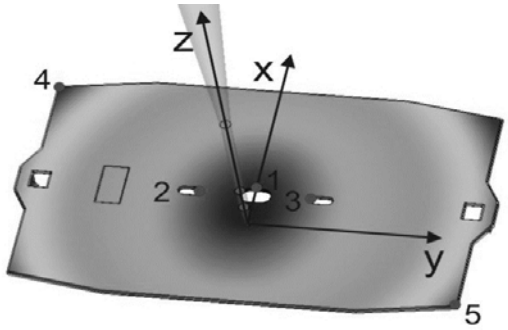

Figure 2. *Measurement points for lid*

For simulation experiments parts were designed using I-Deas software, while simulation was conducted using MoldFlow Plastic Insight software package [21].

Real experimentation was conducted in BMB Automatic manufacturing, Belgrade, Serbia where optical hub is the standard product. Both parts were manufactured using 'Battenfeld BK-T 1300/500' machine, while measurements of geometrical deformations is conducted on Zeiss Contura G2 700 Aktiv coordinate measuring machine (according to ISO 10360-2 recommendations) in ISO 9000 and ISO 17025 certified laboratory [4] at 10 Mechanical Faculty University of Zenica.

2. CASE STUDY 1

Geometrical deformations for combination of factors with minimal geometric deformations in plastic injection molding process for simulation and real experiments were compared. Comparisons was conducted for housing and lid.

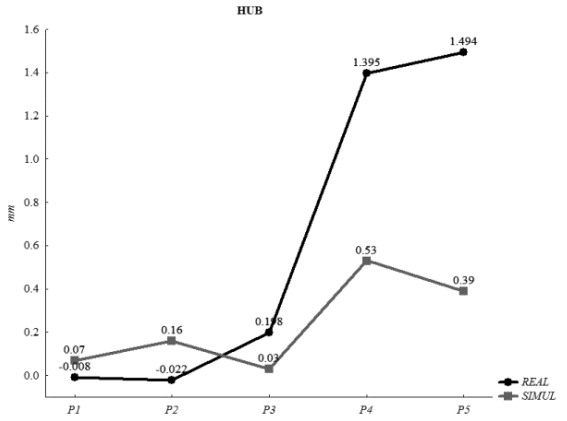

Figure 3. *Geometric deformations in measurement points for housing, regarding simulation and real experimentation*

Comparisons of geometric deformation for housing shows that values for simulation are more predictable, and vary in smaller range from 0.03 to 0.39 mm, i.e. 0.36 mm or 7.69%. In the case of real experiment, variations are from -0.022 mm to 1.494, i.e. 1.516 mm or 69.91%. It means that in furthest point, with maximal optimal geometric deformation difference between real experimental results and simulation are 1.10 mm. In other words real experiment produce 73.89% larger geometrical deformation than simulation.

Furthermore it should be noticed that in simulation there is no shrinkage, only warpage, while in real experimentation both types of geometrical deformation exists.

Fig. 4. represents geometrical deformation for lid, and it changes in measurement points for optimal maximum deformation in furthers point, regarding simulation and real experimentation.

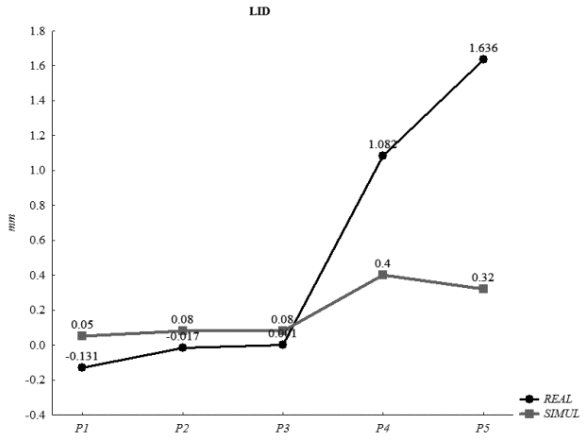

Figure 4. *Geometric deformations in measurement points for Lid, regarding simulation and real experimentation*

As in the case of housing, for lid geometric deformation shows that values for simulation vary in smaller range from 0.05 to 0.40 mm, i.e. 0.35 mm or

12.50%. In the case of real experiment for lid, deformations vary even more than in case of housing from -0.131 mm to 1.636 mm, i.e. 1.767 mm up to 92.59%. It means that in furthest point difference between real experimental results and simulation are 1.316 mm, i.e. real experiment produce 80.44% larger geometrical deformation than simulation.

Furthermore it should be noticed that in simulation either for housing, either for lid there is no shrinkage, only warpage, while in real experimentation both types of geometrical deformation exists in production of both parts.

3. CASE STUDY 2

Second case study on the same experiment involve only analysis of results for real experimentation. Looking at significance levels (Tab. 4 for housing and Tab. 5, for lid), shows that major of influential factors are the similar at all measurement points for housing and for lid. Furthermore there is more influential factors in three points for lid then for housing, while the rest of points have the same number of influential factors.

Table 4. *Significance levels in measurement points for housing*

Housing	P_1	P_2	P_3	P_4	P_5
A	<0.001	<0.001	<0.001	<0.001	<0.001
B	<0.001	<0.001			<0.001
C		<0.05		<0.001	<0.05
D					
E					<0.001

Table 5. *Significance levels in measurement points for housing*

Lid	P_1	P_2	P_3	P_4	P_5
A	<0.001	<0.01	<0.05	<0.001	
B	<0.001	<0.001		<0.001	<0.05
C				<0.001	<0.001
D		<0.001		<0.001	<0.05
E		<0.05	<0.01		<0.05

More detailed analysis that include contribution ratios presents completely different picture (Tab. 6 housing, Tab. 7 lid). Contribution ratios for housing show that main influence have factor A with percentages that vary from 55.18% in one point, up to 87.32%, with influence in the furthest point of 72.17% of all influences, including errors. Influence of other factors are significantly smaller from 0.63 up to 5.05%.

Table 6. *Contribution ratios(%) for influential factors in measurement points for housing*

Housing	P_1	P_2	P_3	P_4	P_5
A	84.62	87.32	55.18	69.25	72.17
B	3.6	1.58			4.63
C		0.68		5.05	1.7
D					
E					2.74

Table 7. *Contribution ratios(%) for influential factors in measurement points for housing*

Lid	P_1	P_2	P_3	P_4	P_5
A	11.74	7.16	6.30	7.30	
B	25.02	12.07		17.53	6.76
C				9.79	16.05
D		15.04		21.34	6.82
E		5.22	10.38		5.18

Contribution ratios for lid shows that factors, although have influence regarding significance level, in reality marginally have an effect on occurrence of geometric deformations due plastic injection molding process. Therefore there exist some other factors that are not identified and examined in experimentation that create geometric deformations in injection molding process.

4. CONCLUSIONS

During the comparison of results of geometric deformations for plastic injection molding, obtained by simulation and from real experimentation, leads to conclusion that for simulation outputs are far more uniformed and overall smaller then in real experimentation.

Differences in geometrical deformations from simulation in critical points are 76.25% smaller for house, and 80.44% smaller for lid, than in real experimentation. In real experimentation there exist both shrinkage and warpage in plastic injection molding, while in simulation exists only warpage.

Comparison of influential factors on geometric deformations in plastic injection molding process in real experimental conditions, for two different parts of optical fiber hub - housing and lid shows that influential factors are similar regarding criteria of significance level.

Further analysis of these experiments based on contribution ratios shows that for housing, dominant influential factor is A, while other factor contribute in far smaller level. For lid values of contribution ratios are small in one point just over 50% for all influential factors, while in the other measurement points is smaller than 50% (16.68-39.49%). It means that chosen factors or it levels are inadequate for lid, since most of variations are caused by random error or with factors that are not examined in experiment.

Therefore, based on the presented case studies, it can be concluded that:

- Simulation as an form of identification of influential factors for geometric deformations that generates in plastic injection molding processes can lead to false results, especially in cases when production equipment is outdated.
- Simulation shows only warpage as a geometric deformation, while in real experiment apart of warpage exists also and shrinkage.
- Factors and designs for different parts must be carefully considered, taking into account the mate-

rials and dimensions of the parts being tested before conducting the experiments.

- Use of contribution ratios rather than significance levels is recommended since it lead to more precise and useful results.

Overall conclusion is that when designing experiment all important factors and experiments had to be consider in order to obtain high quality and useful results.

5. ACKNOWLEDGEMENTS

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OPTIMIZATION OF E-COMMERCE SEARCH ENGINE WITH APPROXIMATE STRING MATCHING TECHNIQUE

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Abstract: *An important factor in the success of any web shop is ability to provide relevant search results to customers. Each web shop operator has its distinctive way of naming and grouping products into categories or site sections. Subtle variations in search queries, although easily recognized by humans, may present a significant obstacle for e-commerce search engine in order to provide relevant search results. Big data based recommendations heavily rely on mathematical approach, demand highly trained analysts and loose any real personalization in the process. In such scenarios approximate string matching technique, or better known as fuzzy search, may prove to be useful. Although under certain scenarios fuzzy search may produce wrong search results, simple corrections in the search logic are sufficient enough to overcome this problem. On the other hand, multiple string matching iterations bring flexibility to the process, simplifying results testing and verification during model building phase.*

Keywords: *Approximate String Matching, Fuzzy Search, e-Commerce Search Engine, Search Results Optimization.*

1. INTRODUCTION

One of the crucial aspects, and a great challenge of success of a e-Commerce business is ability to deliver relevant search results. Approximate String Matching (ASM), or more commonly Fuzzy String Matching (FSM) technique can be of a great help solving this problem.

A single web shop may contain a variety of products, similarly named but otherwise unrelated. On the other hand, a product attribute which is almost impossible to standardize is its name. Besides sole name, it can also contain manufacturer's name, as well as other attributes such as size, color etc. Also, each web shop operator has its distinctive way of naming and grouping products into categories or web shop sections. Let's analyze for a moment a simple but plausible real life search query variants in a sports-equipment web shop:

- Backpack ► category name
- Mammut ► manufacturer name
- Mammut backpack ► product name or group of products
- Mammut backpacks ► group of products

Humans can easily recognize difference in listed variations, but this may prove to be a complex task for an e-commerce search engine.

E-Commerce web portals mostly use lexicographic objects arrangements and searches (i.e. laptop, smart phone, external hard disk) or direct search strings [1]. Instead of allowing us to search with a description only, they measure the relevance of certain product attributes, and do it in an imprecise way. Synonyms can also cause a great deal of trouble, often showing completely unrelated items.

Thus retailers are not comfortable with the current logic of Big Data based recommendations, because mathematical approach loose real personalization [2].

2. APPROXIMATE STRING MATCHING

In such scenarios, ASM/FSM may prove to be quite handy, with multiple string matching iterations.

Each iteration has its own specific role which can be tested and verified during model building phase.

FSM also matches strings based on distance calculating algorithms, categorized as [3]:

- *Edit-based distance* - distance is the count of changes (replace, insert, delete, or characters transposition to make the two strings match. Frequently used algorithms are Hamming, generalized Levenshtein, Longest Common Substring, optimal string alignment, and generalized Damerau-Levenshtein.
- *q-grams based distance* - count of q-character sized packets which are common between both the strings. Larger the count, better the match. Common algorithms are q-gram, Jaccard, and cosine.
- *Heuristic distance* - user based application, with no specific mathematical base.

This paper describes development of a custom e-Commerce search engine using heuristic method approach for a small to middle sized general sportswear and equipment web shop in German language (11,000 products / 9,000 users), based on ClanCats framework and MySQL database.

2. SEARCH ENGINE OPTIMIZATION

ClanCats frameworf (CCF) is an open source, lightweight PHP framework released under MIT licence [4]. Although it possesses standard features that are implied in similar frameworks, such as extendability, scalability, theming, or multilanguage support [5], available documentation is scarce and mostly available in German language.

Initial search engine used a combination of native MySQL LIKE and FULLTEXT search functions on table `articles` (Table 1). Search results produced in this manner were highly imprecise, causing disinterest with site visitors, and finally leading to reduced overall sales.

Initial search testing

A simple query consisting of two keywords '*mammut rucksäcke*' returned zero matches, which was not correct. Such query string was specified as significant by web shop owners, representing a popular, and thus important group of products.

Table 1. Original DB Tables with potential to be used in web shop search engine

Table	Fulltext index	Index
articles	name description	sid group_sid sid_url status availability always_available
categories	/	sid
manufacturers	/	sid

```
SELECT *, MATCH (name, description) AGAINST
('mammut rucksäcke' IN BOOLEAN MODE ) AS
relevance
FROM `articles`
HAVING relevance > 1
```

Alternative approach with MySQL LIKE search function returned 330 results, most of them being imprecise or completely unrelated, Table 2 (i.e. hiking boots and wind jacket).

```
SELECT *
FROM `articles`
WHERE
   name LIKE '%mammut%'
   OR name LIKE '%rucksäcke%'
   OR description LIKE '%mammut%'
   OR description LIKE '%rucksäcke%'
```

Table 2. Query results sample

Product name	Product description
Tatlow LTH Men graphite	Leicht, unglaublich bequem, hochwertiges und edles Nubuk-Leder mit Soft Shell-Erg\u00e4nzungen. Die griffige, von **Mammut** entwickelte gripex Gecko-Sohle...
Segnas Jacket Men black	Die **Mammut** Segnas ist eine technische Hardshelljacke...

Fuzzy search

A simple representation of a fuzzy search method would be iterative replacement of each letter in keyword with a wildcard and then performing a combined fulltext search.

rucksäcke

*ucksäcke

r*cksäcke

...

rucksä*ke

rucksäc*e

rucksäck*

```
...MATCH (`name`) AGAINST ("m*mmot ma*mot ...
mammo* r*cksäcke ... rucksäck* rucksäcke*" IN
BOOLEAN MODE) AS rel...
```

Fuzzy search method flaws

In practice, a certain amount of caution is required when using fuzzy search, because it may produce completely unrelated results with high relevance (Figures 1, 2 and 3 and Table 3).

```
SELECT
        * ,
        MATCH
                (name)
                AGAINST ('ma*mot' IN BOOLEAN MODE)
                AS relevance
FROM `manufacturers`
HAVING relevance > 1

Name                 |  Relevance
---------------------+--------------------
MAMMUT Schuhe        |  2.2537662982940674
MAMMUT Zubehör       |  2.2537662982940674
MAMMUT Bekleidung    |  2.2537662982940674
MAESTRO              |  2.2537662982940674
MAIER SPORTS         |  2.2537662982940674
Hälg Markenschuhe AG |  2.2537662982940674
Mammut               |  2.2537662982940674
```

Figure 1. Fulltext fuzzy search on manufacturers provides imprecise results: relevant manufacturer names have the same relevancy factor as unrelated manufacturers

```
SELECT
        *,
        MATCH
                (name)
                AGAINST (
                        'a*idas ... adida*'
                        IN BOOLEAN MODE
                ) AS relevance
FROM `manufacturers`
HAVING relevance > 1

Name                    |  Relevance
------------------------+--------------------
ARA                     |  1.3695124387741089
BELVIDA by Aco          |  1.3695124387741089
ADIDAS                  |  22.068973541259766
ALLROUNDER              |  1.3695124387741089
ALLPEDES                |  1.3695124387741089
AEROSOLES               |  1.3695124387741089
ABEBA                   |  1.3695124387741089
ICER'S ANTI-SKID SOLES  |  1.3695124387741089
TAMARIS Accessoires     |  1.3695124387741089
ASICS                   |  1.3695124387741089
UGG Australia           |  1.3695124387741089
R'ADYS                  |  5.552858829498291
ASOLO                   |  1.3695124387741089
CAMEL ACTIVE            |  1.3695124387741089
AKU                     |  1.3695124387741089
```

Figure 2. Fulltext fuzzy search on manufacturers provides unrelated results with high relevance

```
SELECT
        sid,
        LOWER(name) AS name,
        MATCH (`name`) AGAINST ("
                m*mmut
                ma*mut
                ...
                r*cksäck
                ru*ksäck
                ...
                rucksäck*" IN BOOLEAN MODE) AS rel
FROM categories
ORDER BY rel DESC

Showing rows 0 - 29 (30 total, Query took 0.0016 sec)
```

Figure 3. Fuzzy search on categories, MySQL query

Table 3. Search results with additional filtering

Category name	Relevance
zubehör rucksäcke	8
running zubehör	2
mädchen	1
reiseaccessoires	1
regenjacken	1
sport- und reisetaschen	1
mäntel	1
militär-/jagdschuhe	1
jupes & röcke	1

This may be corrected by additional search conditions. In given example, the problem was solved by adding a regex correction and two simple conditions into where clause (Figure 4). The outcome is a much smaller, but more precise result set.

Search logic

Obviously, search logic had to be remodeled in order to provide related search results. Besides article's name and description, it also must process information on products' category and manufacturer.

Based on the information whether or not the query contains category or manufacturer name(s), script generates a SQL query with the following logic:

```
SELECT
        sid,
        LOWER(name) AS name,
        IF(`name` REGEXP "mammut|rucksäck", 1, 0) AS reg,
        MATCH (`name`) AGAINST ("
                m*mmut
                ma*mut
                ...
                r*cksäck
                ru*ksäck
                ...
                rucksäck*" IN BOOLEAN MODE) AS rel
FROM categories
HAVING
        reg = 1
        OR rel > 1
ORDER BY
        reg DESC,
        rel DESC
```

Figure 4. Regex correction of categories fuzzy search

- Search for *rucksäcke* will return articles from specific category.
- Search for *mammut* will return articles from specific manufacturer(s).
- Search for *mammut rucksäcke* will perform search for products from manufacturer (mammut) in category (rucksäcke)
- Query *mammut sinergija rucksäcke* will initiate search for products from manufacturer *mammut* in category *rucksäcke* containing a keyword *sinergija* in products' name or description.
- Query *sinergija* will search for products containing a keyword (sinergija) in name or description DB columns.

Figure 5. Search results obtained for selected keywords and search method

3. SEARCH RESULTS PRECISION CONTROL

Native MySQL provides several built in functions to search tables' content. Performance and results precision was tested using different search methods:

- LIKE/REGEX
- FULLTEXT
- FULLTEXT fuzzy search

Search performance and results validation are based on

- Number of articles found under the given search terms
- List of categories and manufacturers found within the search term(s)
- Query execution time

Testing

For search results testing purposes, a simple web application was built with the following features (Figure 5):

- Search term or keywords
- Check for availability (optional, checkbox)
- Search method selector (radio button)

Upon given input data, application tries to find related categories, manufacturers and list of products.

Final result is filtered out in such a manner that only records found with regex, or records with 75% or higher relevance will be kept for further evaluation.

Application outputs the following information:

- Counter value and fulltext relevance
- Product title and description
- Manufacturer or brand name
- Category name

For suggested keywords search '*mammut rucksäcke*', application provided similar results with minor variations with MySQL like and fulltext search functions. In both cases, one completely unrelated product failed to filter out. However, altered fuzzy search provided twice more products in search results without unrelated products, Table 4 and Figure 6.

Table 4. Search results vs method

Method	Time	Products	Availa-bility	Manu f.	Cate-gory
Like	1.043	17*	0	4	4
	0.936	1*	1		
FullText	0.100	17	0	4	4
	0.066	1	1		
Fuzzy	0.091	35	0	4	4
	0.065	4	1		

[a.] 1 unrelated product found in search results

#	Relevance	Product	Manufacturer	Article number	Category
1	10.00	Taranaki 30l smoke-inferno Der ideale Rucksack fu00fcr das Gebirge - der Taranaki 30 v	Mammut	060-50-0003	trekking- / wanderrucksäcke
2	10.00	Lithium Matterhorn 25l poppy Basierend auf dem Lithium Guide passt dieser Rucksack nicht	Mammut	060-50-0009	trekking- / wanderrucksäcke
3	6.00	Nirvana Ride 30l smoke/black Funktioneller, perfekt auf All-Mountain und Freeriding abges	Mammut	060-10-0016	trekking- / wanderrucksäcke
4	6.00	Niva Ride 20l dark space Funktioneller, perfekt auf All-Mountain und Freeriding abges	Mammut	060-30-0009	trekking- / wanderrucksäcke
5	5.00	First Zip 4l black-fire Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-50-0001	kinderrucksäcke
6	5.00	First Zip 8l black-fire Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-50-0002	kinderrucksäcke
7	5.00	First Zip 8l cherry-azalee Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-54-0002	kinderrucksäcke
8	5.00	First Zip 8l lapis-pappel Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-40-0002	kinderrucksäcke
9	5.00	First Zip 16l lapis-pappel Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-40-0003	kinderrucksäcke
10	5.00	Creon Guide 35l black Der Creon Guide von Mammut ist ein sportlich-eleganter Wande	Mammut	060-00-0023	trekking- / wanderrucksäcke
11	5.00	First Zip 8l black-inferno Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-50-0007	kinderrucksäcke
12	5.00	First Zip 8l dark pacific Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-30-0005	kinderrucksäcke
13	5.00	First Zip 8l imperial-inferno Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-30-0006	kinderrucksäcke
14	5.00	First Zip 4l black-inferno Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-50-0008	kinderrucksäcke
15	5.00	First Zip 4l dark pacific Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-30-0007	kinderrucksäcke
16	5.00	First Zip 4l imperial-inferno Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-30-0008	kinderrucksäcke
17	5.00	First Zip 16l black-inferno Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-50-0009	kinderrucksäcke
18	5.00	First Zip 16l dark pacific Kleiner Tagesrucksack mit bew\u00e4hrter Unterteilung, fu00	Mammut	061-30-0009	kinderrucksäcke

Figure 6. Optimized search results for a selected keywords

4. CONCLUSION

Approximate String Matching (ASM), or more commonly Fuzzy String Matching (FSM) technique can be very useful in providing precise search results with mutually tightly related products. ASM/FSM model consisting of multiple string matching iterations is easy to test and modify so it can be easily adjusted for different use-case scenarios.

In order to overcome the known flaws of ASM/FSM technique, additional SQL filtering consisting of only standard SQL string search functions was applied with satisfying results. If needed, search results post processing and additional filtering may be performed on server side, i.e. with PHP programming language.

Demonstrated method of e-commerce search engine optimization is fast, technologically independent and can be reused on different web shop platforms. Initial results and results analytics can be quickly obtained, thus making it budget friendly and suitable for use with small and medium sized e-Commerce businesses.

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CONTACT ANGLE ON COMPLEX SURFACES: A NOVEL PRAGMATIC APPROACH TO DETERMINING SURFACE ENERGY

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ABSTRACT
Wettability of surfaces is a key factor in many industrial printing, converting and finishing processes. Surface energy balance between the surface and the liquid is the determining factor defining wet print adhesion. The sessile drop method is used to determine the contact angle at the circumference wetting front between a droplet of liquid and the surface. However, on highly complex surfaces, being designed to absorb, for example, inkjet ink vehicle, or displaying reactive properties with solvents and interaction with surface roughness or patterning on non-absorbent surfaces, measuring he contact angle using relevant liquid involves many uncertainties if limited to the accepted analysis of a state of equilibrium. We propose an analysis which accounts for a realistic estimate of the surface energy at the instance of liquid-surface contact to assist in the design of desirable ink/varnish-surface interaction properties.
Keywords: contact angle, porous coating, surface energy, complex surface, absorbing surface, reactive surface

INTRODUCTION AND BACKGROUND

Wettability of surfaces plays a major role in many industrial processes, ranging from coating, gluing and printing to plant protection and the application in medicine of pharmaceutical active agents. Surface energy balance between the surface and the liquid is the determining factor defining either phobicity or philicity (wettability) of the surface toward a specific liquid. In the case of requiring adhesion of wet ink or varnish to the surface during application it is necessary to satisfy the positive work of adhesion between the liquid and the solid, W_{ls}, in respect to the balance of surface energy and liquid surface tension such that

$$W_{ls} = \gamma_l + \gamma_s - \gamma_{sl} \quad (1)$$

where γ_l and γ_s are the surface tension of liquid and the surface energy of the solid surface phase, respectively.

Usually, a sessile drop method is used to determine the contact angle, θ, at the circumference wetting front between a droplet of liquid and the surface. Eq (1) can be restated in terms of the contact angle using the Young-Dupré equation

$$W_{ls} = \gamma_l(1+\cos\theta) \quad (2)$$

However, on highly micro and nanoporous surfaces, being designed to absorb, for example, inkjet ink vehicle, or on surfaces that display chemical reactivity with the liquid or complex roughness/patterning, measuring the contact angle involves many uncertainties as the Wenzel model for considering surface roughness or voids is neither relevant for a continuously absorbing surface, nor for a description of a reactive surface or one that shows complex roughness. For phobic surfaces, nonetheless, the Cassie-Baxter model naturally remains valid even though the surface may be porous due to the lack of absorption.

Stages of wetting on a complex surface

Figure 1 shows a schematic of the stages of wetting in the case of an absorbing surface. When applying the sessile liquid droplet to the surface there is some initial inertia retained in the liquid mass as the droplet-forming needle in a typical experimental apparatus is moved away and disjoined from the droplet, whilst simultaneously, if the liquid wets the surface, the droplet interfaces with the solid and the air becoming further extended and, as a result, the

bulk liquid is accelerated inducing a further inertial component. These inertial kinetic effects distort the observed contact angle over short times. In addition, as soon as the droplet contacts the wetting surface the fluid starts to absorb into the porous network structure of the sample. Since this network structure is 3-dimensional, not only does the liquid absorb into the bulk pore volume (*z*-direction) but it traverses beneath the surface laterally in the *xy*-plane, and necessarily re-emerges at the surface at a position that may be ahead of the contact wetting line between the droplet and *xy*-plane. This results in the contact line at the interface consisting of solid, liquid in the surface pores and the liquid of the droplet itself, such that the interface surface energy balance is not solely between liquid and the desired measurable surface but is modified by the liquid already migrated into the neighbouring surface pores. As time progresses this ratio of filled pores to virgin surface increases, resulting in an equilibrium contact angle reflecting this ratio of surface void and surface solid.

There may also be surface roughness on the scale of the micro-solid regions or larger scale roughness spanning both the solid and liquid filled surface, as well as possible material inhomogeneities in the surface itself, e.g. regions of binder, added polymeric water retention aid(s), dispersants and pigment particles of present. The contact angle is, thus, constantly changing with time, firstly discontinuously in the advancing state and secondly discontinuously in the retreating state if evaporation is occurring and/or continued absorption. These factors raise significant doubt in the meaning and reliability of the apparent surface energy result at any stage of the droplet evolution on the surface.

Other classes of materials may themselves not necessarily be absorbent. The sample may perhaps be slightly soluble in the contacting liquid, which can also manifest itself in a change in contact angle after in addition to or after the inertial contact period. Measuring the contact angle on a changing surface using an interacting liquid becomes hugely complex, especially of the interaction yields reaction products, maybe even including a gaseous phase. In either case, this results in the contact line consisting of solid, liquid and solubilised material and the liquid itself, such that the interface surface energy balance is not solely between liquid and the desired measurable surface but is modified by the liquid already having migrated amongst the molecular structure. There may also be surface roughness on the scale of the micro-solid regions or larger scale roughness spanning both the solid and interacted surface, as well as further possible material inhomogeneities in the sample, e.g. regions of polymer and filler in the case of plastics. The contact angle is, thus, constantly changing with time.

The factors discussed above raise significant doubt in the meaning and reliability of the apparent surface energy result at any stage of the droplet evolution on the surface.

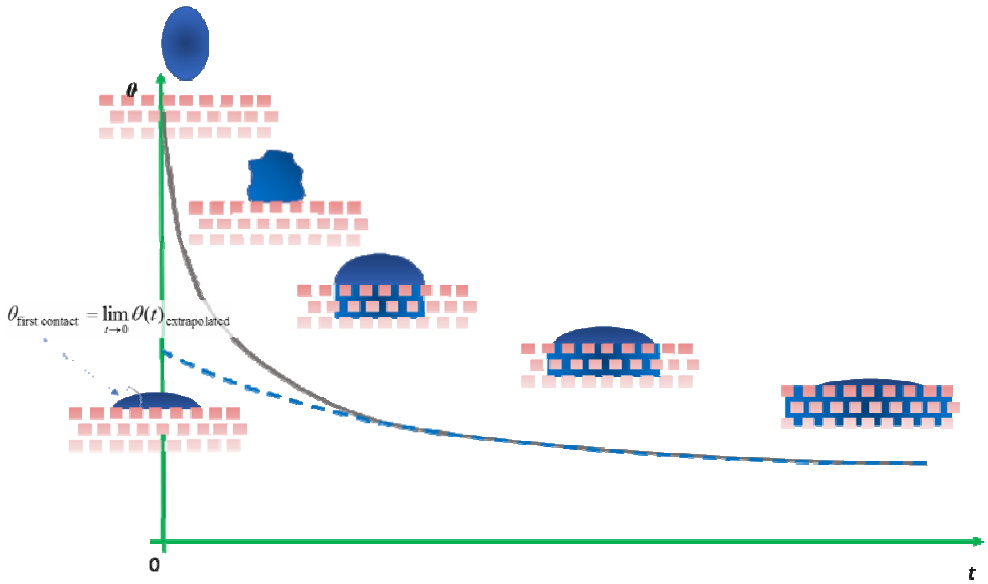

Figure 1 Schematic diagram showing stages wetting of a drop during contact angle measurement: the proposed extrapolation to zero time is shown as the dashed curve.

METHOD PROPOSAL

We newly propose a method to derive a relevant initial contact angle based on the supposition of the ever-increasing ratio of liquid-filled pores/modified surface to that of the virgin surface as a function of time until equilibrium is reached. Thus, by fitting the observed contact angle development with time from the point where it is judged the inertial factor has dissipated until the equilibrium plateau value is reached it is suggested that an extrapolation back to zero time delivers a more relevant contact angle of the droplet liquid related to the surface as if it consisted totally of original surface material or the structure that is relevant. Following this procedure, we can report the initial advancing contact angle value, $\theta_{\text{first contact}}$, derived as

$$\theta_{\text{first contact}} = \lim_{t \to 0} \theta(t)_{\text{extrapolated}} \quad (3)$$

as exemplified in Figure 1 (shown schematically).

Experience shows that a polynomial of order ≤ 4 generally captures the nature of the curve reasonably well without introducing non-physical results. In addition, we undertake to make the fit with the lowest order possible whilst remaining coincident with the experimental data. What is more, the higher the order of polynomial the more rapidly the function oscillates and so this precludes high orders as being non-physical *per se*. The problem here is that the underlying physics, or more exactly the order in which the many factors at play manifest themselves, cannot be precisely defined in each case. This is because all the mechanisms acting depend on the surface energy, and that, unfortunately, is unknown as it is the parameter trying to be measured. This unknown parameter leads, therefore, to a vicious circle in that it is impossible to provide an overarching combination of mechanisms even though each mechanism in principle might be assumed to be known, but the magnitude and rate related through the surface energy remains unknown. Possibly an iterative method could be used in some cases where the surface is non-complex, i.e. make a measurement, then model all the factors with that resulting surface energy and see how it fits, then remeasure and so on until convergence is found. However, if the surface is so simple that this could be applied then it is likely an equilibrium contact angle can be measured anyway. The drawback in proposing such a procedure for more complex surfaces is that one must know *a priori* all the mechanisms occurring and the interactions under which they act. This is not easy, and we give the example of modelling absorption into complex porous media – the best is an approximation based on a model structure, as real structures cannot be fully exploited as the computational complexity is intractable.

In the same way, the time considered for the curve fitting is defined (a) by being post inertial oscillation of the droplet, and (b) before any discontinuities occur in the contact angle, related, for example, to Haines' jumps, chemical reaction with the surface or excessive evaporation. The extrapolation is applied to data obtained from a Dataphysics OCA 50 sessile drop device, capable of delivering drop volumes down to 30 pL, with options to reduce even further to the nL range. A high-speed microscope camera captures the evolution of the droplet configuration over time after it is deposited on the surface. Image analysis and chosen curvature fitting software can be applied in relation to a user-defined linear continuous liquid-solid interface to determine the droplet meniscus shape, droplet volume and contact angle with the surface. The surface energy may be calculated using the Owen, Wendt, Rabel and Kälble (OWRK) calculation (1-3) with the database liquids water (4), diiodomethane (4) and ethylene glycol (5).

EXAMPLE STUDIES

Porous surface

For this study, the initial advancing contact angle value thus derived, $\theta_{\text{first contact}}$, has been used (taken as the average of 3 measurements) to determine the effective surface energy for liquid contact on two representative pigmented paper coatings, A and B. The procedure is applied to example data fitting using a suitable polynomial for three liquids used to determine effective surface energy.

Table 1 shows the extrapolated initial advancing contact angle values $\theta_{\text{first contact}}$ as shown in Figure 2 for the three fluids on the paper samples.

Table 1 Values of initial contact angle $\theta_{\text{first contact}}$ of three fluids on the two coated paper samples.

Sample	Average initial extrapolated contact angle ± standard deviation / °
Paper A water	52.78 ± 2.94
Paper B water	44.43 ± 1.53
Paper A diiodomethane	37.20 ± 3.50
Paper B diiodomethane	44.11 ± 1.85
Paper A ethylene glycol	48.44 ± 0.90
Paper B ethylene glycol	48.74 ± 2.08

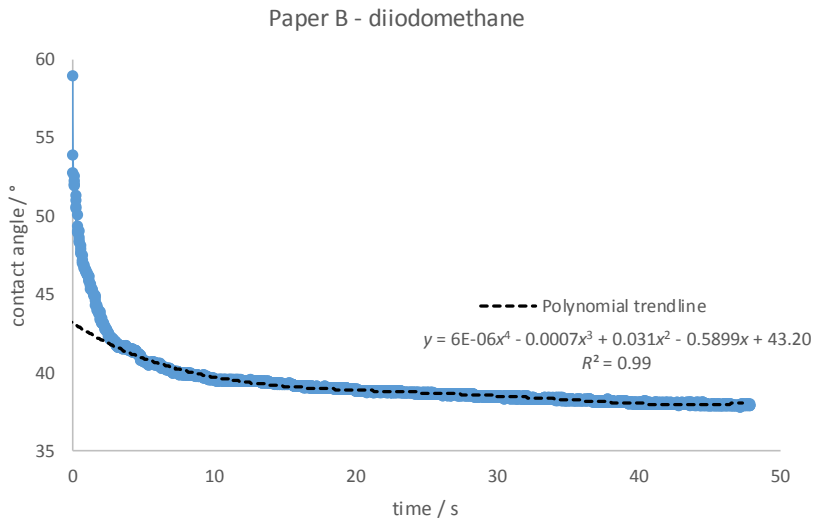

Figure 2 Example fitting to determine the initial advancing contact angle $\theta_{\text{first contact}}$ of diiodomethane on the absorbing coated sample Paper B.

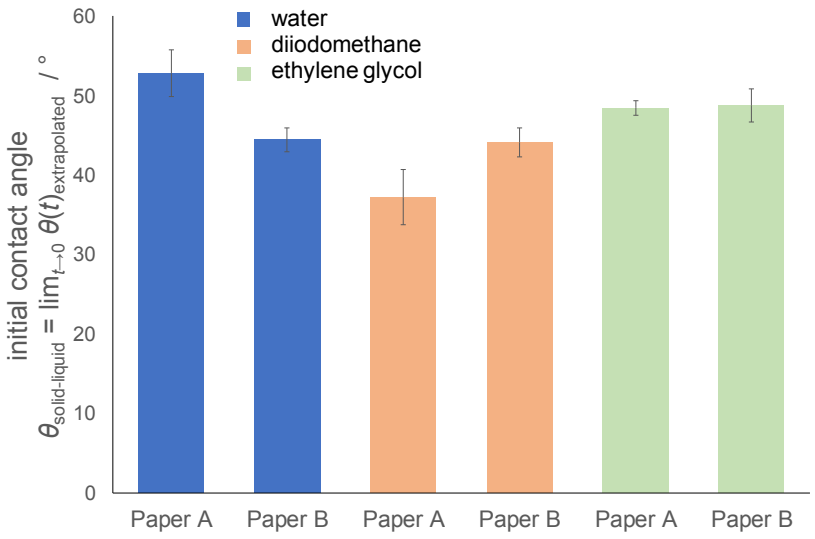

Figure 3 Initial advancing contact angle $\theta_{\text{first contact}}$ of the three test fluids on the two paper samples.

Table 2 and Figure 4 show the surface energy values calculated for the paper samples using the novel extrapolated value of initial advancing contact angle.

The total surface energy of the Paper B sample is seen here to be slightly higher than that for the Paper A sample. The Paper B sample has a higher polar surface energy value based on the extrapolated initial advancing contact angle value and exemplifies the potential of the method to deliver a meaningful surface interaction energy for an absorbent porous medium.

Table 2 Values of surface energy of the three fluids on the samples.

Sample	Total surface energy ± standard deviation / $mN.m^{-1}$	dispersive ± standard deviation / $mN.m^{-1}$	polar ± standard deviation / $mN.m^{-1}$
Paper A	48.08 ± 1.76	33.46 ± 0.93	14.62 ± 0.83
Paper B	49.65 ± 1.28	29.10 ± 0.89	20.55 ± 0.40

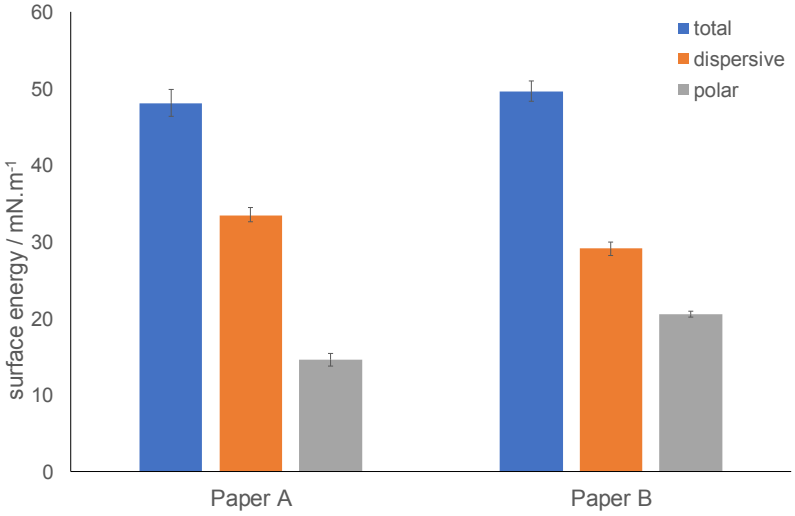

Figure 4 Surface energy derived from the three fluids on the two paper samples.

Non-porous surfaces

Reactive/inhomogeneous surface

Here we take the example of recycled polymer filled with a suitably surface treated alkali metal carbonate filler, designed typically to deliver enhanced stiffness and impact resistance to a native polymer matrix (Figure 5).

In Figure 6 we see the behaviour recorded for the droplet contact angle of the various liquids as a function of time used to determine surface energy. Clearly, the initial contact period for water is not only displaying the inertial region, but also a significant step function as time proceeds. Given the unknown nature of the contact behaviour during this step function, extrapolation is used once the first monotonic behaviour is reached. Diiodomethane, is behaving classically – if only all such measurements were so! – and an equilibrium contact angle can easily be determined. The picture is different, however, for ethylene glycol, where we see several subsequent steps in the contact angle as a function of time, indicating a likely interaction with the surface or the jump effect of the liquid in contact with surface inhomogeneities, in which case an extrapolation is used from the first section of this behaviour to represent the most likely initial state of contact between the liquid and the surface.

Figure 5 Pigment filled polymer (dog-bone shaped) sample (14.7 cm long, 2.0 cm wide at ends, 1.0 cm wide in the middle, 0.4 cm thick)

The resulting surface energy values are displayed in the chart in Figure 7.

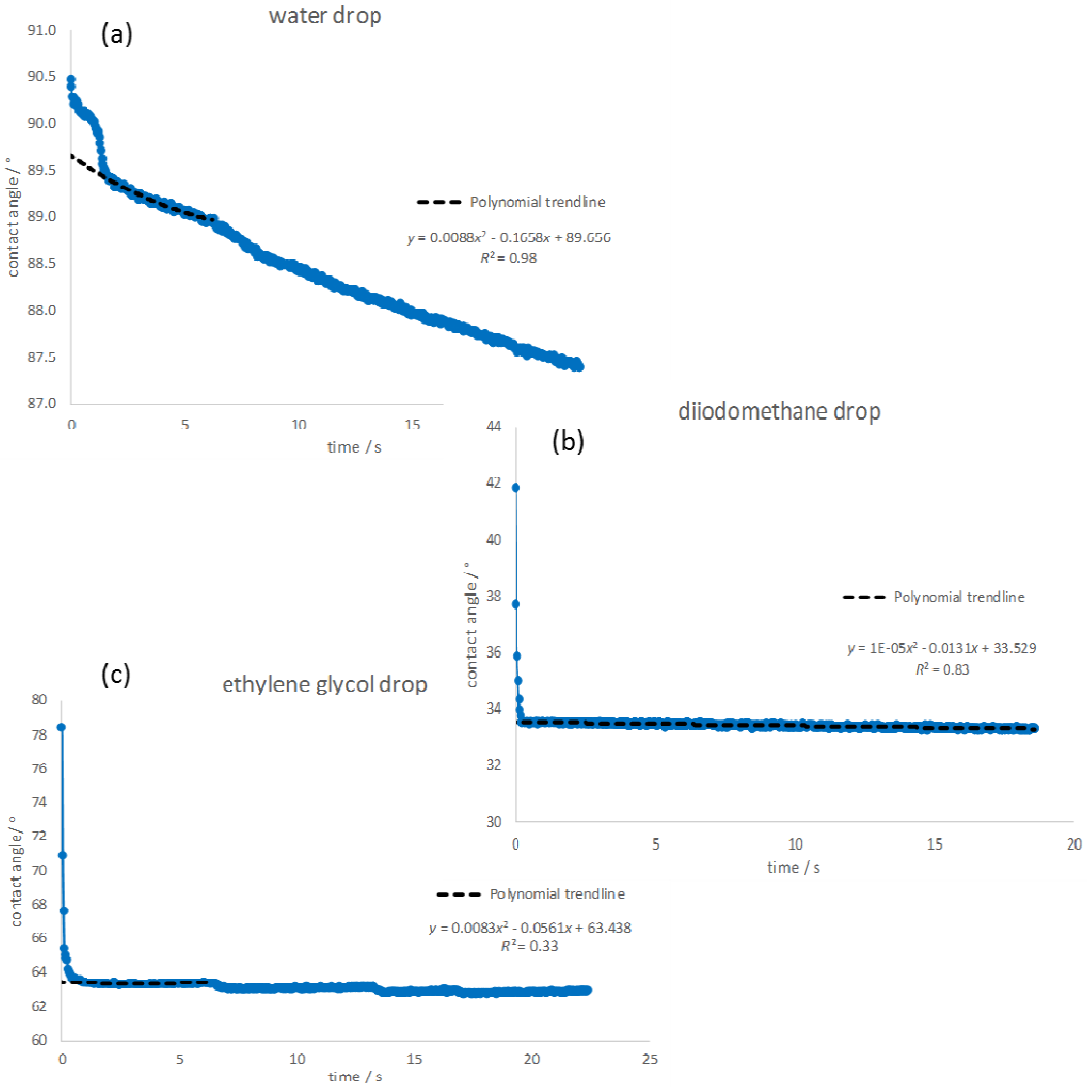

Figure 6 The contact angle development as a function of time for (a) water, (b) diiodomethane, and (c) ethylene glycol.

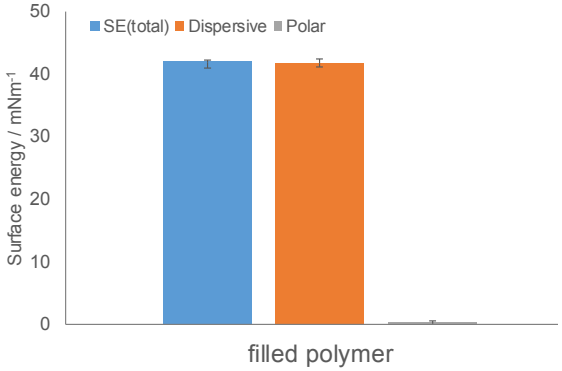

Figure 7 Surface energy – polar and dispersive components

Complex roughness

As a liquid wetting front approaches a discontinuity in the form of a step or sharply defined feature on the sample surface the contact angle abruptly changes. It can be that the angle momentarily exceeds 90°. Under this condition the wetting becomes terminated and the liquid meniscus front halts in a pinned position. Eventually, due to molecular diffusion, surface and/or pore condensation, the liquid continuity is re-established on a molecular or thin film level, such that the front can jump forward and return to its previous wetting progress. Such a sudden change is termed a Haines' jump (6) and is often associated with an equilibrium change in contact angle.

Figure 8 Water on PET – example of surface roughness (area 1.0 x 1.3 cm^2)

In Figure 9 we observe a complex surface microroughness under grazing angle illumination in the form of a polyethylene terephthalate (PET) surface. Studying the wetting property for water, in terms of contact angle as a function of time, Figure 9, the Haines jump phenomenon is seen occurring on a timescale of between 1 and 2 s, preventing an equilibrium being reached monotonically.

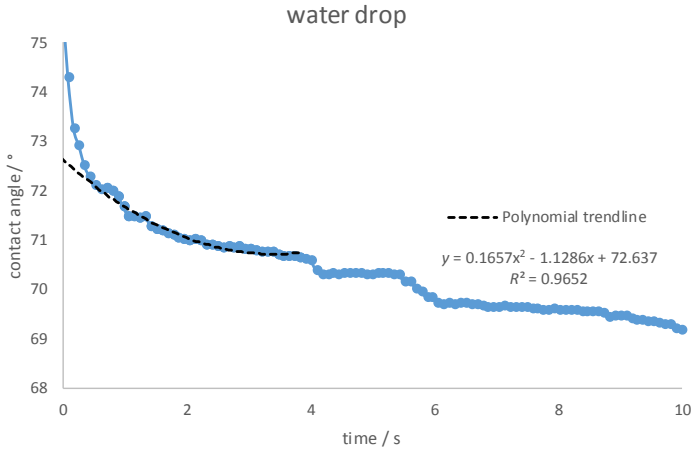

Figure 9 Evolution of contact angle as droplet spreads over surface roughness – $\theta_{\text{first contact}} = 72.6°$

CONCLUSIONS

Surfaces used for printing are becoming ever more complex, especially when considering new materials in packaging and for functional printed designs. Costly time and materials can be wasted seeking to print on a surface that is unsuitable in respect to surface energy balance with that of the ink or varnish to be printed or coated. To ensure adhesion in the wet state during transfer it is essential to be able to have a realistic measure of the surface wetting property and effective surface energy. Surfaces that are designed to be porous, liquid reactive or have a complexity of surface roughness patterning can be particularly difficult to characterise using the traditional sessile drop method. To overcome the shortcomings of the measurement under non-equilibrium conditions, the authors propose a method of extrapolation of the contact angle using the first period of monotonic behaviour after the inertial region to establish and effective advancing contact angle representing the first moment of contact.

The method is exemplified, and the experience of the authors working in an industrial testing laboratory is that enquiries from the printing industry, coatings and metals industry and polymer materials industry, food and personal care, to name but a few, are steadily increasing as practitioners find the results bring an extra security to their operations and support successful developments.

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IMPACT OF FOREST HARVESTING OF WOOD BIOMASS ON SUSTAINABILITY AND REGULATORY IN EUROPEAN BIOECONOMY DEVELOPMENT: learnings from the Finnish model

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ABSTRACT

The bioeconomy in Europe is, by definition, being developed within a so-called 'weak' sustainability concept arising from a predominantly conservative approach amongst many European Union (EU) members. Governments are instigating 'biotechnology strategies' to define necessary investment, technological and economic activities targeting production of sustainable manufactured goods and biofuels. The EU Bioeconomy Strategy, concerning EU biomass utilisation, was launched in 2012 and since then has been variously criticised to be too conservative and lacking a systematic sustainability approach, being more oriented towards 'quick-fix' solutions for improving the, at that time extant, negative economic trend driving potentially destabilising high unemployment. In this paper, the regulatory response to, and the impact on, bioeconomic development is evaluated in the light of this current criticism. To provide a likely model case for the development of bioeconomy, focus is given to activities in Finland as an example of a bioresource-rich country.

Keywords: sustainability, bioeconomy, biomass, land grab, deforestation

INTRODUCTION AND BACKGROUND

Many studies and authors emphasise that the current European Union (EU) policy framework is too optimistic in respect to economic goals for the bioeconomy, having too ambitious demand for wood sources likely to outstrip sustainable extraction levels from European forests leading to significant pressure on forest ecology, sustainability and diversity [18, 25].

In this paper, using systematic literature review from publications in the field of sustainability development in bioeconomy, EU policies and publications, we develop a brief critical overview of current status and trends in sustainability regarding the production of biofuels from wood biomass sources, and whether there is emerging integration towards policies within the EU that will enabled synchronised control of utilisation of forest biomass ensuring long term environmental benefits [6] .

Sustainable development was popularised through the publication of the Brundtland Commission findings in 1993, being defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [5]. Since the introduction of bioeconomy as a trade mark for large investments into biotechnology and research, production of biofuels has escalated as it promised sustainable, renewable and steady sources of energy for European countries [18, 21]. Sustainable development is process intended to lead to social, economic and environmental equilibrium, albeit within a very complex network of interactions [29].

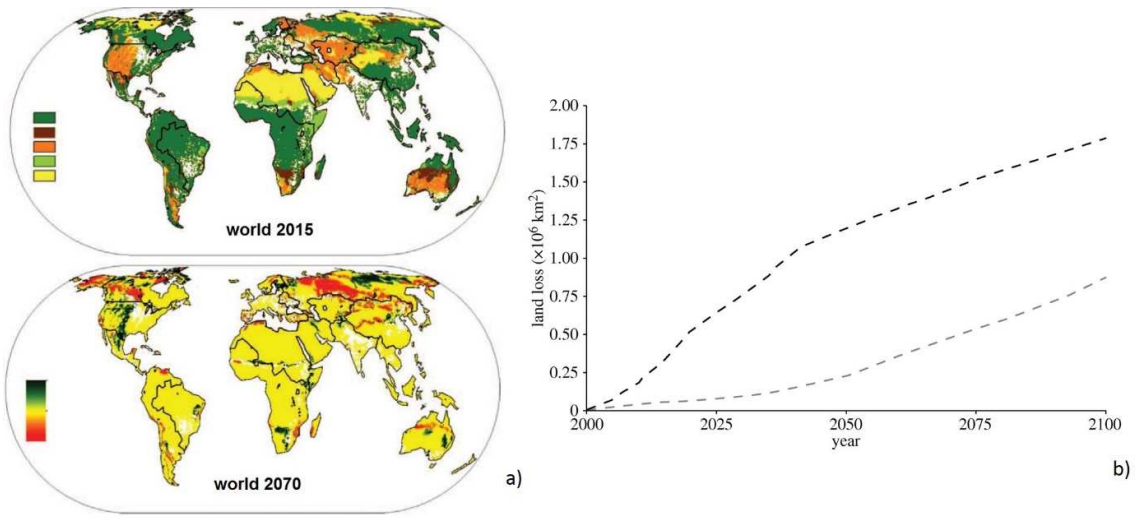

Fig. 1 Possible outcome on the biodiversity Earth map in the scenario where global temperature rises from 2-6 ºC / adapted from [14, 27, 30] /

Whilst the world is said to need to reduce 70 % of current greenhouse gas emission by 2050, at the same time 9 billion people are expected to live on the planet by 2050, needing land for food production and housing [11, 19]. Much of that same land, however, is expected to sustain production of biomass for the increasing demand for biofuels and bio-based manufacturing [3, 21].

A successful bioeconomy additionally requires heavy investment in economic remodelling and research funding activities to achieve the necessary technological step change towards a decrease in fossil fuel consumption and a lowering in greenhouse gas emission [12, 15]. Fig.1 illustrates the projected environmental response to climate change temperature pattern on Earth increasing each year to a level of 6 ºC, with consequent reduction in land productivity and biodiversity. Hence, the concerted effort to reach agreement to a limit of < +2 ºC [28, 31].

Wood is proposed to be an environmentally neutral biofuels source, if, crucially, not counting the reduction in reabsorption of CO_2 by photosynthesis from the cut trees initially used to provide the biomass [14]. Environmental issues under EU laws are similar for the end use of biofuels and fossil fuels in respect to control of emissions of gases and particles into the atmosphere [8]. All large combustion plants and households must undertake necessary measures for pollution prevention, including equipment, for sulphur dioxide (SO_2), nitrogen oxides (NOx) and particulates, employing best-available techniques (BATs) [3]. Generally, emission limits for liquid fuels are similar to those for solid fuel, while emission limits for gas fuels are lower [14, 17].

For large combustion plants that utilise wood source biomass, the adverse effects of emissions are similar to those of fossil fuels, whilst for smaller plants, or households, emissions are lower, depending on the application [25]. The benefit from biofuels is considered derived from using a renewable energy source and a secure supply, considering wood biomass in many cases as a local or friendly neighbour commodity [7, 20]. However, the question of CO_2 neutrality remains open, since it takes many years for planted wood to reach the necessary CO_2 reabsorption level and, depending on climate and species, this can span many human generations up to 100 years in some cases, if biodiversity is to be maintained [19, 30].

While the Regulatory framework is continually being focused in the direction of CO_2 emission reduction, governments highlight the transport industry for public attention. In response, car manufacturers are starting to plan their future on electric propulsion. Fully electric or hybrid vehicle development forms the major investment strategy for the industry. However, the question arises as to the sustainability of electric vehicles based on limited material resources needed for battery technology and the resulting increase in needed electricity generation for, what is today, a relatively inefficient charging-discharging cycle. As a result, we also see, for example, Toyota (Toyota Opens a Portal to the Future of Zero Emission Trucking) defining the hybrid as a transition technology only toward the target of adopting hydrogen sustainably cracked from water [20, 21]. In addition, BlackRock, the biggest private equity fund is raising billion level sums to invest in infrastructure developments (Investing in a

sustainable future: a framework for translating intention into implementation) [22, 23]. Investments have the power to lead the final implementation by giving priority to one technology to the disadvantage of others. In the case of the ultimate solution for mobility, this could eventually support the realisation that energy source distribution to the final consumer, whilst embedded in a circular economy, will be the key to providing sustainable mobility rather than a headlong rush into a technology that is, in the longer-term, unsustainable. Today, the infrastructure to support distribution to the mobility market is mainly designed for fossil fuels for private, public and commercial transport by road, water and air. A hybrid scenario is already in place for rail, although we cannot say that this was ideally planned for in advance, with some gas and mostly electricity for related needs in buildings and communications infrastructure [20-23].

A common denominator for all existing available means of energy supply has been the central generation and subsequent distribution through a network. Today, the possibility for a decentralised production of electricity and even hydrogen is a reality that sometimes is only prevented by a legislation that protects the previous investments in centralised infrastructure and distribution [24, 25]. If new investments are going to continue within the limitations of the distribution status quo, then we could end up just replacing the generation component with one or another that depends primarily on the existing model of distribution.

With the background described above, from the Regulatory point of view, history appears to be repeating itself following almost the same level of discussion that occurred in the last century for fossil fuels, the main open question being: must we burn a natural resource, such as biomass, or would it be wiser to use it as raw material for manufacturing? In pursuing primarily fuels, biorefinery seems to be the only offered answer today, so all relevant laws and political incentives remain focused in this direction. However, private investors are looking for the best use of the available funds, and today this can be much bigger than the fiscal incentives or the real investment possibilities open for governments. If the available money for infrastructure investments is giving priority to electrical or, ultimately, hydrogen-based mobility and Regulation is still focused on just replacing the fuel origin from fossil to biomass, then we could end up in a mismatch between the wider attained results and the Regulatory framework to deal with them. The stability needed for the correct assessment of a potential investment must come from a stable Regulatory framework and a clear understanding of the direction being led by technological evolution. Today, there is little sign of this vital connectivity. Regulation is still following public opinion and governmental edict, and not leading the additional need for sustainability via a circular economy rather than bioeconomy alone.

THE NEED FOR RELEVANT DEFINITIONS

Clarifying interactions

Currently, under EU policies, all member states are obliged to monitor technical progress within their own resources, and they currently make decisions locally on sustainability factors regarding the use of biofuels, wood mass harvesting and technologies used, on the basis of their natural resources, state of technology development and regional environmental conditions [29, 30]. The circular model of bioeconomy assumes that the production of biomass is an ecological and renewable answer to fossil fuels for production chemicals and energy, while the resulting organic waste automatically becomes a new material resource, i.e. raw material, for further productive processes, which are assumed to be always *sustainable* [6, 12, 18]. Circular bioeconomy assumes intrinsically that living nature is an abundant raw material, inherently renewable, and the concept of waste utilisation is considered eco-efficient, since it is not thrown away [6]. Consumerism in this economic model is considered healthy as it generates a greater need for resources and provides for competition, and so must be able to continue through and via the bioeconomy [24, 25, 34]. Furthermore, some research papers claim that EU policies often use the term “renewable” synonymously with sustainable, suggesting that renewable source technologies bring lower air and water pollution and decrease waste [13, 25]. Thus, the conversion of biomass and biowaste into value-added products, according to an EPOBIO report, is defined sustainable as it is ensured through reversible natural resources, in decades to come [7, 8, 14]. There are growing movements within EU politics emphasising a stronger role definition of sustainability, since carbon rotation time of forest biomass energy may be too long to be meaningful from a climate control perspective (European Academies Science Advisory Council (EASAC), 2017) [30].

Integrating biorefinery with biomaterials

The concept of the integrated biorefinery as a pillar of the circular bioeconomy concept requires

integration of biorefining with the production of pulp and micro nanocellulose [6, 8, 24]. The utilisation of forest biomass for pulp, cellulose nanomaterials and energy is essential for bioeconomy development, as significant domestic resources are available within Europe [32]. Forest harvesting for wood biomass should support national industrial and technological development with emphasis on increased employment in the bioeconomy sector [11, 31]. Smaller European countries should not be left behind in the bioeconomy development for the benefit of centralised producers and countries with large forest resources (Nordic countries) [33, 36]. This concept, however, merges the interests of the agriculture and forest industries (seed, fertiliser, micro-nutrients, plant protection, genetically modified crops etc.) with the energy sectors (transport fuels, electricity generation, automotive industries etc.) [16, 27], which treat nature as an economic asset whose productivity must be intensified to attain appropriate market value [9, 14]. This approach if uncontrolled becomes linked with progressive land grabbing leading to deforestation. The most vulnerable are local populations and small farmers, and there is growing concern within academia that the EU policy 6 needs to define sustainable policies applied uniformly across all member states to ensure safeguards to support sustainable exploitation of the bioeconomy principle [2, 16, 24]. Eventually, prices of biofuels should be affordable for all, as regional biomaterials and biofuel will depend on local salaries, biomass prices, productivity, supply logistics and transport costs and legislation [29, 30, 32].

IMPACT OF TREE CULTURE MANAGEMENT

Land stewardship

The negative influence of forest harvesting on ecosystems has already been observed, through the removal of whole trees (spruce and pine) that impaired short-term growth of planted trees of between 5 and 30 years, due to decrease in the net amount of nitrogen in the soil [2, 7, 35]. Changes in species composition in a forest might occur resulting from changed nutrient status or changes ground cover or the amount of canopy sheltering for the benefit of insects, earth aerating creatures and mammals, impacting on rare insects and birds breeding spots etc., whilst wood residue removal or excess may lead to increased levels of pest insects, or fungi, respectively, rising to epidemic levels [14, 35].

The extent to which soil organic matter is affected depends on the quantity of tree biomass removed, the amount of displacement of dead roots, and the degree to which soil moisture and temperature are modified [2, 8]. The removed soil organic matter in the forest can only be replaced by growth of new replacement forests, and under these conditions the level of organic matter might never reach former levels if intensive harvesting is continued or growth is reduced. The removal of nutrients can be compensated by fertilisation or, partly, by wood ash recycling, and addition of nitrogen fertiliser as necessary, since after combustion wood ash contains almost all the required nutrition except nitrogen [12, 17, 24].

SUSTAINABILITY REGULATION WITHIN THE EU

A mixed message – certification standards

It has been observed by some authors that the EU faces a lack of integration over national forest standards, coexisting as a confusion of terminology and lack of rationale in respect to legislation, failing to display a fundamental basis for joining up the sustainability factors in the circular bioeconomy with incomplete evaluation of economic criteria [2, 4, 14].

It is important to standardise best-available harvesting techniques in a way similar to techniques for pollution prevention and control [2, 8] that will serve as parameter-setting for all other policies. The complex nature of restrictions touching different aspects of forest harvesting and the lack of defined EU-wide standards raises the questions whether forest harvesting really can be performed in a sustainable way and what is meant by the European term for sustainability, both of which will define the extent to which forest biomass can be used for biofuels production [13, 29]. Uncertainty is high when scientific results are interpreted and transferred to operational criteria, indicators, recommendations and guidelines, with the final thresholds being set by politicians, certification bodies or other stakeholders [32]. This need for united interpretation is decisive for future utilisation of forest biomass for energy and recycling of wood biomass [36].

Sustainable utilisation of wood biomass for energy use is defined in the EU through certification schemes, such as the International Standard on Environmental Management Systems (ISO 14000 series, ISO 14001 specifically), and the EU Eco-Management and Audit Scheme [33, 35]. These documents provide reporting tools and mechanisms for sustainable management for companies that are also starting to become biofuels producers, e.g. Dong in Denmark or UPM in Finland and Stora Enso spanning Finland

and Sweden, to evaluate and report their environmental performance uniformly [12, 30]. Under the Essent Green Gold or Eugene standards, electricity producers are also accredited as producers of green energy, and they must obtain certificates that the wood used in biogeneration is purchased from Forest Stewardship Certified (FSC) sources within 4 years [29, 30, 32]. Similarly, the same standards require that power generation stations that use energy generated from crops should all have licences that they come from FSC-certified sources. It is suggested in a newly published report that if other regional/national forest certification standards, such as PEFC, additionally must be complied with and accepted for Eugene accreditation [8, 9]. The report also recognises that the certification requirement would limit the supply from countries with only a limited area of FSC-certified forest. The role of these certificates issued by the EU is to ensure sustainable utilisation and traceability of the biomass throughout the entire supply chain, from logging through to the burning of biofuel [14, 25].

National certification schemes under both PEFC and FSC certification often have regulations for use of wood for energy and, therefore, legal, regulatory, institutional, economic policies apply including financial instrument regulations, defined under the first Pan-European Criterion "Maintenance and Appropriate Enhancement of Forest Resources and their Contribution to Global Carbon Cycles" [18, 35]. In the second pan-European criterion, "Maintenance of Forest Ecosystem Health and Vitality", sustainability regulation goes further towards regulating the utilisation of wood biomass in respect to damage caused by biotic and abiotic agents (cf. also PEOLG 2.1.b), and on the base of already evident changes that wood harvesting and deforestation has had on soil nutrient balance and acidity (cf. also PEOLG 2.2.d) regulatory is starting to be addressed in the national PEFC standards [2, 3]. The change of soil parameters due to harvesting causing extraction or loss of nutrients and decreased soil fertility is explicitly addressed in national forestry policies through rules that define frequency of removal of crown/canopy material (Austria, Sweden), or seasonal harvesting in relation to soil fertility (Italy), leaching, and deposition (Denmark), with even prohibition in some countries of harvesting levels that can diminish growth of plantations or even growth potential (Slovenia, UK, Sweden) [2, 8]. Many national standards address supplement-based soil fertilising after harvesting, in respect to safeguarding nutritional needs (Austria, Denmark, Germany, Latvia, Luxembourg, Spain and Sweden), while some address the need that fertilising must also be strictly regulated within environmental protection standards (Czech Republic). Additionally, in some countries there exist also restrictions for sludge recycling (Latvia) [35, 36].

Since minimising waste production whilst maximising waste re-use and recycling in a sustainable way are the most essential components in sustainable waste management, European law reflects this [30]. As a result, the law in turn is ill-equipped to cope with conflicts of definition in respect to what is waste and what is raw material. Wood ash is regarded as waste material [15, 21], whereas wood ash has been used for soil fertilisation for centuries and Finland has a long history of re-using wood ash in forestry [24, 25]. Where considered legally as waste, wood ash is liable to the levy of land deposition penalties, which if adhered to would mean it might not only be prevented but uneconomical to use as fertiliser. In this respect, wood ash recycling is allowed only under strict government regulations (Austria, Sweden) [17, 35].

National and European Forestry policies on the road to bioeconomy

The most marked political support for bioeconomy is found within the EU in Finland, where the political climate has been created to lead the country towards a mature bioeconomy, due to assumption that Finland has unlimited wood biomass resources without the need for extensive limiting regulation. Subsidies have already been implemented in some Nordic countries that motivate forest owners to sell wood for production of biofuels, like in Finland, whilst in others, Sweden and the Baltic countries, it is still the matter of personal choice the purpose for which logs may be sold [24, 32]. Denmark has a similar "biomass agreement" from 1993, in which straw and wood chips are considered biomass for energy supply, while Swedish forest policy, although supporting the increase in biofuels and biomaterials production, recognises possible future problems in biomass supply [12, 32].

The increase in production of biomass in the future will result in sectors such as agriculture and forestry most probably competing for land and investment, research funding and subsidies [25, 27]. Despite this likelihood, no concrete actions are yet proposed in respect to the sustainable management of competing natural resources. Whilst many EU strategies, such as the forest strategy [7], biodiversity strategy [8] and agricultural policy [30], refer to sustainable management and sustainable use of natural resources, the integrated replacement of fossil

fuels based with biofuels is considered generally as a stand-alone policy area and, as yet, does not address competitive conflict [10]. In this context, bio-technological innovation is expected to develop new forms of biocapital, e.g. plants or plant cells as biofactories, new forms of microorganisms and biocatalysts, supporting the new forms of bioenergy supply that will have higher value through increased productivity [9, 24].

The sustainability approach considers very clearly considered that the ground is set to meet the idea of the bioeconomy being a high tech innovative value driver, enabling quick economic returns has been approached differently in different EU countries, in respect to available natural resources feed this value growth potential through agriculture development (Germany, Austria, the Netherlands) and utilisation of wood biomass (Nordic and Baltic countries) [33, 36].

Over the last decades, several policies have been set for establishing a more sustainable bioeconomy with appropriate use and reuse of natural resources, such as the circular economy strategy, e.g. European Commission, 2015, which suggests implementation of closed material loops utilising resources (BMEL, 2014; European Commission, 2012) based on a value-added hierarchical system of biomass for the production of materials, chemicals, fuels and energy – the so-called biomass pyramid [29, 30]. This concept includes the proviso; only after providing the sufficient and healthy supply of food and feed to meet the basic needs of society. This is achieved through the Cascade principle, described elsewhere [6]. The transition towards a bioeconomy is complex and predicting the role of the forest industry towards the 2050 climate target will involve an understanding of high-end speciality products and the necessary development of alternative energy sources that eventually will not utilise biomass [1, 3, 31, 34], as presented in Fig 2.

Generally, from all these policies it is obvious that wood as a renewable resource for biofuels production is prioritised and supported by the forest policy of the EU. Production of biofuels from the use of forests is furthermore favoured by employment and regional policies, as forestry and bioeconomy are expected to create new jobs [13, 24, 26]. Nonetheless, there are major differences in forestry policies among countries, which is not coordinated well, and which might work against each other, resulting in conflicts in the use of public money [29, 33]. In order to avoid such conflict, it will be necessary to study how different policies can co-exist in a meaningful way [6, 8].

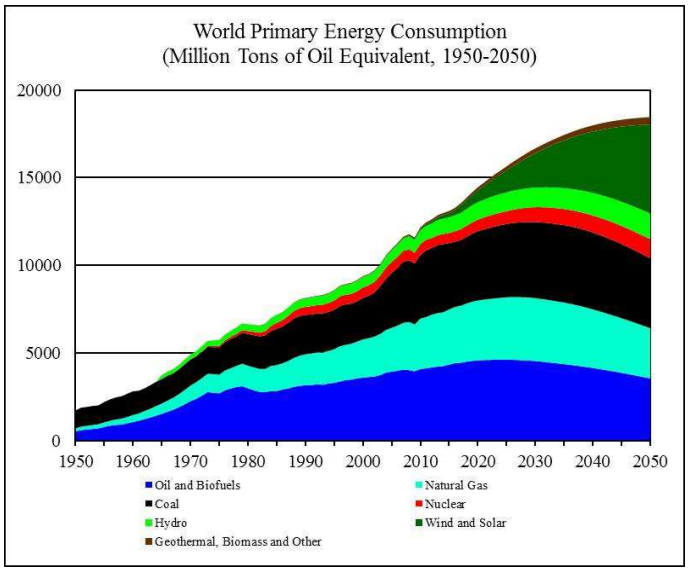

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Fig 2. Prediction of world energy consumption by the year 2050 generated from different renewable energy ources [3, 13].

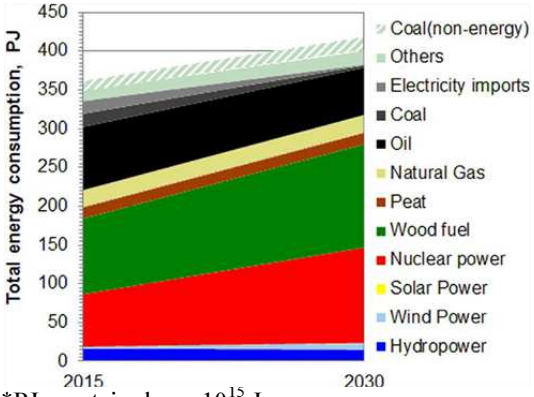
TRANSITION ANALYSIS OF THE FINNISH BIOECONOMY

Finland is a highly technology and natural resource-driven industrialised country with a market economy that is heavily dependent on (imported) fossil fuels [2, 3]. The main strengths of the economy and exports that count for one third of GDP in recent years lies in manufacturing within the forest sector, metals, engineering,

telecommunications and electronics. Except for wood and some minerals extraction, Finland mainly imports raw materials for its industry and components for manufactured goods [4]. The world financial-economic crisis had bad consequences for Finland, accompanied with decreasing demand for paper products and foreign political uncertainty in Russia, its largest export-import market, resulting in a major economic crisis in the period 2009-2017 [3, 28]. Therefore, when observing the potential for a bioeconomy Finland's starting position is among the best in Europe, biomass being its obvious strength since 70 % of the country is covered by forest. In parallel, countries with fewer forest resources than Finland are planning development of the bioeconomy by counting on import of biomass, e.g. Germany, France, the Netherlands [12, 28]. There exists traditionally a strong interaction and dependence between the paper industry, forestry and production of renewable energy, where forestry produces over 70 % of Finland's renewable energy, in the form of traditional biomass via burning wood logs for heating, adopting municipal heat distribution systems [15].

Finnish bioenergy is currently based mostly on side-streams and waste from the forestry and paper industries. By increasing the reliance on biofuels and nuclear power, Finland decided to cut the use of coal, and eliminate its use completely by 20130 (National Energy and Climate Strategy, 2016) [18, 28]. With this decision, Finland joined five other countries, Austria, Canada, France, Germany, the Netherlands, to be pioneers in the move away from coal. Fig. 3 illustrates the changes in the shares of the different energy sources in Finland planned by 2030 [17]. Wood-based bioenergy in Finland is expected to provide 32 % of energy needs by 2030 [15, 16].

The bioeconomy or, as it is called in Finland, the 'biobased economy', is, however, founded on the 'weak-conservative' sustainability concept, claiming that wood biomass is natural, abundant and endlessly renewable. Particularly, forestry naturally takes a leading role on the bioeconomy platform [23]. There are two opposing views, however, on the bioeconomy in Finland within academic circles; the one being very optimistic, assuming the bioeconomy is sustainable as such, the other expressing a more pessimistic view, which expresses that development of a bioeconomy reliant solely on forest biomass will have a net negative impact on sustainability [2]. Hence, when climate concerns are integrated in bioeconomy policy objectives, assuming unquestioningly that they provide benefit from sustainable economic development led by the forestry sector, there arise environmental challenges, such as the need to maintain biodiversity and the inherent unsustainable reliance on wood biomass alone as being CO_2 neutral (European Commission, 2016) [25]. Some authors argue that to have a successful transition to bioeconomy the stakeholder silo structure in Finland should be reconsidered, and a more technology-integrated solution is needed, i.e. a horizontal, cross-sectoral economic structure [13, 16, 28].



*PJ = petajoules = 10^{15} J

Fig. 3. Transition in energy resources in Finland by 2030, when use of coal for production will be banned and oil use will be reduced by a quarter by 2030. At the same time use of nuclear power will significantly increase / adopted from [18] /

Finland cultivates an innovation culture, and focus remains strong amongst researchers on alternatives to forest biomass reliance [4, 14]. Electric, flexi-fuel vehicles, solar photovoltaics, for example, are excepted to make up to 10 % of the personal car stock by 2030, as the investment has been made in nuclear power to meet such electricity demand increases (Finnish Energy Ltd, 2016) [16, 17]. Even though Finland has one of the highest spending per GDP on research and development in the EU, as recorded in International Energy Agency, 2016, it, nonetheless takes the risk to be marginalised once upcoming sustainability-related legislation within the EU caters for the emergence of alternative renewable energy sources.

Remote locations with low population density make Finland the perfect candidate to increase the use of decentralised energy generation solutions. In this respect, simply replacing one central source by another could mean losing an opportunity for sustainable improvement. However, even with this somewhat limiting case scenario, the proper selection of the source of energy for the final consumer could at least lead

positively to a more efficient distribution network.

In a context of circular economy, where the outputs of a process must be inputs into the next one. The distribution must take into consideration the "bidirectional" flow of goods. Efficiency, therefore, needs to be increased on both sides of this two-way exchange, much more so than today, because we currently think of only two unidirectional flows, one for distribution of supply and goods, and one for waste disposal.

Conclusions

The bioeconomy is gaining increasing attention due to the obvious change in climate and loss of biodiversity, but no less because of the economic opportunities presented in its development, often referred to as the "green gold rush" [3, 31]. With increased interest in forest harvesting for production of biofuels it will be necessary to create an integrated regulatory environment for recommendations and guidelines to ensure sustainable extraction of forest biomass. The risks of negative consequences in the utilisation of biomass are dependent on policies and regulation within different countries and at the European Union (EU) level, and include: risks for deforestation, food price increase, decrease in biodiversity, land and water quality degradation, air pollution and conflict due to land-grabbing [14, 34].

Whether the use of biomass to generate energy and raw materials is in a centralised or decentralised structure can have a big impact on the future development of a circular economy [20, 23]. Private fund investments could emerge to take the lead in areas where the national government finance is lacking resources, for example, in advancing necessary infrastructure. Care needs to be taken that such investments work positively toward sustainability and do not support vested interests amongst bioeconomy protagonists, resulting in a monopolistic energy, materials and/or mobility policy.

Finland provides a good model to monitor bioeconomic development., relying mainly on its historical experience and established resources in bioenergy and nuclear power, whilst it also demonstrates how scaling up of existing technologies may provide one solution to achieving a bioeconomy relying on its own natural resources [18]. Following this route alone, however, could mean that possible improvements arising from a decentralised energy generation could be overlooked in a country with low density population and remote locations. With most decisions concerning distribution networks being taken based only on the current unidirectional incoming flow model, whilst considering outgoing waste flows separately, restructuring is needed to establish a circular economy, in which bi or multidirectional flows, in and out, and once again into and out, must be key variables in the design of energy generation units, more or less centralised, and the efficiency of the distribution network, which in turn must include not only inputs but also outputs upgraded to future inputs.

The case for monitoring Finnish developments closely is further underpinned by the high-risk strategy of considering biomass usage alone as being CO_2 neutral, given the biomass regrowth and greenhouse gas reabsorption imbalance foreseen to arise if a 'weak-conservative' sustainability concept is the sole advancement mechanism [4,13, 16, 17].

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NITROGEN PLASMA SURFACE TREATMENT ON MICRO NANOFIBRILLATED CELLULOSE FILMS

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ABSTRACT

Micro-nanofibrillated cellulose (MNFC) films were formed from aqueous suspensions of progressively enzymatic pretreated wood-free cellulose fibres. The mechanical properties of each film are highly dependent on the enzymatic pretreatment time. The films were surface modified by exposure to dielectric-barrier discharge (DBD) nitrogen plasma, seen to increase wettability by both polar (water) and non-polar (hexadecane) liquids, but the increase is proportionally greater for the polar liquid. The change in surface chemistry is revealed using X-ray photoelectron spectroscopy (XPS). An increase in surface roughness acts to link the increase in both polar and dispersive components. The relative change between the polar and dispersive surface energy components favoured trapping of organic-based polar-solvent inks, such as are used in the production of printed solar cells.

Keywords: DBD plasma, nitrogen plasma surface treatment, nanocellulose films, enzymatic nanocellulose, printing of organic-based polar inks

INTRODUCTION AND BACKGROUND

Sustainability is one of the key targets for industrial practice today, and related research aimed at new biobased materials derived from renewable sources, is considered highly relevant in the emergent bioeconomy. In the bioproducts industry, micro nanofibrillated cellulose (MNFC) has attracted attention due to a number of potential applications, not only in forest products, such as paper and board manufacturing, but also in a broad range of industrial value chains, such as biodegradable packaging films, laminates for paper/board. MNFC has interesting intrinsic properties derived from high specific surface area, regions of crystallinity and hydroxylated surface chemistry, ideal for possible chemical modification. Films formed from MNFC are considered smart materials and are being researched for functional materials applications. One such application is as a substrate for printed solar cells using organic-based inks [1].

Enzymatically treated fibres used to produce cellulose nanofibrils provide higher crystallinity in the resulting nanocellulose, as enzymes digest amorphous cellulose. The surface properties of nanocellulose films, such as wettability, topography, chemistry, surface charge, the presence of hydrophobic and hydrophilic domains, density and conformation of functional groups, all play a crucial role in printability and barrier properties. Their ability to support controlled migration of solvent ink vehicle and chromatographic differentiation of ink components is important in the printing of IP inks, and especially for production of bio-based printed functionality in a wide range of applications, such as printed electronics and printed diagnostics [2, 3].

Solar panel inkjet printable (IP) photovoltaic (PV) inks contain a complex mix of materials, including the organic electron acceptor (p-type) and negative electron donor (n-type) suspended in solvent together with specific surfactant(s) intended to keep the p-type and n-type components de-mixed. Although especially drop-on-demand (DoD) IP is a

very competitive candidate for printing PV inks on film substrates, there are some limitations in respect to mutual compatibility between highly hydrophilic surface MNFC films and mixed polar-dispersive solvents constituting the PV ink [4-9]. This complexity of polar-dispersive surface energy balance is, therefore, critical.

The plasma technique is a convenient method to modify the surface properties of polymeric materials, keeping intact their bulk properties. Furthermore, it is an easy way to introduce the desired groups or chains onto the surface of materials with increased roughness. Surface properties of paper and cellulose based materials also may be altered by plasma treatment techniques using careful control of operational parameters, including the gas used, reaction conditions (power, pressure and exposure time) and the reactor geometry [10].

In this work, we aim at modifying the MNFC film surfaces using nitrogen plasma to enhance their amphiphilic surface affinity to polar and non-polar IP PV inks. Surface energy (sessile drop method), surface roughness (atomic force microscopy (AFM)) and X-ray photoelectron spectroscopy (XPS) were used to parameterise the MNFC film surface before and after plasma treatment. The affinity for IP PV ink was assessed visually after inkjet printing.

The mechanical properties of the obtained films were studied to ensure satisfactory film strength.

MATERIALS AND METHODS

Preparation of MNFC

For the manufacture of short MNFC fibrils, the pulp was first washed to create the sodium form by adding sodium hydroxide to a 2 w/w% fibre suspension until the pH reached 10, and then re-washed with deionised water to a conductivity of 8.2 µS. The enzymatic treatment was performed with a commercial enzyme ECOPULP® R (Ecopulp Finland Oy), a genetically modified strain of Trichoderma reesei fungus. An amount of 3 mg of enzyme per gram of pulp fibre was added to a 2.5 w/w% suspension and the temperature was increased to 57 °C at pH 5.5 during hydrolysis, whilst keeping under constant agitation. The period of digestion was increased for each subsequent sample in 30 min steps, Table 1. The enzymatic activity was terminated by adjusting the pH to 9-10 by sodium carbonate and increasing the temperature to 90 °C. After cooling the suspension overnight in cold storage, the samples were refined through an homogeniser (model M-110P, Microfluidics, USA) under a pressure of 2 000 bar through a 100 µm flow gap. The solids content of the MNFC suspension after the fluidisation was 1.65 w/w%.

Enzymatic hydrolysis of pulp as a route for production of low-charged MNFC results in production of short fibrils, which have much lower aspect ratio than MFC and NFC produced via chemical oxidative pretreatment or mechanical refining alone, as presented in Fig. 1, observed with imaging comparing MNFC/300/ and MNFC/0/ suspensions, i.e. Fig. 1a) reveals much shorter fibrils obtained upon 300 min of enzymatic hydrolysis.

Enzymatic treatment time / min	0 (reference)	30	60	90	120	150	180	210	240	270	300
Sample label	MNFC /0/	MNFC /30/	MNFC /60/	MNFC /90/	MNFC /120/	MNFC /150/	MNFC /180/	MNFC /210/	MNFC /240/	MNFC /270/	MNFC /300/

Table 1. Materials used in this study: bleached hardwood Kraft pulp treated with enzymes under controlled conditions, with progressive increase in enzymatic digestion time by 30 min steps for each subsequent sample.

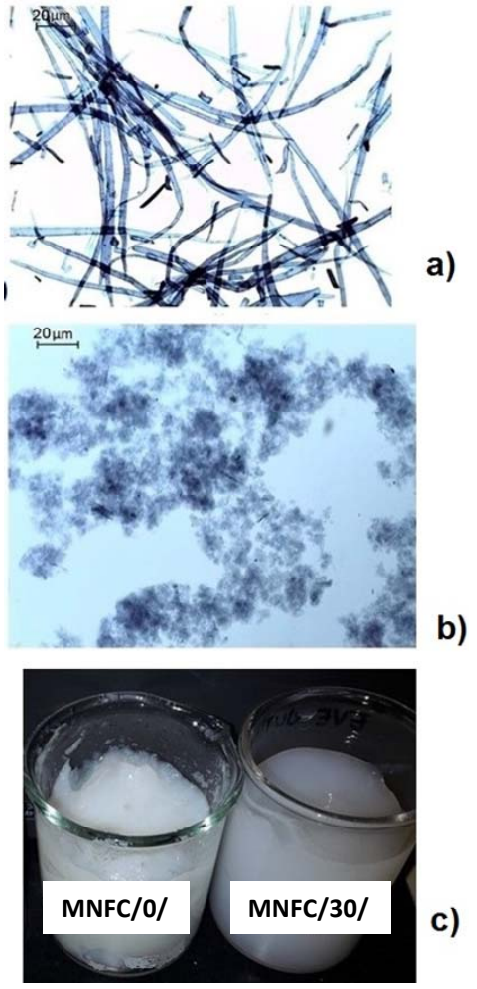

Fig 1. Images of fibrils sample suspensions obtained with optical microscopy revealing the effect of processing conditions on the fibril size and aspect ratio: a) without enzymatic treatment produced MNFC/0/ yielding long fibrils, b) MNFC/300/ short, low aspect ratio fibrils, and c) displaying the corresponding 2 w/w% MNFC suspensions of MFC/0/ and MNFC/300/, showing the difference in gelation strength due to the different size of fibrils and corresponding water dispersed within the fibrillar matrix.

MNFC film preparation

Depending on enzymatic treatment time, the resulting MNFC suspension viscosity decreased significantly, and so the solid content for preparation of the respective films ranged from 0.6 w/w% to 1.9 w/w% to meet the target film grammage of 60 gm^{-2} produced under conditions of 23 °C and relative humidity (RH) 50 %. Films were made on a sheet-former according to ISO standard 5269-1, with some modification of the screen to aid fines retention. The system was pressurised to 0.3 bar and the sealing lid was used on the sheet-former, with a 10 µm mesh supplemented nylon screen in addition to metallic wire screen, so that the slurry of pulp was poured at high viscosity onto the former without adding water or stirring the slurry. Double-sided adhesive tape, width of 5 mm, was attached to the edges of the drying plate between plate and formed film, with purpose of fixing the edge of the film to prevent it shrinking during drying.

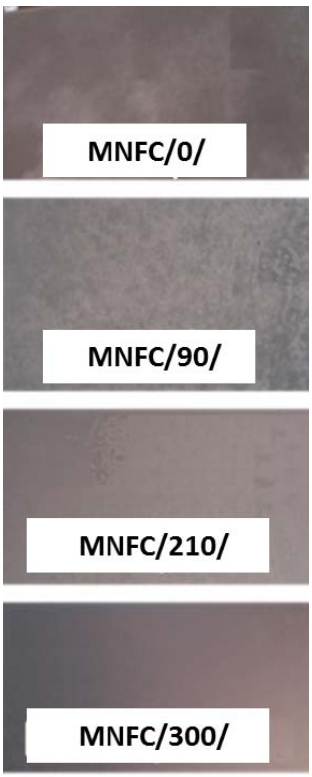

Fig. 2 Samples of cut-offs (60 x 15 mm^2) from MNFC films produced from pulp refined with different enzymatic pretreatment time (Table 1). Transparency and uniformity of films increases with hydrolysis time.

Material treatment and characterisation

Optical microscopy was used to study the fibrillar sample suspensions and films using an Olympus BX 61 microscope equipped with a ColorView 12 camera. The water retention value (WRV) of the MNFC was determined in accordance to the standard SCAN-C 102XE with a slight modification in that a polyamine monofilament open mesh fabric SEFAR NITEX® 03-1/1 with a pore size of 1µm was placed on top of a 125 µm metal screen. The experiment was performed in triplicate for each sample.

Plasma treatment

Dielectric Barrier Discharge (DBD) plasma operates in a thermodynamically non-equilibrium condition (so-called cold plasma) in which the ion

and molecular translational temperature is much lower than the electron temperature, such that excessive gas heating can be suppressed. The advantage is that the plasma can be generated at atmospheric pressure, both in open or closed environment. In an open atmosphere the plasma discharges can be produced with a gas flow between the electrodes. A further attractive characteristic of the DBD plasma at atmospheric pressure is that it can be used to modify or activate surfaces of a wide range of materials, from polymers, textile fibres to biological tissues, without damaging them. To generate the DBD plasma we used a home-made device built at the Faculty of Physics, University Belgrade, Fig. 3. The DBD is assembled in a chamber with nitrogen gas injected into the discharge volume (6 dm^3min^{-1}) through ten equidistant holes to ensure homogeneous gas flow. MNFC films were treated for 0 s, 30 s and 60 s, respectively. The device was operated at 300 electric field pulses per second (Hz) for the prescribed durations of time.

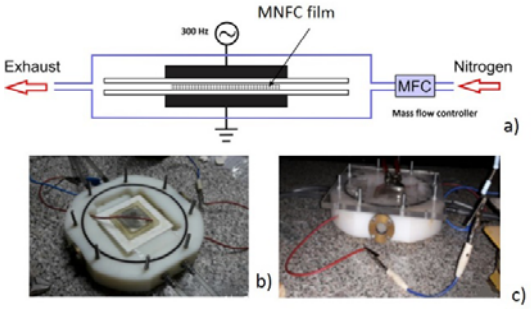

Fig. 3. DBD device with two electrodes and sample placed between them: a) schematic illustration of DBD plasma devise, b) plasma chamber housing the sample placed 1 mm from the upper electrode, and c) closed plasma set up with glass lid placed above the top of the upper electrode.

Free surface energy (FSE)

Measurement of high energy surfaces

Most liquids are rapidly spreading on a high energy surface, and so a representative contact angle (CA) cannot be readily measured. Schultz (1977) [11] developed a method where CA can be measured by submerging the surface in one liquid and using a second liquid to measure the contact angle. In this case a hydrocarbon n-hexadecane is used as the submerging liquid having the purely dispersive liquid-vapour surface tension of $\gamma_{LV}^{h} = 27.4$ $mJ.m^{-2}$, much lower than the expected surface free energy of the MNFC samples, and water as the contact angle liquid with the highly polar liquid-vapour surface tension $\gamma_{LV}^{w} = 59.4$ $mJ.m^{-2}$. A sessile drop of water is lowered into contact with the horizontal film immersed under hexadecane using a precise pipette delivering 70 µl of liquid and the progressive change in drop shape due to the change in CA recorded with a Nikon camera (D5000) in time steps of 1 ms. The CA of water is also recorded separately to represent the print challenge of a highly polar ink. For each given MNFC sample and given liquid data variation is within 10 %. The identification of contact line geometry and evaluation of CA uses numeric software tools, as presented visually in Fig. 4. For a parallel optimal method for polar FSE determination with water alone, the Girifalco and Good approach [12], combined with the Neumann equation of state was used. This latter allowed the polar contribution to SFE be estimated and thus can be added to the formerly measured dispersive component. Each measurement was conducted five times.

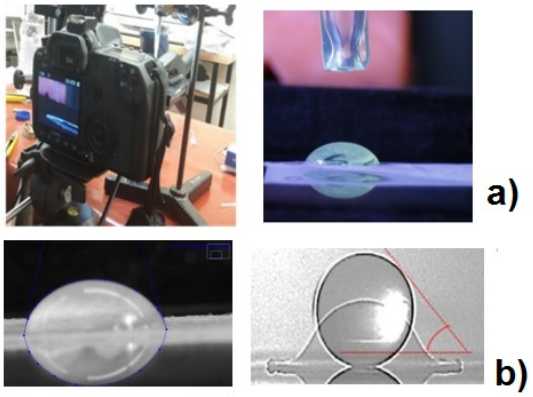

Fig. 4. Contact angle (CA) measurements as made at the Belgrade Institute for Physics: a) set-up for evaluating water CA under n-hexadecane with camera, b) determination of CA with use of image processing software and Java program for calculation.

Surface topography

Plasma action on the film surface can lead to a degree of debonding of fibrils as well as electrostatic charging and potential for subsequent additional moisture adsorption. Such changes can lead to re-conformation of the surface, even though no mechanical forces have been applied. The change in topography of the MNFC films was investigated by Atomic Force Microscopy (AFM) (Veeco Instruments, model Dimension V). using a MultiMode 8 with Bruker NanoScope V controller. Each MNFC film sample was dry-cast onto a Mica support for AFM imaging. Micrographs were obtained in trapping mode under ambient conditions, using TAP 300 tips (resonant frequency 300 kHz, line force being kept constant at 40 Nm^{-1} and the AFM images were processed and analysed with the Bruker NanoScope Analysis 1.5 software.

Mechanical properties

Mechanical properties of the MNFC films were measured by a MTS 400/M vertical tensile tester equipped with a 20 N load cell. The instrument was controlled by a TestWorks 4.02 program. Specimen strips with dimensions of 60 x 15 mm^2 were clipped from the MNFC films with a lab paper cutter. The thickness of the strips was separately measured with an L&W micrometer SE 250. The gauge length was 40 mm and the testing velocity was 0.5 $mm.min^{-1}$. The results are presented as an average value obtained from five parallel specimens. The suspension was filtered subsequently using a Britt Dynamic Drainage Jar (DDJ), stirred by an overhead stirrer at 200 min^{-1} (rpm), based on Tappi test method T261cm-00, to collect fibres retained on the 200-mesh screen (105 μm).

Surface chemical composition

Surface composition of the MNFC films was evaluated with X-ray photoelectron spectroscopy (XPS), using a Kratos AXIS Ultra electron spectrometer, with monochromatic Al Kα irradiation at 100 W and under charge neutralisation. Both the untreated MNFC films and plasma treated specimens were analysed. For the preparation, samples were pre-evacuated for at least 12 h, after which wide area survey spectra (for elemental analysis) as well as high resolution regions of C1s and O1s were recorded from several locations, and an in-situ reference of pure cellulose was recorded for each sample batch (Johansson and Campbell 2004). With the parameters used, XPS analysis was recorded on an area of 1 mm^2 and the analysis depth is less than 10 nm. Carbon high resolution data were fitted using CasaXPS and a four component Gaussian fit tailored for celluloses.

Printing

The photovoltaic (PV) inkjet printing inks (IP) contain a complex mix of materials, solvent and surfactants that keep the p-type and n-type components de-mixed. A piezoelectric laboratory scale drop-on-demand (DoD) materials inkjet printer (Dimatix 2831-DMP) was used to test the printability of the plasma treated MNFC films. The solvent of the IP ink is 3-methoxypropionitrile, which is highly polar and non-volatile (boiling point 164 ºC), viscosity 1.2 mPa.s and density 0.937 gcm^{-3}, as stated by the supplier, Sigma Aldrich. The surface tension measurement was performed on the ink with an optical tensiometer (CAM 200 from KSV instruments) in pendant drop mode, giving a value of 29.2 $mN.m^{-1}$ ($mJ.m^{-2}$)

RESULTS AND DISCUSSION

The change in dewatering of the MNFC suspensions and change in fibre morphology, expressed as the fines content using the dynamic drainage jar (DDJ), are given in Table 2.

It is clear to see that with increase in enzymatic hydrolysis time, dewatering decreases as fibrils become thinner and smaller, and suspensions become more gel-like. At the same time, crystallinity of fibrils increases.

The *mechanical and optical* properties of MNFC films are presented in Table 3 where it is evident that the sheet density of the films increases with increase in hydrolysis time, while the packing density of the smaller crystalline particles increases. The permeability of those films created with the finer nanofibrils obtained after 120 min hydrolysis in turn falls rapidly, and it was not possible to measure using air flow techniques. The light scattering coefficient decreases also as the packing density is increased and the amorphous parts of the cellulose fibres were reduced, while, due also to higher packing density, the elasticity modulus increases, showing that films had improved strength.

Table 2. Properties of MNFC suspensions

MNFC suspensions properties		
Enzymatic treatment time / min	WRV / cm^3g^{-1}	DDJ fines value / %
0	1.25	93.8
30	1.61	88.8
60	1.83	79.5
90	2.19	62.4
120	2.55	27.0
150	2.85	21.0
180	2.98	11.8
210	3.33	9.6
240	3.37	6.5
270	3.32	1.5
300	3.34	0.2

Table 3. Mechanical and optical properties of MNFC films

Film properties					
Enzymatic treatment time / min	film weight / gm^{-2}	density / gcm^{-3}	permeability / $\mu m(Pa\ s)^{-1}$	light scattering coefficient / m^2kg^{-1}	E-Modulus / GPa
0	73.91	0.637	69.86	37.43	2.53
30	76.12	0.794	9.96	22.83	4.16
60	71.35	0.910	1.06	16.12	5.12
90	72.31	1.016	NA	9.94	7.02
120	70.53	1.090	NA	6.93	8.59
150	70.81	1.127	NA	5.81	9.13
180	69.57	1.145	NA	4.48	8.95
210	71.08	1.178	NA	3.74	11.26
240	70.10	1.179	NA	3.08	9.17
270	71.18	1.226	NA	3.11	9.76
300	65.27	1.187	NA	3.31	10.03

Roughness colour contour and profile plots of the surface of MNFC/30/150/300 films before and after plasma treatment are presented in Fig. 5. Before plasma treatment, the roughness of the films is directional, being different in in the two measured directions (red and blue profile lines). The map for MFC/30/ indicates that there are voids present between 1-2 µm wide, while in the case of MFC/300/ the surface is flatter with less voids and of much smaller size. This means that the degree of enzyme hydrolysis directly increases the resulting smoothness due to the ever finer fibrillar elements produced, as the crystalline parts are separated due to breakdown of the amorphous constituent. After plasma treatment, the amorphous material containing surfaces, e.g. MNFC/30/, are also seen to become relatively rougher than the highly hydrolysed crystalline films, e.g. MNFC/300/. The action of the plasma is to increase voidage in the courser particulate systems, as previously described, due to effects of charge, fibril debonding etc. In MFC/30/, it is possible to identify irregular both small and large voids appearing after plasma treatment, while in MFC/300/, the surface of the film has almost no such jagged appearance with only voids smaller than 1 µm. Nitrogen plasma treatment, thus, obviously changes the morphology of the films, on both the micro (nano) and macro level, which is likely also to have an influence on the wetting behaviour and decrease in CA due to the increased meniscus liquid-solid wetting line length.

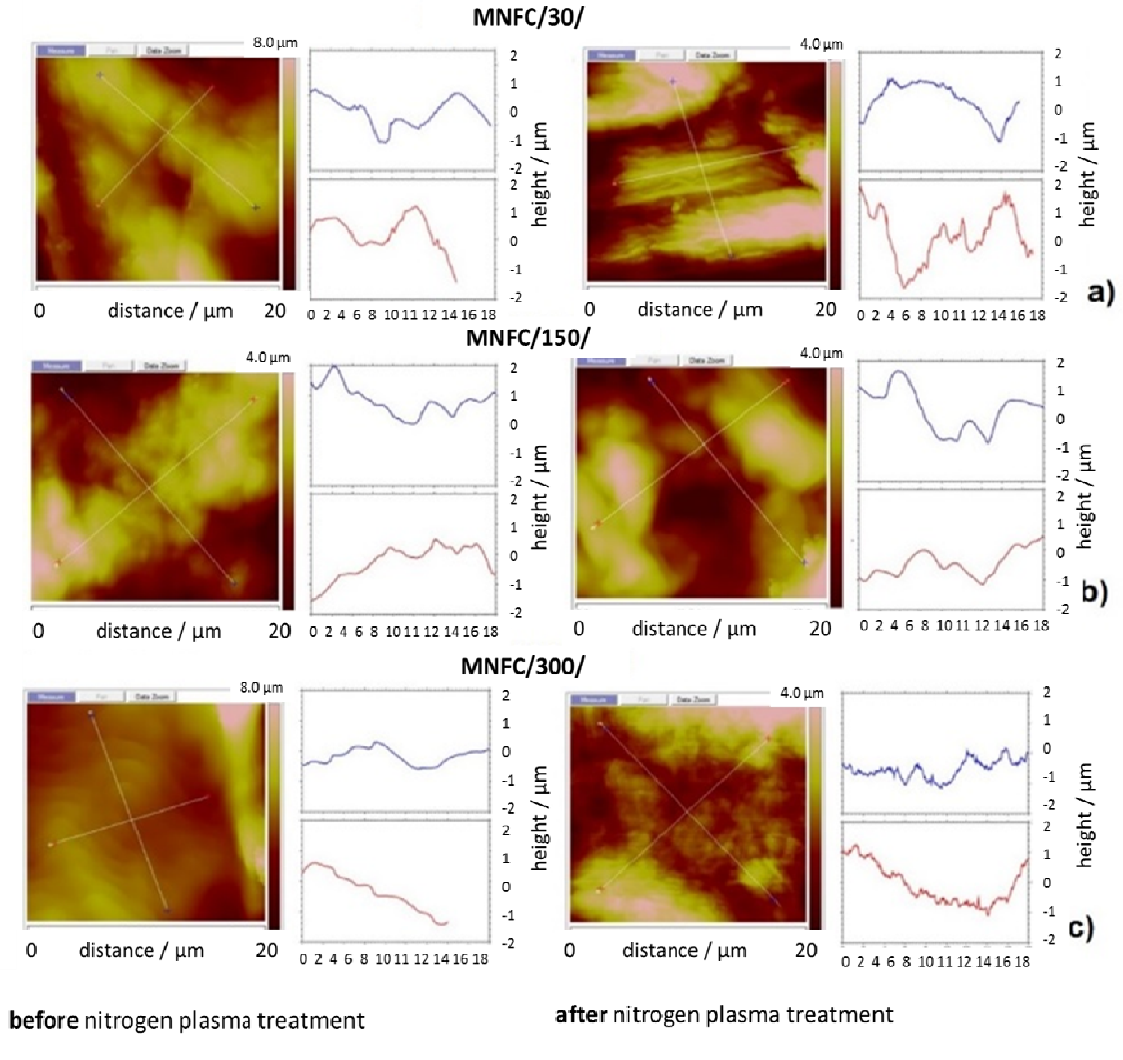

Fig. 5. Surface morphology and roughness of (a) MNFC/30/, (b) MNFC/150/ and (c) MNFC/300/ before and after nitrogen plasma treatment

The *surface chemical species* are revealed by the XPS spectra, from which the atomic % of C-C, C-O, O-C=O and N can be derived, Fig. 6. The effect of surface modification after nitrogen plasma can be clearly seen as the level of N attachment increasing as a function of the enzymatic removal of

amorphous content [13, 14]. The samples with increased crystalline proportion after longer enzymatic treatment nonetheless show similar C-C bond content. Similarly, with reduction of the amorphous part with increased hydrolysis, the amount of C-O groups decreases while C=O groups are formed, and other groups, having C atoms, form with N atoms.

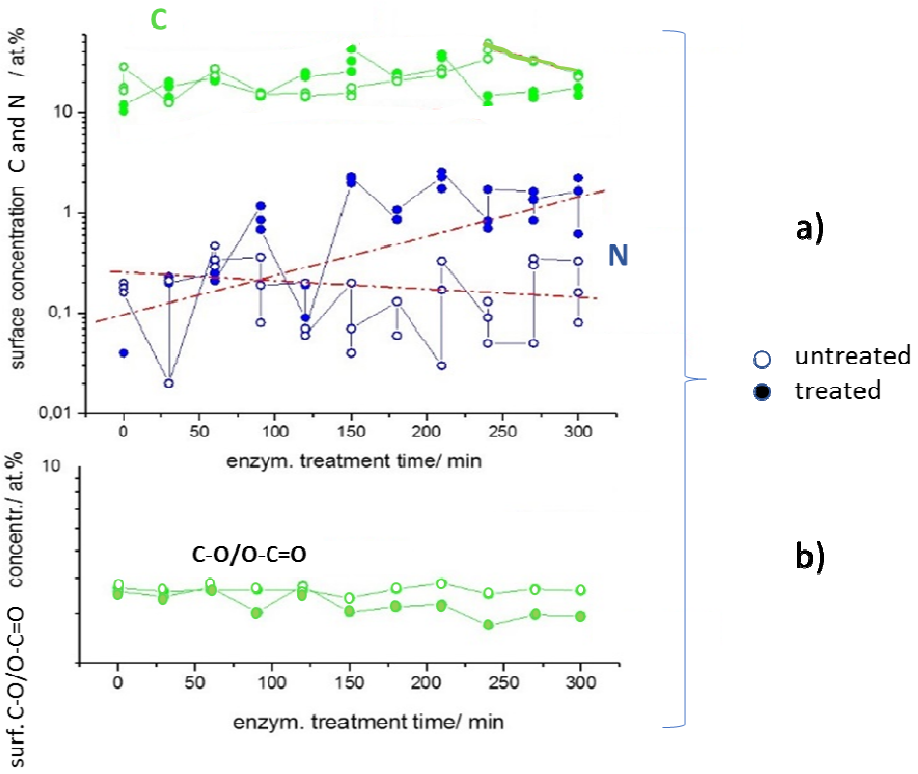

Fig. 6 Surface modification obtained through XPS data showing (a) increase in N atoms at constant carbon content, and (b) change in ratio of C-O/O-C=O groups.

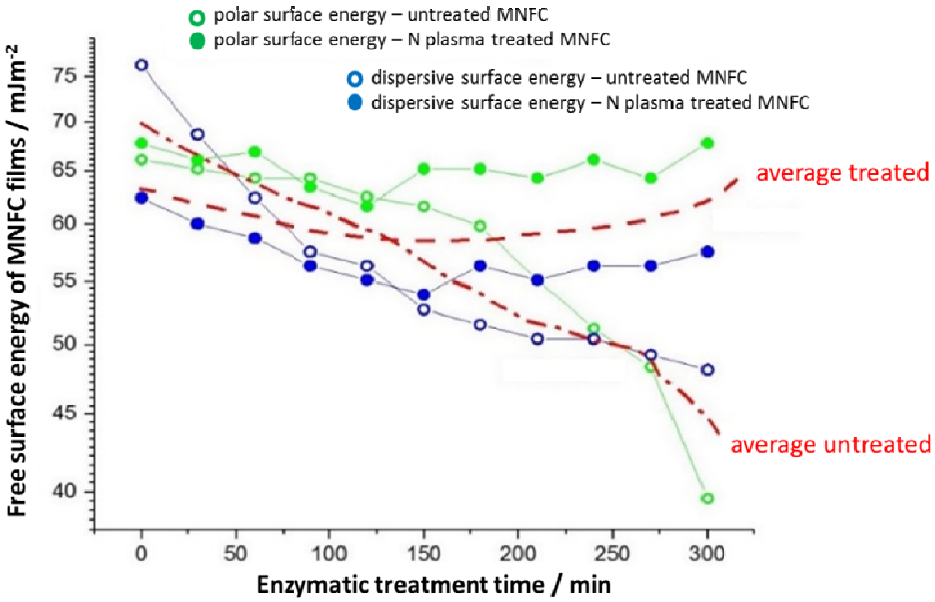

Fig. 7 Free surface energy (FSE) of MNFC films as a function of the treatment time (Table 1).

Results from Fig. 7 reveal that with the increase in enzymatic treatment of the raw material pulp, there is a reduction of total FSE in the corresponding MNFC films, corresponding with a reduction in both polar and dispersive energy of the untreated samples (green and blue unfilled symbols, respectively) [15, 16]. A reversal of the decline in FSE as a function of enzymatic treatment can be observed resulting from nitrogen plasma treatment, showing compensating increases in both polar and dispersive measured components (green and blue filled symbols, respectively). Thus, an increase in wettability for water and n-hexadecane is reflected by a decrease in CA as the plasma treatment acts on the more crystalline samples [17-19]. However, as the roughness is also seen to increase as a function of plasma treatment for the lower crystalline samples (less exposure to enzymatic breakdown), one would expect from the Wenzel model that the wettability would increase. That we see a recorded increase in n-hexadecane CA, and thus decrease in dispersive FSE, we can conclude that the action of the plasma discharge on the amorphous part is initially to reduce the dispersive energy component, and so likely act, at least partially, to breakdown first the amorphous content resulting in debonding and hence roughening [20-22]. This effective etching of amorphous parts of fibrils, is then replaced by the action of nitrogen attachment, such that the higher average FSE values regained in the more crystalline samples after plasma treatment are significantly higher than the theoretical FSE 59.4 $mJ.m^{-2}$ of cellulose, and this is achieved via the major contribution of the plasma-induced increase in polar component.

The increased contribution of the polar component in the FSE donated by the cationic N adsorption under plasma exposure is, therefore, expected to enhance the compatibility with the application of highly polar inks, especially if their components are anionic. The images in Fig. 8 confirm this expectation, where the improved wetting of the surface by water as a function of plasma exposure time is paralleled by the greater pick-up of ink colorant.

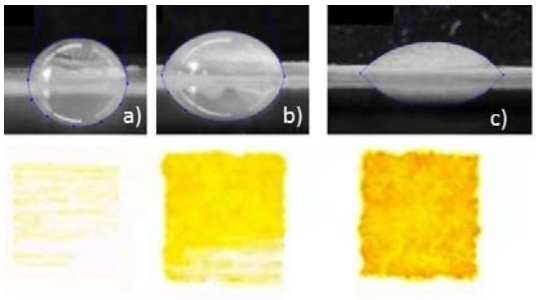

Fig. 8 IP ink printed on MNFC/300/ film showing the dependence on wettability of the surface after nitrogen plasma treatment; lower water droplet CA on the film corresponds with a significant increase in print colour density: (a) untreated film, (b) plasma treated for 30 s and (c) plasma treated for 60 s.

SUMMARY AND CONCLUSIONS

Micro nanofibrillated cellulose films formed from aqueous suspension can be made stronger by pretreatment of the raw fibre using enzymatic hydrolysis. However, the wettability by ionic liquids, including functional inkjet printing inks, such as are used for printed electronics, solar cells etc., decreases as a result, limiting the use of such films in practice. Nitrogen plasma treatment, however, enables wettability by such formulations to be improved. The mechanism by which this occurs has been studied in this work presented in this paper and the following conclusions can be drawn:

- Total surface energy increases with nitrogen plasma treatment of highly enzymatically hydrolysed fibrillar films (contact angle decreases), with a major increase in the polar component.

- Dispersive surface energy initially decreases on unpretreated or low enzymatic treated films on exposure to nitrogen plasma, whereas the polar surface energy component remains relatively unchanged.
    - This effect is related to the interaction of the nitrogen plasma with the amorphous cellulose component in the non-hydrolysed fibrils.
    - The dispersive energy component can once again be increased by exposure to nitrogen plasma in the case of the more crystalline fibrillar material derived from increased hydrolysis via enzymatic pretreatment

- Highly ionic liquids, water and solvents typically used to disperse surfactant-containing organic-based inks, wet MNFC film better as hydrolysing pretreatment of fibres is increased and subsequent nitrogen plasma is applied.

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An Analysis of defects in products and processes of a Furniture Production Company and possible Improvements in the Framework of Auto-control and Normalization of Workstations: a Case Study

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Abstract. The present article aims to implement self-monitoring procedures through the treatment of internal complaints of non-conforming products and the normalization of workplaces (Standard Work) in the areas of self-monitoring through the creation of work instructions to support production in a furniture production company.
Using certain tools such as Pareto diagram, Ishikawa diagram, flowcharts, among others, it was possible to do a detailed analysis of the store floor and to identify different ways of executing said tasks.
Through this analysis, it was possible to verify a lack of standard work in the areas of self-monitoring, rework, waste, and also a high number of defects. As such, through the implementation of self-monitoring procedures and standard work, it was possible to overcome these problems and the main improvements were: reduction of error rates, increased employee mobility, easier problem visualization, easier learning of new tasks and reduction of variability in task execution.
Keywords: *Standard Work; Self-monitoring; Work instructions*

1. INTRODUCTION

In recent decades, the sustainability concept has acquired growing importance, and a large number of methodologies, tools, standards and regulations have been developed to promote the implementation of its principles inside industrial companies [1]. With the implementation of more effective techniques it is possible to increase productivity, prevent failures and reduce waste [2].
Intensifying global competition and increasing demand for better quality by customers have caused more and more companies to realize that they will have to provide high quality product and/or services in order to successfully compete in the Marketplace [3].
Therefore, in order to increase the quality of products and services, continuous improvement methodologies are implemented, which include Total Quality Management (TQM) and the PDCA cycle, in addition to quality tools and Lean tools such as Standard Work.
Standard Work is cited as one of the most important elements of the Lean methodology [4], which is used in the improvement of organizational performance and to reduce error rates. Standardization is achieved by setting formal rules to guide employees' activities, which are operationalized in organizations by means of work instructions, guidelines, manuals, and work procedures [5]. Standard work consists of three crucial elements [6]: the cycle time, that is, the time needed to compile a task, the sequence of operations and, finally, the WIP (work in process), that is, the amount of stock between operations.
This being said, Standard Work is not a rigid work normalization that never changes, on the contrary, Standard Work is a level of fluctuation of work that has to be worked on by people and machines, daily, in order to satisfy the client's demand. In other words, normalization should incorporate both the products and the processes so as to ensure the low price of the products, the high quality and a short delivery time for each product [7]. Figure 1 shows the formula used to stabilize standards.

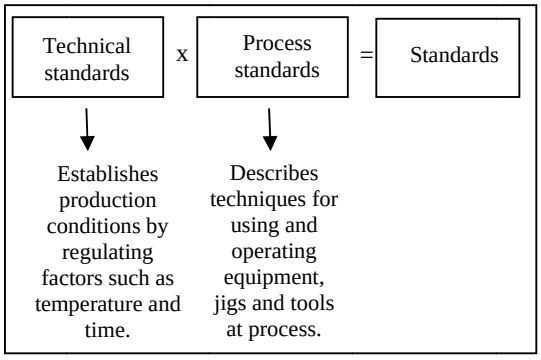

Figure 1 – Formula to stabilize standards (adapted from [7]).

Given the potential advantages of Standard Work it was decided to implement it in the areas of self-monitoring so as to fix the lack of standard work method in the production lines, the high percentages of defects that were detected and the scrap produced. The lack of document normalization, such as documents that are in workstations for the verification
of self-monitoring and documents that register internal complaints, is also a problem that needs to be overcome.
Self-monitoring arose due to the increase in quality restrictions [8].
It is a management tool that helps control the production right at the workstation, which contributes to the quality of the final product and also to the decrease of the factory costs because it does not require any sort of rework at the end of the production line [9].
In this article, all internal claims, i.e. defects that don't reach the end customer and that are detected and fixed in the repair section during the final inspections, were analysed in order to try to implement self-monitoring procedures on the production lines in order to minimize the number of defects produced.
From the data on Figure 2, it can be observed that roughly 40% of internal claims have as defects the thinning/high edge and wrong drilling.

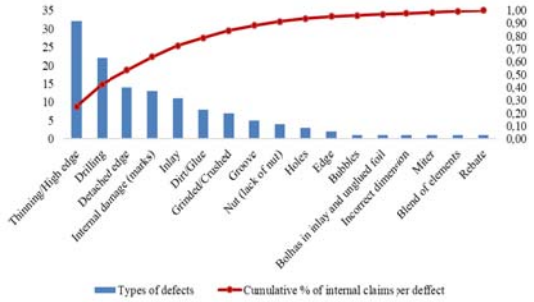

Figure 2 – Pareto chart of the main defects and their respective accumulated percentage.

In order to analyse production, in terms of quality, it is also necessary to analyse the scrap produced. During the analysis period, 116 025 pieces were scrapped out of a total of 1 3928 924 pieces produced, giving a scrap rate of 0.83%.
On Figure 3, it is possible to observe the scrap values (€) for different types of defects. There are four defects that are responsible for near 60% of the scrap value: marks and scratches, damage to flat sides, transport and handling of parts and wrong drilling.

Using the data obtained in the analysis of internal claims and produced scrapped, it is possible to understand which are the most critical defects, and, in a next phase, implement self-monitoring procedures to decrease the rate of defects. Besides this, and as the main focus of the article, all the work tasks performed in the areas of self-monitoring were analysed with the aim of creating a standard and also

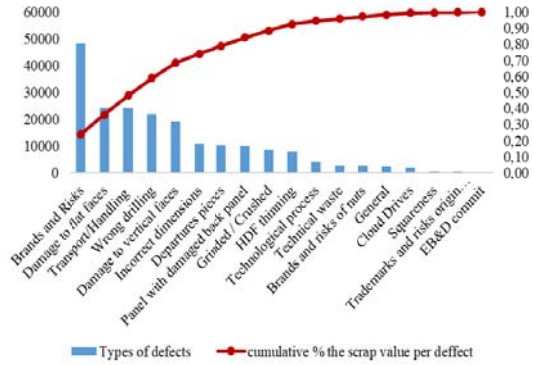

Figure 3 – Pareto chart showing the scrap value per defect.

creating all the work instructions necessary for the execution of said monitoring tasks.

The lack of documentation associated with the tasks executed in each workstation carries a bigger difficulty for new employees, because it implies a waiting time where more experienced workers can demonstrate how to perform the tasks and it can also lead to an increase in defects and failures caused by the new employee. This way, the introduction of future workers in the production lines was difficult due to the lack of support such as work instructions, where it is described, step-by-step, all the procedures that are to be carried out. Because each employee works their own way, this led to a difference in the productivity indicator and also made it difficult to determine the source of the quality defects and the problems that arose on the line. Because of these difficulties, there was the need to create a new work method to be followed equally by all teams, as well as to create their respective work instructions.
For a better visualization of the problems encountered, Table 1 presents a summary of all the problems identified during the project. For this, the 6M1E technique was used (Men, Method, Materials, Machine, Management, Measurement and Environment).

Table 1 – Summary of the problems encountered.

	Problem
Men	Self-monitoring tasks not normalized. Insufficient number of workers in the final inspection workstation.
Method	Production parameters not normalized. Excel file for internal claims not normalized. Document for the verification of first piece OK and periodic control not normalized.
Materials	Calipers used are not adequate to measure drilling. There are several non-conformities in the area due to the lack of material to verify the parts during self-monitoring.
Machine	The equipment used to segregate quality defects is fallible. High quantity of detached edge and wrong drilling.
Management	Lack of work instructions.
Measurement	Information given to workers is difficult to understand (filling in the paper for first piece OK and periodic control and technical drawings).
Environment	Workers unsatisfied with environment conditions (room temperature and noise)

2. METHODOLOGY

The research methodology used was the method action research, characterized by the application of theory to practice and that learns with the process to improve the theory [10]. The main idea of this methodology consists on using a scientific approach to solve important operational problems, together with those that directly experience these problems [11].

Following the logic of the methodology, all the non-conformities, caused both by the workers and by the process, were initially analysed with the aim of establishing goals to reduce the frequency of non-conformities and, later, the implementation of self-monitoring procedures.

In a subsequent phase, all the tasks executed during the inspection tests, i.e. during self-monitoring, were analysed. This analysis was crucial because it allowed the registration of the time spent to complete the production cycle (takt time), the time spent on each task, the identification of all the manufactured products and the verification of the work tools being used in each task, as well as how they were being used.

This data was obtained through the use of quality tools, such as: Pareto diagram, flowchart, and cause-effect diagram and verification sheets.

This analysis also allowed for a better understanding of the different ways of executing the same tasks, and, later, deciding which was the best way. Therefore, a very thorough analysis of the best sequence of tasks was made in order to make a combination of sequence of tasks and their times, defining alternatives to the current method in use.

When the plan of action was thoroughly planned and accepted, it was time to implement the improvements.

For most of the problems identified in Table 1, improvement proposals were presented, as seen in Table 2.

Table 2- Summary of the proposals for the improvement of the problems identified.

Problems	Proposed improvements
- Self-monitoring tasks not normalized. - Insufficient number of workers in the final inspection workstation.	- Self-monitoring tasks normalized through the filming of workers of different shifts, study of times and movements made by the workers. - Increase in the number of works in the final inspection workstation.
- Excel file for internal claims not normalized. - Document for the verification of first piece OK and periodic control not normalized.	- Creation of a new Excel file with only the necessary fields for the analysis of data of internal claims - Alteration of the document (modification of the layout and custom preparation of the document per workstation)
- Callipers used are not adequate to measure drilling. - There are several non-conformities in the area due to the lack of material to verify the parts during self-monitoring.	- Implementation of self-monitoring procedures: • Introduction of a new callipers with a longer range and less variability/error • Introduction of gauges
- Lack of work instructions.	Creation of 45 work instructions in the areas of self-monitoring
- Information given to workers is difficult to understand (filling in the paper for first piece OK and periodic control and technical drawings).	- Alteration of verification sheet for first piece OK and periodic control

It should be mentioned that of all the suggestions for improvement that were presented and implemented, the one with the most importance for the company was the drafting of work instructions that will be used as support for the execution of tasks.

For the preparation of the work instructions it was necessary to acquire all the detailed knowledge of

the production process and the tasks associated with it. For this, it was decided to interview all the operators of different shifts. After all the information collected was passed to the preparation of working instructions. For the elaboration of the work instructions, the company had two templates, the Standard Operation Sheet (SOS) and the Work Element Sheet (WES). The SOS details the exact procedures for each task and the time required to accomplish it and the WES serves to detail some specific activity described in SOS. Thus, for a better understanding of the elaborated working instructions, figure 4 illustrates the SOS created for the self-control performed in the first piece OK and figure 5 illustrates the WES created for the activities that needed to be detailed in SOS.

Figure 4 - SOS: Self-control of the first piece OK

Figure 5 - WES: Self-control of the first piece OK.

3. CONCLUSIONS

Throughout this project, the main goal was the implementation of self-monitoring and standardization procedures and their respective documentation. To understand the possible causes for the problems previously identified, it was necessary to study in detail the production system. Besides this, it was equally crucial to understand the area flows, both for material and for people. As such, the project started with daily interviews to the workers of the study area. Then, all the different ways of executing a task were compared and the data relating to the self-monitoring task was gathered. This way, several problems were identified, as well as some opportunities for improvement, which were used as a foundation to normalize all the tasks. Thus, a few improvement proposals were presented which consisted mainly on the elaboration of work instructions. 45 self-monitoring work instructions were drafted, however, it was not possible to predict the impact of the work carried out because this would require a very slow and arduous process. The implementation of this kind of instructions is almost always difficult because the workers seem reluctant to learn new tasks. It should still be noted that all the work performed is very much dependent on the company goals and the problems they wish to tackle first. It is crucial to get the workers more involved in a culture of continuous improvement, considering that improvement is a never-ending process and one should always try to improve what has already been done.

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PROCESS CAPABILITY IMPROVEMENT BY IMPLEMENTING SPC AND DOE IN POWER TRANSFORMERS MANUFACTURING

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Abstract. *The paper presents implementation of SPC system in a major Asian power transformers manufacturer. After identification of capability issues in a current processes DoE was used for process optimisation, which resulted in a deployment of the robust process with capability and performance indices exceeding Six Sigma requirements.*
Key words: *Statistical Process Control (SPC), process capability, Design of Experiment (DoE), voltage transformer, resistance, Six Sigma*

1. INTRODUCTION

The implementation of Statistical Process Control (SPC) is the main technique for monitoring and quantification of process variability and capability [1], which has remained in manufacturing practice for more than a century. Even the most contemporary business improvement initiatives still relay on SPC as one of the most important segments [2]. The ultimate goal is to deploy SPC company-wide in all business process, to systematically and consistently trace the variability and promote process error eradication [3]. To quantify process behaviour, the most commonly used indices are Cpk (process capability) and Ppk (process performance). For any kid of distribution, the main difference is that Cpk takes into account only the average values in all samples, while Ppk considers the whole process i.e. all individual values in all samples, showing its long term perspective.

However, SPC itself is not a tool to improve process capability. The process optimisation by the Design of Experiment (DoE) is the main techniques to increase process capability and performance. Among a number of DoE methods, the Taguchi's robust process design stands out since it simultaneously addresses both the process characteristic mean and variability using signal-to-noise (SN) ratio and quality loss (QL) function [4]. The process robustness implies the acceptable behaviour of a process even in a case of substantial changes in an environment, i.e. random variation caused by the effect of noise (uncontrollable) factors. In a robust manufacturing process, the change of the nominal values of critical parameters (control and noise) is done in such a way that the process behaviour becomes insensitive to manufacturing variation [4]. In Taguchi method, process variability reduction is achieved by a proper selection of process control factors that reduces the effect of noise factors. That is why SN ratio was introduced, presenting a basis for QL function that shows the customer dissatisfaction with a product characteristic as it deviates from the target value.

There were a few attempts to express process robustness in terms of process capability. A robust process maintains a consistent acceptable behaviour i.e. within the specification limits, since it is insensitive to noise effect. Taguchi robust design is proven effective in reducing process variability, hence improving process capability, performance and process yield. It could be seen that both process

capability and process robustness have common elements: variation, yield and specification range. A capable process may not be robust all the time but a robust process must be capable [5].

2. IMPLEMENTATION OF SPC SYSTEM IN TRANSFORMERS MANUFACTURING LINE

In a major South-East Asian manufacturer of power transformers (along with the other high voltage equipment, switching devices, switching boards, switchgears, etc.), Six Sigma project was conducted to improve the quality of a process that produce the dry type voltage transformer (product type VexL-24). According to DMAIC (Define – Measure – Analyse – Improve - Control) approach, in the Define stage process mapping was performed using IDEF0 method and the main processes were identified. The first main process (Active part process) is of a major interest, and it was further decomposed into sub-processes. It was decided to focus on the improvement of one of its sub-processes: High Voltage Coil Winding. The defect types were ranked using Pareto analysis, showing that the transformers resistance was a major source of defects. In order to analyse, improve and control this process with respect to the transformers resistance, it was first necessary to perform measuring system analysis (MSA). In the Measure stage, MSA was performed showing very good performance for all criteria: stability, gauge R&R, bias and linearity. Hence, measuring system was accepted for the usage in the remaining DMAIC stages [6], that are presented in the next subsections: the Analyse stage (process analysis using SPC); the Improve stage (process improvement using DoE); the Control stage (implementation of the improved process, and monitoring using SPC).

2.1. Process Analysis

The software for on-line SPC was developed by IT department of the observed company, to monitor manufacturing and assembly processes in a real time. SPC software was implemented as a module of manufacturing execution system (MES) information system, since SPC uses the manufacturing data (e.g. quantity, pass/fail, type of defect, etc.) collected from the shop floor and stored in MES database (Fig.1). The SPC software includes calculation and presentation of all types of variable and attribute control charts, process capability (Cp, Cpk) and process performance indices (Pp, Ppk), alarms, normality tests, Box-Cox transformation, etc.

Since the transformer resistance is measured once on each product, the control chart I-MR is selected to monitor the characteristic. According to the industrial standards IEC 61869-2: 2012-09 and IEC 61869-3: 2011-07, the lower and upper specification limits for resistance are, respectively: LSL ÷ USL = 10.52 ÷ 11.63 kΩ; the resistance target value is 11.075 kΩ, the sample size is one measurement for each transformer.

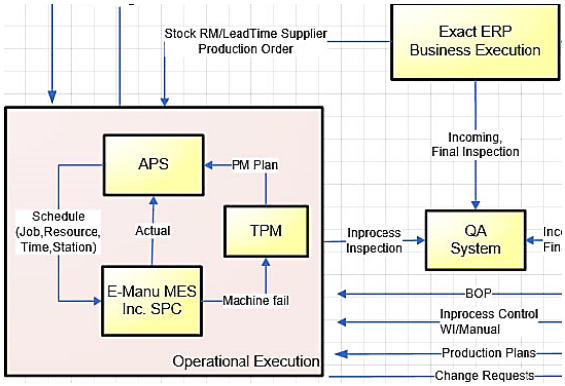

Fig.1: A part of software for operational execution that refers to MES, including SPC software

Fig.2 shows I-MR chart for the resistance (kΩ) that was monitored over the two months period. The following conclusion could be drawn from the chart:

- The process is well centred, since the average resistance value (11.089 kΩ) is relatively close to the target (11.075 kΩ), but the variation is high (standard deviation i.e. SD=0.228).
- Several points out of specification limits caused by high variability present actual defects/scraps.
- Process capability and performance indices are very low (Cpk=1.112 and Ppk=0.791).

Based on these results, it was decided to optimise the process in order to reduce the resistance variability and keep the resistance average close to the target.

2.2. Process Improvement

In order to optimise the High-Voltage Coil winding with respect to the transformer resistance (kΩ), an experiment was performed with two process parameters (control factors) varied on three levels:

- Winding tension: 170, 200, 230 gram-force (gf);
- Winding speed: 600, 650, 700 rpm.

According to the Taguchi method, an orthogonal array L9 was selected. For each experimental trial, three transformers were produced and each part's resistance was measured once. Table 1 shows a part of the experimental results: average (AVG), standard deviation (SD), and signal to noise (SN) ratio.

Table 1. A part of experimental trials and results

Trial no.	Winding tension	Winding speed	AVG	SD	SN ratio
1	170	600	110.800	0.061	452.088
2	170	650	111.267	0.059	455.701
…	170	700	111.033	0.081	427.577
9	230	700	112.767	0.127	389.395

The resistance belongs to the nominal-the-best (NTB) type since the goal is to achieve the target (nominal) value. The SN ratio for NTB characteristic is [4]:

$$SN.ratio \approx 10\log(\frac{\bar{y}^2}{\sigma^2})...for.NTB \qquad (1)$$

where $\bar{y}$ is average value, and σ is standard deviation of the characteristic.

ANOVA showed that both factors are significant for SD and SN ratio, and Winding tension is significant for AVG. Fig. 3 shows the control factors' effects on SN ratio of the transformers resistance.

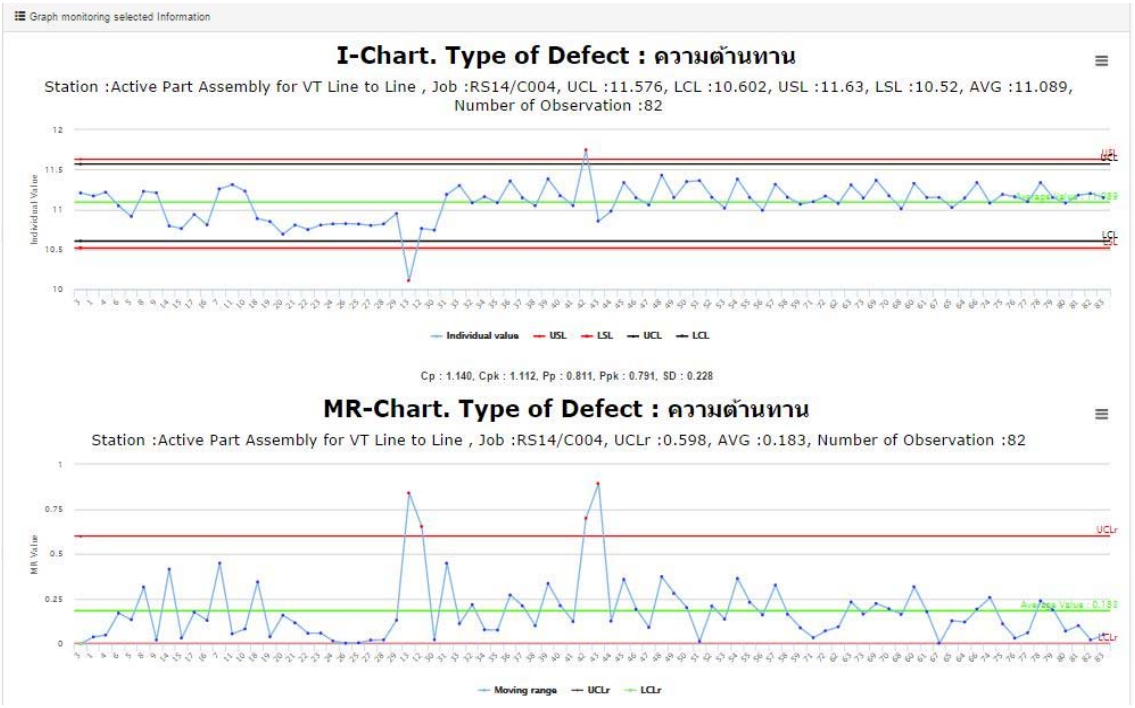

Fig.2: I-MR control chart for the transformer resistance (product type VexL-24), before process improvement

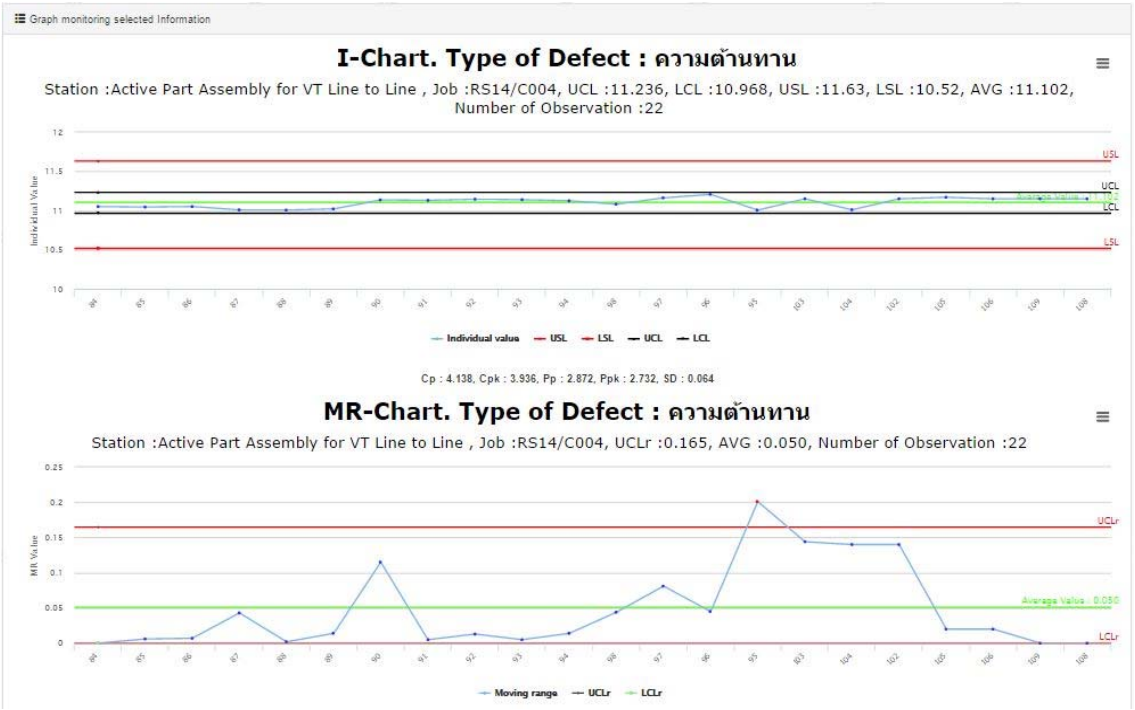

Fig.4: I-MR control chart for the transformer resistance (product type VexL-24), after process improvement

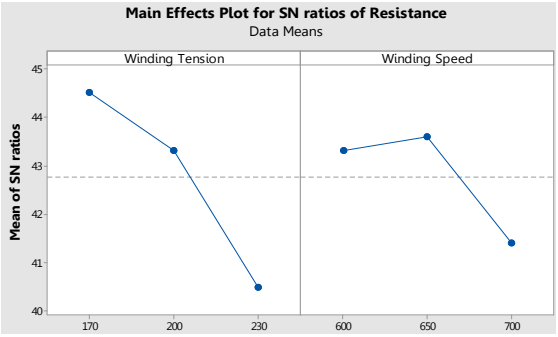

Fig. 3: Main effect of control factors on SN ratio

Aiming to achieve the target resistance value and minimise variation, i.e. to maximise SN ratio, the following setting was selected as optimal: Winding tension = 170 gf, Winding speed = 650 rpm. The verification run was performed using the optimal setting and six transformers were produced: the resistance ranged from 11.03 kΩ to 11.15 kΩ; the average value was 11.1 kΩ which is close to the target, and SD was 0.05 showing significantly reduced variability. Hence, the optimal process setting was adopted for a long-run production.

2.3. Process monitoring and control

The effect of the optimal process parameters setting on the transformers resistance was monitored using I-MR chart over one month time period (Fig.4):

- The process is still well centred, and the variation is notably reduced: from SD=0.228 to SD=0.064.
- There are no points out of specification limits.
- Process capability and performance indices are significantly improved: from Cpk=1.112 and Ppk=0.791 before process improvement, to Cpk=3.936 and Ppk=2.732 after improvement.

Hence, experimental results are confirmed not only on a short verification run, but also on a long-run. A very capable and high performance High Voltage Coil Winding process was established, satisfying a long-term criterion for Six Sigma level (Ppk > 2.0) [2]. The cost of poor quality (COPQ), caused by a high variability of transformers resistance, could be expressed by the quadratic quality loss function [4]:

$$QL(y) = K \cdot (\frac{n-1}{n}.\sigma^2 + (\bar{y} - m)^2)...for..NTB \qquad (2)$$

where $QL(y)$ is the average loss per unit due to deviation of the characteristic y from the target m; K is the coefficient, and n is the sample size. After process optimisation, a significant $QL(y)$ (y is the transformers resistance) reduction of almost 30% was achieved. Following a well-established practice for Six Sigma results sustainability [7], the improvement was institutionalised and on-line process documentation was updated, i.e. all documents related to the process were automatically updated in MES, total productive maintenance

(TPM) and quality assurance (QA) information systems.

3. CONCLUSIONS

In a quest for zero defect manufacturing, Six Sigma is still the major world-wide used methodology, especially in a manufacturing sector, and SPC and DoE are its main techniques. This study presented a successful and comprehensive implementation of SPC program, including development of SPC software that was used to analyse the current and the improved process capability and performance. The process improvement was achieved by DoE, resulting in a significant variability decrease and establishing the robust process (within the robust operating range). The achieved process capability and performance indices exceed Six Sigma requirements.

The future activities will include optimisation of complex multi-response processes using an advanced methodology [8], as well as research on the in-line process optimisation for dynamic processes and its integration with SPC in a unified on-line system.

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IMPROVING QUALITY OF RECYCLING PROCESS - SELECTION OF RECYCLING CENTER LOCATIONS BY USING GENETIC ALGORITHM

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Abstract. *As quality has been recognized as one of the main drivers of modern economy, it is important to enhance it continuously through the whole lifecycle of products as well as in the process of recycling so obtained materials could be used again. It is important to optimize each step of recycling process, especially foundation such as selection points of recycling items where new equipment should be installed. From the perspective of methodology approach, the proposed issue may be solved by using modern meta-heuristic techniques for instance Genetic Algorithm (GA). The proposed model is supported with illustrative example and real life data obtained by analysis of several regions in Serbia. The issue of location selection usually depends on several criteria. In the presented model, two criteria are considered that are of equal importance. This can be considered as the main limitation of the developed model.*
Key words: *reverse logistic, routing problems, genetic algorithm.*

1. INTRODUCTION

It may be considered that several sources are shaping the management of reverse logistic chains (RLCs) in the few past decades. Those sources are laws, regulative, different standards such as ISO 14000. Challenges originating from these demands may be treated the sense of technical, practical and research domains emphasizing the meaning of quality in every aspect [1]. In compliance with the results of the best practice of technologically advanced societies, it is suggested that new solutions in the domain of reverse logistic may positively impact the economy of enterprises. Also it has significant impact on environmental protection, resource conservation, health care, etc.

In order to provide conditions for high quality recycling process, the selection of locations [2] where the recycling process should be organized is supposedly be treated as one of the main strategic management tasks. Generators of ideas for the solution of this problem are experts in the field of recycling, local self-government, and even state government, as well as other stakeholders. It may be suggested that companies in modern societies which care about recycling process are dealing specifically with the following issues: increasing costs of establishing an appropriate infrastructure for recycling material collection and processing, the overall cost optimization, fuel consumption, overall route reduction, etc. [3]. Recognizing the above-mentioned facts it could be clearly concluded that the issue discussed in this paper is one of the burning issues all over the world and it the same time, tackling with the named issue could be used as a starting point for the overall quality improvement of the recycling process.

While solving many issues connected to quality, different analytic methods may be employed. However, the named issue may be analyzed from the multi criteria decision making perspective so one of the potential solutions may be designing the decision support system [4]. In this way, the decision makers are supplied with information relevant for the planning the optimal number of locations, or determining the optimal quantities and the characteristics of recycling items. It is worth to mention that methods under umbrella of multi criteria decision making perspective could be

developed in different mathematical and logical frameworks, so there is no need to compare them.

On the other hand, the location selection problem could be presented as p-median optimization problem. It could be characterized as NP-hard class of problems. For large-scale NP-hard problems optimal solution may be obtained by applying the heuristic methods, such as genetic algorithm (GA) [5], or variable neighborhood search (VNS) [6]. Those solutions are characterized by reasonable computational time consumption.

The main contribution of this paper may be defined as: (a) describing the considered problem in a realistic manner, as p-median optimization problem, and (b) solving of the considered problem by using modern meta-heuristic techniques for instance GA. The proposed model is suitable for evaluation and selection of locations in reverse logistic domain.

2. LITERATURE REVIEW

Managing quality in contemporary organizations include every aspect of business and every day operations. Assessing the locations where recycling centers could be built is based on the assessment of the possible locations' attributes. Determining the attribute value at the level of each location can be viewed as a task for itself. It should be noted that there are no procedures or databases in which the measured or estimated values of the attributes according to which the locations are evaluated are found. It is known, that location selection may be observed as multi-attribute decision making problem. Multi-attribute approach for considered problem calculations is a significant tool. However, when the problem is of large scale, this approach is not appropriate because it requires a lot of computation time.

Many problems such as the optimal route selection in various cases of routing issues [7] - [9], different waste management problems [10], [11] are solved by the exact algorithms, which include branch and border algorithms [12] and branch and cut-out algorithms [13], heuristic [14] and metaheuristic methods [15], for example VNS [6], and GA [8].

GA as a heuristic method is very suitable for this kind of problem, since it has been applied to any problem if the feasible solutions may be represented as strings that correspond to genetic encoding of the solutions. The waste collection issue may be considered as an important issue in the recycling process [16]. McLeod and Cherrett [17] claim that effective strategies for waste collection are not only vital from an economic standpoint, but also from the standpoint of environmental protection due to reduced emission of pollutants. A common approach is to model waste collection as vehicle routing problem (VRP) [18], [19]. In theory and in practice it is shown that the stochastic variant of VRP could be employed [20]. While analyzing optimization, it is worth to mention that the amount of waste in containers is of high variability. This fact represent a constraint having in mind that the optimization method is a method of routing nodes, where each node represents the position of the container from which waste should be collected but it does not take in account the amount of stored waste. Another form of a more complex vehicle routing problem VRP, which is used for the collection of waste, is VRP with time windows (TWVRP). Time windows include stopping for breaks and stopping for waste loading. This type of problem can be solved by an algorithm based on a cluster [19]. It is known that 60% to 80% of the total cost is spent during the process of garbage collection so waste collection effectiveness can be considered as very serious issue [21]. In order to solve this issue, the authors have used already mentioned ant colony algorithm (ACA), where ants (trucks) are trying to find the most optimal route for a given set of containers' locations. The process' starting point is the creation of initial random cycling through the whole area of waste collection, and the leaving of a pheromone trace in the form of the intensity of the found solutions expressed in units of measurement of length. The route with the highest pheromone density is a route that will most likely be followed by other artificial ants in order to find a better route.

All variables of basic p-median are considered to be deterministic [22]. However, the real problems are faced with data that are dynamic. Therefore, a large number of approaches are focused on solving this and similar problems [23].

In this paper, possible solution may be achieved if the p-median model is used to present possible locations of recycling centers, alongside with GA optimization method applied to determine optimal location selection.

3. THE PROPOSED GA MODEL

In this paper, the problem of determining possible locations for recycling centers construction is considered. The number of possible I locations is considered, from which K number of locations should be selected for recycling centers building. Possible locations for recycling centers is set of

considered indices $I=\{1,...,i,..,I\}$. The set of indices of possible locations selected as p-median on which recycling centers could be built is $K=\{1,...,k,..,K\}$, and it is a subset of I, $K \in I$. It should be mentioned, that there is assumption that the collection of waste, dismantling and recycling are realized at the same place. The proposed methodology is further discussed.

The objective function of the proposed GA model is:

$$\min \sum_{i=1,..,I} \sum_{k=1,..,K} mind_{ik} \cdot Y_{ik} \qquad (1)$$

The objective functions are stated as minimization of the total distance, between randomly selected locations for recycling center building and the other nearest locations that are not selected for recycling center building.

The constraints insure that the various properties of the problem are enforced.

Subject to:

$$\sum_{i=1,..,I} Y_{ik} = 1 \text{ for } k = 1,..,K; k \neq i \qquad (2)$$

$$Y_{ik} - X_i \leq 0,\ i = 1,...,I; k = 1,...,K; k \neq i \qquad (3)$$

$$X_i = 0,1, \quad i = 1,...,I; k = 1,...,K; k \neq i \qquad (4)$$

Specifically:

(2) requires that each allocation variable i, i=1,…, I may be selected as a possible location variables k, k=1,…,K,

(3) link the location variables and the allocation variables, and

(4) ensure that the location variables (Y) and allocation variables(X) are binary.

Decision variables are:

$$k = \begin{cases} 1 \text{ if a location is selected as p-median site} \\ 0 \text{ if not} \end{cases}$$

$$mind_{ik} = \begin{cases} 1 \text{ if a location } j \text{ is connected to location } i \\ 0 \text{ if not} \end{cases}$$

Inputs i = 1,…,I set of possible location which recycling center could be built on, and k=1,…, K – selected location on which recycling center could be built on, such that i, k, i≠k locations.

4. THE ILLUSTRATIVE EXAMPLE

The proposed model has been applied to determine optimal configuration of recycling centers in which end-of-life vehicles are recycled. In this paper, 15 locations that are situated in the Republic of Serbia have been considered (Table 1).

By applying defined GA near optimal solution is obtained and it is ordered triplet (k=1, k=4, k=9). The overall calculated optimal distance value between locations selected for recycling centers construction and other locations is 1020 kilometers.

The optimal configuration of the recycling centers network in the Republic of Serbia is given in Figure 1.

Table 1: The distance values

location	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***
1	0	40	93	127	246	276	242	217	185	218	118	168	62	122	205
2	40	0	128	124	271	318	243	264	213	225	146	228	89	120	132
3	93	128	0	228	239	294	246	213	193	247	133	125	153	216	300
4	127	124	228	0	265	261	217	255	204	164	169	245	90	65	113
5	246	271	239	265	0	91	61	109	66	154	134	157	192	232	374
6	276	318	294	261	91	0	55	179	125	122	158	230	203	239	384
7	242	243	246	217	61	55	0	124	70	93	110	175	155	181	326
8	217	264	213	255	109	179	124	0	79	205	130	97	189	229	371
9	185	213	193	204	66	125	70	79	0	132	63	112	128	168	310
10	218	225	247	164	154	122	93	205	132	0	114	236	157	102	290
11	118	146	133	169	134	158	110	130	63	114	0	104	78	140	282
12	168	228	125	245	157	230	175	97	112	236	104	0	156	246	388
13	61.5	89	153	90	192	203	155	189	128	157	78	156	0	76	198
14	122	120	216	65	232	239	181	229	168	102	140	246	76	0	174
15	205	132	300	113	374	384	326	371	310	290	282	388	198	174	0

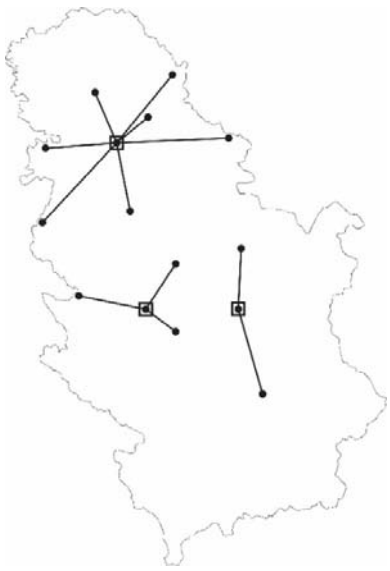

Figure 1: The optimal design of reverse logistic in Republic of Serbia

On the presented figure, possible solution that can be accepted as optimal solution that respect to the criteria equally is presented. In fact, the recycling equipment that need to be installed is very efficient but expensive. Having in mind the mentioned facts, the optimal solution should provide such conditions that could enable increased level of recycling centers efficiency so the final consequence the recycling potential of the whole state should be improved. One of the indirect consequences is cost reduction of recycling.

5. CONCLUSIONS

Waste management at the state level is one of the most important problems for both governments and local -governments. Assessment and selection of locations where recycling centers should be built is a part of the waste management problem. Solving this problem may lead to the effective collection of waste, its recycling and recycling distribution.

The considered problem can be viewed as a p - median problem. The optimal solution to this problem can be found by the heuristics method. In this paper authors used the GA method. The criterion is defined as the distance between the observed locations. GA is an appropriate heuristic method, since it allows the near optimal solution to be found in a short time of period, with the relatively small consumption of computation resources.

Practical implications of the proposed model is addressing the possibility of increasing technological level of recycling which should improve overall efficiency of recycling centre and make impact on the recycling on the state level.

Social implications of the proposed model is oriented to satisfaction of ISO 14001 standard demands' in recycling centres and providing conditions for responsible usage of resources in industry.

The main contribution of the paper is the proposal of the model for determination of recycling centers where new equipment will be installed.

Based on the results of good practice, it is known that the selection of location may, in a long term period, depend on the traveling cost. In this paper, one criteria is considered, and this can be considered as the main disadvantage of the developed model. Future research should include the extension of the proposed model in terms of: 1) increasing the number of possible locations, 2) increasing the number of criteria, 3) determining and incorporating the relative importance of the criteria considered in the model, and 4) applying other heuristic methods and comparing the obtained results.

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THE SELECTION OF EQUIPMENT FOR RECYCLING BY USING FUZZY COPRAS METHOD

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Abstract. *The aim of this study is to propose a new fuzzy multi-criteria model to evaluate recycling equipment with respect to numerous criteria, simultaneously, taking into account the type of each criteria and its relative importance. The all existing uncertainties into the criteria weights and their values are described by pre-defined linguistic expressions which are modelled by fuzzy sets theory. Fuzzy assessments of the criteria weights are performed in direct way. Determining the criteria weights is based on method for comparison of fuzzy numbers. The rank of possible recycling equipment is obtained by applying modified Fuzzy COPRAS (Complex Proportional Assessment of alternatives) technique. The proposed model is illustrated by example with real-life data come from reverse supply chain existing in the Republic Serbia. The presented solution provides base for successful improvement of reverse supply chain management.*

Key words: *recycling equipment, fuzzy sets, fuzzy COPRAS, rank, degree of belief.*

1. INTRODUCTION

During the last few decades, management of sustainable development is getting a lot of attention in variety of disciplines. There are numbers of different engineering, business, environmental and social factors which impact sustainable development (Ziout et al., 2014). By respecting the results of the good practice in developed countries, it can be said that the solving of reverse logistic problems can lead to reducing the consumption of natural resources, reducing waste and increasing environmental protection. As a positive consequence, this may lead to increasing effectiveness of many industries and achieving sustainable development of national, regional and global economy.

The selection of recycling equipment may be stated as a strategic management task. The solution of this task depends on experts' knowledge in the field of recycling. Respecting the mentioned facts, it can be concluded that the selection of equipment for recycling represents one of burning issues in the field of recycling.

The selected recycling equipment has the highest impact to a successful ELV recycling. In the current literature, many research papers may be found in the field of reverse logistics such as selection of recycling technologies (Pavlović et al, 2016), determination of the optimal material flow from collecting centres to recycling centres (Diener and Tillman, 2015). For solving mentioned issues, different mathematical tools have been applied (Tadić et al., 2018).

In solving issues, such as selection of recycling equipment, the evaluation criteria can be given according to literature data or results good practice. In this paper, the evaluation criteria is selected in compliance with assessment of stakeholders and manufacturers of recycling equipment. The existing uncertainties in the relative importance of criteria for assessment of recycling equipment and criteria values are described by linguistic variables which are modelled by triangular fuzzy numbers (TFNs) (Dubois and Prade, 1980).

In this paper, all uncertainties are described by five linguistic variables. The domains of defined TFNs are defined on common measurement scale (Saaty, 1990). The fuzzy assessment is performed by decision makers and the determination of criteria weights is based on method of comparing fuzzy

numbers (Bass, and Kwakernaak, (1977); Dubois and Prade, (1980). The ranking of recycling equipment is based on modified COPRAS method.

The paper is organized in the following way. The proposed model and the proposed Algorithm are presented in Section 2. In Section 3, the proposed model is illustrated by an example with a real-life data. Conclusion is set in Section 4.

2. METHODOLOGY

The selection of recycling equipment is a problem that can be set as a multi-criteria decision making task. Criteria for assessing recycling equipment are formally presented as set $\kappa = \{1,...,k,..,K\}$. The total number of criteria is denoted as K and k, k=1,..,K is index of criteria. As it is known, criteria can be benefit and cost type. Hence, set κ is composed of two sub sets, so $\kappa' = \{1,...,k,..,K'\}$ and $\kappa'' = \{K'+1,...,k,..,K\}$. Let the sub set $\kappa' = \{1,...,k,..,K'\}$ represents the set of benefit criteria which are employed for assessment of recycling equipment and K' is the total number of benefit criteria. Also, let the sub set $\kappa'' = \{K'+1,...,k,..,K\}$ represent set of cost criteria. the number and type of criteria is determined by the decision makers in compliance with their knowledge and evidence data. The total number of different recycling equipment is denoted as I. The set of recycling equipment which is treated is $\iota = \{1,...,i,..,I\}$ and i, i=1,..,I is index of recycling equipment. The assessment of criteria weight is based on subjective opinion of decision makers. They articulate their opinions by using pre-defined linguistic expressions which are modelled by triangular fuzzy numbers (TFNs). The domains of these TFNs are defined on the common measurement scale (Saaty, 1990) in the following way:

very low (VL) - $(x;1,1,5.5)$, low (L) - $(x;1,3,7)$, moderate (M) - $(x;1.5,5,8.5)$, high (H) - $(x;5,7,9)$, and very high (VH) - $(x;4.5,9,9)$.

It may be assumed that the decision makers form decision by consensus. The assessment of criteria weights and criteria values on the level of each type of recycling equipment is performed by decision makers who perform their decision in direct manner.

The proposed Algorithm

The proposed Algorithm is realized through the following steps:

Step 1. The weight of each criteria k, k=1,..,K , $\tilde{\theta}_k$ as well as the value of criterion k for each type of recycling equipment i, i=1,..,I, $\tilde{\gamma}_{ik}$ is assessed by decision makers which use one of five pre-defined linguistic expressions.

Step 2. The degree of belief that a fuzzy number $\tilde{\theta}_k$ is bigger than/equal to K fuzzy numbers $\tilde{\theta}_1,...,\tilde{\theta}_k,...,\tilde{\theta}_K$, (Bass, and Kwakernaak, 1977) is determined:

$$\mathrm{Bel}\left(\tilde{\theta}_{k'} \geq \left(\tilde{\theta}_1,...,\tilde{\theta}_k,....,\tilde{\theta}_K\right)\right) =$$

$$\sup \min\left(\mu_{\tilde{\theta}_{k'}},\mu_{\tilde{\theta}_1},...,\mu_{\tilde{\theta}_k},...,\mu_{\tilde{\theta}_K}\right) =$$

$$\mathrm{Bel}\left(\left(\tilde{\theta}_{k'} \geq \tilde{\theta}_1\right),\text{and}\left(\tilde{\theta}_{k'} \geq \tilde{\theta}_2\right),...,\left(\tilde{\theta}_{k'} \geq \tilde{\theta}_k\right),...,\left(\tilde{\theta}_{k'} \geq \tilde{\theta}_K\right)\right) =$$

$$\min_{k',k=1,..,K;k'\neq k} \mathrm{Bel}\left(\tilde{\theta}_{k'} \geq \tilde{\theta}_k\right)$$

Weights vector is set as:

$$W_p = \left(\left(\mathrm{Bel}\left(\tilde{\theta}_1\right)\right),...,\left(\mathrm{Bel}\left(\tilde{\theta}_k\right)\right),...,\left(\mathrm{Bel}\left(\tilde{\theta}_K\right)\right)\right)$$

The normalized weights vector is:

$(w_1,...,w_k,...,w_K)$

is nonfuzzy number (Isiklar G. and Büyüközkan, 2007; Paksoy, 2012).

Step 3. Fuzzy rating of each type of recycling equipment i, $\tilde{\gamma}_{ik} = (l_{ik}, m_{ik}, u_{ik})$, i=1,..,I, are normalized by using the linear normalization procedure (LIT):

$$\tilde{r}_{ik} = \left(\frac{l_{ik}}{u^*},\frac{m_{ik}}{u^*},\frac{u_{ik}}{u^*}\right) \text{ where } u^* = \max_{i=1,..,i}(u_{ik})$$

Step 4. The weighted normalized fuzzy decision matrix $\left[\tilde{d}_{ik}\right]_{IxK}$, whose elements are calculated according to fuzzy algebra rules (Dubois and Prade, 1980), is calculated as:

$$\tilde{d}_{ik} = w_k \cdot \tilde{r}_{ik}$$

Step 5. The aggregated value of alternative i, i=1,..,I with respect to all benebit criteria by using fuzzy algebra rules (Dubois and Prade, 1980) is determined as: $\tilde{P}_i = \sum_{k=1}^{K'} w_k \cdot \tilde{r}_{ik}$

Step 6. The aggregated value of alternative i, i=1,..,I with respect to all cost criteria by using fuzzy

algebra rules (Dubois and Prade, 1980) is calculated as:

$$\tilde{R}_i = \sum_{k=K'+1}^{K} w_k \cdot \tilde{r}_{ik}$$

Step 7. The relative value of each type of recycling equipment i, i=1,..,I is determined as:

$$\tilde{Q}_i = \tilde{P}_i + \frac{\sum_{i=1}^{I} \tilde{R}_i}{\tilde{R}_i \cdot \sum_{i=1}^{I} \frac{1}{\tilde{R}_i}}$$

According to fuzzy algebra rules (Dubois and Prade, 1980) the obtained value is not TFN. In the same time, an assumption that the value $\tilde{Q}_i, i = 1,..,I$ may be described as TFN (Dubois and Prade, (1980)) with enough preciseness.

Step 8. The maximum relative value $\tilde{Q}_{max}$ is determined by using the method for comparison fuzzy numbers (Dubois and Prade, (1980).

Step 9. The degree of efficiency of each type of recycling equipment is calculated:

$$\tilde{\varsigma}_i = \frac{\tilde{Q}_i}{\tilde{Q}_{max}}$$

The degree of belief that one type of recycling equipment is better than the rest with respects to treated criteria is calculated $Bel\left(\tilde{Q}_{i'} \geq (Q_i)\right), i, i' = 1,.., I; i \neq i'$ according to procedure which is proposed in Bass, and Kwakernaak, (1977) and Dubois and Prade, (1980).

Step 10. The rank of treated types of recycling equipment is determined according to the rank of TFNs, $\tilde{\varsigma}_i, i = 1,.., I$.

Step 11. The decision about the selection of recycling equipment is performed by management team of recycling centre by respecting the obtained rank as well as calculated degrees of belief.

3. ILLUSTRATIVE EXAMPLE

The wide literature review has included the guidelines suggested by different recycling equipment manufacturers (Marathon, WESSCO and Caterpillar) and relevant surveys so chosen set of criteria is: Size of Waste (k=1), Recyclables (k=2), Safety Standards (different) (k=3), Power Source (different) (k=4), Convenience (k=5), Available Space (different) (k=6).

The treated equipment is: mobile press (i=1), oil recycling device (i=2), the shredder for cables (i=3). Fuzzy rating of the relative importance of evaluation criteria (Table 1) are: M, VH, H, VL, L, and H, respectively (Step 1 of the proposed Algorithm).

Table 1 - Fuzzy rating of the relative importance of evaluation criteria

	K=1	K=2	K=3	K=4	K=5	K=6
i=1	L	L	M	L	H	VL
i=2	M	VL	L	L	M	M
i=3	H	VL	M	L	L	VH

By using the proposed Algorithm (Step 2 to Step 3), the weights vector is calculated and it can be presented as:

$$W_p = (0.062, 0.294, 0.500, 0.692, 1)$$

The normalized weights vector is:

$$(0.025, 0.115, 0.196, 0.272, 0.392)$$

The weighted normalized fuzzy decision matrix is presented in Table 2 (Step 3 to Step 4 of the proposed Algorithm).

Table 2 - The weighted normalized fuzzy decision matrix

	k=1 max	**k=2 max**
i=1	(0.022,0.065,0.152)	(0.044,0.131,0.305)
i=2	(0.033,0.109,0.185)	(0.044,0.065,0.218)
i=3	(0.109,0.152,0.196)	(0.044,0.065,0.218)
	k=3 max	**k=4 max**
i=1	(0.045,0.151,0.257)	(0.003,0.008,0.019)
i=2	(0.030,0.091,0.212)	(0.003,0.008,0.019)
i=3	(0.045,0.151,0.257)	(0.003,0.008,0.019)
	k=5 max	**k=6 min**
	(0.064,0.089,0.115)	(0.054,0.181,0.272)
	(0.019,0.064,0.109)	(0.032,0.054,0.181)
	(0.013,0.038,0.089)	(0.030,0.030,0.061)

The aggregated value of recycling equipment i, i=1,..,I with respect to all benefit criteria (Step 5 of the proposed Algorithm) is determined. The developed procedure is illustrated by example:

$$\tilde{P}_1 = (0.178, 0.444, 0.848)$$

$$\tilde{P}_2 = (0.129, 0.337, 0.819) \quad \tilde{P}_3 = (0.214, 0.414, 0.886)$$

The aggregated value of recycling equioment i, i=1,..,I with respect to all cost criteria are (Step 6 of the proposed Algorithm):

$$\tilde{R}_1 = (0.054, 0.18\,1, 0.272) \qquad \tilde{R}_2 = (0.032, 0.0\,54, 0.181)$$

$$\tilde{R}_3 = (0.030, 0.0\,30, 0.061)$$

The relative value of the each recycling equipment i, i=1,..,I is calculated by using the proposed procedure (Step 7 of the proposed Algorithm):

$\tilde{Q}_1 = (0.189, 1.444, 2.218)$ $\tilde{Q}_2 = (0.135, 0.391, 1.843)$

$\tilde{Q}_3 = (0.229, 0.444, 1.010)$

The greatest relative value of recycling equipment $\tilde{Q}_{max}$ is obtained by using the proposed Algorithm (Step 8), so that: $\tilde{Q}_{max} = \tilde{Q}_1$

By using the proposed Algorithm (Step 9 to Step 11), the value of efficiency coefficient, degrees of belief and rank of the considered recycling equipment are given and presented in Table 3.

Table 3 - Efficiency coefficient, degree of belief and rank

	$\tilde{\varsigma}_i$	Degree of belief	Rank
i=1	(0.085,1.00,11.735)	1	1
i=2	(0.061, 0.271, 9.751)	0.929	2
i=3	(0.103,0.307,5.344)	0.884	3

On the basis of the obtained results it can be clearly concluded that the most suitable type of equipment is mobile press (i=1). At the second place in rank, there is oil recycling device (i=2). At the last place in rank, there is shredder for cables (i=3). Respecting the calculated value of degrees of belief measures, it can be said that it is impossible to make a clear difference which type of recycling equipment is dominantly better than others. From the perspective of decision-makers, this result shows that decision makers should purchase all three devices simultaneously or evaluate them according to additional criteria.

4. CONCLUSIONS

This paper investigates the issue of selection of appropriate equipment for recycling. This is one of the most significant issues in the activities of reverse logistics entities due to complex processes and a certain level of uncertainty associated with recycling centers and market demands.

The main contribution of this paper is represents the ranking of recycling equipment based on modified COPRAS method.

The main constraints of the proposed model are associated with the need of expert team and their relevant knowledge in recycling.

The future research should include testing of the model in different recycling centers and comparative analysis of obtained results so the proposed model could be verified.

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FACTOR OF RISK EXPOSURE IN PROJECT IMPLEMENTATION IN STARTUP COMPANIES REGARDING TECHNOLOGY DEVELOPMENT IN SERBIA

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Abstract. *The aim of this paper is to explain a model for evaluating project success of startup companies of ICT sector that operates in Republic of Serbia. Political-economic situation in Serbia states that large number of startup companies struggle with realization of their projects mainly due inability to predict future outcome. In this paper authors propose a different exposure approach of these startup companies in early stages of project conceptualization from economic/financial aspect of the uncertainty in their business. The approach is applicable in variety of industry fields, such as ICT, recycling and services.*

Key words: *Project analysis, project realization, project management, startup companies, risk evaluation, ICT sector*

1. INTRODUCTION

Start-up as a new business concept is the subject of a large number of definitions, each from its own perspective and the activity it deals with. As a matter of fact, start-up is a newly founded company with global ambitions and global potential. It is interesting that startups are dealing with wide range of technology development which is applicable in different domains (ICT, recycling, services, etc.).

Given the rapid development of technology, the information technology field is the fastest growing industry with the greatest potential for employment, as currently IT specialists cannot meet demand in the constantly growing market.

Some start-up companies start from the idea of a brand new product or service, while others are dealing with well-known activities. Today, there are a large number of sympathizers of this approach and many programs have been created to support development in start-up business.

However, an established rule in the IT industry is that there is no problem as such, but every problem is a precondition for development. One way to achieve competitiveness in the IT market is to organize start-up companies into clusters and exchange experiences, resources, and technologies.

2. ICT SECTOR IN THE REPUBLIC OF SERBIA

According to the strategy of development of the information society in the Republic of Serbia until 2020 [1], the ICT sector has been recognized as the main factor for the impact on economic growth and innovation, and is among the seven leading initiatives of the economic strategy Europe 20202, which shows the importance ICT plays in the development of the modern economy.

The development of the information society should be directed towards the utilization of ICT potentials for increasing labor efficiency, economic growth, higher employment and improving the quality of life of all citizens of the Republic of Serbia. The same activities undertaken with the aim of developing the information society should be focused on the fulfillment of priorities in the field of human resources development, development of startup and innovative companies, export and cross-border outsourcing, etc.

3. PROBLEMS OF STARTUP COMPANIES IN THE REPUBLIC OF SERBIA

Start-up is a young company that develops a whole new, innovative product (often based on the latest

technologies) or service where success is very uncertain.

The reasons for entering the uncertain business and entrepreneurship are numerous, among others: loss of work, desire for its own business, perceiving business opportunities, improving social status, etc. [2].

According to the analysis of the Ministry of Finance and Economy of the Republic of Serbia, the biggest problem is their financing and this is very important thing to be looked into while establishing. Namely, classic firms would take a loan from a bank, based on some business plan, and this loan would be approved by the bank only if the very idea is something that is very traditional and secure. Start-up companies are funded by investments that do not have to return to the investor, and this is the fundamental difference. In practice, it means that someone invests such idea even a few hundred thousand euros (in a developed world, this number can approach millions), and if the firm fails, this companies owe nothing to anyone.

In Serbia, the problem is that almost two-thirds of the startup funds are financed from their own funds, and half of the lending companies have difficulties or are late with repayments to cover these loans, also in the aim of success of startup companies, the biggest constraints relate to great competition, low demand and monopoly.

4. CRITICAL SUCCESS FACTORS IN STARTUP TECHNOLOGY DEVELOPMENT PROJECTS

Critical success factors usually vary from project to project implemented in such startups because, for example, a critical factor for the development of computer software can be qualified staff, and a critical factor for a project that has team members in different locations can be communication.

From the perspective of the project management, Critical Factors of Success (CFS) are characteristics, conditions or variables that can have a significant impact on the success of a project that is starting up in this way for companies.

Literature on success factors of new firms put forward especially two critical factors success [3]: human capital of the entrepreneur and the initial organizational setup of the new firm.

According to them number of variables are used to explain the impact of human capital of the entrepreneur (motivation and entrepreneurial orientation, general human capital, working experience, preparation and pre-founding activities).

A number of studies have developed “trait models” and link the success of new firms to personality characteristics of the entrepreneur, as strong motivation for example ([4]-[6]). While on the other side organizational characteristics are another explanation for differences between successful firms and failures. The initial organizational setup should have a strong impact on the sustainability of start-ups, especially in the initial stages of product realization or service that this company wants to provide [7].

Most authors in literature emphasize the importance of financing and firm size [8-10].

4.1 UNCERTAINTY IN BUSINESS OF START UPS

According to Western standards, the Serbian startups as well as IT industry looks very modest. It is characterized by a large number of micro enterprises without significant financial strength, insufficient technological knowledge and managerial experience. All these factors entail a certain amount of uncertainty in the business that is of a largely financial nature.

Uncertainty itself is a natural part of any business and it is defined as a state of limited knowledge where it is not possible to know the future outcome. It represents a lack of predictability and can lead to both positive and negative outcomes. In other words, uncertainty does not always lead to risk because sometimes it is possible to lead to very favorable opportunities through the company's risks.

But when a risk arises, managing such a risk is a process for systematic identification, evaluation, and mitigation in order to improve the likelihood of a company's success.

4.2 EXPOSURE OF PROJECT REALIZATION

In the scope of technology development, any product or service that the startup potentially wants to provide is a project for itself. Simply speaking, the project may be seen as a combination of human and material resources used over a limited period of time to meet the set goals. All executing projects are susceptible to factors that may lead to uncertainty and, therefore, to potential risks. Therefore, their impact must be monitored, analyzed, documented and controlled.

In this area of management, a procedural approach is defined by standards such as BS 6079-2: 2000, BS 6079-3 [11],[12]. This standard describes the risk management process as the basis for any organization, regardless of size or sector of activity.

BS 6079-3 defines good practice for the above: risk identification, risk analysis, assessment and control.
It consists of 7 risk groups, among which there is a group of risks that are related to economic and financial factors that represent the most critical link in the startup business in the Republic of Serbia. These economic and financial factors are shown in Annex E of this standard and are as follows:

- Exchange rate fluctuation
- Interest rate instability
- Inflation
- Shortage of working capital
- Failure to meet revenue targets

In the implementation of the project it goes through many phases. Each phase is separate from the previous one and has its own defined goals, but very often they are overlapping depending on the type of project. This undoubtedly derives from the complexity of the realization, and the management process gets on its complexity, while the possibility of the occurrence of uncertainty exponentially increases. According to the PMI PMBOK (Project Management Institute - Project Management Body of Knowledge) [13] project management model, there are five phases:

- Project conception and initiation
- Project definition and planning
- Project launch or execution
- Project performance and control
- Project closure

Each of these risk factors affects the implementation of the project through each of these phases, but practice has shown that the early concept and initiation of the project is the most critical for the realization of projects in companies of this size for the simple reason that there is no economic stability of the company itself in these early stages of realization.

5. MODEL OF RISK EXPOSURE

Exposure to risk by definition is the quantified potential for loss of business.
It is usually calculated by multiplying the probability of an incident that occurs. This factor is one of the most important risk assessment metrics.
In the literature, according to many authors, the company's exposure to risks is calculated as follows:

$$RE = RP + RI - (Rp * RI)$$

In the given equation: RE - (Risk exposure) is defined as the total exposure of a company to a risk; RP – (Risk probability) the likelihood of risk occurrence (represents a number on a scale of 0 to 1, which means that for a value of 0 there is no likelihood that the risk will occur while the value 1 assumes that the risk is definitely going on); RI – (Risk impact) represents the overall risk impact (this value also varies in the scale from 0 to 1, which means that the risk does not have an impact on the project, while value 1 represents the indicator of the greatest impact of the risk on the project).
It is important to note that the overall risk exposure is also obtained on a scale of 0 and 1. Value 0 means that the risk is not critical at all and should not be managed, while 1 means that the risk is very critical.
The problem lies in the fact that project exposure to risks can be viewed in a different way because there are many more factors that influence the risks themselves in relation to the likelihood of risk occurrence and its impact.
In the observed problem, there are many inaccurate and uncertain data values that are related to the mentioned elements. Bearing this in mind, it seems to be more realistic to use linguistic variables [14] instead of precise values for describing the problem.
These uncertainties were modeled using the theory of the fuzzy of sets [15]. The fuzzy-set theory is a suitable mathematical tool whose application makes it possible to quantify easily the introduction of linguistic expressions [14].
The simplest form of this approach and also the most used form in the modeling of uncertainties that exist in the management of problems is triangular.
The scale of linguistic expressions for the assessment of exposure of risk in this problem looks like this: Very small exposure - an estimate $\tilde{R}_1 = (0, 0, 0.25)$; Small exposure - estimate $\tilde{R}_2 = (0.1, 0.3, 0.5)$; Medium exposure - estimate $\tilde{R}_3 = (0.3, 0.5, 0.7)$; High exposure - estimate $\tilde{R}_4 = (0.5, 0.7, 0.9)$; Very high exposure - estimate $\tilde{R}_5 = (0.75, 1, 1)$
The assessment of the exposure of these risks to each phase is assessed linguistically and this assessment is provided by an external expert team since startup companies do not have enough experience to provide estimates of these factors. An external expert team give their grades by using linguistic expressions rather than precise numbers because this approach is closer to the human way of thinking, and then with such estimates are inputs of the mathematical model:
Step 1. The fuzzy evaluation of each phase of the project, f = 1, ..., F at the level of each risk, r = 1, ..., R is obtained from each member of the management team, k = 1, ..., K,

$\tilde{R}_i^k, i = 1,..,I; = 1,..,K$

Step 2. The total value of the exposure of each phase of the project, f = 1, ..., F at the level of each risk, r = 1, ..., R is calculated by using the operator of fuzzy averaging:

$$\tilde{v}_{fr} = \frac{1}{K} \cdot \sum_{k=1}^{K} \tilde{R}_i^k, \; f = 1,..,F; r = 1,..,R; k = 1,..,K; i = 1,..,I$$

Step 3. The maximization of the obtained values is respected in accordance with the rules of the fuzzy TOPSIS method for each phase of the project to determine the highest imapct of economic and financial group of risks.

Subsequently, in the final **Step 4**, ranking of the most critical phases for this type of potential risks is performed to obtain visual representation from the highest to the lowest impactfull phase (Figure 1).

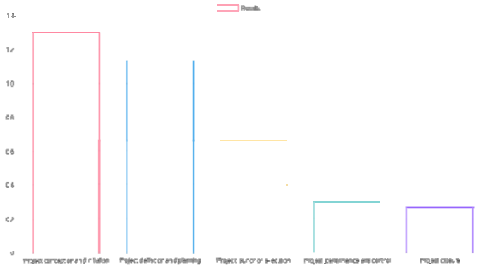

Figure 1. Ranking of the project phases

6. CONCLUSION

The main contribution of this approach represents the fact that it enable a more precise analysis of the of the project idea of the start-up company while it strives to enter into this type of business. The startup manager can easily predict the stage in which the project implementation will have the greatest impact from the aspect of financing and more easily allocate its resources in order to preclude or alleviate the problems listed in this paper.

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IMPORTANCE OF PARAMETERS OPTIMISATION FOR LASER MATERIAL PROCESSING

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Abstract. *Superalloys are designed to operate in demanding condition, at high temperature and pressure and in harsh environment, making requirements for designing parts of these alloys very strict with tolerances near zero. That's why laser processing of materials emerged as very promising technique. However, for the best results there is a need for the optimization of the parameters. In this work the importance of modelling and optimization of laser processing parameters is explained and discussed in two laser machining of nickel based superalloy Nimonic 263.*

Key words: *superalloy, laser, optimization, drilling, cutting.*

1. INTRODUCTION

In this paper different methods of optimisation of processing parameters are applied to different types of laser beam processing of nickel based superalloy Nimonic 263. Nimonic 263 is an alloy designed to operate at elevated temperature and pressure and in harsh environment. It is suitable for responsible parts of machines, aeroplanes etc. [1]. Laser beam processing is promising technique to obtain defect free parts for high demanding performance and with tolerance near zero [2]. That is the reason that optimisation of processing parameters has a great role and significance. In this paper the importance of optimisation of laser beam processing parameters for various material processing is discussed. This paper consists of two experiments optimised by different approaches. The first, laser drilling process, have been optimised using artificial intelligence techniques. An artificial neural network (ANN) was employed to model the relationship between a synthetic process performance measure and process parameters, presenting an objective function for a genetic algorithm (GA) [3, 4].

To model and optimise the second experiment - laser cutting processing parameters PSO (particle swarm optimisation) is used and benchmarked with SA in terms of the quality of an optimal solution, the algorithm robustness i.e. the effect of algorithm's own parameters on the quality of a final solution, and the speed of convergence [5-8]. The most important PSO algorithm's parameters (initial population, population size, inertia weight and learning factors) were studied in detail in terms of their effect on the final solution.

2. METHODOLOGY

The chemical composition of the Nimonic 263 samples is: C - 0.06%, Si - 0.3%, Ti - 2.2%, Al – 0.5%, Co – 20%, Cr – 20% , Mn – 0.5%, Cu – 0.1%, Fe – 0.5%, Mo – 5.9%, Ni – balance, and their dimensions were 150x150x1.2.

The first part of experiment – laser drilling - was conducted using a pulsed Nd3+: YAG laser type HTS Mobile LS-P160 (OR Laser) to produce the holes in nickel-based superalloy Nimonic 263 sheets.

Two-process input parameters were selected and their effects on quality characteristics of the holes were studied. The selected parameters considered as control factors for the experiment are: pulse frequency (f) and pulse duration (t).

Pulse energy was 64 J, the average power 128 W, focal length 50 mm, and no assisting gas was used.

The alerted drilling parameters were: pulse frequency (5, 7, and 9 Hz) and pulse duration (0.5, 0.7, 1.0, 1.2, and 1.8 ms) and they were combined. The focus position was situated just below surface of material.

Quality of the considered laser drilling process refers to the quality characteristics of the holes. Seven quality characteristics of the laser-drilled holes considered as responses in the experiment are: entry side hole diameter, exit side hole diameter, circularity of entry side hole, circularity of exit side hole, aspect ratio, taper and spatter. The response type of entry side hole diameter is NTB, i.e. to achieve nominal value 420 μm; responses of exit side hole diameter, circularity of entry and exit side hole and aspect ratio are of the larger-the better-type (LTB) and responses of taper and spatter are of smallest-the better – type (STB).

Superalloy Nimonic 263 sheets, thickness of 2mm, are cut by Bystronic laser, (2000), BYSTAR 3015 CNC Laser cutting machine.

The laser with following characteristics is used to perform the laser cutting process: laser beam power 2800 kW, circular polarisation, velocity up to 6000 mm/min, pulse frequency up to 2500 Hz. The pressure of assisted gas Nitrogen is up to 20 bar.

The process parameters considered as a control factors in this experiment are: gas (Nitrogen) pressure, focus position, laser power, and cutting speed. As explained above, four process parameters were varied on three levels in the experiment. Therefore, the experiment was designed using an orthogonal matrix L9. In order to collect enough data to perform accurate process modelling using ANNs nine trials from L9 were repeated two times, so in total 18 experimental trials were conducted. The response types for the kerf deviation, kerf tapper, grate, roughness, root mean square and peak to valley is small the better (STB); while for the microhardness response type is larger – the- better (LTB).

The resulting structural changes of a treated material are determined by optical microscope, scanning electron microscopy (SEM) model JEOL JSM-5800. Elemental analysis of the surface was done by energy-dispersive spectroscopy (EDS). Also, surface morphology changes of the irradiated areas were analysed by Zygo NewView 7100 optical profiler.

3. DISCUSSION

The laser drilling experiment was designed on a full factorial basis. The factor f was varied on three and the factor t on five levels. Using full factorial experiment enabled providing enough data for neural networks that are used for the process modelling.

The proposed ANN- and GA-based approach searches for the global optimal solution in a continual space. However, for a practical application, the adopted optimal parameter settings are: f=7 and t=0.5.

The testing run was performed using the obtained optimal process parameter values, confirming the results of the experimental analysis. Figure 1a shows the entry-side hole drilled before optimisation by process parameters: pulse frequency f = 9Hz and pulse duration t = 1.8 ms, and Fig. 1b shows the hole drilled by the optimised process parameters: pulse frequency f=7 Hz and pulse duration t=0.5 ms. The laser pulse energy was 64 J. It could be seen that the hole drilled using optimal process parameters shows better geometrical characteristics than the hole drilled using initial process parameter values.

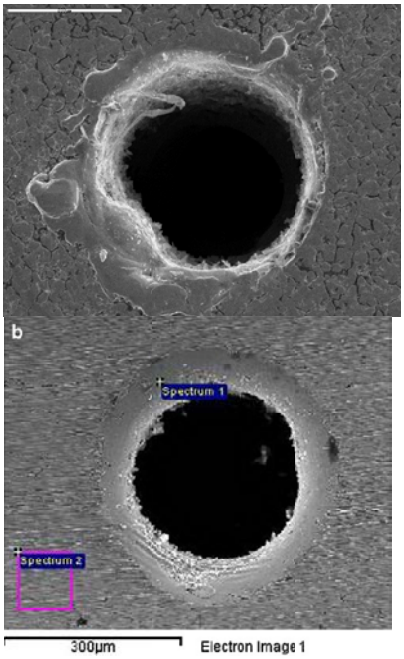


Figure 1. Entry side hole drilled a) by non-optimised parameters; b) by optimised parameters (SEM).

Analysing the obtained results, it could be noticed the following: The circularity of the entry side hole obtained by optimised parameters is very close to one, i.e. to perfect, it's value is 0.97, making it the second best of all holes drilled in this experiment. The exit side circularity is, also, very precise and its value is 0.94, the second best of all holes. The entry side diameter is 407.93μm, percentage deviation of nominal value (410 μm) is 0.5% only. In two cases

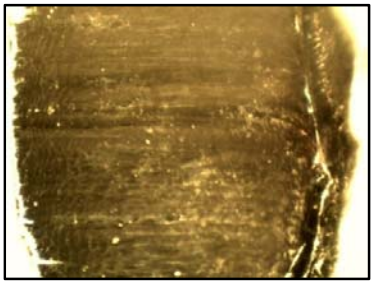
only the entry side diameter is closer to nominal value. Spatter area is also small. It could be noticed that there is no characteristic that is the best, i.e. that the analysed characteristic is the closest to the required value, but all together, overall, make the hole with the best geometrical and metallurgical characteristics.

Comparing to the characteristics of the other holes, the hole drilled by optimised parameters has value of diameter up to 5.52% closer to the nominal, value of the circularity up to 13% closer to the one. The amount of spatter around the holes drilled by the non-optimised parameters in this experiment is up to 125% greater than the amount of spatter around the optimised hole.

Taking in account the above mentioned considerations, the laser drilling process gave satisfactory results. The spatter can be subsequently removed by light polishing using a coarse emery paper. From the above discussion, it can be concluded that the application of the proposed strategy was successful for the design of a robust Nd:YAG laser drilling process of Ni-based superalloy, with respect to the specific requirements for seven quality characteristics of the drilled holes.

In the second experiment, Np = 14 bar; f = 0.5 mm in front of the material; P = 2034 kW; v = 4000 mm/min was adopted as the optimal setting of the laser cutting parameters in processing Nimonic 263 sheets. The PSO algorithm with the fastest convergence is adopted as the best one. The confirmation run was performed using the optimal solution, and the microstructural characterisation of the cut has been performed. These findings were compared with the cut microstructure characteristics obtained by the non-optimised laser cutting parameters.

Figures 2a and 2b present the surfaces taken by optical microscope after laser cutting process before and after optimisation, respectively.



Figures 2a. Surface of laser cut obtained by non-optimal parameters;

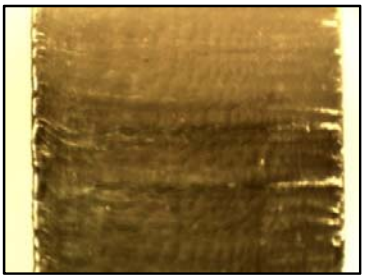


Figure 2b. Surface of laser cut obtained by optimal parameters. Taken by optical microscope.

Figure 2a shows the microstructure obtained by non-optimised parameters: Np = 8 bar; f = on the bottom of a material; P = 2100 kW; v = 4000 mm/min. It can be noticed that flow pattern of striation has two different zones. From the top of the cut edge to approximately 1.6 mm penetration depth, cutting zone is smother and striations are straight and parallel. At the second zone, the striations become irregular, non-parallel, with no clear direction. Figure 2b shows the structure after the optimisation. It is noticeable that striations are almost parallel, and straight along the whole cutting area. Almost no dross or adhered material was observed.

The optimised parameters of laser cutting process provided uniform structure with narrow and edge parallel kerf, similarity in processing geometry, high edge quality and minimum waste of material.

The optimised parameters provided up to 50% lower kerf deviation and kerf taper compared to the kerf deviations and tapers obtained in this experiment by the others non-optimised parameters. Kerf deviation obtained by optimised parameters is second lowest deviation obtained in this experiment, while kerf taper on third place. The optimised parameters provided the best results for the average roughness, i.e. the lowest average roughness and root mean square in this experiment. The obtained results for average roughness and root mean square, compared to the other results, reaching up to 62% of the roughness and root mean square of the cuts obtained by non-optimised parameters. The grate (G) has occurred, neither beneath the treated area nor anywhere around the area. Hence, the observed responses are significantly improved by using the optimise laser cutting parameters, some of them (kerf deviation) improved even for 200%, as it can be seen comparing results with the experimental results.

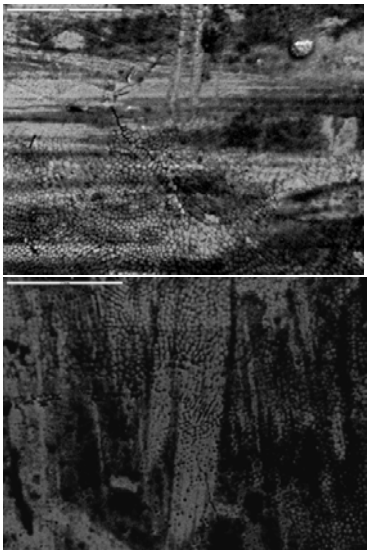


Figure 3. Micrograph of laser cut surface obtained a) by nonoptimal parameters; b) by optimal parameters. SEM. The bars in upper left corners denote 20 μm.

Figure 3a presents the microstructure obtained by the non-optimised laser cutting parameters. From the micrograph in Figure 3a a few microcracks and a few unwanted phases are noticed. The grain boundaries started to segregate. This structure is suitable for local stress concentration, and consequently for the cracks initiation. Figure 3b shows the cut surface after optimisation. The cut surface is homogeneous, there are no microcracks and the cut face is smooth. In both, Figures 3a and 3b the twinned grains are noticed, due to the laser interaction on the material.

The implementation of the proposed PSO-based methodology shows very good results in optimising laser cutting of Nimonic 263 alloy sheets.

4. CONCLUSION

In the present research, laser drilling and laser cutting of Ni based superalloy Nimonic 263 sheets and has been performed.

The laser drilling parameters are optimised by an advanced design strategy to determine the optimal combination of process parameters to simultaneously meet the specification of seven quality characteristics of the drilled holes. The achieved results have proved satisfactory. The holes drilled by optimised parameters have good geometrical hole characteristics and favourable microstructural changes.

The laser cutting process parameters is optimised by PSO-based methodology. Appling this methodology significantly improves the quality of Nimonic 263 cut area and microstructure. The microstructure is more uniform compared to the cut obtained by a non-optimised laser beam. The surface characteristics of optimised holes are outperformed the surface characteristics of non-optimised up to 200%.

ACKNOWLEDGEMENT

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THE USE OF FUZZY LOGIC IN THE PROCESS OF RISK ASSESSMENT FOR WORKPLACES ON MACHINES

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Abstract: *Risk assessment for workplaces on machines is very important process in safety management with the machines, which are a common source of injuries at work. The most commonly used methods for risk assessment provide fast, but not so precise assessment results, while not considering all parameters. In searching for more comprehensive and relevant risk assessment often used, and guided by the complexity of the process of risk assessment, in this work is presented the possibility of creating fuzzy logic controller, which provides output risk value. Fuzzy logic controller is created by the parameters which are defined by the experts. For the creating of the fuzzy variables, their values, the membership functions, and for definition IF-THEN rules, is used expert's knowledge and experience in the field of occupational safety and health at work.*
Keywords: *fuzzy logic, risk assessment, fuzzy logic controller, occupational safety and health at work.*

1. INTRODUCTION

The daily routine in many enterprises is determined by machines and machinery. The workers with and at the certain machines mustn't suffer from a physical damage health. Because of this fact the European Union (EU) made a systemic preventive security concept for machinery which is contained in the Machinery Directive 2006/42/EC. (RISK IN EU). [7] As an integral part of the work process, employers are in obligation by national legislation to systematically manage workplace risks in order to prevent the injuries of workers and to avoid the multiple detrimental effects that each injury carries with them. Working equipment and especially machines are very frequent source of serious and even fatal injuries at work, and as such are always in the focus of occupational safety and health at work. The most common reasons for injuries to workers on the machines are defective or outdated machines, negligence of the operator or disregard of the working norm and working procedures, insufficient training of the operator, non-compliance of machine with requirements of standards and technical conditions, inadequate maintenance of the machine and absence of regular inspection. Safety management of the machine is a very complex process and therefore requires the application of an appropriate management model. This model starts from designing a safe workstation on the machine, and successively, involves the purchasing of a "safe machine", i.e. a machine that conforms to the requirements of the standards and technical conditions, then installs the machine in a manner that enables its safe operation, control tests and inspections prior to the use of the machine, the risk assessment on the machine, the application of preventive measures and the safety training of the workers as a result of risk assessment.

Risk assessment is the systematic evidention and assessment of all factors in the work process that can cause injuries at work, illness or damage to health, and determine the possibilities, or ways of preventing, eliminating or reducing the risk [4]. Based on this definition, risk assessment requires the analysis and assessment of all relevant factors that can cause injury, while on the other hand, the methods most commonly used for risk assessment do not, in practice, give this possibility, but provide a unsatisfying estimate that is based on the probability and frequency of events. There are a number of published and applied risk assessment methods in workplaces such as the AUVA method (Allgemeine Unfallversicherusanstalt), the "5 Steps" method, the Singapore model, and are all relatively easy to apply. Each of these methods has its advantages and disadvantages [5]. The KINNEY method is the most commonly used method in practice because it is simple and gives a result by which the level of risk is immediately detected. The KINNEY method increases risk (R) through 5 levels [5]. KINNEY method [8] is simple and gives a result

where the level of risk is immediately noticed, but in the method it self encounters the problem of imprecision in determining the level of risk, due to the probability of two categories that are not clearly delimited. Such a rough estimation level is acceptable only for a quick and general risk assessment. Also, in mathematical terms, it is difficult to estimate the error here because the scale of values 0 - 10 is not constructed on equal parts. In addition, the likelihood that an injury or illness will occur is in this method unequal discretized to only 7 values with very imprecise boundaries. [8] In searching for opportunities with more precise and better quality risk assessment than those offered by common used methods, which could include the possibility of evaluating more relevant parameters, the possibility of applying fuzzy logic in risk assessment for workplaces on machines has been recognized, which is described in this paper.

2. METHODOLOGY

Risk assessment is the basis for deciding what preventive measures need to be applied in order to eliminate or minimize the risk on workplace. Sometimes risk assessment has to be done immediately, on the spot, sometimes more times a day, if it's needed. Risk assessment is carried out by competent and professionally qualified persons who possess specialized professional knowledge and skills, who are considered experts for this particular field. Expert services are not always quick and available at the right time, and require substation financial investment. [10] Also, certain criteria that are relevant to risk assessment on a single machine are not relevant to the other, and the assessment process is considered to be very complex. It can also happen that risk assessors have difficulty in subjective consideration of input elements in the assessment, as well as in the interpretation of the collected facts and knowledge, which diminishes the quality of the assessment. The ability of the software to reliably assess the risk by pre-determining the input elements and creating rules that will control the conclusion, which is determined by the expert (in this case, the expert in the field of occupational safety and health at work) has been recognized as significant quality in risk assessment, cost savings estimation and availability of a software solution.

Artificial intelligence is a field of computing designed to create intelligent simulation software (they can conclude, provide answers to complex questions, make decisions, perform certain operations, simulate human thinking and knowledge, etc.). Expert system is a type of artificial intelligence - software that simulates the knowledge and experience of experts and solve a certain problem for the expert. Fuzzy logic was presented for the first time by Lotfi Zadeh in 1965 and at that time it gained a lot of attention. [9] This concept has enabled the application of knowledge of a phenomenon, problem, or system using the different values of variables. In complex systems, it is recognized that the more complexity of the system increases, the ability to describe its behavior is reduced. [10] Fuzzy logic controllers (FLCs) are used in the following cases:

- the object or management problem is non-linear,
- there are structural or non-structural uncertainties,
- the mathematical model of an object is not known or is variable,
- the management object is very complex.

Unlike the binary logic that requires precise formulations such as true/false, it is/is not, black/white, exists/does not exist, fuzzy logic gives a wider possibility in the inaccuracy of interpretation of concepts that are much more susceptible to the human brain and are more close to human understanding. Fuzzy logic is a concept that extends binary logic. For example, a person does not have to describe himself as being exclusively high or low. The membership of a fuzzy set is determined by several values of linguistic variables such as, for example, very low, low, medium high, high and extremely high. The theory of fuzzy sets as a term introduces a membership function that determines how much a particular element meets the requirement of belonging to a particular set. In the binary logic, this element has a value of 0 or 1, i.e. belongs or does not belong to the set. In fuzzy sets, the element can belong to a set at any value between 0 and 1. [9].

In creating the fuzzy logic controller for risk assessment on machines, a Fuzzy logic designer in Matlab can be used. The inference fuzzy system, Mamdani type, uses the *min* function as the implication, and the method is compatible with the "cutoff" method, see Figure 1.

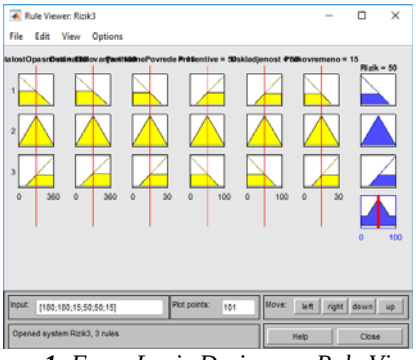

Figure 1: *Fuzzy Logic Designer – Rule Viewer*

Creation of the Mamdani type of the fuzzy logical controller includes the following steps:

1. Definition of input fuzzy variables (this implies the identification of input values, their number and linguistic terms, as well as ranges).

2. Definition of the output fuzzy variable (this implies the identification of the output, linguistic terms and range. Usually, there is one output).
3. Definition of membership functions for each input and output value.
4. Definition of the fuzzy of IF-THEN rules.
5. Selection of the implementation method of the fuzzy logic operators and defuzzyfication method.

First, the input fuzzy of the variable that must be measurable are formed. For example, this may be the number of injuries on the machine in the previous 3 years, or the noise of the machine, or the level of illumination at the workplace. Which and how many variables will be defined, are determined by experts. The Level of risk [%] was formed as the output element. The membership function must be specified for each linguistic value of the fuzzy variable. The linguistic values of the fuzzy controller are defined by the triangular membership function:

$$trimf(x) = max\left(min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$$

Mamdani FLC uses multiple rules, meaning that in addition to *n* facts, there are *m* rules.

premise 1: x_1 is A_{01} , ... , x_n is A_{0n}
premise 2: If (x_1 is A_{11}) and ... and (x_n is A_{n1}) Then (y is B_1)
...
premise m+1: If (x_1 is A_{1m}) and ... and (x_n is A_{nm}) Then (y is B_m)
conclusion: y is B_0

The final conclusion B_0 derived from the m rules is calculated as follows:

$$B' = \bigcup_{i=1}^{m} B_i'$$

Functioning of Mamdani FLC can be described by the following steps:
1. Input fuzzyfication;
2. Applying Fuzzy logic operator, inference conclusion for every rule by Mamdani implication;
3. Output aggregation, forming a summary conclusion;
4. Defuzzyfication.

In the following example is shown the functioning of FLC which contains 6 input fuzzy variables and one output fuzzy variable – risk assessment. The input fuzzy variables are: frequency of hazard/harmful exposure, possible consequences - duration of sick leave because of injury/disease, frequency of previous injuries, application of preventive measures on the machine, compliance of machine with requirements of standards and technical conditions and working overtime on the machine. Changes in the values of the input variables have a different effect on the outcome of the risk. Examples are given in Table 1:

Table1: *FLC inputs*

n.o	FREQUENCY OF EXPOSURE	CONSEQUENCES	FREQUENCY OF INJURIES	PREVENTIVE	COMPLIANCE	OVERTIME	RISK
1.	0	0	0	100	100	0	0
2.	49.79	57.45	6.702	100	100	13.72	23.5
3.	95.74	164.7	12.45	100	100	29.04	50
4.	95.74	164.7	12.45	0	0	29.04	65
5.	195.3	180	30	51.09	100	30	50
6.	360	180	30	51.09	100	30	50
7.	195.3	340.9	27.77	46.74	52.13	14	74.5
8.	360	360	30	0	0	30	99.5

2.1 Discussion

Variables *preventive* and *compliance* are inversely proportional to the risk. Other variables are directly proportional to the risk. The variable *frequency of exposure* in the combination of variable values which are shown under number 5 and 6, did not affect the level of risk at all, although its values are significantly different (195.3 and 360). Comparing the combination of variable values which are shown under number 2 and 7 can be seen that variable *overtime* has values 13.72 and 14 which are similar values, but the level of risk is significantly different (23.5 and 74.5), because of a significant difference in other values of variables.

3. CONCLUSION

By using FLC it make a connections between facts, which would be hard to see in circumstances with many data. The application of fuzzy logic in risk assessment for workplaces on machines would make it possible to reduce human error when assessing risk, implementing knowledge and experience of experts in software, interpreting large amounts of obscure data, and excluding subjectivity in risk assessment, thus achieving significant quality in risk

assessment. [1] Also, there is possibility for creating different fuzzy logic controllers for each different machine, which would make possible highly-specialized risk assessment for workplace on a given machine.

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PREDICTION OF SKIING TIME BY STRUCTURED REGRESSION ALGORITHM

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Abstract. *In this paper, the application of Gaussian conditional random fields (GCRF) in the case of prediction skiing time between ski gates in ski center Kopaonik, is presented. Gaussian conditional random fields is well-known structured regression method that exploits advantages of unstructured predictors and combines them with the information concerning correlation between outputs. Four different unstructured predictors were used: ridge regression, LASSO regression, Random forest regression and support vector machine regression. Even though, only 18 features are used for prediction of skiing time, GCRF achieved better results, concerning R^2 and mean absolute error, compared to unstructured predictors.*

Keywords: *structured regression, Gaussian conditional random fields, GCRF, skiing.*

1. INTRODUCTION

One of the most fundamental problems in machine learning that have numerous application in various application fields is a regression. A wide variety of machine learning algorithms for unstructured regression have been developed [1]. A comparative empirical study on both well established, supervised machine learning technique including regression and classification, was carried out on different tasks and data sets originating from different domains by Singh et al. [2].

Besides unstructured regression predictors that are well known and widely used, an increased amount of information concerning relations between outputs, have made a drastic impact on prediction performances. Due to that, it is necessary to exploit additional information concerning structure between outputs. Gaussian conditional random fields (GCRF) are a widely used structured model for continuous outputs that use multiple unstructured predictors to form its features and in the same time exploits structure among outputs, which is defined by given similarity measure [3]. Furthermore, various adaptations and procedure improvements have been developed in order to extend the algorithm on directed graphs [4], or to reduce the computational cost of the learning procedure [5].

In this paper, GCRF was used to predict average skiing time between two ski gates in ski center Kopaonik. GCRF prediction performances (mean absolute error and coefficient of determination (R^2)) were compared with unstructured predictors performances: ridge regression, LASSO regression, random forest regression and support vector machine regression. The advantages of GCRF are emphasized and experimentally evaluated.

2. RELATED WORK

Machine learning supervised algorithms have been used in a various sports for prediction of: basketball outcomes [6], golf ball trajectories [7], football players selection [8] etc.

Additionally, Akgol et al. [9] used General Regression Neural Networks and Decision Tree forest to predict upper body power, one of the most important determinants of cross-country ski performance. The result shows that gender and oxygen value is the most important parameters for

prediction of upper body power. Similarly, Delibasic et al. [10] developed model for ski injury predictive system by analyzing skier transportation data from six consecutive seasons. The predictive system is based on logistic regression and chi-square automatic interaction detection decision tree. The lowest ski injury risk is observed for skiers who spend more time in the ski lift transportation system and ski faster than average skier. In the same manner, a comparison of several models based on data mining, expert modeling and a combination of both have been evaluated in [11]. The analysis showed that expert models are 10-15% less accurate in comparison with data mining models.

In addition, analysis of different ski tasks is up to date research area [12, 13].

In this paper, we showed that structured regression algorithms can significantly improve prediction performances in cases when unstructured predictors scores are poor due to a small number of relevant features.

3. METHODOLOGY

The generalized form of GCRF conditional distribution $P(\mathbf{y}|\mathbf{x},\alpha,\beta)$ is given in form of condtional random field (CRF) and can be expressed as:

$$P(\mathbf{y}|\mathbf{x},\alpha,\beta)=\frac{1}{Z(\mathbf{x},\alpha,\beta)}exp\left(\sum_{i=1}^{N}A(\alpha,y_i,\mathbf{x_i})+\sum_{i\neq j}I(\beta,y_i,y_j)\right) \quad (1)$$

Two different feature functions are used: *association potential* $A(\alpha,y_i,\mathbf{x})$ to model relations between outputs y_i and corresponding input vector $\mathbf{x_i}$ and *interaction potential* $I(\beta,y_i,y_j)$ to model pairwise relation between nodes. Vectors α and β are parameters of the association potential A and the interaction potential I. The *association potential* is defined as:

$$A(\alpha,y_i,\mathbf{x_i})=-\sum_{i=1}^{N}\sum_{k=1}^{K}\alpha_k\left(y_i-R_k(\mathbf{x})\right)^2 \quad (2)$$

where $R_k(\mathbf{x})$ represents unstructured predictor of y_i for each node in the graph. This unstructured predictor can be any regression model that gives independent prediction of output y_i for given attributes $\mathbf{x}$. K is the total number of unstructured predictors. The *interaction potential* functions is defined as:

$$I(\beta,y_i,y_j)=-\sum_{l=1}^{L}\sum_{k=1}^{K}\beta_l S_{ij}^{l}(y_i-y_j)^2 \quad (3)$$

where S_{ij}^{l} is a value that express the similarity between nodes i and j in graph l. L is the total numbers of graphs (similarity functions). Graphs can express any kind of relations between nodes e.g., spatial and temporal correlations between outputs. Hence, the conditional probability distribution of the presented model is defined as:

$$P(\mathbf{y}|\mathbf{x},\alpha,\beta)=\frac{1}{Z(\mathbf{x},\alpha,\beta)}exp\left(-\sum_{i=1}^{N}\sum_{k=1}^{K}\alpha_k(y_i-R_k(\mathbf{x}))^2-\sum_{l=1}^{L}\sum_{k=1}^{K}\beta_l S_{ij}^{l}(y_i-y_j)^2\right) \quad (4)$$

The quadratic form of interaction and association potential enables conditional distribution $P(\mathbf{y}|\mathbf{x},\alpha,\beta)$ to be expressed as multivariate Gaussian distribution. The canonical form of GCRF is:

$$P(\mathbf{y}|\mathbf{x},\alpha,\beta)=\frac{1}{(2\pi)^{\frac{N}{2}}|\Sigma|^{\frac{1}{2}}}exp\left(-\frac{1}{2}(\mathbf{y}-\mu)^T\Sigma^{-1}(\mathbf{y}-\mu)\right) \quad (5)$$

where precision matrix $\Sigma^{-1}=2Q$ and distribution mean $\mu=\Sigma\mathbf{b}$ is defined as, respectively:

$$Q=\begin{cases}\sum_k\alpha_k+\sum_h\sum_l\beta_l S_i h^l, & \text{if i = j}\\ -\sum_l\beta_l S_{ij}^{l}, & \text{if i} \neq \text{j}\end{cases} \quad (6)$$

$$b_i=2(\sum_{k=1}^{K}\alpha_k R_k(\mathbf{x})) \quad (7)$$

The representation of GCRF is illustrated in Fig. 1.

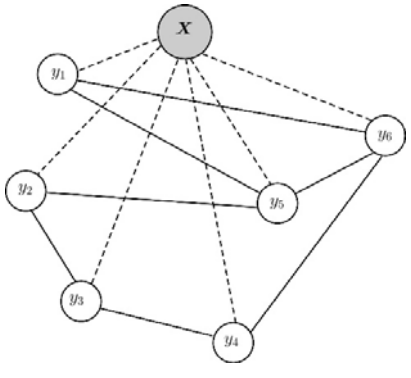

Figure 1. GCRF representation.

Due to the convexity of multivariate Gaussian distribution the inference task $\underset{\mathbf{y}}{\text{argmax}}P(\mathbf{y}|\mathbf{x},\alpha,\beta)$ is straightforward. The maximum posterior estimate of $\mathbf{y}$ is the distribution expectation μ.

The objective of the learning task is to optimize parameters α and β by maximizing conditional log likelihood $\underset{\alpha,\beta}{\text{argmax}}\sum_{\mathbf{y}}logP(\mathbf{y}|\mathbf{x},\alpha,\beta)$. One way to

ensure positive definiteness of covariance matrix of GCRF is to impose constraints that all elements of α and β be greater than 0. The derivative od the conditional log likelihood can be expressed in the following form:

$$dlogP = -\frac{1}{2}Tr(d\Sigma^{-1}(\mathbf{y}-\mu)(\mathbf{y}-\mu)^T - 2\Sigma^{-1}(\mathbf{y}-\mu)d\mu^T) - \frac{1}{2}Tr(\Sigma^{-1}d\Sigma) \quad (8)$$

The optimization of the parameters can be obtained by gradient descent method with log transformation of derivatives. Moreover, the optimization can also be performed by a truncated Newton algorithm for nonlinear functions with constraints or sequential quadratic programming. The GCRF code used in this work is publicly available.[1]

4. RESULTS AND DISCUSSION

Kopaonik is one of the largest ski resort in a southern part of Europe with more than 55 km of ski slopes and 25 ski lifts. One of the biggest problem in Kopaonik is crowds on ski lifts, due to that it is necessary to predict average skiing times between two ski gates. With this average skiing times it is possible to predict occurance of rush hours on ski-lifts.

Dataset used in this research includes information on ski lift entrance for a period from 15th to 30th of March for years between 2006-2011. Totally seven ski lifts were considered: Karaman Greben, Mali Karaman, Marine vode, Duboka I, Karaman, Pancicev vrh, Duboka II.

All used features are separated in the three distinct groups:

1. Descriptive features: the total number of skiers, total unique number of skiers, time expressed in hours and minutes
2. Statistical features: mean, tenth percentile, first and second quartile, ninetieth percentile, median, minimum value, maximum value, kurtosis and skewness of average skiers velocity
3. Weather features: wind speed, temperature, dew point, cloud cover and pressure

All features were evaluated by observing shifts in time periods of 5 minutes, whereas prediction was made 15 minutes in advance.

The two graphs for potential interaction between ski lifts (nodes) were used. The first graph is obtained by differences between the history of average skiing time in the period of 30 minutes, whereas the second graph was obtained by differences between the history of average skiing time in slopes for the whole dataset. A total number of instances in the dataset was 4850 for each ski lift, which is totally 33950. The 20% of the dataset was used for testing, whereas the rest was used for training. Half of the training data was used for unstructured predictor learning, whereas the rest was used for optimizing GCRF parameters. All methods are implemented in Python and experiments were run on Windows 16 GB of memory and 2.5 GHz CPU. The results of the learning, concerning score metrics, are presented in Table 1.

Table 1. Prediction performances

	Ridge regression	LASSO regression	Random forest	Support vector machine	GCRF
Mean absolute error	364.87	367.72	343.6	388.05	336.44
R^2	0.578	0.585	0.549	0.484	**0.613**

It can be seen that GCRF outperformed unstructured predictors. Even though best-unstructured predictor Random forest provides satisfactory prediction performances, GCRF has best metrics R^2 and mean absolute error. It is important to emphasize that not only features are important in this particular case, but also the correlation structure between ski lifts.

5. CONCLUSION

In this paper, Gaussian conditional random fields (GCRF), well-known structured regression algorithm is applied on task of predicting skier average time between ski gates. The unstructured predictor that are used as association function in GCRF are: ridge regression, LASSO regression, random forest and support vector machine. It was shown that in this particular case dependencies among outputs are significant, such that GCRF outperformed all other regression algorithms. Further studies should concern comparing GCRF with other structured regression on real-world sports tasks.

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THERMO-ECONOMIC OPTIMIZATION AND CONTROL OF SMALL-SCALE WATER DESALINATION PLANT

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Abstract. *In this paper, the multiobjective optimization of small-scale water desalination plant with respect to exergy and plant profit is presented. The Non-dominated Sorting Genetic Algorithm (NSGA II) algorithm is used to obtain Pareto fronts for mass flow rates in the range from 0.05 kg/s to 1 kg/s. Based on obtained Pareto fronts, optimal pump frequencies and valve hydraulic resistances for each mass flow rate are evaluated by decision-making technique. Also, the control-oriented model of the system has been developed and linearized around different operating points to design a gain scheduling nonlinear PI controller. The proposed methodology showed satisfactory results in plant control in order to maximize profit and sustainability.*

Keywords: *multiobjective optimization, dynamical model, decision making, PID control, Optimal states tracking.*

1. INTRODUCTION

One of the most fundamental problems in modern society is connected with the lack of potable water [1]. Additionally, the problem of water desalination is connected with high energy consumption and price of water. In order to lower down this prices and achieve sustainability, concerning high environmental impact it is necessary to develop novel technologies for water desalination and purification [2].

A wide variety of technologies connected with the solar energy utilization in water desalination procedure have been studied recently by Li et al. [3]. Al-Othman et al. [4] presented a novel solar driven multi-stage water desalination plant driven by parabolic trough collectors and a solar pond. The objective was to satisfy water demand for a small community with a total population of five thousand citizens. Similar studies concerning the experimental and theoretical investigation of low-temperature Rankine organic cycle coupled with the reverse osmosis is presented in [5].

Besides the development of novel technologies, the single and multiobjective optimization has also been the focus of many studies recently.

Mokheimer et al. [6] developed hybrid wind/solar powered reverse osmosis plant and performed single objective optimization in order to design plant with minimum operational costs. Furthermore, Petrovic et al. [7] performed optimization of water desalination plant with ejector refrigeration cycle with respect to investment cost and profit.

Similar but somewhat simplified water desalination plant was analyzed in this paper. For different values of water mass flow rate (disturbances) the optimal regimes of system actuators are obtained by multiobjective NSGA II algorithm coupled with the SAW method. The total exergy loss and plant profit were evaluated as objective functions. For obtained values the controlled oriented model of the plant was developed and linearized around different operating point in order to design a gain scheduling nonlinear PI controller. The advantages of the presented methodology have been emphasized.

2. WATER DESALINATION PLANT

Model of water desalination plant is presented in Fig. 1. Thermo-dynamic states of the hot water are marked by three-digit numbers.

The plant is supplied with water from one or more hot springs. Water flows to the vessel P1, which is under low pressure, corresponding to the

evaporation temperature of the inlet water. Pressure in P1 is maintained by a water-steam ejector E1. The evaporated water is condensing in the ejector, where mixing of the primary water with steam is occurring. In order to preserve constant temperature of motive fluid water a heat exchanger HE1 is used. The desalinated water from vessel P2 is used as a motive fluid for ejector E1.

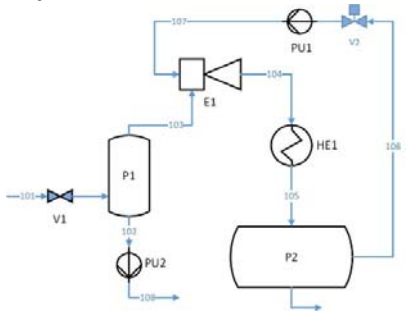

Figure 1. Water desalination plant - scheme

Conversion of mass and energy equation with the combination of fixed thermodynamic states lead to a set of the equation for the steady-state simulation of the water desalination plant. The number of transmission units (NTU) method was used for balancing and sizing heat exchangers, Incorprera et al. [8]. In addition, the swater-steam ejector was modeled by equations from [9].

3. OPTIMIZATION

Multi-objective optimization of water desalination plant has been performed by the Non-dominated Sorting Genetic Algorithm (NSGA II). The objective of the NSGA II algorithm is to improve the adaptive fit of a population of candidate solutions to a Pareto front constrained by a set of objective functions. The algorithm uses an evolutionary process with surrogates for evolutionary operators including selection, genetic crossover, and genetic mutation. The population is sorted into a hierarchy of subpopulations based on the ordering of Pareto dominance. In order to choose optimal solutions based on the obtained Pareto fronts for each mass flow rate the SAW method was used.

The two objective functions were optimized:

- Profit maximization

$$f_1 = 24 \cdot \left(\dot{m}_{103} \cdot 3600 \cdot price_{H_2O} - \frac{(P_{PU1} + P_{PU2})}{1000} \cdot price_{EL} \right) \quad (1)$$

- Exergy loss minimization

$$f_2 = \sum_i Exloss_i \quad (2)$$

The results of Pareto front for $\dot{m}_{101} = 0.9$ kg/s is shown in Fig. 2.

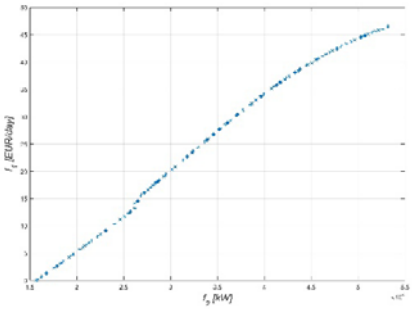

Figure 2. Pareto front for $\dot{m}_{101} = 0.9$ kg/s

4. CONTROL

4.1 System Modeling

Dynamical model suited for the control purposes is obtained by introducing certain but reasonable assumptions:

- The specific heat capacities of liquid at the constant pressure (c_p) and at the constant volume (c_v) are constant;
- Volumes occupied by vapor (V_V) and liquid (V_L) are constant;
- Steady-state conditions of the liquid jet vacuum ejector are assumed;
- Mass accumulation in vessel V1 is negligible;
- Water density is constant;
- Water vapor is saturated at the position 103, whereas liquid is boiled at the position 102 such that, $p_{102} = p_{103}$ and $T_{102} = T_{103}$.

Using mass and energy balance the dynamical model for vessel P1 has been developed as follows:

$$\dot{m}_{101} = \dot{m}_{102} + \dot{m}_{103} \quad (3)$$

$$\frac{d}{dt}\left(\rho_L \cdot V_L \cdot c_{vL} \cdot t_{102} + \rho_V \cdot V_V \left(c_{vL} \cdot t_{102} + \Delta h_{LAT} \right) \right) = \dot{m}_{101} \cdot c_{pL} \cdot t_{101} - \dot{m}_{102} \cdot c_{pL} \cdot t_{102} - \dot{m}_{103} \left(c_{pL} \cdot t_{102} + \Delta h_{LAT} \right) \quad (4)$$

The plant is considered to be in steady-state with turned off pump PU1. Thus, combining equations (3) and (4) the nonlinear simulation has been performed with initial conditions $T_{102}^0 = T_{101}$, and it is shown on Fig 3.

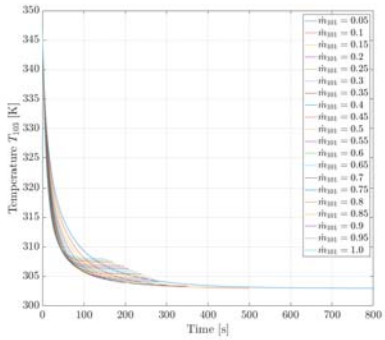

Figure 3. Step responses of nonlinear plant model for some operating point initiated with chosen values of f and ζ_v.

4.2 Linearization

To tune conventional controllers such as PID, a linear model around the desired operating point is necessary. Linearization is carried out using polynomial curve fitting with least squares error method for every nonlinear simulation as it is shown in [10].

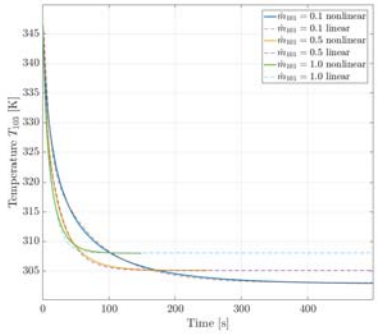

Figure 4. Step responses of nonlinear and linearized plant model for three operating points initiated with chosen values of f and ζ_v

Linearization results have been verified by comparing nonlinear and linearised step responses. The comparison is shown only for three operating points, Fig 4. This result is considered to be accurate enough to calculate the controller parameters. Furthermore, in Table 1 the linearised models of the plant has been presented in the form of the transfer functions.

Table 1. Transfer functions of the linearized plant for three operating points.

Linearization point	Transfer function $G_p(s)$
$\dot{m}_{101} = 0.1$ kg/s	$\frac{\text{-1.93 s - 0.051}}{1.021s^3 + 0.73s^2 + 0.09s + 0.001}$
$\dot{m}_{101} = 0.5$ kg/s	$\frac{\text{-2.27 s - 0.24}}{0.82s^3 + 0.51s^2 + 0.16s + 0.006}$
$\dot{m}_{101} = 1.0$ kg/s	$\frac{\text{-2.53 s - 2.10}}{0.047s^3 + 0.11s^2 + 0.70s + 0.05}$

4.3 Control Strategy

The nature of process for this kind of plants is that it always goes in the steady-state for arbitrary input, Fig 3. Those steady-states for uncontrolled plant are suboptimal, therefore, tracking characteristics are poor and time constants are too high. Hence, to improve the system performance a PID controller is introduced with following control law [11]:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(\tau) \qquad (5)$$

$$e(t) = r(t) - y(t) \qquad (6)$$

where $u(t)$ is control signal; $e(t)$ is error signal; K_p, K_i and K_d are proportional, integral and derivative gains respectively, and $r(t)$ is reference signal.

Parameters of the PID controller are selected using nonlinear dynamical simulation to obtain maximal performances [11]: $K_p = -2.25$, $K_i = -0.802$ and $K_d = -0.369$.

The optimal reference signal, $r(t)$, and optimal hydraulic resistance, ζ_v, are obtained using the optimal values table and are applying dynamically, Fig 5.

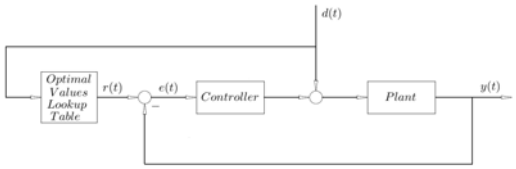

Figure 5. General control system block diagram

5. SIMULATION RESULTS

Simulation has been performed for initial conditions $T_{103}^0 = 346.65$K Changes in the disturbances was chosen to simulate a worst-case scenario in short period of time, where mass flow rate, $\dot{m}_{101}$, drops and temperature, T_{101}, rises over a period of $400s$, as it is shown in Fig. 6.

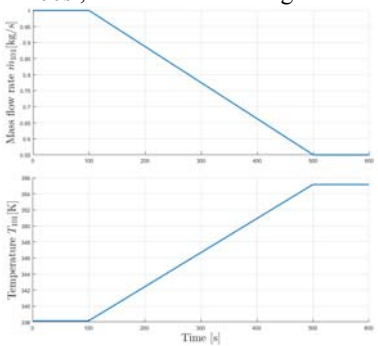

Figure 6. Changing of input mass flow rate, $\dot{m}_{101}$, and temperature, T_{101}, during $600s$ of simulation.

Results of control simulation with PID controller are given in Fig. 7. Although the disturbances are taking place after the 100^{th} second of simulation, the controller can stabilize the system around desired value with the minimal error, Fig. 8.

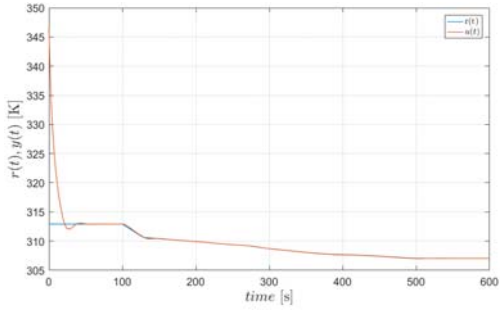

Figure 7. Simulation of the nonlinear system controlled by PID controller under the influence of disturbances, and with the initial condition $T_{102}^{0} = 346.65\text{K}$.

In Fig. 9 can be seen that during all time of simulation the control signal, $u(t)$, was within the acceptable boundaries.

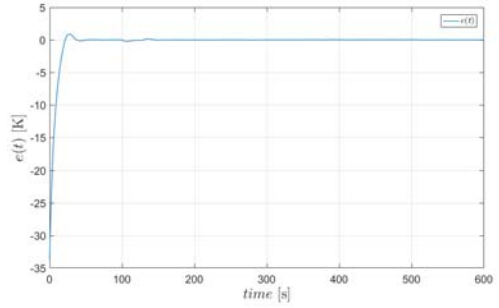

Figure 8. Error signal, $e(t)$, generated during simulation.

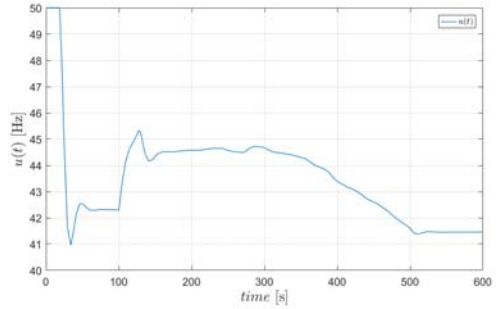

Figure 9. Control signal, $u(t)$, generated during simulation.

5. CONCLUSION

A dynamical model of the plant has been developed and linearized around operating points in order to design a PID controller which will guide the plant through optimal thermodynamic states. The optimal reference signal has been changed over time in accordance to inlet mass flow rate, and has been obtained from the lookup table derived using multiobjective NSGA II algorithm in combination with SAW decision-making method.

It can be seen that the control system can guide the system through the vicinity of optimal thermodynamical states with enough accuracy for engineering purposes.

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GRAPH MINING AT THE HIGH-ENERGY PHYSICS EXPERIMENT LHCB

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Abstract. *The paper presents a set of graph mining studies that can be performed on the graph database that was developed to capture the provenance of experimental data and software at the LHCb experiment at CERN. We explore four different scenarios in which data mining could help us better understand the LHCb data and software. The first scenario covers isolating complex software dependencies, which need to be captured to allow software reuse through for example a virtual machine or a virtual container. The second scenario is troubleshooting of data which could occur when a software version contains a bug. In this scenario, we need to understand what datasets were processed with this software version and thus affected by the bug. The third scenario covers application classification into logical groups according to what dataset they can process for long-term preservation and testing purposes. Finally, the last scenario covers identification of obsolete software versions that could be removed or archived as well as legacy software versions that should be preserved for future use.*

Key words: *database systems, nosql, data provenance, graphs, scientific software*

1. INTRODUCTION

LHCb is one of the four large experiments at the Large Hadron Collider (LHC) at CERN [1]. It is located 100 m underground at the Swiss and French border. The experiment studies a wide range of physics phenomena that test the Standard Model of particle physics and search for New Physics effects. This is done by performing physics analyses on data collected from hadron collisions in the LHC. The primary program involves proton-proton collisions, however, collisions of lead ions are also studied as well as "fixed" target collisions. The fixed target experiments are conducted when a small amount of gas is injected inside the beam pipe allowing collision of these gas molecules with the beams of protons or lead ions. There has been several proton-gas and lead-gas data collection periods at LHCb, which is the only experiment that can conduct fixed target experiments at the LHC.

The LHC experiments collect vast amounts of data over a lifetime of several decades. In 2016 only, the LHCb experiment collected 9.89 PB of raw experimental data.

To process and analyze the data, experts at CERN develop scientific software [2]. There is a wide range of software applications which are used for data collection while the experiment is running, data processing to interpret the detector readout and data analysis to learn about particle properties. Software is, however, a fragile component dependent on operating system and various other dependencies such as compilers, libraries and computer hardware. In addition, the LHC experiments are constantly changing with regular detector upgrades that require new software releases and introduce changes in the collected data [3]. Even though some software applications follow backwards compatibility (meaning that newer versions of the software can process both old and new data), this is not enough to effectively analyze old data in all necessary scenarios.

To capture the complex dependencies between the data, software and hardware dependencies at LHCb, we designed and developed a graph database presented in Ref. [6]. This paper documents a continuation of the previous work with further

developments on the database in regards to graph mining methods.

2. DATABASE IMPLEMENTATION

Due to fact that the number of LHCb datasets and software releases increases over time, a requirement for database design and development was that it needs to scalable. This is why we chose a NoSQL solution, in particular a graph database. Such databases allow forming implicit connections i.e. relationships (edges), between objects i.e. nodes (vertices). Both relationships and nodes can store a number of properties within the database entry itself. In our solution, we use Neo4j graph database, which is an open source database implemented in Java programming language. For object manipulation and for graph mining we use the query language called CYPHER.

The following nodes are implemented to capture the LHCb data, software and computational environments such as operating systems and hardware:

1. **Data** node (in the database called Production as datasets are produced in "data production" processes) describes datasets collected at LHCb. It captures stages of transformation of a dataset including software applications and options that were used in these processes. With this information, the chain of transformation can be independently recreated and the datasets can be reproduced. This node also contains a location of datasets among other information. It is directly linked to the software nodes as shown in Figure 1.
2. **Project** node describes one application and application version of LHCb software. It is defined as name and software version. An example of this would be Brunel v44r8 or DaVinci v36r2. Brunel [4] is the application that is used for particle reconstruction from the detector readout and DaVinci [5] is a data analysis application which uses the reconstructed data as input. However, a software project is often dependent on other project nodes and these dependencies are also captured in the database. An example of this dependence graph featuring DaVinci application can be seen in Figure 2.
3. **Platform** (hardware) node describes a computing environment compatible with the LHCb data and software. The LHCb software is normally developed for the official CERN operating systems, which are Scientific Linux CERN versions 5 and 6, and CERN CentOS 7. In the database, these operating systems are captured with other relevant options, such as for example hardware architecture and compiler options.

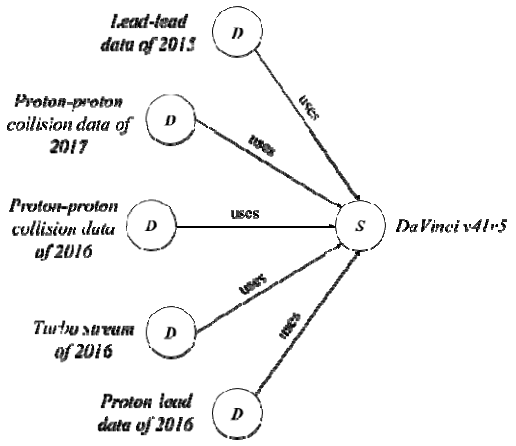

Figure 1 Relationships between data and software nodes. These edges are labelled with "uses". Nodes labelled as D represent data, and nodes labelled as S software. Each data node represents datasets collected under different experimental conditions.

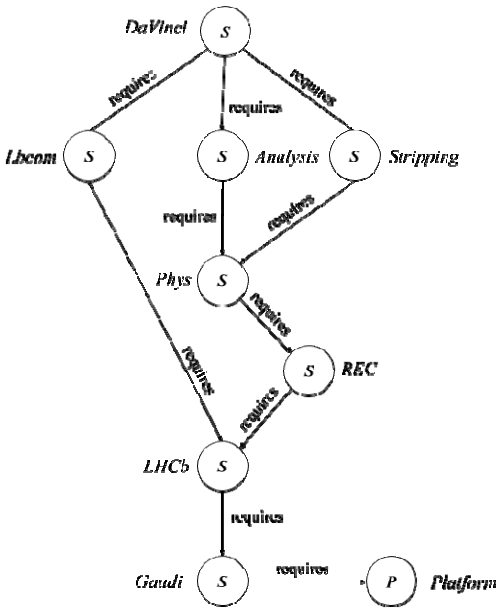

Figure 2 Dependencies of software nodes on other software nodes (many of which represent frameworks, components and libraries). The edge direction indicates the requirements of a software node, and it is labelled as"requires". Software nodes are labelled as S and platform nodes (representing operating systems and computational environments) as P. For clarity, not all possible relationships are shown in the figure. Software applications such as Lbcom, Phys and REC represent components and libraries in the LHCb software, but their

purpose will not be discussed here as it is not important for the purposes of this paper.

3. METHODOLOGY AND IMPLICATIONS

The database contains thousands of nodes describing data, software and computational environments. Graph mining, which is a study of concealed information from graphs, allows us to draw valuable conclusions about these entities. In this paper, we explore several scenarios in which graph mining can be used.

3.1. Software reuse

The challenge with capturing a particular version of LHCb software is that it is often dependent on many other projects (as shown in Figure 2). We can learn about these dependencies using the graph database. By capturing a particular software version with its dependencies we could, for example, encapsulate it into a virtual machine or a virtual container, thus making it portable and independent of the rest of the software. Such LHCb application can be made open access and used for outreach and educational purposes to analyze LHCb open data.

For example, if we would like to capture a top-level application such as DaVinci v33r1, we need to query the database in the following way to learn about its dependencies:

```
MATCH p = (a:Project{name:"DAVINCI",
version:"v33r1"})-
        [r:REQUIRES*..]->
        (d:Project{name:'GAUDI'})
RETURN p LIMIT 1
```

The variable p in the query represents a path from the application to the base framework of the LHCb software. The result of the query is the following list:

Application	Version
DaVinci	v33r1
Analysis	v10r3
Phys	v16r3
REC	v14r3
LHCb	v35r3
Gaudi	v23r5

In this particular example, there may be other projects that also need to be captured to make this application usable in every scenario and portable within a virtual environment.

3.2. Troubleshooting

With a large number of software releases, there is a possibility that a software version is released with an undetected bug in the code. If the bug is not promptly found, this software version can be used for processing of a number of datasets, which may cause problems in following data analysis. When the bug is found, we need to learn of all datasets that it had affected and restrict their use until the problem is solved. Using graph mining, we can perform troubleshooting by querying the graph to learn about affected datasets.

For example, in order to learn how many datasets have been processed with a project called Phys v18r2p1 we can execute the following CYPHER command:

```
MATCH (n:Production)-
      [:REQUIRES|:USES*1..100]->
      (b:Project{name:"PHYS",
version:"v19r2p1"})
RETURN COUNT(n)
```

The relationships between this project and datasets are indirect as Phys represents a library component in the software suite. This scenario demonstrates the power of graph databases as such query is able to identify secondary relations with data nodes within milliseconds. The query returns a number of produced datasets, which is in this case 280. The list of exact data nodes can be obtained by modifying the query to return the node instead of returning the count.

3.3. Software classification and testing

Due to the fact that the LHC running time is divided into periods of active running and periods of detector maintenance and upgrade that can last for several months, the software applications can be classified into groups according to the data they are designed to process. For example, applications released in 2015 are likely to be compatible with data collected in the same year. Using graph clustering, we are able to sort the software applications into such groups. This is particularly important for software testing in the future as we can implement cross-checking by verifying whether a software version can process different datasets recorded under the same conditions.

An application used in data collection for selecting interesting particle collisions in real time while the experiment is running is called Moore [2]. If there is a need to understand which versions of Moore are

compatible and useful for data collected in 2016, we can easily learn that from the graph database with the following CYPHER query:

```
MATCH (a:Production {year:"2016"})—
(p:Project {name:"MOORE"})
RETURN COLLECT (DISTINCT p.version);
```

The unique set of application versions gathered with the query is:

Moore
v25r4
v25r5
v25r3p1

3.4. Archiving software and legacy versions

Legacy software versions are the ones that capture data processing of a particular time period and the ones that will be maintained and preserved for the future. They are used for future data processing of the old data to identify particle decays that may not have been previously studied. The legacy versions are often thoroughly tested and released with most recent developments that solve known bugs in the code. Using graph mining, we can identify the most used version of each LHCb software application. Such a version is the one that produced the highest number of LHCb datasets. We can identify such versions by sorting the nodes descending according to their degree count (the number of edges incident to that node). This can be achieved with the following CYPHER query:

```
MATCH(p:Project)-->(a:Production)
RETURN id(p), count(*) as degree
ORDER BY degree
```

However, it does not necessarily mean that such version will be the legacy version even though it would be a good candidate. The legacy version is most likely to be the one which represents the latest patch release that captures the most recent code developments. For example, if we consider the aforementioned application called DaVinci, at the time of the database development the most frequently used application version was DaVinci v32r2p1. This version would be preceded by the newer version such as DaVinci v32r2p3 that includes the third patch (p3) release, thus solving the bugs in the code whilst preserving the previous functionality and data compatibility. DaVinci v32r2 (all patch versions) was vastly used for processing of data collected in 2010, 2011 and 2012, which was the first data-taking period of the LHC.

The legacy software versions should likely be used for outreach and open science outside of the LHCb collaboration. It can be isolated and captured into a virtual machine or a virtual container in a way that was discussed in Section 3.1 and released to the general public.

In a similar manner, we are able to learn about the project nodes that were used the least, by sorting node degree count ascending. By doing this, we can identify software versions that are obsolete and should be archived as they are likely to be replaced with newer releases. However, in such list, there are software versions used for special runs at LHCb such as for example ion-proton data collection or for fixed target data-taking. Therefore, these versions should be excluded from the study as they would still be valuable for software preservation.

3. CONCLUSIONS

This paper explored several data mining studies of the graph database that was developed for data provenance capture at LHCb. The database represents a fully working implementation, even though it is currently a prototype. It needs additional development such as integration with the existing LHCb systems in order to be actively used by the community.

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PREPARATION FOR SPC IN SHORT RUN AND SMALL MIXED BATCH PRODUCTION: CASE OF BAKERY EQUIPMENT ORGANIZATION

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Abstract. *The purpose of this paper is to present preliminary research in statistical process control (SPC) of short run and small mixed batches (SRSMB) at the organization producing bakery equipment. The starting point is a literary survey of possibilities of using SPC for SRSMB and analysis of the current state of production in a particular organization. Using SPC in the bakery equipment industry is far from standard practice. By SRSMB-SPC, it is possible to understand the behavior of the process and to organize better and control the production of expensive precision components. After Pareto analysis, verifying the normality of the data obtained during eleven months, it was possible to prepare control charts. Finally, the case study shows that the proposed control charts are applicable in a small batch and mixed production in the organization producing bakery equipment.*

Key words: *bakery equipment; control chart; short run; small mixed batch; SPC;* X_i, mR *;* $\bar{X}, R$ *; Hotelling T2*

1. INTRODUCTION

The competitive pressure on the continuous improvement of organizations' performance in the current, ever-changing environment is very high. The business environment increases the need for versatility and flexibility of production in highly efficient production systems. These systems do not need to have material on stock but require products, respectively their components, to receive and deliver "just-in-time" in "Lean" organizations [1].

Therefore, organizations must be able to produce a broader range of products in smaller batches and shorter production cycles. Production systems need to be flexible, ready for adjustments, prepared to change, and change the changes.

The opportunity for research is in a less explored and literally-documented field that focuses on short-run (SR) processes and small mixed batches (SMB) in bakery equipment industry. This industry is characterized by its high requirements for material safety and precision components and products.

Consequently, the implementation of statistical process control (SPC) must focus on critical manufacturing processes of such products.

The presented research is going through preparation for the dissertation thesis and is divided into several phases. In the first phase, the current state of the organization was examined regarding production organization and production control, quality assurance and conceptual research framework according to [2] [3]. The second phase aimed at problem definition and determining performance metrics. The third, analytical phase presented in this article, after identification, validation and selecting the causes using Pareto analysis aims to create control charts for SRSMB-SPC.

Phases of improvement and design of a new management method will be gradually solved in the next stage of research.

2. RESEARCH PROBLEM AND OBJECTIVES

Products that are generated by one or more similar processes are usually considered as different entities. As a result, organizations often focus on the product and analyze the sources of process changes. Due to the fact, that in short production cycles with a small

number of identical products it is not possible to obtain sufficient information for management (quality management, logistics or financial management), it is necessary to focus on the common element, and that is the process itself.

Based on best practices for the application of control charts for processes with long production cycles and a single product characteristic, it is generally recommended that at least 25 subgroups of data be gathered, and these data can be used to create the basis for the control chart [4].

In case of small mixed batch production, many subgroups cannot be created and therefore processes need to be grouped in a predetermined way.

The goal of this research phase is to use Lean Six Sigma analytical tools for taking decisions in the bakery equipment organization about pros and cons of introducing SPC in a small batch and mixed production and to testing it under specific conditions. Control charts for univariate measurement processes were presented in [2] [3]. Therefore only short summaries will be given in this paper. Control charts for multivariate will be described in detail.

2.LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Bakery production lines and equipment are based on the customer's requirements for the final product, which is the bakery dough. Equipment that prepares and modifies the dough is called bread and rolls equipment, dough processing equipment, pizza product equipment. Production of such equipment represents a precision engineering, in some cases, it is a mechatronic production that meets strict standards to produce equipment used in the food industry. Components that come into direct contact with the dough are made of high-quality stainless steel and food grade material.

Research in the field of short run and small mixed batches was in the past mainly focused on products and less on processes, so SPC implementation was related mainly to products. In literary sources and professional practice, by the end of the last century most of the terms "piece production" and "small batch production" were used and were mainly characterized by the number of pieces produced in a batch [5]. Examples are in publications [6] [7] where the following terms can be found: "one-off and small batch production" and [5] "small batch and piece production".

Nowadays, when there are a growing need for the possibility of modifying production according to individual specifications and customer preferences and "Lean" [1], [8] and "Agile Manufacturing" [9] paradigms, organizations need to focus on SPC to improve processes. This leads to the need to better characterize such production based on cycle time [10] and control time [5]to identify planned and actual production time about a certain number of pieces produced and to provide corrective actions.

According to ISO 7870-8:2017 the term "short run" (SR) means that only a few pieces are produced, and consequently a different part or item (characteristic) is going will be produced. It means that the production cycle is very short, the repeatability of the production batch is low, and a very small volume of items is in a batch.

The term "small mixed batch" is used when different products are in the batch, but according to some characteristics they can be investigated together [5].

Based on a more detailed survey [4] [5][6][8][11] for short production cycles and small mixed batches, the following situations can be considered: (a) a small quantity of a same product in a batch; (b) one production process is used when producing different products; (c) several operators use same machines or devices; (d) lack of parts in one production process to create and maintain process regulation limits; (e) it is not possible to obtain sufficient data due to a short production cycle; (f) a large volume of different parts are produced for several different customers.

SPC techniques are applicable in any short-run production in small mixed batches, which are repeatable in any way.

The procedure of identifying and grouping similar characteristics and, if necessary, its modifications can be described according to [4], in three steps:

Step 1: Identification of processes→ Formalization of processes→ Determination and evaluation of influencing characteristics.

⇓

Step 2: Expert knowledge or analysis of existing data→ Identification of systematic process influencing→ Groping of characteristics

⇓

Step 3: Use of control charts→ Periodic and alarm triggered check of the group→ Systematic influences→ … In case of a systematic impact, return to step 2.

Multiple processes can be grouped when the same procedure follows them but with different characteristics such as nominal/target value, tolerance, material, measurement process,

production machine, tool, environmental conditions, etc. Characteristics that differ between processes are plotted in the cause and effect diagram together with the appropriate parameter.

If there are no significant differences or these differences are systematic, they can be compensated by transforming the values into a single scale. Then, the characteristics can be grouped, and a standard control chart can be used.

During the application of control charts, numbers of data is collected, and much knowledge is acquired about processes. Therefore, it is necessary to regularly verify that the terms of data grouping are still valid. This is particularly true when there are warning signs for which no attributable cause can be found. To flexibly group and reorganize processes, it is essential to record characteristics such as meta-data along with the measured data so that each measured value is associated with a group of processes.

The theoretical framework presented in this paper is about selected tools of Six Sigma, which will be used for analysis in a particular organization producing bakery equipment: (1) Normality test; (2) Homogeneity of variances; (3) Measurement Systems Analysis (MSA); (4) Control charts for short run and small mixed batch processes: X_i, mR; $\bar{X}, R$ control charts for univariate data; and multivariate *Hotelling T-square* (*T2*) control chart for multivariate data using QI Macros SPC Software for Excel [12].

3. CASE STUDY

The company where the research was conducted specializes in developing and delivering innovative solutions for the bakery industry.

The organization has its quality assurance system, which is not ISO 9001 certified. The main products of the company are shafts, rollers, electro-cabinets, hoppers and conveyors, which are assembled to dough processing units, dough thickness reducing units, shaping or dosing units. Almost every project has specific customer requirements and is a so-called "turn-key" solution. Repeatability of production is very low (5 pieces of products are considered to be series), and this predetermines high degree of detail of construction and technological preparation of production as well as the scope of work related to the development of the technological process.

Frequent changes and workplace adjustments place increased demands on time consumption, and work interruptions, high level of work-in-progress is present, and so is an uneven use of production facilities.

The following components are included in the overall research: tube, shaft, flange and roller (400; 600, 800) made of AISI 304 DIN 1.4301.

The manufacturing process is as follows:

(1) Cutting raw material in cutting room (vertical separation of seamless tubes to exact length, cutting of round bars).

(2) Advance preparation of individual parts of the roller on lathe machine (flanges, tube, and shaft), axial alignment and turning diameters.

(3) Welding flanges to the shaft, welding tube to the shaft with flanges.

(4) Turning individual shaft diameters, roller diameter concerning the required roughness, circular and total runout tolerances, and straightness (form tolerance).

(5) Milling shaft keyways and shaft threads. Incoming inspection is not performed as a raw material is purchased from certified vendors with an attestation.

Only post-operational control is in place in the plant. Technical Control Department does measurements of selected characteristics of the final products.

The management of the organization has decided to explore the possibilities of optimizing production regarding time consumption, work interruptions, reducing the number of work-in-progress processes, use of production facilities and SPC implementation.

3.1Preparation for SPC implementation

Before the SPC implementation, it was necessary to identify processes and monitored variables. Processes: cutting raw material, lathe operation.

Observed variables: tube length (tolerance ±0.05); precise shaft diameter (ϕ50g6); total runout (0.05 mm) and straightness (0.05 mm).

Furthermore, it was necessary to ensure the conditions for SPC, i.e. steadiness of all known effects: temperature in the range of 16^oC – 20^oC; air humidity 50% - 60%, and material quality according to DIN 1.4301 (AISI 304) austenitic chrome-nickel steel.

Subsequently, MSA was performed, while all measurements were made by calibrated measuring devices and by experienced and trained personnel of the Technical Control department. MSA processed in [12] showed that the influence of the measurement process is less than 10%.

Period of data collection is January 2017 – November 2017. A number of tube length measurements is 50. A number of diameter

measurements: 150, with a range of subgroup 3 and the number of subgroups are 50.
In the case study, the summaries of the short run and small mixed batch control charts applications are present:

- X_i, mR control chart for cutting precise tube length (404±0.05, 604±0.05, 804±0.05)
- $\bar{X}, R$ for measuring precise shaft diameter (ϕ50 g6)
- *Hotelling T2* control chart for a mutual combination values for straightness and total runout (0.050 mm and 0.050 mm).

3.2Control chart X_i, mR

Cutting (vertical separation) of three types stainless steel tubes to exact length (Table 1) was monitored for eleven months. Fifty data were obtained which, after clustering and transformation to a single scale, were recorded in X_i, mR control chart (Figure 1, 2). The tubes vary in length; their common sign is material and tolerance. Data originates from a normal distribution (processed in [12]).
Table 1 – Dimensions of 3 types of monitored rollers

Roller type	**Shaft length** [mm]	**Tube diameter** Ø [mm]	**Tube length** [mm]
400	941	182	404 ± 0.05
600	1,141	182	604 ± 0.05
800	1,341	160	804 ± 0.05

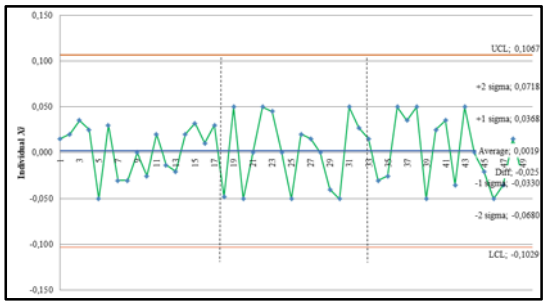

Figure 1 – Control chart for transformed individual values X_i for the process of vertical steel cutting

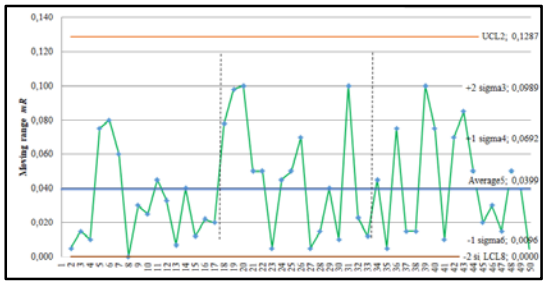

Figure 2 – Control chart for moving range mR for the process of vertical steel cutting

Summary: *Data in a control chart for individual values X_i, mR are centered, located within the control zone, and deviating measurements were not detected.*
In the moving range chart, mR has used ranges between consecutive values. The regulatory zone was not exceeded, while the upper control limit is more times bigger than the lower control limit. The process is stable.

3.3Control chart $\bar{X}, R$

Lathe operation of stainless steel roller diameters has been monitored for 11 months. Overall 150 data were gathered and grouped into 50 selections, each of which contained 3 pieces. The data were recorded in $\bar{X}, R$ control chart (Figure 3). The rolls vary in length and tube diameter. Their common sign is material and shaft diameter ϕ50 h6.
Standard probability plot processed in [12] shows that the data are from a normal distribution.

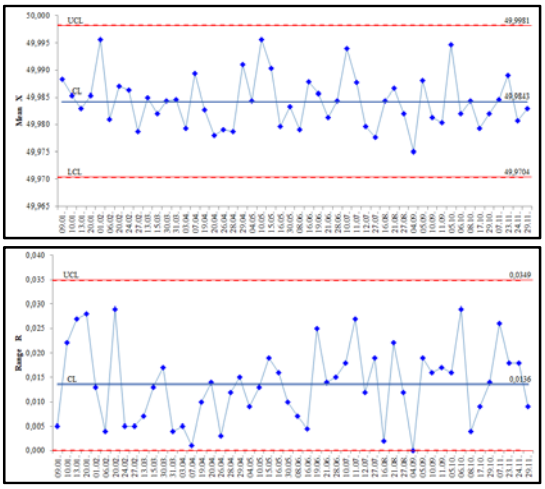

Figure 3 – Control chart $\bar{X}, R$ for the process of precise shaft diameter $\phi 50\ h6$

Summary: *Through $\bar{X}, R$ it has been verified that production of all three types of rollers (400, 600 and 800 mm) is considered as statistically under control, all values of monitored characteristics are within the regulatory limits.*

3.4Hotelling T2 control chart

Similar to the X_i, mR chart, the Hotelling T2 chart evaluates the covariances of the ranges between each of the two measures and the covariances of the actual data points.
For the mutual combination of values, preliminarily* the results from measurements of straightness and total runout were recorded in the Hotelling T2 control chart (Figure 4, 5).

Note: **because further measurements are not yet available*.

Standard probability plot processed in [11] shows that the data are from a normal distribution.

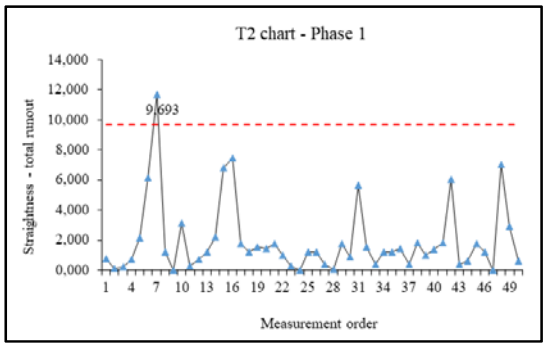

Figure 5 – Phase 1 Hotelling T2 control chart

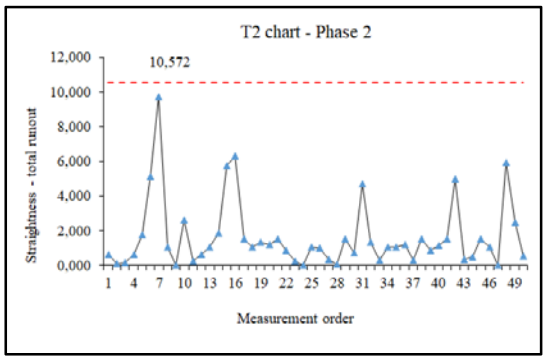

Figure 6 – Phase 2 Hotelling T2 control chart

Summary: *The 1st chart (Phase 1) shows an outlying measurement, which was detected as measurement no. 7. The measured value of straightness and total runout is higher than the allowed tolerance (0,071 mm – 0,065 mm towards 0,050 mm – 0,050 mm).*

CONCLUSION

Research in the area of short run and small mixed batches production is based on a preliminary literature review and focuses on preparing the implementation of the SPC in an organization producing bakery equipment. As part of this preparatory phase of the SPC, the process of cutting and lathe operations were monitored. $\bar{X}, R$; X_i, mR and Hotelling T2 shows that both processes are stable, but according to the Hoteling T2 control chart and the reports of experienced operators, it can be assumed that the processes are significantly affected by characteristics of the current machine state, by set-up the machines, and of what level experiences have operators.

Future research opportunity we see in the continuation of the measurements so that the same number of measurements is ensured for both monitored processes. Data transformation into a single scale, better use of Hotelling statistics, more detailed inspection of downtimes, searching for possibilities to reduce production completeness (work-in-progress) and optimizing the use of production facilities using Lean Six Sigma tools.

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OPEN INNOVATION ADOPTION AMONG THE ORGANISATIONS IN CENTRAL EUROPE (HUNGARY, SLOVAKIA AND CZECH REPUBLIC) AND EUROPEAN UNION: A COMPARATIVE RESEARCH

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Abstract. *The aim of the paper is to present the perception of Open Innovation (OI) adoption in the organisations operating in the countries of Central Europe (Slovakia, Czech Republic and Hungary) and overall in the European Union (EU). The partial goals of the paper are focused on the comparison of adoption of the OI practices, level of OI capabilities, self-perceived status of open innovation and level of innovation performance. The background of the research was information obtained from the OI-NET (European Academic Network for Open Innovation) project. The questionnaire developed within the OI-NET project was used in a research. The findings showed that organisations in Slovakia and Hungary are in the early stages of OI adoption but with high potential to implement it in near future. The majority of organizations in Czech Republic haven't adopted OI yet. Organizations in Slovakia and Czech Republic are under the EU average in OI adoption. Organizations in Hungary are at the EU average or slightly exceed it. Organizations which already adopted OI reported higher increasing level of innovation performance over the last three years than those which haven't adopted OI. A certain limitation of the study was the representativeness of the samples for the individual countries. Despite of this fact the implication can be deduced from the findings of the research for OI strategy in the countries as well as for education within Universities. The main originality is in the implication for the selected countries of Central Europe and their comparison with the EU average.*

Key Words: *Open Innovation, Open Innovation Practices, Open innovation capability, Open innoation culture, Innovation Performance*

1. INTRODUCTION

Globalization and fast technological development has changed business framework in European countries and also worldwide. Innovation has become a driving force of business success. According to [1] the organizations which prioritize innovation are also those who experience the highest increase in turnover. There are different ways for organizations to innovate. They can approach to product/service, process/technology or business model innovation. Henry Chesbrough, Executive Director of the Center for Open Innovation at the University of California, Berkeley, notes that, "Today, innovation must include business models, rather than just technology and R&D. A better business model will often beat a better idea or technology [2]". Open innovation (OI) and open business models have received a lot of attention during the last decade both from practitioners and academia. Organizations have begun recognized that traditional closed business model based on the philosophy "it has to be invented here" is no longer sufficient. This model is expensive and doesn't provide sufficient access to technology and talents [3]. Opening up of organizations for knowledge flowing outside in (in-bound OI mechanism) or inside out (outbound OI mechanism) as well as combined form (coupled OI mechanism) have been becoming increasingly necessary for organizations.
Innovation and research development are key priorities of the European Union (EU). Innovation is vital to European competitiveness in the global economy and sustainable growth. Open innovation is an important component of the European Innovation System [4]. Open Innovation 2.0 is a new approach to driving forward innovation in Europe and to solve key challenges. OI 2.0 is based on a Quadruple Helix Model where government,

industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organization or person could do alone [5]. Creating and supporting OI 2.0 encourages dynamic knowledge circulation and facilitates the translation of that knowledge into socio-economic value [6] .

Hungary, Slovakia and Czech Republic are Central European countries, which have shared common ground in history culture and economics. Following the EU strategy and the goals in the field of innovation, the countries developed national strategies and policies to adapt the aims to their own reality and objectives. The results of European Innovation Scorecard (EIS), which is one of the most complex comparative studies of innovation performance within the EU shows that Hungary, Slovakia and Czech Republic unsuccessfully, under performing in all indicators of the study over years. The study categorizes EU countries into four innovation performance groups: modest innovators, moderate innovators, strong innovators and innovation leaders. Hungary, Slovakia and Czech Republic belong to moderate innovators [7] below the average of the EU. The highest innovation performance among the three countries has Czech Republic.

This research focuses on the adoption of open approach to innovation and compares the levels of OI adoption among organizations operating in Slovakia, Hungary, Czech Republic and overall in the EU. It also compares innovation performance of organizations with different OI adoption levels. The background of the research was information obtained within the (OI-Net), what is an EU co-financed project designed to promote cooperation on open innovation research and education. One of the outcomes of the project was the report: Identification of Industrial Needs for Open Innovation Education in Europe [8]. For the purpose of this research the selected parts of the questionnaire developed within the OI-Net were used. This research is structured according to main findings into following blocks:

- Comparison of adoption of the OI practices among organizations in Slovakia, Hungary, Czech Republic and EU.
- Comparison of the level of OI capabilities among organizations in Slovakia, Hungary, Czech Republic and EU.
- Comparison of OI status of organizations in Slovakia, Hungary, Czech Republic and EU.
- Comparison of innovation performance among OI Non-adopters, Planners and Adopters.

2. LITERATURE REVIEW

The term Open Innovation was first introduced by Henry Chesbrough in his book "Open Innovation" in 2003, where he defined OI as paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology [9]. According the definition, innovation practices can be divided into inbound and outbound [10] modes. Inbound practices use external sources for the firm's innovation process, while inbound practices allow others to use under-utilized or unused assets of a firm. Examples of inbound OI practices include IP in-licensing, contracted R&D services, using specialized open innovation intermediaries, idea & start-up competitions, university research grants, customer & consumer co-creation, crowdsourcing, informal networking and examples of outbound practices include joint-venture activities, spin-offs, IP out-licensing, participation in standardization, donations to commons or non-profits, etc. [11]. Inbound and outbound open innovation can be also combined into a coupled process in which organisations work in alliances that involves both giving and taking [12]. The studies show that inbound open innovation is more commonly used than outbound open innovation [13] [14].

There are studies focused on identification of organization capabilities, which are important for successful implementation of OI e. g. [15] [16] [17]. The study of [18] created the OI capability framework comprises of 23 capability areas grouped along the factors strategic alignment, governance, methods, information technology, people, and culture. Culture supporting OI in an organization is important for successful implementation and functioning of open innovation approach. This is often translated into a shift of culture, whereby working with other companies became accepted and endorsed throughout the organisation. It requires direct involvement of top management. Making changes to company structure, skills, incentives and control methods can gradually help to develop a company culture that supports OI [19]. OI culture implies that OI is embedded in values and norms, practices and behaviours. According to [20] OI culture is emerging at mature levels of OI implementation.

Many authors have highlighted the importance of innovation for increasing organization performance. Innovation performance reflects the success of innovation and comprises the actual output or results of innovation as measured against its intended outputs (objectives). There isn't generally accepted common set of indicators of innovation performance [21], but sources dealing with innovation performance measurement provide various innovation metrics, which can be used by organization e.g. [22] while the organization strategy and characteristics must be taken into account. According to [23] there is increasing interest in the research of empirical evidence regarding the effect of open innovation on innovation performance. Scholars have explored

different points of view, emphasizing industry-specific characteristics, company size, or verifying their hypotheses in the case of country-specific samples. The studies have mostly focused on exploring the effect of inbound OI modes on innovation performance e.g. [24]; [25]; [26]. There are less studies, which tried to investigate the effect of outbound OI or coupled OI modes on innovation performance e. g. [27]; [28];. The majority of articles on that topic concluded that implementation of open innovation had a positive effect on innovation performance, but there were some of them, which discussed inverted U-shaped relationships or even in some OI-modes cases negative effect on innovation performance [23].

3. METHODOLOGY

The background of the research was information obtained within the European Academic Network for Open Innovation project. The study used the questionnaire developed in the OI-NET project and selected areas were examined, which focused on:

- OI practices – this area included 13 items and the adoption intensity of individual OI practices (inbound and outbound) were evaluated using 7 points Likert scale.
- OI capabilities – the items covering the area of OI capabilities were divided into 2 groups. The first group of capabilities describes what company does to organize and facilitate OI and includes 6 items. The second group is addressed to organization behaviour and consists of 9 items. For evaluation of the items the respondents used 7 points Likert scale.
- Status of OI – the perceived level of OI status were evaluated by 5 points Likert scale to categorize organizations into groups of non-adopters, early adopters and adopters.
- Innovation performance – the area was examined by 5 items, which were evaluated using 5 points Likert scale.

The questionnaires were distributed to companies of all size and industrial sectors´ representatives and regions. There were 23 questionnaires collected from Slovakia, 47 from Czech Republic and 45 organizations participated from Hungary. The survey respond rates in the three countries were over 20%. Overall, 500 questionnaires were collected from EU organizations. The data were processed graphically and results were compared among Slovakia, Hungary, Czech Republic and EU.

4. RESULTS AND DISCUSSION

1.1 Adoption of OI Practices

Figure 1 shows the average adoption intensity of the inbound and outbound practices in organizations operating in Slovakia, Hungary and Czech Republic. The results can be compared with the EU average, which is also illustrated. Slovakia and Czech Republic is under the EU average level in the adoption of all OI practices. Hungary has the highest level of adoption of OI practices in comparing with Slovakia and Czech Republic and in some cases exceeds the EU average except in the participation in standardization. The least adopted OI practices in the three countries are:

- Crowdsourcing;
- Using external networks;
- Idea and start-up competitions;
- IP-out-licensing and Free revealing.

In general, compared to other OI practices, the most adopted in the three countries are:

- Collaborative innovation with external partners;
- Customer and consumer co-creation in R&D projects;
- Scanning for external ideas.

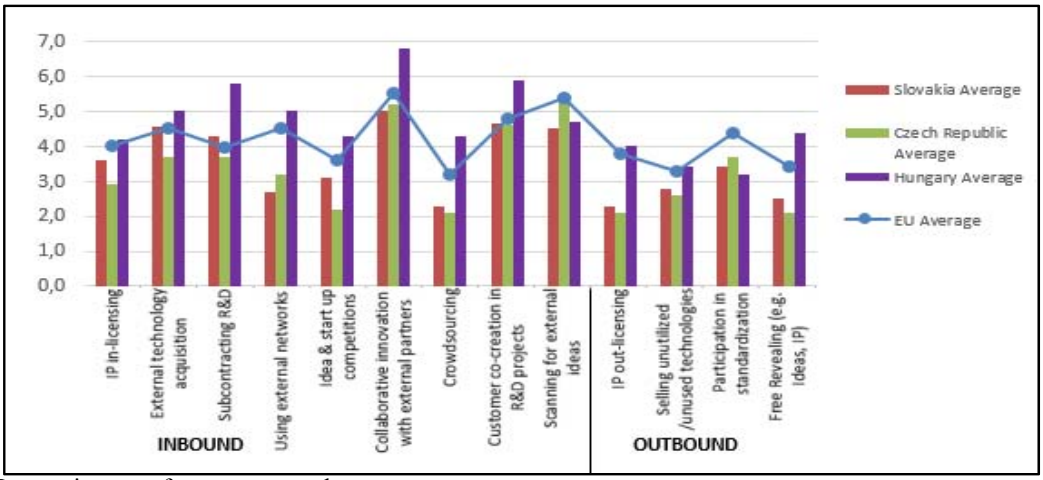

Figure 1: Intensity of adoption of the OI practices

1.2 Level of Innovation Capabilities

Figure 2 shows the average levels of open innovation capabilities related to what company does to organize and facilitate OI. Organizations in Slovakia and Czech Republic don't achieve the EU average. Organizations in Hungary reported the highest levels of open innovation capabilities among the three countries, which are slightly above the EU average. The lowest values among the reviewed OI capabilities are reported for:

- Rewarding of employees for OI activities;
- Applying interactive tools and methods to facilitate OI.

The highest levels among the examined OI capabilities in the three countries are indicated for the following aspects:

- The organizational structure of company is designed to be open according to needs of company;
- Top management strongly supports open innovation activities.

Figure 3 shows the values for individual OI capabilities related to organization behaviour and manifestation of OI culture. Behaviour and culture of organizations in Slovakia and Czech Republic don't support enough OI activities. The values of individual items are slightly under the EU average. Organizations in Hungary reported the highest level of interviewed aspects of organization behaviour and culture supporting OI. The highest scores in the three countries are for the following aspects:

- Externally obtained knowledge is integrated into company's products, processes or services;
- Accepting the possibilities of mistakes in external knowledge sourcing.

The areas with the lowest reported levels are:

- Relevant departments are actively participating in knowledge sourcing and exchange;
- Employees have positive attitudes towards having other companies using company's knowledge and technologies.

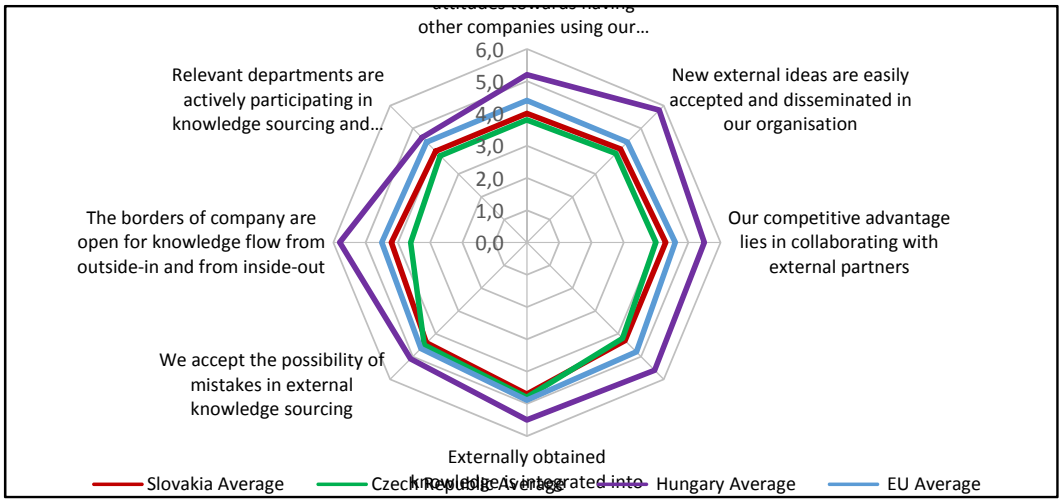

Figure 2 Levels of OI capabilities related to organization and facilitation of OI

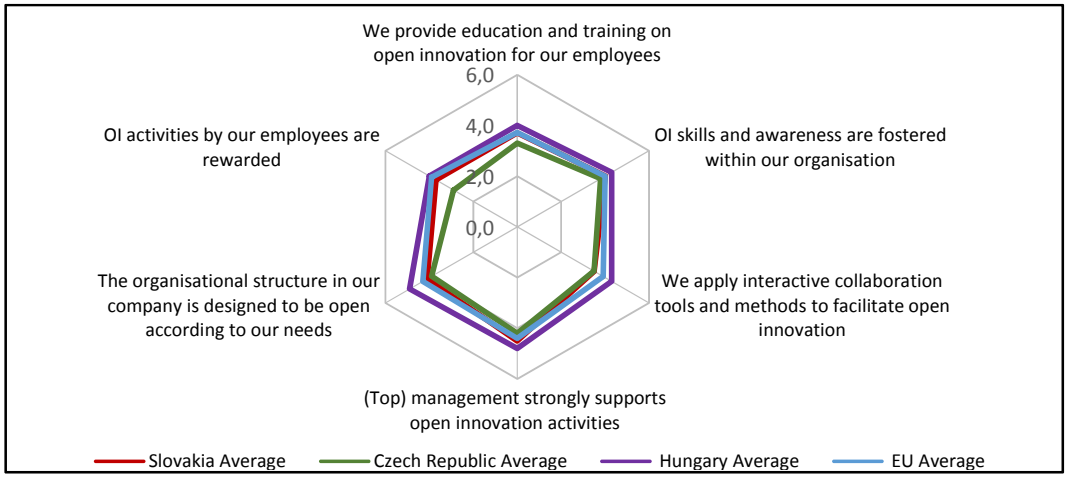

Figure 3 Levels of OI capabilities related to organization behaviour and culture

1.3 OI status

Figure 4 illustrates the perceived OI status of organizations in Slovakia, Czech Republic, Hungary and overall in the EU. Majority of organizations (over 60%) in Slovakia and Hungary are in the early stage of implementing OI activities or planning to adopt OI. The highest percentage of organizations in Czech Republic don't adopt OI (60%) and 20% are in the early stage of implementing OI activities or planning to adopt OI. The three countries are below the EU average in achieving the status of adopters and experienced adopters (levels 4 and 5).

1.4 Innovation performance

Figure 4 illustrates the changes in innovation performance over the last 3 years in organizations in Slovakia, Czech Republic and Hungary.

Organizations were categorized as OI Adopters (OI status at the level 3, 4 and 5), Planners (OI status at the level 2) and Non-adopters (OI status at the level 1, 2) to examine if there are some differences in innovation performance levels among the categories. Adopters had the highest levels of innovation performance in comparing to Non-adopters and Planners, which is reflected by the levels of indicators: Success of new or significantly improved products and services development, ROI of innovation activities, Market acceptance of innovative products and services. New product development time is slightly higher compared with Non-adopters and planners. The risk of innovation activities achieves the highest level in the case of adopters.

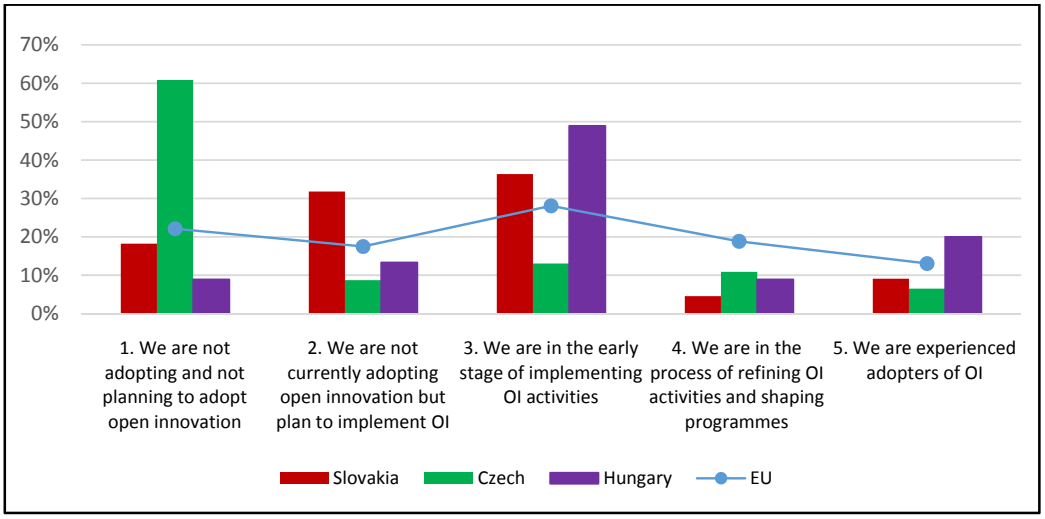

Figure 4 Open innovation status

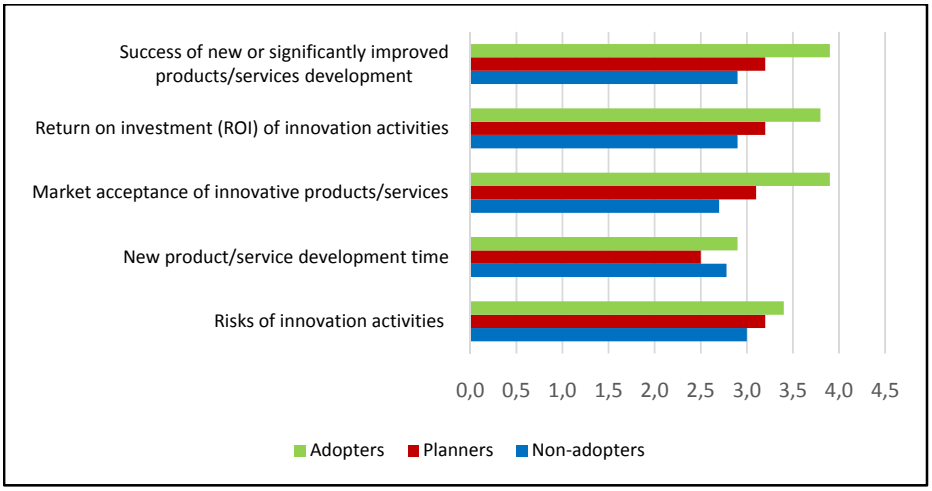

Figure 5 Levels of innovation performance

5. CONCLUSION

The results of the study showed that majority of organizations (over 60%) in Slovakia and Hungary are in the early stage of implementing OI activities but with high potential to do it in a future. Slightly over 60% of organizations in Czech Republic don't adopt OI and 20% of them are in the early stage of implementing OI activities or planning to adopt OI. Organizations in Slovakia and Czech Republic are below the EU average in implementing of OI practices and levels of OI capabilities, while organizations in Hungary are at the level of EU average or slightly exceed it. The study showed that organizations which already adopted OI reported higher increasing level of innovation performance over the last three years than those which haven't adopted OI. On the other hand these organizations also reported the higher risk of innovation activities. A certain limitation of the study was the representativeness of the samples for the individual countries. However the implication can be deduced from the findings of the research for OI strategy in the countries and supporting open innovation within the national innovation systems. The study can be also used within education at Universities.

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EXAMPLE OF PRODUCTION PROCESSES OPTIMIZATION

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Abstract. *The paper shows research of production program optimization in business-production systems. In paper is shown generating optimal criteria and constrains, and finding optimal solution for each product volume. Nonlinear functions in model are used. Extremes of objective functions are used for calculating deviations from optimal volume and size of admissible area for each product.*
Key words: *Production processes, optimization, criteria and constrains.*

1.INTRODUCTION

By production program optimization we mean on determine optimal volume of product involved in production process while optimal criteria and real constrains must be fulfilled in specific business production system [1-5] . The problem of production program optimization should be applied in mass type of production.

By production resources optimization we mean on fulfillment optimal criteria such as maximal usage of material resources, maximal usage of machine capacity, and maximal usage of human resources with real constrains. The problem of production program optimization could be applied to any type of production.

By production process optimization mostly we mean on rationalization of production cycle, when production volume is determined (serial and single type of production) and also with respecting existence of real constrains. In this case criteria such as: maximal usage of production resources, min costs, max profit etc. can exist as additional criteria with lower weight coefficient in multi-criteria analysis.

2. METHODOLOGY

Notations are defined as follows.
m - product in production program
n - machines or other production devices
h - category of worker
l - production operation for one product
Constrains - machine capacity:

$$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1m}x_m \leq a_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2m}x_m \leq a_2$$

....

$$a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nm}x_m \leq a_n$$

where a_{11} is time for production product x_1 on first machine, a_{21} is time for production product x_2 on firts machine, and so on until time a_{1m} for m-th product in production program, and all sum must be lower then maximal available time on fist machine - a_1. For n-th machine maximal available time is a_n, and time for production products $(x_1, x_2, .., x_m)$ are $(a_{n1}, a_{n1}, \ldots a_{nm})$ in consequence.

On the same way, defining of constrains for available workers capacity is performed:

$$b_{11}x_1 + b_{12}x_2 + \cdots + b_{1m}x_m \leq b_1$$

$$b_{21}x_1 + b_{22}x_2 + \cdots + b_{2m}x_m \leq b_2$$

....

$$b_{h1}x_1 + b_{h2}x_2 + \cdots + b_{hm}x_m \leq b_h$$

On same way, constrains for material resources could be defined. In design the model other constrains can be exist. For example: market needs, risks link to production of certain products. Risk commonly is involved in mathematical model as follow:
for production product x_1 there exist k_1 type od risks, and each R_{k1} must be lower then alowed value R_{k1doz}, ie:

$$R_{k1} \leq R_{k1doz}$$

$$R_{k2} \leq R_{k2doz}$$

...

$$R_{km} \leq R_{kmdoz}.$$

Time of production cycle t_1 for production product x_1, are sum of times each production operation $t_{l1}$and time for transport t_{tr1}, ie:

$$t_1 = \sum_{i=1}^{l} t_{i1} + \sum_{tr=1}^{k} t_{tr1}$$

Utility coefficient of machine capacity are calculated on followed way:
for n-th machine utility are division of realized machine hours and available fond of machine hours, ie:

$$\mu_1 = \frac{a_{11}x_1 + a_{12}x_2 + \cdots + a_{1m}x_m}{a_1}$$

$$\mu_2 = \frac{a_{21}x_1 + a_{22}x_2 + \cdots + a_{2m}x_m}{a_2}$$

...

$$\mu_n = \frac{a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nm}x_m}{a_n}$$

Objective function (objective criteria/goal) for maximal profit:

$$Z_{cp} = W_{cp1}x_1 + W_{cp2}x_2 + \cdots + W_{cpm}x_m$$

where W_{cp1}- is selling price per unit of product x_1. Selling price per unit of product x_m is not constant, already depends on product volume for given product.

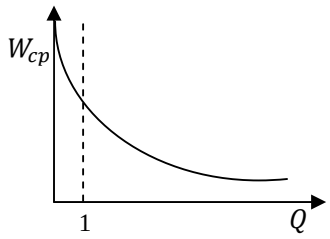

Fig. Selling price per unit of product depending to product volume

Function of selling price per unit could be described by quadric function:

$$W_{cp} = aQ^2 + bQ + c, \quad Q \in [1, Q_{max}]$$

Cost per unit could be described on the similar way:

$$W_{ck} = a_1Q^2 + b_1Q + c_1, \quad Q \in [1, Q_{max}]$$

Function of selling price and costs per unit could be add up, and final result represent function of profit:

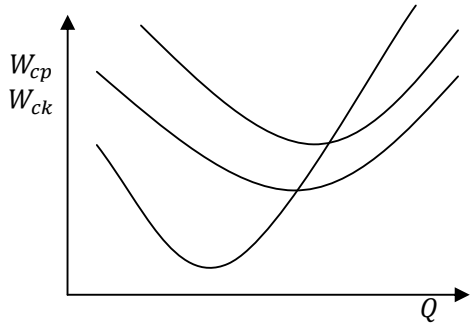

Fig. 2. Function of profit

Profit per unit of product is subtraction of selling price per unit and costs per unit:
$d = W_{cp} - W_{ck} = (a - a_1)Q^2 + (b - b_1)Q + (c - c_1), \quad Q \in [1, Q_{max}]$

for n-th product, ie:
$d_1 = (a_1 - a_{11})x_1^2 + (b_1 - b_{11})x_1 + (c_1 - c_{11}), \quad x_1 \in [1, x_{1max}]$

$d_1 = (a_2 - a_{21})x_2^2 + (b_2 - b_{21})x_2 + (c_2 - c_{21}), \quad x_2 \in [1, x_{2max}]$

$d_m = (a_m - a_{m1})x_m^2 + (b_m - b_{m1})x_m + (c_m - c_{m1}), \quad x_m \in [1, x_{mmax}]$

and total profit will be:

$d = \sum_{i=1}^{m}(a_1 - a_{i1})x_i^2 + \sum_{i=1}^{m}(b_i - b_{i1})x_i + \sum_{i=1}^{m}(c_i - c_{i1}), \quad x_i \in [1, x_{imax}]$

By equalizing total profit function with zero, will be:

$$\sum_{i=1}^{m}(a_1 - a_{i1})x_i + \sum_{i=1}^{m}(b_i - b_{i1}) = 0 \quad (1)$$

Function of capacity utilization (in percent) is linear and is in direct dependence with volume of production of m-th product:

$$\mu_n = \frac{a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nm}x_m}{a_n} = \frac{a_{n1}}{a_n}x_1 + \frac{a_{n2}}{a_n}x_2 + \cdots + \frac{a_{nm}}{a_n}x_m$$

$$\mu_n = \sum_{i=1,j=i}^{m,n}\frac{a_{ji}}{a_j}x_i \quad (2)$$

By replacing (1) in (2), we can get optimal value of production volume. In case of 3 optimal criteria (profit, cost and capacity utilization) only one solution for product volume exist. This formula can be used instead of multicriteria analysis.

2. EXAMPLE

In this specific example from production practice, it is shown application suggested methodology. Data in presented example is form Insa factory for production water meter. In presented example, 6 type of water meter is observed (C_1, C_2, … C_6).

Tab.1. Selling price

Volume	C_1	C_2	C_3	C_4	C_5	C_6
1	4778	4284	4017	6774	12707	34798
10	-	-	-	-	11436	31318
50	4634	4155	4866	6570	10800	29578
100	4539	4069	4766	6096	-	-
1000	4061	3641	4515	5757	-	-
2000	3822	3427	4013	5419	-	-

Tab.2. Costs

Volume	C_1	C_2	C_3	C_4	C_5	C_6
1	3630	3150	3920	4740	9210	28900
10	-	-	-	-	8930	25410
50	3500	3120	3900	4690	8640	22050
100	3250	3102	3900	4640	-	-
1000	2945	3063	3750	4357	-	-
2000	2712	3020	3700	4320	-	-

Tab.3. Profit

Volume	C_1	C_2	C_3	C_4	C_5	C_6
1	1148	1134	1097	2034	3497	5889
10	-	-	-	-	2506	5908
50	1134	1035	966	1880	2160	7528
100	1289	967	866	1456	-	-
1000	1116	578	765	1400	-	-
2000	1110	407	313	1099	-	-

For water meter C_1 stands:

$$C_{p1} = 2.1622 \cdot 10^{-5} \cdot x^2 - 0.87 \cdot x + 4697.12$$

$$C'_{p1} = 2 \cdot 2.1622 \cdot 10^{-5}x - 0.87 = 0$$

$$x_{C'_{p1}} = 2011.8$$

$$C_{k1} = 1.988 \cdot 10^{-4} \cdot x^2 - 0.79 \cdot x + 3506.83$$

$$x_{C'_{k1}} = 1986.9$$

$$d_1 = 0.1742 \cdot 10^{-4} \cdot x^2 - 0.08 \cdot x + 1190.3$$

$$x_{d_1} = 2183.9$$

By repeating presented steps for each of observed water meter, we can get next results:

$$C_{p2} = 1.94 \cdot 10^{-4} \cdot x^2 - 0.778 \cdot x + 4211.33$$

$$C_{k2} = 1.61 \cdot 10^{-5} \cdot x^2 - 0.086 \cdot x + 3129.31$$

$$d_2 = 1.779 \cdot 10^{-4} \cdot x^2 - 0.69 \cdot x + 1082.02$$

$$C_{p3} = -3.035 \cdot 10^{-5} \cdot x^2 - 0.384 \cdot x + 4907$$

$$C_{k3} = 5.869 \cdot 10^{-5} \cdot x^2 - 0.2263 \cdot x + 3983.7$$

$d_3 = -8.9 \cdot x^2 - 0.158 \cdot x + 990.2$

$C_{p4} = 2.91 \cdot 10^{-4} \cdot x^2 - 1.14 \cdot x + 6550.9$

$C_{k4} = 1.67 \cdot 10^{-5} \cdot x^2 - 0.53 \cdot x + 4717.4$

$d_5 = 2.07 \cdot 10^{-4} \cdot x^2 - 132.88 \cdot x + 3627.8$

$d_4 = 1.25 \cdot 10^{-4} \cdot x^2 - 0.611 \cdot x + 1833.61$

$C_{p6} = 7.003 \cdot 10^{-4} \cdot x^2 - 463.7 \cdot x + 35254.7$

$C_{p5} = 2.557 \cdot 10^{-4} \cdot x^2 - 169.3 \cdot x + 12873.9$

$C_{k6} = 6.199 \cdot 10^{-5} \cdot x^2 - 455.97 \cdot x + 29349.7$

$C_{k5} = 0.487 \cdot 10^{-5} \cdot x^2 - 36.467 \cdot x + 9245.9$

$d_6 = 0.78 \cdot 10^{-4} \cdot x^2 - 6.506 \cdot x + 5894.7$

In tab 4 and 5 are given results of calculation and deviation between optimal volume of product obtained form different criteria.

Tab.4. Profit

	C_1	C_2	C_3	C_4	C_5	C_6
$x_{C_p'}$	2011.8	2030.9	-6326	1958.7	33.1	33.1
$x_{C_k'}$	1986.9	2670.8	3855	1586.8	37	36.77
$x_{d'}$	2183.9	1939.8	-887.64	2444	32	4.7

Tab.5. Results

Water meter	C_1	C_2	C_3	C_4	C_5	C_6
deviation $x_{d'}$ and $x_{C_p'}$	172.1	-91.1	5438.36	485.3	-1.1	-28.4
deviation $x_{d'}$ i $x_{C_k'}$	197	-731	-4742.64	857.2	-5	-32.07
deviation in percent $x_{d'}$ and $x_{C_p'}$	7.88%	-4.70%	-612.68%	19.86%	-3.44%	-604.26%
deviation in percent $x_{d'}$ and $x_{C_k'}$	9.02%	-37.68%	534.30%	35.07%	-15.63%	-682.34%

Production volume should converges to $x_{d'}$ value. As deviation $x_{d'}$ between $x_{C_p'}$ or $x_{C_k'}$ is greater, there exist greater need for calculation of $x_{d'}$ because area of admissible solution is bigger.

Optimal production volume ($x_{d'}$) in good designed production processes should be equivalent exploitation capacity machines and workers resources. In shown example, water meter C_1 i C_4 has low deviation optimal volume value from extreme of profit and cost functions. This is very important in serial type of production. Other products in given example are very sensitive in aspect to production volume value, specially product C3 and C6, so that some serial volume could lead to loss.

3. CONCLUSIONS

Paper shows methodology for optimization production process and its application in specific business production system. Basic methodology starts form creating optimal criteria and constrains for each product in production program. By adopting that some of criteria are quadric function (elimination of linear approximations), extremes of function was searching. Combining two or more functions for optimal criteria sets, we gets single solution for optimal volume value for each product in production program.

Paper gives insights in real practice problems in business production systems where serial type of production exist, because not all serial volume are cost-effective when we take into account all aspect of production resources utility.

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INFORMATION SYSTEM DATA-FLOW ANALYSIS

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Abstract. *The paper shows research of analysis concrete example of information system and discovering its data-flow failures. In this example student service information system at Faculty was observed. Besides failure detection in data flow, paper indicates on key criteria for failure monitoring, such as: failures type and link to process time spent in failure, frequency of failures, severity of failure etc.*
Key words: *Information system, data-flow failures.*

1. INTRODUCTION

Problem of failures in data flow at the specific information system is actual as appearance of computers in supporting each business system. As each business system has its own specificity, also its information system requires special attention. There is lot of methodology in scientific literature about failure detection in data flow [1, 2, 3]. But in this concrete example of student service information system, process approach with some modification is applied.

2. METHODOLOGY

Notations are defined as follows.
N_i - number of processes (i=1,2..n)
F_{ij}- failure in data-flow on i-th process
C_{ik} - consequence on i-th process
In table 1 is shown list of identified processes in student services extracted for existing information system data-flow

Tab.1. Identification of process in student services

Process ID	Process	ID
0.	Student services information system	0
1.	Study program	1
1.1.	Management of study programs	6
1.2.	Module management	7
1.3.	Courses management	8
1.3.1.	New subjects	68
1.3.2.	Link to accreditation	69
1.3.3.	Management of equivalence	70
2.	Student activity	71
2.1.	Management of student data	72
2.1.1.	Management of student identification data	73
2.1.1.1.	Management of basic student identification data	74
2.1.1.2.	Management of social - economic student identification data	75
2.1.2.	Management of financial data	76
2.1.2.1.	Student debts	77
2.1.2.2.	Payment transactions	78
2.1.2.3.	Financial reports	79
2.2.	Management data about studding	80
2.2.1.	Enrollment at Faculty	81
2.2.1.1.	Management of examination period	82
2.2.1.2.	Candidate application	83
2.2.1.3.	Admission exam	84
2.2.1.4.	Filling ranking list	85
2.2.1.5.	Student enrollment	86
2.2.2.	Management during studies	87
2.2.2.1.	Enrollment in the school year	88
2.2.2.2.	Student sign-out	89
2.2.2.3.	Graduation	90
2.3.	Documents and standards	91
2.3.1.	Making documents	92
2.3.1.1.	Certificate of graduation	93
2.3.1.2.	Status confirmation	94
2.3.1.3.	Certificate of passed exams	95
2.3.1.4.	Creating a complete report	101
2.3.2.	Student standard	96
2.3.2.1.	Application for dormitory	97
2.3.2.2.	Filling list for dormitory	98
2.3.2.3.	Application for credit / scholarship	99
2.3.2.4.	Creating a list for a loan / scholarship	100
3.	Teaching and exams	3
3.1.	Organization of classes	25
3.1.1.	Managing school years	26
3.1.2.	Execution of courses	27
3.1.2.1.	Creating an courses execution	45
3.1.2.2.	Determining the list of teachers for courses	46
3.1.2.3.	Creating courses blocks	47
3.1.3.	Modules	28
3.1.3.1.	Creating study modules	48
3.1.3.2.	Determining the required module courses	49
3.1.3.3.	Determination of optional module courses	50
3.1.4.	List of students courses choices	29
3.1.4.1.	Collection and processing of students' wishes for optional courses	51
3.1.4.2.	Assigning courses based on student wishes	52

3.1.4.3.	Direct assigning of the courses to the student	53
3.1.4.4.	Reporting of assigned courses	54
3.2.	Exams and results	30
3.2.1.	Pre-payment obligations	31
3.2.1.1.	Filling signature	55
3.2.1.2.	Disclaimer from signature	56
3.2.1.3.	Reporting	57
3.2.2.	Exams	32
3.2.2.1.	Management of examination period	58
3.2.2.2.	Management of exams	59
3.2.2.3.	Exams application	60
3.2.2.4.	Exams applied students	61
3.2.2.5.	Result processing	62
3.2.2.6.	Result analysis	63
3.2.3.	Graduation thesis	33
3.2.3.1.	Application for graduation thesis	65
3.2.3.2.	Checking the pre-request for graduation	66
3.2.3.3.	Graduation records	67
4.	Analyzes and Administration	4
4.1.	Analyzes	34
4.1.1.	Choice of analysis	102
4.1.2.	Transient analysis	103
4.1.3.	Continuity of student status	104
4.2.	Reports	35
4.2.1.	Report selection	105
4.2.2.	Student Finance Reports	106
4.2.3.	Students by years and subjects	107
4.2.4.	Graduates and graduates	108
4.3.	Administration	36
4.3.1.	Graduation Administration	109
4.3.2.	Contract administration	110
4.3.3.	Administration of the code book	111
5.	Exchange	5
5.1.	Exchange with the University	37
5.1.1.	Import from ISU	38
5.1.2.	Export to ISU	39
5.2.	Exchange with the faculty website	40
5.2.1.	Import from Student Service	41
5.2.2.	Export to the base of the website	42
5.3.	Exchange with staff services	43
5.4.	Exchange with financial services	44

Failure detection was performed only for process ID3 in this experimental research. Aim of research was to detect type of failure, multiplication of failure though different processes, detection process with multiple failures, except plain failure detection.
Table 2 shows list of detected failures.

Tab 2. Identification of failures

Process ID	**Failure ID**	**Failure**	**Type of failure**
3.1.2.1.	F1	Creating an incorrect version of the course	S System
3.1.2.1.	F2	Access the wrong course for creating a performance	P Process
3.1.2.1.	F3	Wrong semester for course	S System
3.1.2.2.	F4	Non complete data for course	S System
3.1.2.2.	F5	Wrong ranking of teachers for course	S System
3.1.3.1.	F6	Wrong query for module creating	P Process
3.1.3.2.	F7	Non assigned courses for module	S System
3.1.3.3	F8	Optional course is not on right place in list	S System
3.1.3.3.	F9	Excel table is changed in accordance to required	P Process
3.1.4.1.	F10	Not updated data about student wishes	S System
3.1.4.1.	F11	Wrong student ranking calculation	P Process
3.1.4.1.	F12	Wrong student ranking calculation	P Process
3.1.4.1.	F13	Student wishes is not clear stated	S System
3.1.4.1.	F14	Wrong data for student course choice	S System
3.1.4.1.	F15	Not available data about student wishes	S System
3.1.4.2.	F16	Slow down system work	S System
3.1.4.3.	F17	Added non active courses	S System
3.1.4.3.	F18	After the assignment of the course to the student, it is necessary to repeat the complete procedure for the next course	P Process
3.1.4.4.	F19	Non updated list	S System
3.2.1.1.	F20	Signature in current year is accepted as signature form previous year	S System
3.2.1.1.	F21	Signature form course with new ID	S System
3.2.1.2.	F22	Disclaimer from signature is not processed.	S System
3.2.1.3.	F23	Lists of compulsory course and lists by shifts are not compatible	S System
3.2.2.2.	F24	Creating an exam with a nonconforming year of the exam	S System
3.2.2.3.	F25	The exam is classified in the wrong category which allows for free registration of the exam	S System
3.2.2.3.	F26	Applying for the exam is in wrong category that requires payment of the exam application	S System
3.2.2.3.	F27	The exam was also submitted at the same time through the student service and through the student service desk	S System
3.2.2.4.	F28	List of student with non-existent date of exam	S System
3.2.2.4.	F29	List registered with a duplicate student	S System
3.2.2.5.	F30	Subsequently entered exam mark was not processed	P Process
3.2.2.5.	F31	Compromised content of XMF file	P Process
3.2.2.5.	F32	Unacceptable entry of a student's grade for the course	P Process
3.2.2.5.	F33	Incorrect number of indexes added subsequently to the student	P Process
3.2.2.5.	F34	Invalid XML file with ratings	P Process
3.2.2.5.	F35	Incompatible XML file with "offline exam management program" program	P Process
3.2.2.5.	F36	Unacceptable student rating input	P Process
3.2.2.6.	F37	Invalid analysis of passing through from exams	S System
3.2.3.2.	F38	Incorrect analysis of the completeness of the study program with the exact number of exams	P Proces

3.2.3.2.	F39	An inaccurate analysis of the study program's fulfillment with the exact number of ESPB	P Proces
3.2.3.3.	F40	The date of graduation is not the last date of fulfilled obligations of the student	S System
3.2.3.3.	F41	Commission members incorrectly sorted	S System
3.2.3.3.	F42	Disagreement of the average grade in the entered data on graduation and in the software budget	S System
3.2.3.3.	F43	The final exam at the BSc study program is not the last one	S System

On the figure 1, is given diagram of process for this specific example.

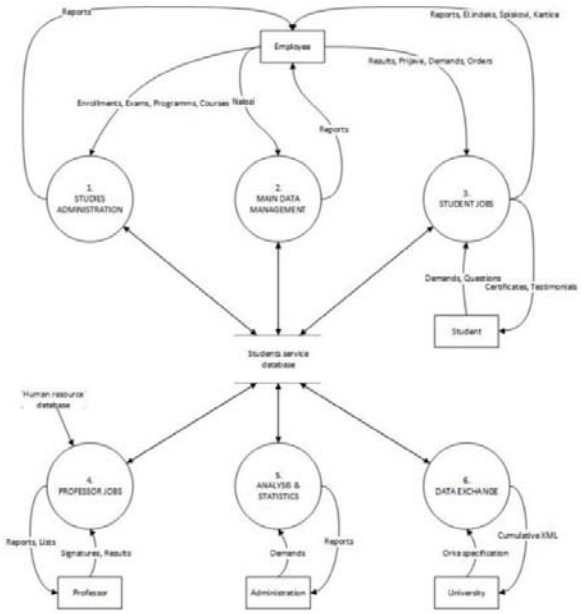

Fig. 1. Flow data diagram

Table 3 shows number of failures by process.

Tab.3. No of failures by process ID

Process ID	Failure ID	No of failures
3.1.2.1.	F1, F2, F3	3
3.1.2.2.	F4, F5	2
3.1.3.1.	F6	1
3.1.3.2.	F7	1
3.1.3.3.	F8, F9	2
3.1.4.1.	F10, F11, F12, F13, F14, F15	6
3.1.4.2.	F16	1
3.1.4.3.	F17, F18	2
3.1.4.4.	F19	1
3.2.1.1.	F20, F21	2
3.2.1.2.	F22	1
3.2.1.3.	F23	1
3.2.2.2.	F24	1
3.2.2.3.	F25, F26, F27	3
3.2.2.4.	F28, F29	2
3.2.2.5.	F30, F31, F32, F33, F34, F35, F36	7
3.2.2.6.	F37	1
3.2.3.2.	F38, F39	2
3.2.3.3.	F40, F41, F42	3

Fig 2 shows no of failures by the process. It is clearly shown that processes 3.1.4.1. and 3.2.2.5. generate the most different type of failures.

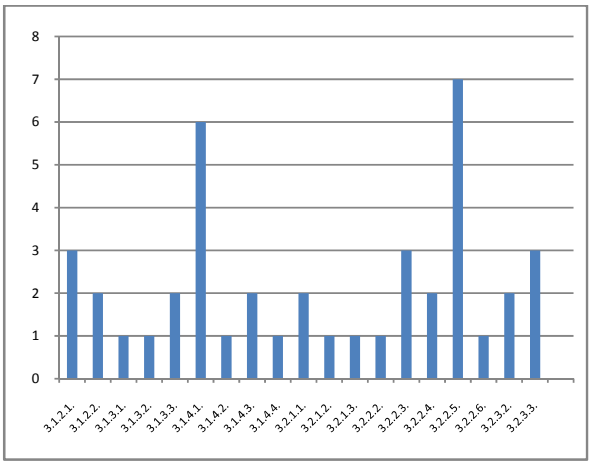

Fig. 2. No of failures by process ID

Probability of detected failures is next step in analysis observed student service information system.
According to [4] failure rate could be defined as total number of failures divided by total time expended:

$$\lambda(t) = \frac{f(t)}{R(t)}$$

where:
$\lambda(t)$ - failure rate
$f(t)$ - time to (first) failure distribution
ie. failure density function
$R(t) = 1 - F(t)$ - probability of no failure before time t.
For dependent events, dependent failures we must apply conditional probability:

$$\lambda(t) = \frac{R(t_1) - R(t_2)}{(t_1 - t_2) \cdot R(t_1)}$$

or

$$\lambda(t) = \frac{R(t) - R(t + \Delta t)}{\Delta t \cdot R(t)}$$

In observed information system we didn't have times spent in failures, so next suggestion is to add system

adding for measuring time spent in failure and if this failure cause failure of other process working.
Same problem was detect by frequency of failures. As frequency of failures is not recorded before, as its detection isn't performed. So, the next suggestion to new improvement of observed information system is to record detected list of failures.
Influence of one failure on other process or stoppage whole system is related to failure severity. Failure severity was assessed in this research by the expert team, scale 1-5 (1-lowes, 5-highes).

Tab. 4. Failure severity

Failure ID	Severity	Failure ID	Severity
F1	5	F21	3
F2	1	F22	5
F3	5	F23	5
F4	5	F24	5
F5	5	F25	3
F6	5	F26	5
F7	5	F27	5
F8	5	F28	3
F9	5	F29	5
F10	5	F30	3
F11	1	F31	5
F12	1	F32	3
F13	5	F33	3
F14	5	F34	2
F15	5	F35	1
F16	5	F36	5
F17	5	F37	1
F18	5	F40	5
F19	5	F41	5
F20	5	F42	3
F21	3	F43	3
F22	5	F40	5
F23	5	F41	3

Table 4 shows number of different failure severity assessment. Very large number failure ID has the highest marks. This unfavorable data indicates fast action measurement for preventing failures in data flow.

Tab. 4. Failure severity analysis

Severity assessment	No of severity assessment
1	5
2	1
3	9
5	28
Total	**43**

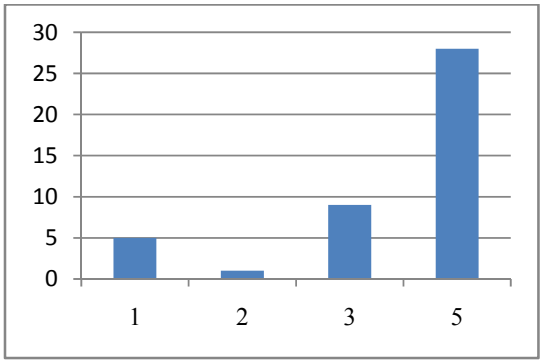

Fig. 3. Number of severity assessment

3. CONCLUSIONS

Paper shows practical example of failure detection in information system data flow. Information system of student services was decomposed on key process, and for each process failure type in data flow was detected. Some of process has more different type of failures then others. In this paper process with the most different failure types in data flow was detected. For observed information system, research indicates in next improved version, to introduce metrics for time spent in different failures and frequency of different failures occurrence. Also, this research shows severity marks for each of detected failures. High score of failures severity indicate action measure for preventing failures.

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OPTIMIZATION VIA SIUMULATION: A MAINTENANCE PROBLEM STUDY

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Abstract. *The paper shows study in maintenance optimization process by defined criteria. Complex mathematical description of system is avoided because of reasons of complexity and uncertainty. Based on literature review and own research, as an optimization method is used approximate algorithm. The obtained result can be used with high confidence.*

Key words: *maintenance, simulation optimization, model*

1. INTRODUCTION

In the maintenance field, one of the most popular areas is optimization. Strictly in mathematical terms, optimization is defined as the process of finding the conditions that give the maximum or minimum value of a function. Consequently, it is required that a specific problem is described mathematically, for example [1]:

$$\text{Find } X = \begin{Bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{Bmatrix} \text{ which minimises } f(X)$$

$$g_j(X) \le 0,\ j = 1,2,...,m$$

$$l_j(X) = 0,\ j = 1,2,...,p$$

where *f(X)* is objective function, X is n-dimensional vector named design vector, *g* and *l* are constrains.

In maintenance, optimization problem is growing when problem is usually complex and difficult for mathematical description.

Authors [2-4] describe a variety of optimization models in maintenance. As one approach with the greatest possibilities for optimization of complex problems, they describe the modeling, simulation (discrete event, stochastic simulations) and optimization process. More importantly, they found that there is a small connection between practice and scientific research. In addition, existing mathematical models are difficult to understand and interpret.

2. SIMULATION OPTIMIZATION

Simulation optimization is the remarkable simulation technology in the recent time [5]. Nowadays, main simulation software's have embedded optimizers fully integrated into simulation packages. The term simulation optimization is a wide term for methods applied to optimize stochastic simulations [6]. Simulation optimization comprises examine for specific settings of the input parameters to a stochastic simulation such that a target objective, which is a function of the simulation output, is, without loss of generality, minimized. As opposed to algebraic model-based mathematical programming, simulation optimization does not suppose that an algebraic description of the simulation (simulation uses model of system that represent real problem) is available, the simulation may be available as a black box that only allows the evaluation of the objective and constraints for a particular input. The nature of the stochastic simulations under study will determine the specific technique chosen to optimize them. The simulations, which are frequently discrete-event simulations, may be partly available to us in algebraic form, or may be completely available as an input-output model (as a black box); they may have single or multiple

outputs; they may have deterministic or stochastic output(s); they may include discrete or continuous parameters; and they may or may not contain explicit, or even implicit/hidden constraints. Common simulation optimization problem can be represented by [6]:

$$\min \ \mathrm{E}_{\omega}\left[f\left(x,y,\omega\right)\right]$$
$$\mathrm{E}_{\omega}\left[g\left(x,y,\omega\right)\right] \le 0$$
$$h\left(x,y\right) \le 0$$
$$x_l \le x \le x_u$$
$$x \in R^n, y \in D^m$$

Here, f is objective function, continuous inputs x, discrete inputs y, and vector ω is realization of random variables. Constraints are represented by vector value function g (evaluated with each simulation run). Other constraints are represented by h, and there are bound constraints on the decision variables.

As in usual optimization problem, also the simulation optimization problem is defined by main components: 1. input and output variables; 2. objective function; 3. constraints.

There are various categorizations provided for various optimization approaches. One such categorization is shown in Figure 1 [7].

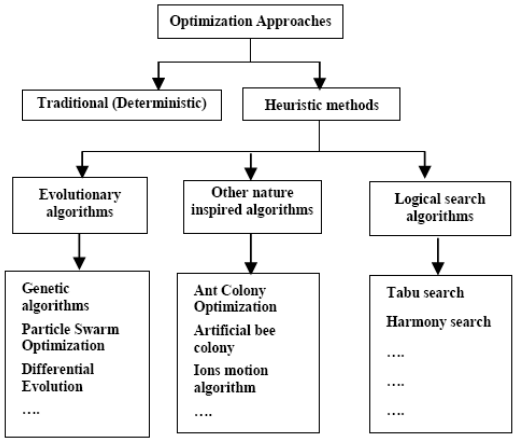

Figure 1. Categorization of optimization approaches

Optimization methods and algorithms are classified into two sets: exact algorithms and approximate algorithms. The exact algorithms can exactly find the most optimized response; however, they have no efficiency for complicated optimization problems and their solution time increases exponentially in these problems. On the other hand, the approximate algorithms are able to find reasonable responses for difficult optimization problems. The approximate algorithms are classified into two groups: heuristic and meta heuristic algorithms [8].

3. PROBLEM

In maintenance optimization problems, the bulk of papers describe very simple technical system or simple organization [2-3]. Moreover, field maintenance is not well explored. This is a reason why we examine maintenance system with dispersed maintenance facilities, with numerous and different types of equipment and strong interconnections among maintenance subsystems. Our goal is to achieve highest equipment availability in connection to desired resource utilization.

4. METHODOLOGY

We defined model of complex maintenance process in Arena Simulation® software package. This model describe maintenance process with all dominant influence factors: maintenance capacity (by personnel), number of maintenance requests over time (preventive and corrective), logistic delay times, spare parts timing, distance of equipment to workshop, price of all activities and materiel and MTTR. Model tuning is based on historical maintenance data. The simplified model is shown in Figure 2. Purpose of model is given in detail in [9].

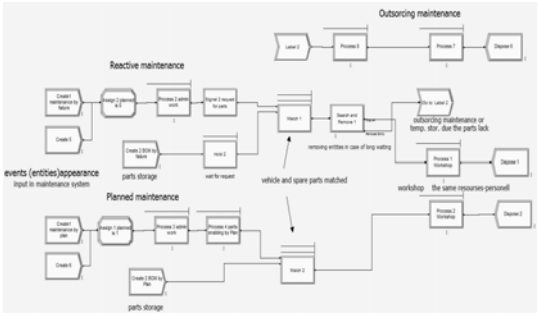

Figure 2. Maintenance model [9]

With this model we have established an excellent instrument for system reconstruction and evaluation, but also one excellent prognostic tool. Figure 3 [9] is an example of resource usage over time.

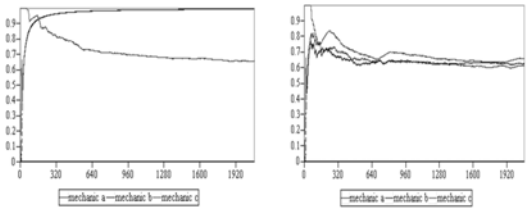

Figure 3. Display of mechanic work utilization

However, the peak of the use of the model is optimization by the desired criterion. Arena package has embedded optimization engine *OptQuest*. According to [10-11], finding an optimal solution for a simulation model generally requires search in a heuristic or meta-heuristic manner. Simulation optimization is based mainly to approximate algorithms. Many meta-heuristic optimization methods have been developed to solve hard optimization problems. Performances and efficiency of such algorithms are discussed in [12-14].

After determining the outcome of the model with one set of control values, OptQuest uses its search algorithm to establish a new set of values and repeats the simulation run process. OptQuest's main optimization engine is based on the Scatter search methodology coupled with Tabu search strategies to obtain high quality solutions to problems defined in complex settings. The OptQuest GUI is shown in Figure 4.

We are especially interested in highest possible value of repaired means (e.g. vehicles)-our objective function, minimum of waiting means for maintenance (e.g. no more than 5)-constraint, and control variable - number of resources.

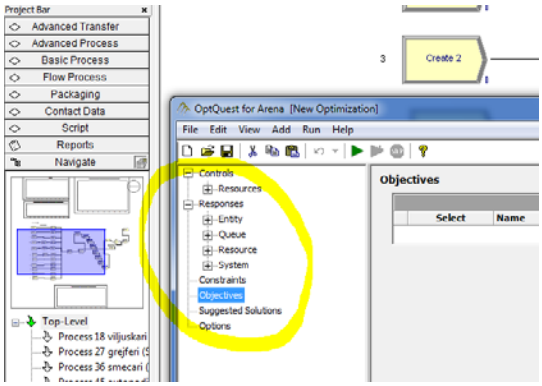

Figure 4. The OptQuest GUI

In software context, objective function is defined as: *„maximize ([Kamion.NumberOut]+[Kamion2.NumberOut])“;* constraint is defined as: *„ [Match1.Queue1.NumberInQueue] <=5, [Match2.Queue1. NumberInQueue] <= 5“*, and control variable are limited by value from 0 to 2.

The result of simulation optimization is shown in Figure 5 (simulation steps) and Figure 6 (rank of solutions).

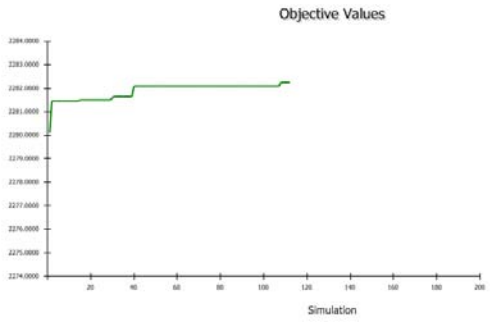

Figure 5. Optimization via simulation- steps

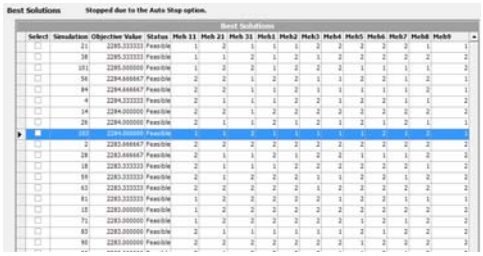

Figure 6. Solutions table

The effect of optimization is shown in figure 7.

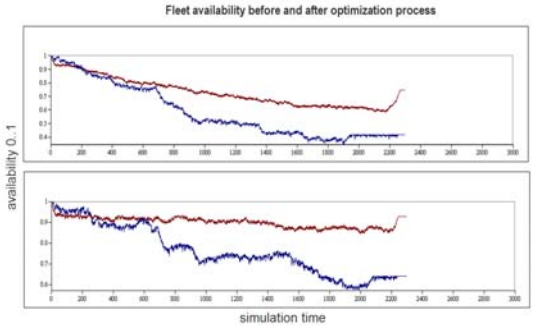

Figure 7. Optimization result

The increase in resources by 10 percent has resulted in increased availability of equipment by 15-20 percent. It is very important to point out that a solution is accepted that is not first in the ranking . Namely, the best solution in terms of the number of mechanics, requires a significant increase in the number of mechanics with insignificant benefit in terms of availability.

5. CONCLUSIONS

Our developed model is based on one type of common category of equipment. It is clear that it can be multiplied and generalized. Optimization of process without mathematical description of problem, but based on mathematical foundation, is clearly demonstrated. Future researches could go in

the direction of comparing results with exact optimization algorithms.

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CONNECTION AND RELATIONSHIP BETWEEN GDPR AND ISO STANDARDS FOR INFORMATION SECURITY MANAGEMENT SYSTEMS

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Abstract. *After four years of negotiations and harmonization, the European Union adopted in April 2016 the General Data Protection Regulation, known as GDPR (General Data Protection Regulation), which came into force on May 25, 2018. The International Organization for Standardization following the global trends in the development of its standards, greatly helps in the implementation of laws, regulations and by-laws. The ISO / IEC 27001 standard, as well as a whole series of standards related to security information can in many ways help organizations in the implementation of the GDPR requirement.*
Key words: *ISO / IEC 27001, ISO / IEC CD 27552, GDPR, information technology, information security management systems, personal data, ICT systems.*

1. WHY GDPR?

"Privacy is the right to leave the face alone" - Louis Brandeis (1890).

The GDPR, or the General EU Data Protection Regulation, is the result of a debate on the need to better protect the privacy of ICT users (information and communication technologies). The first proposal of this regulation was in January 2012.

The adoption of this Regulation was also speeded up by a judgment in the famous dispute before the European Court of Justice C 362/14 (Max Shrems vs Data Protection Commissioner). On 6 October 2015, the European Union Court of Justice (CJEU) issued a final verdict in favor of a law student, Austrian citizen Max Shrams, against the Data Protection Commissioner, in connection with the US giant Facebook and its method of data collection.

The GDPR is primarily the result of a compromise between the demands of the industry to enable the smooth flow of personal data, the creation of a single digital market within the EU, and the need to enable the protection of personal data to a greater extent.

2. WHAT ARE PERSONAL DATA AND WHO COLLECT THEM AND WHY?

You must have at least heard a story from your friends or acquaintances, and we hope that you were not one of those who withdrew money from a bank account, an open company on your behalf, or you received a notice when you wanted to raise a loan You are already a endorser to an unknown person for a loan without losing your ID or passport. How was that possible?

How many times did you happen to be asking for some information about a phone bill or some information from a bank or lecturing for some cards with your fellow guests and that the operator or kind seller asked you to give your name, surname, street and number, as well as Unique Master Citizen Number JMBG? How many times have they told you to send or bring a scanned passport or ID or a copy of these documents?

Do we even know more about what personal data are and where are they all, who and why are they using them?

The definition of personal data in the GDPR is broad and therefore it tells us that personal information is not only the name, surname or address, it is also our e-mail address, phone number, fingerprint, photos or snapshot on which you are, current location, the

number of our visits to a site and the like, or everything that directly or indirectly can point to us.
We create our own personal data that inevitably follow us through life and point to us. Every time we used a social network or broke the Internet, we left some of the personal traces on it.
By browsing the internet, you've often encountered some of the questions that someone asked you for permission that you did not read carefully. At the present time, not only high-tech companies, their product and service placement, growth and development are based on the collection of various types of data. A lot of companies have processed these data to perfection. Have you ever wondered how some sites like Facebook persist, as if Viber or WhatsApp are free? You must already know the answer - by processing and by direct use or resale of your personal information. Our personal data are the most sought-after goods in the 21st century.
When we take it all in consideration, we can say that our data is collected in different ways and processed for different purposes. They are collected through social networks, through cookies when visiting some websites; they are picked up by various institutions and organizations. We must not forget that personal data is collected by our parent organization, any public institution such as a municipality, a school or a hospital, any organization dealing with video surveillance, banks and many others.
Some believe that the application of this regulation will primarily affect marketing companies and online businesses, but the question arises as to whether it will really protect our personal data from unauthorized use. For starters, it will be enough if we do not use private e-mails to relate a variety of products, when reading texts on the sites, they will not interfere with various advertisements and other information that constantly drag us and draws attention and spend valuable time.

3. WHERE IS CONECCTION OF ISO/IEC 27001 AND GDPR

The ISO / IEC 27001 standard provides a great starting point for achieving the technical and operational conditions necessary to prevent the violation of the General Data Protection (GDPR) Regulation.
In fact, the company that implemented ISO 27001 has already done at least half the work to achieve GDPR compliance by reducing the risk of non-compliance with basic requirements in relation to information security.
The GDPR requirement does not differ much from the requirements of the management system standard, where it is said that organizations must establish appropriate policies, procedures and processes to protect the personal data they possess.
Article 42 of GDPR organizations are offered the possibility to comply with the requirements of GDPR by obtaining the appropriate certificate. Standard ISO / IEC 27001 with accompanying standards which are not for certification but represent good practice for companies from the aspect of information technology security techniques based on the general basics of all management systems.
Within the ISO organization, as an adequate assistance in the implementation of the GDPR, it is soon before the final adoption of the standard ISO/IEC CD 27552 - Information technologies - Security techniques Enhancement to ISO/IEC 27001 for privacy management - Requirements that will precisely offer an adequate solution for the application GDPR.
Article 32 of the GDPR Regulation requires the organization or "controller or processor" to carry out, if necessary, appropriate technical and organizational measures to ensure the level of security that corresponds to risk, including, inter alia, the following: pseudonymization and encryption of personal data; the ability to ensure the current confidentiality, integrity, availability and resilience of processing systems and services; the ability to timely renew the availability and access to personal data in the event of a physical or technical incident; a process for regular examination, assessment and assessment of the efficiency of technical and organizational measures taken to ensure the safety of processing.
This Article 32 also requires the identification and mitigation of the risk of "accidental or unlawful destruction, loss, alteration, unauthorized disclosure or access to personal data". Application of the information management system to the information, that is, the application of ISO / IEC 27001 or ISMS abbreviated ISMS, all of the above requirements can be fulfilled.
Applying the ISO / IEC 27001 standard will result in a comprehensive data security not only for personal data, but also for data that represents intellectual property and organizational information. ISMS also provides an integrated set of recommended policies, procedures, documents and technologies, as well as an effective way of managing, re-examining and improving your information system.

Compliance with the requirements of ISO / IEC 27001 means that you have taken steps to regularly identify and manage risks related to the security of information or data, which helps you to deal with the threats that each organization has in its market survival and development. The standard itself provides guidance for identifying and implementing appropriate measures to mitigate the security of information, with recommended technical measures that are in line with the requirements of the GDPR.
Certification ISO/IEC 27001 provides a noun and impartial assessment of the fulfillment of information security requirements and is a test that your ISMS complies with internationally accepted standards of good practice of information security, and at the same time is a convincing evidence that you have taken the necessary measures to comply with the requirements of the GDPR- a.

What are the measures recommended by ISO/IEC 27001?

Cryptography, or data encryption, is a measure recommended in the ISO/IEC 27001 standard to be undertaken in order to reduce the identified risks. ISO / IEC 27001 describe 114 controls that can be used to reduce the security of information. Since the controls implemented by the organization are based on ISO / IEC 27001, the organization will be able to identify what is at risk, and what assets and what requirements encryption requires in order to adequately protect it.

Risk assessment. ISO/IEC 27001 provides guidance organizations to conduct a detailed risk assessment by identifying threats and vulnerabilities that may affect the organization's IT assets, or assets bearing certain information, and take steps to ensure the confidentiality, availability and integrity of such data. The GDPR specifically requires a risk assessment to ensure that the organization identifies risks that may affect the security of personal data.
Business continuity. ISO/IEC 27001 emphasizes the importance of business continuity management, providing a set of controls that will help the organization to protect the availability of information in the event of an incident and to protect critical business processes from the effects of major disasters in order to ensure their timely restoration. When talking about the continuity of the possession, we must not forget the standard ISO 22301, Social Security-Business Continuity Management Systems-Requirements.

Testing the assessment. After the validation, each organization is obligated to comply with the requirements of the standards to verify and evaluate the degree of implementation of the requirements of the ISO/IEC 27001 standard. An external check is carried out by certification companies that are organized periodically as well as interns in order to confirm the applied data protection measures as well as continuous improvement ISMS.
Regardless of the fact that these are not strictly stated and other requirements of the ISO/IEC 27001 standard as the requirements required for fulfilling the GDPR, they represent support processes that are necessary for the effective functioning of the entire organization from the aspect of information security.
ISO/IEC 27001 can help meet the requirements of GDPR in these nine ways:
1. Certification-designated expert assessment of the certification body supported and recognized by the GDPR.
2. Security-certification scheme as a certain kind of guarantee that an organization effectively manages the information security risks.
3. Not only electronic data are concerned-the standard applies to all media that carry certain information, such as IT equipment, paper form, but also people.
4. Control and safety framework-represents the choice of appropriate technical equipment and organizational controls to mitigate the identified risks.
5. People, processes and technology - the standard includes these three essential aspects of information security. Threats according to the standard can be not only technological but also risks based on poor information or inefficient work procedures.
6. Responsibility - the established system must be supported by the highest management and integrated into organizational strategy and culture. Also, the ISMS clearly defines the need to establish clear responsibility for data protection throughout the organization
7. Risk assessment-Conduct regular risk assessments in order to identify threats and vulnerabilities that may affect information security. From this aspect, GDPR insists that special attention be paid to risks related to personal data
8. Continuous improvement-the organization is required to continuously monitor, review and improve its ISMS. Accordingly, ISMS needs to be constantly adapted to changes, as well as continuously work on identifying and reducing risks.

9. Regular examination and review - this is done in order to provide proof of compliance with the GDPR and confirmation of system efficiency. ISMS must be checked in accordance with ISO 19011, Management System Checking Guide.

4. GDPR AND OTHER RELATED ISO STANDARDS

The ISO/IEC 27000 series contains a set of standards to support the application of ISO/IEC 27001 standards. The umbrella standard as ISMS support are standards ISO/IEC 38505-1 and ISO/IEC 38505-2 that provides basic principles for the top management in organizations about the efficient and acceptable use of data within their organizations, using the system management, in other words governance of data in organization.

If we talk about privacy framework there is ISO/IEC 29100 standard. For "what we can do" there are: ISO/IEC 29314, Guidelines for privacy impact assessment; ISO/IEC 29151, Code of practice for personally identifiable information protection; ISO/IEC 27002, Code of practice for information security controls, ISO/IEC 27018, Code of practice for protection of personally identifiable information (PII) in public clouds acting as PII processors; ISO/IEC 27552 (under development), Enhancement to ISO/IEC 27001 for privacy management-Requirements. In faze for reducing a risk we can use following standards: ISO/IEC PDTR 27550, Security technique-Privacy engineering (under development); ISO/IEC CD 29184 Guidelines for online privacy notices and consent under development); ISO/IEC 29190, Security techniques-Privacy capability assessment model.

The new standard ISO/IEC CD 27552, which is still in the development phase, was created on the initiative of the French Data Protection Officer (CNIL). This standard sets requirements for the implementation of the Personal Data Management System (PIMS). This standard, although it is intended for certification, is planned to completely replace certification requirements for organizations according to ISO / IEC 27001 standard.

5. CONCLUSIONS

As many times before, the ISO organization has demonstrated its promptness in following the world trends and legislative foundations in world practice. The development of information technology and Big Date has made it a matter of privacy that it became a thing of the past and that today it is no longer a question of whether we can reach any information, it is a question of time and ease of access.

The ISO/IEC 27000 series helps us shorten the time and take good practice in keeping our information in the organization and will surely require a lot of effort, that is, both the organizational measures and the money resources to ensure the security of our information.

How much will it cost me to adjust to the GDPR and how fast do I have to adjust? The law, both within the EU and in our country, but not with such drastic measures and requirements, is already in force. At the beginning of 2018, or only a few months until the full implementation of the GDPR regulation, Veritas conducted a survey based on which it found that only 2% of respondents really adjusted their way of applying the GDPR regulation, but 31% said it was fully applied. Some estimates are that the companies in Serbia will cost an average of 50,000 EUR per organization, without the cost of external consultants, employment of the Data Protection Officer (DPO).

As a summary of all of the above, if the organization has not already started implementing the ISO / IEC 27001 standard, it is already late.

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RESPONCE TIME AS A NEW APPROACH FOR MEASURING MANAGEMENT SYSTEM EFFICIENCY

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Abstract. *The number of organizations that have implemented some of the ISO standards in their operations is very large and growing every day. The basis for the good functioning of a management system is its high degree of effectiveness. In theory and practice, there are several methods used to assess the effectiveness of the management system: internal audit, second party audit, third party audit, risk analysis, interested party responses, and so on. What this paper is supposed to present is a new method, which analyzes the response times, that is, the speed of the business system response, as a factor in assessing the effectiveness of the management system. The paper analyzes data related to the four major business systems in Serbia that deal with the maintenance of vehicles or fleets - hundreds of vehicles in each, or more than a thousand vehicles in total.*

Key words: management system, efficiency, response time

1. INTRODUCTION

Every year the number of organizations that implement and apply ISO management system in the course of regular business, grows. For example, in China alone, there are more than three hundred thousand companies that have successfully implemented and certified their management system according to the ISO 9001 series [1]. The implementation of the ISO standard aims to improve the organization's business with the continuous satisfaction of the interested party requirements. [2]

In order to monitor the level of compliance with the requirements of the standard itself, as well as meeting the demands of end users, organizations use tools such as internal audits, corrective and preventive measures, risk management, and so on. [3] An independent certification audit is the most commonly used method for verifying the effectiveness of the implemented management system. However, organizations also need more efficient methods for checking the effectiveness of their systems, primarily because external certification audits very often require large financial allocations, and also due to the fact that certification/surveillance audits are generally conducted only once a year.

Some previous research have already pointed to the problem of achieving a high degree of efficiency and effectiveness of the management system and emphasizes this as one of the main problems encountered by companies with the implementation of ISO standards [4]. However, in addition to the known methods, which are described in detail through numerous literature dealing with the field in question ([5], [6], [7], [8], [9]), in research and in practical applications, there is still a need for the

introduction of a new method, that is, principally and substantially a new way of observing the problem of measuring and improving the effectiveness of the management system. This paper depicts one such new method, called the Response Time Method.

The response time method (response = reaction speed) is based on the fact that the effectiveness of the management system is directly dependent on the system's level of implementation and its readiness to take effect and to achieve the expected outputs in the minimum time and given environmental conditions. [10]

Data analysis of the response rate is presented here, that is, the analysis of the time segments that have elapsed since the implementation of the Internal Audit to the start-up and closing of Corrective Measures resulting from Internal Audit (response rate). For the purposes of this analysis, the data collected through the software application "ISO 9000", developed by the authors, tested and implemented for continuous use in the organizations managing the fleets: Euro Sumar llc; Delta Motors llc; TC Lastra llc and TC Lasta AD.

2. ANALYSIS OF MANAGEMENT SYSTEM RESPONSE TIME

In accordance with the standard requirements, the decision on the number of audits and periodicity of the internal audit is left to the organizations, i.e. their assessment and, accordingly, the planning of the audit. All four analyzed companies planned two internal audits on an annual basis, mainly during the first half of the year and the second, before the end of the year.

	2012	2013	2014	2015	2016	2017
Euro Sumar llc	2	2	2	2	2	2
TC Lastra llc	1	2	2	2	2	2
Delta Motors llc	2	2	2	2	2	2
TC Lasta ad	2	2	2	2	2	2

Table 1: Number of conducted internal audits yearly

After conducting an internal audit, reviewing the findings, and forming a report, the Person responsible for managing the system, together with the executives in whose organizational parts (or processes) the nonconformity has been identified, launches appropriate measures. The time period for initiating corrective measures after the completed internal audit is not defined by the standard, but it is definitely one of the important parameters for assessing the effectiveness of the management system. In Euro Sumar llc it takes one day for the implementation of corrective measures, in Delta Motors llc, one to three days, in TC Lasta ad, this period is 2-3 days, while in TC Lastra llc, that time period ranges from one to seventeen days (shown in Table 2 and Figure 1).

	2012	2013	2014	2015	2016	2017
Euro Sumar llc	1	1	1	1	1	1
TC Lastra llc	0	9	0	17	2	0
Delta Motors llc	2	1	3	1	1	1
TC Lasta ad	2	3	3	2	3	3

Table 2: The number of days that elapsed from detecting the nonconformity during the internal audit until the corrective action was initiated

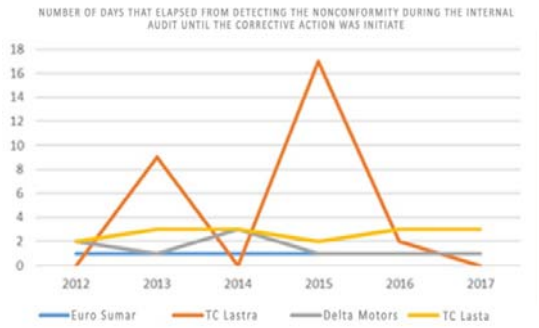

Figure 1: Graphical representation of the number of days that elapsed from detecting the nonconformity during the internal audit until the corrective action was initiate.

The reasons for such large oscillations in the measured times for the initiation of corrective measures, can be various - from the fluctuation of employees and / or the change of the person in charge of system maintenance, to the lack of resources (time i.e. workers, workspace, spare parts) necessary for smooth functioning system. Whatever the reason, large time intervals, from the moment of nonconformity discernment to the initiation of a corrective measure, are certainly not in favor of an effective management system.

Table 3 below shows the number of corrective measures that have been initiated on the basis of

conducted internal audits yearly. We see that, at the beginning right after the implementation of the standards, there were far more corrective measures, and that, in later years during the application of the standard, this number was reduced as a result of continuous application, or as a result of improvements in accordance with the requirements of the standard. We can also see that the number of initiated corrective measures is slightly higher with TC Lastra llc at the beginning of the implementation, which is logical given that it is a larger organization with more complex processes. We can also see that the number of corrective measures in Delta Motors is far greater than in other organizations, the reason being the implementation of inoprincipal, that is, BMW's standard, and the required period of adapting to additional requirements.

	2012	2013	2014	2015	2016	2017
Euro Sumar llc	5	2	0	1	1	1
TC Lastra llc	8	3	1	2	1	0
Delta Motors llc	12	22	18	27	4	11
TC Lasta ad	10	6	5	8	4	5

Table 3: The number of initiated corrective measures yearly

However, in addition to the number of initiated corrective measures, a much better parameter for assessing the effectiveness of a management system is, the number of days that pass from the moment of initiation of the corrective measure to the time of its closure. This is shown in Table 4 and Figure 2.

	2012	2013	2014	2015	2016	2017
Euro Sumar llc	32	35	0	24	14	12
TC Lastra llc	28	62	58	61	40	0
Delta Motors llc	14	17	10	15	7	10
TC Lasta ad	25	72	60	72	45	30

Table 4: Average number of days required to close corrective measures

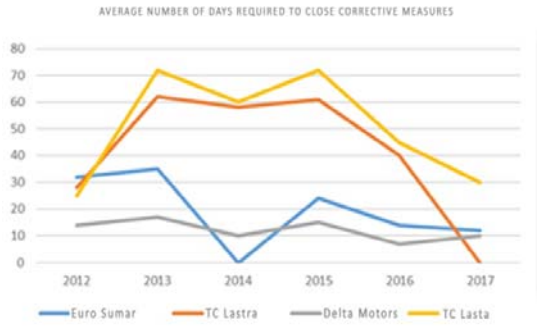

Figure 2: Graphical representation of the average number of days required to close corrective measures.

Of course, the large time period required to close the corrective measure does not necessarily mean the ineffectiveness of the system. The reason may also be the complexity of the inconsistency, or its cause, which, as a rule, requires the involvement of a large number of people for its dislocations, higher financial expenditures, etc.

3. CONCLUSIONS

The system response time is one of the better ways to monitor and measure the effectiveness of each system (in this particular case of management system). Rapid response and response to impulses from the environment (either internal or external) is a basic requirement for adequate function in a dynamic time in which most systems work.

Authors have focused their future research on the development of mathematical models and algorithms based on experiential and statistical data, and which would, therefore, give accurate or approximate (in the form of fuzzy functions or fuzzy numbers) boundary value for the evaluation of the system's response speed, or the evaluation of its effectiveness.

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ASSESSMENT OF THE SCOPE OF TESTING REQUIRED TO QUALIFICATION THE BMS USING FMEA METHODS

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Abstract. *In the pharmaceutical industry, BMS qualifications are carried out by applying structures models for risk management, in accordance to relevant GMP requirements. In this paper, the FMEA method of risk analysis for assessing the scope and qualification level of the BMS was applied. FMEA is a desirable method for risk management in the pharmaceutical industry because it involves improved reliability, superior quality, increased security and it is based on understanding the processes and on knowledge of the characteristics of the system itself. Through this paper potential problems are identified, the level of risk is assessed, and actions to reduce or completely eliminate risks from their impact on the BMS are proposed.*

Keywords: *BMS, FMEA, qualification, pharmaceutical industry.*

1. INTRODUCTION

GMP (Good Manufacturing Practices) requires from the pharmaceutical industry to implement a program of control, qualification and validation based on the risk. To identify known and possible mistakes in the operation of the plant and equipment or the non-compliance of the pharmaceutical product, as well as to identify the consequences of such errors, the FMEA method is most often used. [2]

The air conditioning implies the regulation of certain ambient conditions, within narrow limits of optimal values, whereby that process is carried out automatically, adapting to the changing effects of the external climate. The HVAC (Heating, ventilation, and air conditioning system) system represents the best technical solution by which maintenance of an acceptable environment for production in the pharmaceutical industry is achieved, while the BMS (Building Management System) is an automatic system for regulating and monitoring the operation of the HVAC system itself [7].

Annex 15 [4] describes the principles of qualification and validation that applied to premises, equipment, auxiliary systems and processes used for drug production. Any planned changes in space, equipment, auxiliary systems and processes that may affect on product quality should be formally documented and impact on validation principles or an estimated control strategy should be assessed. The extent of testing within the conditioned requalification depends on the type and extent of the change made on the equipment / system. All initial qualification tests (IQ, OQ, and PQ) should be considered and repeat those affected by the change. Assess of the scope of testing should be performed using a risk analysis. The source document for major changes to the system is URS (*User requirements specifications*). After a properly written URS, according to Annex 15, it is necessary to follow the steps: URS - DQ - RA – FAT (Factory Acceptance Test) / SAT (Site Acceptance Test) - IQ – OQ – PQ (Performance Qualification).

DQ (Design qualification) – Using Design qualification it's testify to given design corresponds to the needs of users and GMP requirements.
RA (Risk analysis) – It defines the scope of tests that should be performed on the equipment and system.

IQ (Installation qualification) – The Installation qualification is the establishment of documented evidence that the equipment and belonging systems are properly installed and should include at least the following: checking the correctness of the installation of components, instruments, equipment, pipelines and work on them in relation to the technical schemes and specifications; checking the correctness of the installation in relation to the previously defined criteria; collecting and checking the supplier's operating instructions for work, handling with equipment and requirements for maintenance; calibration of instruments; and verification of construction materials.

OQ (Operational Qualification) – The Operational qualification is the establishment of documented evidence that the whole system really functions in the prescribed way and should include at least the following: tests developed on the basis of knowledge of processes, systems and equipment, to ensure that the system functions as designed; tests that confirm the upper and lower operating limits, and / or the conditions of the "worst case". Successfully completed OQ should provide the finalization of SOP (standard operational procedures) of working and cleaning, operator training and defining requirements of preventive maintenance.

The qualification of the HVAC system by using the FMEA analysis and the results of the performance qualification are shown in [1]. In this paper the qualification of the BMS using the FMEA risk analysis, which can be considered as a continuation of the mentioned qualification of the HVAC system, will be shown. In practice, the qualification of HVAC and BMS are rarely analyzed together, although they are in separable entities. Therefore, in following of the paper the BMS qualification by using the FMEA method for determining the scope of testing required in order for the system to be qualified properly and in accordance to the regulations, will be shown.

2. METHODOLOGY

If there is a change on the BMS (installation of sensors, software change, system parameters, change of critical alarm values, etc.), it is required to qualify the system, and evaluate how many changes can affect the quality of the product as well as on the process itself. It is necessary to identify all possible Failure Modes (FM) relevant to each process phase, where S (Severity) can be estimated with 1 - Low (FM does not affect to the functionality of the system and does not affect the product), 3 - Medium (FM has moderate influence on the functionality of the system, but alternative method scan be applied to ensure the execution of the process. 5 - High (FM has a direct impact on system functionality and product quality, but there are no alternative methods for performing operations); P (Probability of Occurrence) can be estimated with 1 - Low (a rare occurrence of a potential cause of failure), 2 - Medium (probably will appear during the life cycle), 3 – High (it will appear during the life cycle), and D (Determine) can be estimated with 1 – Low (detected automatically), 2 – Medium (detected following manual check) , 5 – High (not detected). The next step would be determination of potential risks, i.e. what can go wrong, what are the consequences of these events, as well as the collection of enough number of data to establish the relation between the different risks in the process that be analyzed. Table 1 shows the risk analysis for the selection of tests due to the BMS qualification.

Table 1. Risk assessment for BMS

Risk No.	Risk Scenario	Risk Cause / Comments	S	P	D	Risk Score	Qualification Testing Required
1	The control system does not work properly.	Backup of software is not available. In case of software deletion, recovery is not possible.	5	1	2	**10**	IQ - Test of software. OQ – Test of documentation.
		The system does not store the alarm history after the alarm state disappears. Missing relevant GMP record.	5	1	2	**10**	Check DQ. OQ - Alarm verification test.
		The system does not allow display of alarm properties and confirmation of alarm status. Alarm cannot be explored.	5	1	2	**10**	Check DQ. OQ-User interface verification. OQ - Alarm verification test.
		There are no new screens for newly installed devices. The components are not displayed correctly.	5	1	2	**10**	OQ - Test of user screens and navigation.

Table 1. Risk assessment for BMS

Risk No.	Risk Scenario	Risk Cause / Comments	S	P	D	Risk Score	Qualification Testing Required
		The audit trail does not record all the necessary information for the execution of the changes, does not apply to all input electronic data, the information contained in the audit trail can be changed. Copies of relevant GxP data cannot be shown to inspections.	5	1	2	**10**	Check DQ. OQ-Audit trail verification. OQ-Audit trail report generation verification. OQ-Audit trail integrity verification.
		There is no archiving of data on the system. Data can be forged, no trace. The system cannot detect an invalid record. Possible loss of original data, invalid data is stored.	5	1	2	**10**	Check DQ. OQ - Report generation verification. OQ - Invalid records verifications.
		The system does not generate alarms of critical parameters and does not allow the alarm threshold to be set. Critical parameters of the system cannot be detected.	5	1	2	**10**	Check DQ. OQ – Alarm verification test.
		The system does not generate alarms if the equipment failure happens. Potential impact on the production process.	5	1	1	**5**	Check DQ. IQ-Input / output verification test. OQ - Audit trail.
		The system does not allow the control/ monitoring of the installed device status, and cannot enter the trace of change the status of the device.	5	1	2	**10**	Check DQ. IQ – Input / output verification test. OQ - Audit trail.
		The system cannot preserve the supervised critical system parameters. Inability to record and monitor critical system parameters.	5	1	2	**10**	Check DQ. OQ - Trends test.
		The system does not allow generating the trends of supervised critical parameters. Trends cannot be generated and attached to the records and used for regular operations.	5	1	2	**10**	Check DQ. OQ - Trends test.
		A report which contains trends and set parameters is not available, it cannot be printed. Incorrect information about the supervised values of critical parameters.	5	1	2	**10**	Check DQ. OQ – Configuration parameters. OQ - Print data test. OQ - Trends test.
		The control system can be accessed by unauthorized persons. Can Log On to a system without Username and password.	5	1	2	**10**	Check DQ. OQ-Username and password verification. OQ-Security check.

By applying the FMEA method, the overall risk that can affect the BMS, combining with individual risks, is estimated. As the HVAC system belongs to systems with a direct impact on product quality and it is closely related to BMS, the severity will, in most cases, be assessed with "5". It is clear then that the overall risk will depend mainly on the probability of occurrence and the possibility of detection. Priority should be given to reducing the probability of occurrence rather than increasing the level of detection. By evaluation of the severity level (S), assigned to each of the potential risks, by identification of potential causes (P), and evaluating relevant levels of detection (D) ranks the final score for each of the potential risks. The last column shows the list of recommended tests which should be performed for each of the potential risks. Only test names are given, the purpose of the tests and the acceptance criteria are not explained because of the goal and scope of the work itself. Based on the final

risk assessment of each scenario, appropriate risk reduction actions are defined as actions that should reduce the severity and probability of risk, or processes and / or methods that enhance the ability to detect risk. Risk reduction actions are applicable in the manner described in Table 2. After defined risk reduction actions, qualification tests for any potential risk have been proposed. If the level of risk is not acceptable, a reassessment of qualifications needs to be done and improved detection methods in order to reduce the risk to an acceptable level. As a final act, it is necessary to document risk analysis, with detailed explanations about the estimated extent of testing and the impact on the system.

Table 2. Risk analysis score

Level	Risk Score	Risk Reduction Actions
1	1-5	Testing is not necessary. Relevant SOP. Training of users.
2	6-19	Nominal testing required - Nominal testing is performed to prove that the functions are working properly. Relevant SOP. Training of users.
3	20-31	Required extensive testing - Extensive testing that includes testing in the zone of alarm activation limit values. Relevant SOP. Training of users.
4	32-49	Required extensive testing – Predict extensive testing and possible additional routine checks/controls. Relevant SOP. Training of users. Consider the level of the system redesign.
5	50-75	Required extensive testing–Predict extensive testing and possible additional routine checks/controls. Relevant SOP. Training of users. System redesign.

3. CONCLUSIONS

By FMEA risk analysis the evaluation of the scope of testing is carried out, as well as the impact on the system that needs to be qualified. The contribution of this paper is in the way of identifying possible risks, which is the most complex part of the analysis, because it is necessary to identify and describe all the individual risks that can affect the BMS. Risk ranking and scales used in risk analysis are difficult to define, so their constant review and improvement is needed. With the successful identification of possible risks, recommended actions for their reduction or total elimination are given. The contribution of the FMEA method is in identification potential problems that can be reduced or completely eliminate the risk of their impact on the system. By focusing on risk management and separation of funds for research, unnecessary efforts for qualification can be eliminated. The inspection of the BMS and HVAC systems varies depending on the inspector, which is why it is important to apply regular guidelines during document writing and during execution of qualification protocols. This paper presents a unique example of how critical systems can be qualified.

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QUALITY 4.0

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Abstract. *The paper presents the features of Quality 4.0 the term derived from Industry 4.0. As the fourth industrial revolution has already started, this paper discusses the aspects of Quality 4.0 and how quality professionals should deal with the challenges in the future related to quality.*

Key words: *Quality 4.0. Future of Quality. Quality 4.0 framework. Technology.*

1. INTRODUCTION

In the last decade the world of technology has been rapidly changed. We have faced significant developments in connectivity, mobility, analytics, scalability, and data. These new trends have created something what is called the fourth industrial revolution, or Industry 4.0. Quality 4.0 is a term that references the future of quality within the context of the exponential growth of technological advancement and the unprecedented rate of change that those advancements are causing. The new landscape, created by new trends, requires individuals and organizations to constantly learn and apply new things, discard the practices and assumptions of the past and obtain new set of skills how to survive and succeed in an ever evolving climate of advancement, development, and change [1]. This fourth industrial revolution has digitalized operations and resulted in transformations in manufacturing efficiency, supply chain performance, product innovation, and in some cases enabled entirely new business models. This transformation should be a top priority for quality leaders. Quality 4.0 is aligning quality management with Industry 4.0 to enable enterprise efficiencies, performance, innovation and business models. However, much of the market isn't focusing on Quality 4.0, since many quality teams are still trying to solve past problems like inefficiency of processes, manual metrics calculations and erroneous decisions based on this, ineffectiveness of the quality teams and many others. Quality 4.0 is about how new technology improves culture, collaboration, competency and leadership. It's also about the digital transformation of management systems and compliance. Although it's an advanced topic, the application of Quality 4.0 methods has already started, since leading organizations are already on their digital transformation path. This article highlights main aspects of required to lead the Quality 4.0 transformation necessary for tomorrow's survival.

2. QUALITY 4.0

Quality 4.0 is a reference to Industry 4.0. The First Industrial Revolution embodied three revolutionary changes: machine manufacturing, steam power and the move to city living for people who had previously been

agriculturalists. During the Second Industrial Revolution, the production line and mass manufacturing drastically reduced the cost of consumer and industrial products. The Third Industrial Revolution was barely a revolution as electronics and control systems gradually penetrated manufacturing, allowing greater flexibility and more sophisticated products at a significantly lower cost. The Fourth Industrial Revolution is happening around us right now. It extends the digital impact of the third revolution and merges it with the physical and natural worlds. Several critical technology changes have enabled this, including advances in data, analytics, connectivity, scalability, and collaboration. As the fourth revolution takes hold, it will impact everything that we do. It connects people, machines and data in new ways, it democratizes technologies that were previously only accessible to the certain entities. For quality, these technologies are important because they enable transformation of culture, leadership, collaboration, and compliance. Quality 4.0 is truly not about technology, but the users of that technology, and the processes they use to maximize value [2].

Quality 4.0 certainly includes the digitalization of quality management. More importantly it is the impact of that digitalization on quality technology, processes and people. Many sources [2, 3] have identified specific areas of Quality 4.0 that need to be addressed in order for the organizations to implement them. Using this framework and research, leaders identify how Quality 4.0 can transform existing capabilities and initiatives. The framework also provides a perspective on traditional quality. Quality 4.0 doesn't replace traditional quality methods, but rather builds and improves upon them. It appears that some areas should also be included.

The areas that are usually associated with Quality 4.0 framework are [2, 3]:

- Innovation
- Data-Driven Decisions
- Analytics
- Connectivity
- Collaboration
- App Development
- Scalability
- Management Systems
- Compliance
- Culture
- Leadership
- Competency.

Innovation is an imperative for any organization and it will become critically important in the future. Creativity is the process of producing new ideas, while the innovation process addresses creating and applying these ideas. In the context of an organization, the term innovation process refers to the entire process by which people generate new ideas and convert them into commercial products and practices. Creativity and Innovation result from a high degree of people involvement and creates a higher sense of personal fulfillment. The Innovation process is usually comprised of the following steps:

- Discover the opportunity.
- Find the solution.
- Make the solution work and
- Deliver the results

Data-Driven Decisions have been at the heart of quality improvements for decades. Many recently updated standards re-emphasize the importance of evidence-based decision making. However, much of the market continues to struggle with evidence while more mature companies have mastered traditional data and are now leveraging big data.

Data has five important elements to consider:

- Volume (large quantity of different records),
- Variety (structured, unstructured and semi-structured data),
- Velocity (the rate at which a company gathers data),
- Accuracy (correctness of data) and

- Transparency (the ease of accessing and working with data no matter where it resides or what application created it).

Analytics reveal the insights captured within data. Presently, analytics are often a stumbling block for quality – 37% of the market identifies poor metrics as a top roadblock to accomplishing quality objectives [2]. Also, there is insufficient adoption of real-time metrics by most of the market. Analytics fall into four categories:

- Descriptive (the most traditional metrics to monitor known or suspected correlations),
- Diagnostic (quality process cycle times to identify bottlenecks),
- Predictive (trend analysis) and
- Prescriptive (What action is supposed to be taken).

Connectivity is the connection between business information technology and operational technology, where business technology includes the enterprise quality management system, enterprise resource planning, and product lifecycle management, and operational technology is the technology used in manufacturing and service. Industry 4.0 transforms connectivity through a creation of inexpensive connected sensors that provide near real-time feedback from 4 different entities [2]:

- Connected people (leverage personal smart devices or intelligent wearable devices that sense workers),
- Connected products (provide feedback on their performance across their lifecycle and they can communicate use conditions, performance, and failure to perform),
- Connected edge devices (efficiently connect sensed equipment) and
- Connected processes (provide feedback from connected people, products, and equipment into processes).

Collaboration is critical for quality management, as quality is by nature cross-functional and global. Companies execute traditional quality business processes with the help of digital messaging (email), automated workflows, and portals. Much of the market has yet to take advantage of automated workflows and portals, and in fact, only 21% have adopted a core enterprise quality management system [2]. Collaboration has changed dramatically in recent years, within and across companies and with customers. Social media has enabled the public to directly weigh in on quality, which has increased the visibility of quality issues.

App Development is a process of developing supporting software. Apps are the mechanisms through which companies fulfill processes, collect and expose data, visualize analytics, and establish collaboration. Traditional quality apps are most commonly web-based, and nearly all of them have been optimized for mobile, although it usually requires a large mobile device such as a tablet. As software has become more powerful, the trend has been to develop role-based apps for a better, simpler experience through multiple interfaces divided by role. Mobility provides greater accessibility, participation, adoption, and efficiency. There are three types of apps that will run quality management:

- Wearables (devices that sense and connect human performance),
- Augmented Reality (overlay of virtual content on physical assets or surroundings) and
- Virtual Reality (simulates the real world and offers value for operations and management).

Scalability is the ability to support data volume, users, devices, and analytics on a global scale. Without global scale, traditional quality and Quality 4.0 are much less effective, unable to harmonize processes, best practices, competencies, and lessons learned corporate-wide. Cloud computing is an important

contributor to scalability. Through Cloud, manufacturers can acquire software, easily adding capabilities and users, data, analytics, and devices without the need to acquire, install, and manage the software on premise. Data scalability is also important, particularly with connected devices. Data lake technologies have been developed to support the voluminous data sets inherent with connected devices and Big Data.

Management System, especially the enterprise quality management system is the hub of quality management activities, providing a scalable solution to automate workflows, connect quality processes, improve data accuracy, provide centralized analytics, ensure compliance, and foster collaboration within a common app. It is a hub because quality touches every part of the value chain and how it's managed.

Compliance activities include conforming to regulatory, industry, customer, and internal requirements. Compliance is important to quality teams across industry since quality often takes a lead role in ensuring that processes, products, and services conform to requirements. Quality 4.0 introduces even more opportunities to automate compliance.

Culture, especially the culture of quality, is the imperative for many leaders that have an initiative to develop it, since quality often owns process execution with insufficient participation and ownership from other functions. A company that has "a culture of quality" exhibits four key elements: process participation, responsibility, credibility, and empowerment. Quality 4.0 makes a culture of quality more attainable through better connectivity, visibility, insights, and collaboration.

Leadership, particularly quality leaders should lead quality across the organization, with increasingly broad ownership by cross-functional executives and top management to broaden the focus on quality and enable effective corporate-wide quality. Quality 4.0 has already drawn interest from cross-functional leaders. According to Hacker [4] the future leadership has to be transformational leadership, to have the skill set to move rapidly, efficiently and effectively through the changing process driven by external and internal forces.

Competency is an individual's ability to complete a task effectively and efficiently. Organizations have battled to improve the baseline competency of personnel, and to scale specialized knowledge. Quality leaders looking to improve upon the structured approach of traditional quality can use several Quality 4.0 approaches:

- Experience (to share experiences and lessons learned across internal groups),
- Expertise (to improve the expertise of workers),
- Appraisal (deploy connected worker strategies to sense worker actions, ensuring compliance, competency, efficiency, and safety) and
- Management (encapsulate these learnings in Learning Management Systems).

The completely new set of skills and competencies are required to master the challenges related to Quality 4.0 [5].

3. CONCLUSIONS

Quality 4.0 is the digitalization of quality leveraging the technologies of Quality 4.0. People and processes are important to all areas of business but are particularly key to quality. Therefore, while Quality 4.0 makes critical new technologies affordable and accessible to the broad market, Quality 4.0 is about the application of these technologies to solve quality challenges and to provide new, better solutions.

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SIMPLE BUILDING INFORMATION MODELING BY USING INDUSTRY FOUNDATION CLASSES

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Abstract. *Building Information Modeling (BIM) is a rising technology, already widely used in AEC & HVAC industry around the world. The basic idea of BIM, to create, store and use the building information efficiently is currently the work in progress. Namely, a significant amount of relevant information about the building is impossible to create or use by the existing software. Originally established as an exchange format, Industry Foundation Classes (IFC) represent both the information repository and the framework to generate new or use the existing information. The paper presents a way of low-level information modeling by using an IFC format.*

Keywords: *Building Information Modeling, Industry Foundation Classes, low-level BIM*

1.INTRODUCTION

Since the genesis of Computer Aided Design (CAD) in the 1970's, this technology is in a persistent process of development. Originated in mechanical engineering in the early 1980's, 3D CAD is shortly thereafter adopted by architects and structural designers, which eventually lead to establishing of BIM by the end of 1980's. In 2011, the UK government created a strategy [1] for adopting BIM as mandatory for all government construction projects. In the past few years, several European countries followed the UK's example.

As opposed to CAD, BIM is much more than a 3D geometry model of a building. It is rather a comprehensive building information database, including all the relevant data regarding planning, design, construction, operation, and maintenance. Furthermore, BIM stands for the special collaborative business model which supports the establishment of such a database [1].

Benefits of using BIM are widely recognized by investors, owners, designers, contractors, and operators of buildings. Although emphasized as one of the main advantages of using BIM, a free flow of all possible kinds and formats of information about the building is currently limited to the modeling functionalities of BIM software. A considerable amount of relevant data lacks modeling framework in available software solutions.

Another challenge of the efficient use of BIM is interoperability i.e. the ability to transfer data between applications [2]. To overcome the interoperability obstacle, the buildingSMART organization [3] developed a standardized data format for the manufacturer-independent exchange of digital building models: IFC. Currently, all commercial BIM software solutions can export their native formats to IFC. Although an exchange format, IFC can be used as a modeling tool for non-standard information. After a short introduction to IFC basics, the paper presents the method to modify the IFC file content in order to model the specific information. Finally, the case study illustrating the proposed solution is presented.

2. PROPOSED SOLUTION

The IFC schema is a specification for sharing data between disciplines and software applications during the project life-cycle [3]. The schema is written in the EXPRESS data definition language. It contains definitions of classes (entities) representing almost

all relevant elements to be modeled. Besides element classes, the schema specifies various kinds of relationships between different elements. Instances of some element classes can have one or more geometric representations. Several methods for defining geometry are provided in the schema as well. Therefore, the IFC schema provides an open framework for BIM. In order to be able to generate a highly detailed IFC files, commercial software modeling frameworks should comply with the IFC schema as much as possible. However, currently available BIM software solutions considerably vary in the quality of IFC export. Moreover, some information is impossible to model. This paper proposes the information modeling by externally modifying the IFC file. It could be done manually in case of minor modification, or by using some of the available programming toolboxes [3] for large-scale modification.

IFC file is a clear text file with ".ifc" file format extension. It is in accordance with the STEP physical file format, governed by the IFC schema in EXPRESS [3]. To model the lacking data, one should follow the algorithm presented in Figure 1.

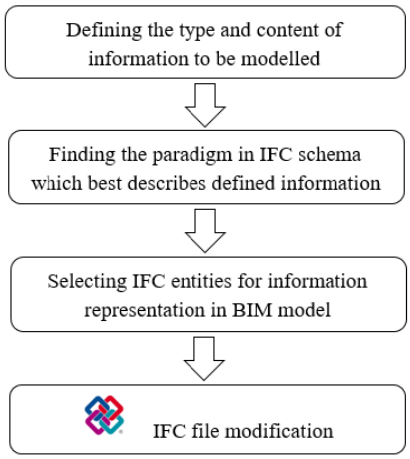

Figure 1. Algorithm for modelling by external IFC modification

3. CASE STUDY

For the purpose of illustrating the proposed method, an IFC file representing a part of heating equipment will be modified so that a part of user manual i.e. Troubleshooting is added. The IFC file capturing the BIM representation of Buderus Oil and Gas Fired Boiler Logano G215 is downloaded from the Open IFC Model Repository [5] (Figure 2). Following the proposed algorithm, firstly it is necessary to define the type and content of information to be added to the model. For the sake of easier operating, a snippet of the user manual regarding troubleshooting is going to be added. The snippet is the textual data describing two potential problems.

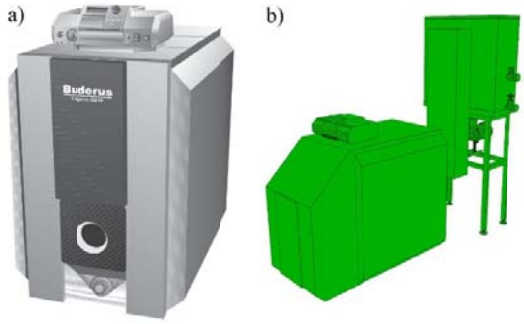

Figure 2. Buderus Oil and Gas Fired Boiler Logano G215: a) Render from user manual, b) IFC geometric representation

This kind of data is possible to model in a few different ways. Although troubleshooting cannot be strictly categorized as a property of the device, in this case, the use of the "property paradigm" for troubleshooting description is completely justified. To support this statement, the existing model is examined. The entity used for the representation of the equipment unit is IfcEnergyConversionDevice from the Shared Building Elements layer of the schema. Properties defining the instance of the mentioned entity contain information such as the manufacturer's website, or compilation date. Thus, the information of interest will be modeled by IfcComplexProperty and IfcPropertySingleValue entities. The architecture of the data and relationships to be added is shown in Figure 3.

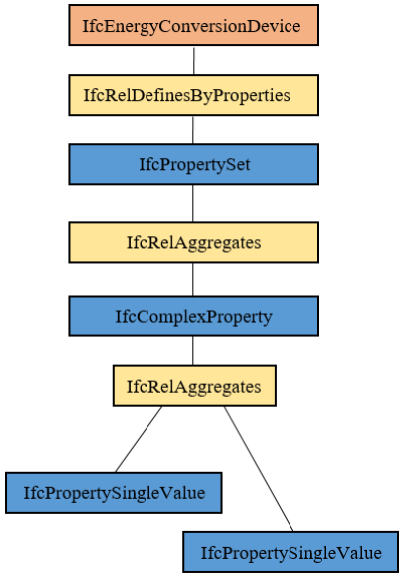

Figure 3. Diagram of the established data structure

The IFC file is modified using text editor. Relevant parts of the file are presented in Figure 4.

```
#120 = IFCENERGYCONVERSIONDEVICE('3M7BrgwhP5MQMQ
  $fudrMnF', #101, '\S\Vl-Brennwertk. Logano
  G215 mit Logamatic 2107 55 kW bud1811', '', $,
   #125, #126, $);
#11333 = IFCRELDEFINESBYPROPERTIES
  ('0nAgIGEXjDbOXtd4dPiA8M', #101, $, $, (#120,
  #11252, #11259, #11266, #11273, #11280,
  #11287, #11294, #11301, #11308, #11315,
  #11322), #11334);
#11334 = IFCPROPERTYSET
  ('0pkUooy8533817opqaghW6', #101, 'VDI3805
  PropertySet', $, (#11335, #11342, #11349,
  #11356, #11569));
#11569 = IFCCOMPLEXPROPERTY('Troubleshooting
  your Heating System', 'Operating
  Instructions', $, (#11570, #11571));
#11570 = IFCPROPERTYSINGLEVALUE('Burner related
  problems', $, 'An alarm light on the burner
  will typically light up during a burner lock -
   out condition (See burner manual). Typically
  this problem is resolved by pressing the
  burner reset button.Press the burner reset
  button once. If the burner does NOT fire,
  contact your local service company for
  assistance.', $);
#11571 = IFCPROPERTYSINGLEVALUE('Problems
  related with the control system and heating
  system', $, 'Problems related to the control
  panel and/or heating system itself, are
  typically shown on the display of the control
  panel, if the boiler is so equipped.Further
  information can be found in the manuals
  supplied with the control panel.', $);
```

Figure 4. Relevant parts of IFC file

4. CONCLUSIONS

The general idea of the BIM is clear: it is supposed to be a central repository of all kinds and formats of information about the building and everything related to it. In spite of the large of available software solutions, a considerable amount of important data lacks the modeling framework. The paper presented a simple method of modeling such an important data and thus supporting BIM. As shown, it is possible to modify the content of the IFC file such that the lacking data comply with the IFC schema ontology and syntax. The paper presented a simple case where only the textual data is added. Nevertheless, IFC provides a consistent framework for establishing much more complex data structures. The result of IFC file modification is shown in a form of the EXPRESS code, however by creating a wrapper around the code, the modeled information would get the missing context. By following the proposed algorithm, it is possible to model a wide variety of information.

5. AKNOWLEDGEMENTS

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PRODUCT DESIGN IN GLOBAL PRODUCTION NETWORK

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Abstract:. *Global competition and shortage of product design resources demand special ways of compromising global economic effect with local requirements for product quality . Global standardization of product design process applied to local product design outsourcing is proposed to reconcile the contradiction. ISO 9000 series and black box design system are represented here as a methods of achieving it.*

Key words: *Global Standardization, Local Outsourcing*

1. INTRODUCTION

As markets globalize, the need for product design standardization increases. On the other hand, managers are also under pressure to adapt their organization to the local characteristics of the market, the legislation, the fiscal regime, the sociopolitical system, and the cultural system. This balance between consistency and adaptation is essential for corporate success. To be able to offer products at competitive prices, a global production network is needed [1].

Customer demands for higher quality products at lower costs and shorter product lifecycles are putting extra pressure on the product introduction process. Cost and quality are essentially designed into products in the early stages of this process. The designer has the great responsibility of ensuring that the product will conform to customer requirements, comply with specification, and ensuring quality in every aspect of the product, including its manufacture and assembly, all within compressed time-scales [2,3,4].

If product assemblers could not recruit sufficient engineers and workers to deal with the rapid expansion of design tasks, which is the case in rapidly changing global market environment, it would be reasonable to predict that pressures to subcontract out a larger fraction of their design tasks to the parts suppliers increased during that time. In fact, there is a tendency that the assemblers start to purchase subassembly components, rather than piece parts, from their first-tier suppliers, and that they emphasize "specialist" parts suppliers.

Thus, it would be reasonable to infer that the automakers actually subcontracts out a larger fraction of the design tasks to the suppliers under pressure to grow rapidly while constrained by in-house design resources, so there is a need for global systemic approach to design task subcontracting. The combination of design outsourcing and ISO 9000 system is proposed here as the solution [5].

2. PRODUCT DESIGN OUTSOURCING IN THE FORM OF ISO 9000

There is a need of efficient communication between producers and suppliers in order to achieve efficient cooperation in global production network. A way to achieve this is the global standardization of the communication between producers and suppliers, and ISO 9000 is ready at hand for these purpose. The purpose of ISO 9001 is to provide requirements which, if met, will enable suppliers to efficiently demonstrate they have the capability to consistently provide product that meets customer and applicable regulatory requirements. ISO 9001 states that the standard can be used to assess the organization's ability to meet customer, regulatory and the organization's own requirements. The standards were created to facilitate mutual understanding of quality management system requirements in national and international trade. The associated certification schemes that are not a requirement of any of the standards in the ISO 9000 family were launched to reduce costs of customer-sponsored audits performed to verify the capability of their suppliers. The schemes were born out of a reticence of the assemblers to trade with organizations that had no credentials in the market place. The primary users of the standards are intended to be organizations acting as either customers or suppliers. Although all ISO standards are voluntary, one of the standards in the ISO 9000 family has become a market requirement. This standard is ISO 9001. The standard requires the organization to control design and development of the product. The standard was primarily intended for situations where customers and suppliers were in a contractual relationship. It was not intended for use where there was no contractual relationship [2,3,4].

As to the product design outsourcing methods, three basic categories has been identified here: supplier proprietary parts, black box parts, and detail-controlled parts. This classification is basically the same as that by Asanuma: marketed goods, drawings approved, and drawings supplied [5,6,7].

2. SUPPLIER PROPRIETARY PARTS PRODUCT DESIGN CONCEPT

In the Supplier Proprietary parts design system (Figure 1.), the supplier develops a component entirely from concept to manufacturing as its standard product; the assembler simply orders the item from the supplier's catalogue. In this way, the supplier carries out almost all of the developmental work for the component. Some highly standardized components, such as bearings, may belong to this category [5].

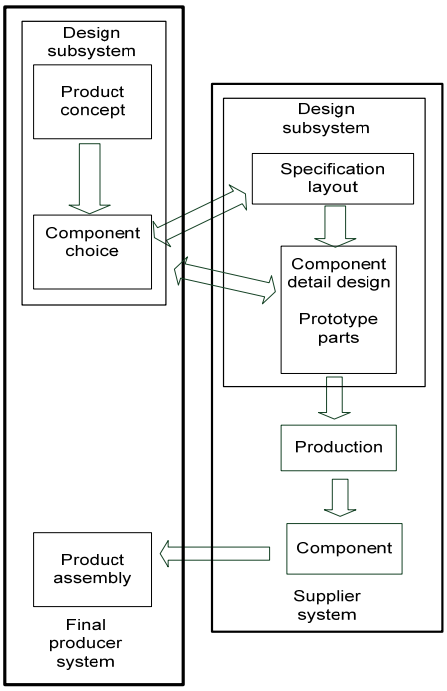

Figure1. The system of supplier proprietary parts

3. BLACK BOX PARTS PRODUCT DESIGN CONCEPT

The black box parts system (Figure 2.) refers to a certain pattern of transactions in which a parts supplier conducts detailed engineering of a component that it makes for an automobile maker on the basis of the latter's specifications and basic designs. In a sense, this is a kind of joint product development between a system maker and a component supplier, in that the latter is involved in the former's new product development process. The black box parts system means a particular pattern of interfirm task partitioning that can be characterized as bundled outsourcing.

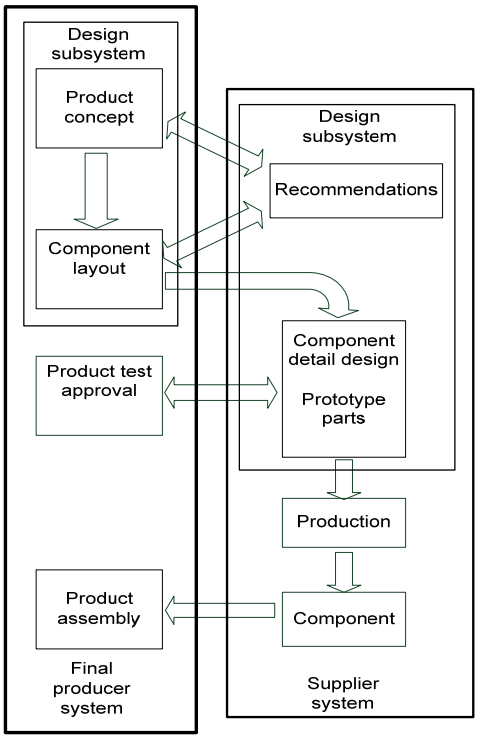

Figure 2. The system of Black Box parts

Iinformation on component requirements may be provided to two or three potential suppliers, who compete for the job based on their component development capabilities.

The intensity of development competition among suppliers differs depending upon the parts categories: in conventional parts, the supplier for an old model strive to get a new contract for the new model; for technology-intensive items such as plastic resins for bumpers, switching of suppliers occurs more often and development competition is more harsh. The suppliers may launch developmental actions and suggestions without waiting for inquiries from the car makers.

With Black Box parts system, developmental work for the component is split between the assembler and the supplier. In a typical case, the former creates basic design information such as cost/performance requirements, exterior shapes, and interface details based on the total vehicle planning and layout, while the parts supplier does the detailed engineering.

With approved component models system (Figure 3.), after the supplier is selected, it carries out detailed engineering, such as modeling of parts and subassemblies, prototyping, and unit testing. The car maker then reviews the parts models, tests prototype vehicles using the parts, makes sure that the requirements are met, and approves the design. In this case, the design documentation (component

model) is eventually owned by the supplier (design documentation owners are yellow colored), which assures design quality and patent rights over the parts in question. That is, the supplier has to make engineering actions in response to field claims related to the parts. In exchange for this responsibility for quality, the supplier enjoys a greater degree of design discretion for better manufacturability and cost reduction. Switching suppliers between the engineering stage and manufacturing stage is rather rare in this case.

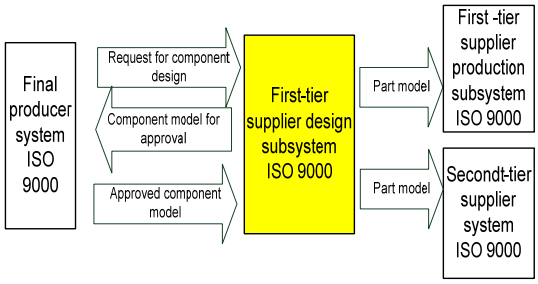

Figure 3. Information flow with Approved component model (Black box parts)

With consigned component model system (Figure 4.), unlike with approved component model system, design documentation is owned by the car maker, but detail engineering work is subcontracted out to the supplier. The former pays the design fee to the latter as a separate contract, and is free to switch suppliers at the manufacturing stage. It is the car maker that takes responsibility for quality assurance, though. Generally, the consigned component model system comes between approved component modes and detail-controlled component models systems in terms of the degree of supplier involvement in product engineering. While approved component models tend to be applied to functional parts, the consigned component model system is found more often when dealing with press and plastic parts [5,8,9,10,11,12,13,14].

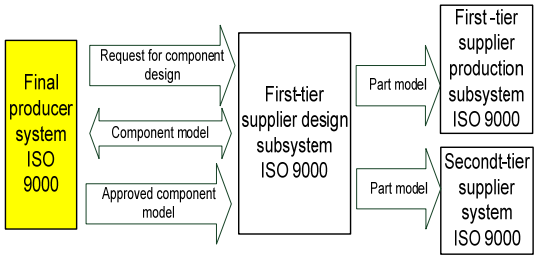

Figure 4. Information flow with Consigned component model (Black box parts)

4. DETAIL CONTROLLED PART DESIGN CONCEPTS

The third category is the case in which most of the component engineering work, including parts drawing, is done in-house. In this way, not only basic engineering but also detailed engineering are concentrated in the hands of the car maker, although the suppliers can make requests for design changes for better manufacturability and cost reduction. In the typical case of a functional component in the United States, the suppliers, selected through inquiries and bids, take responsibility for process engineering and production on the basis of blueprints provided by the car maker. For this reason, it is called the provided component model system in Japan. Fabrication of prototype parts may be carried out by a different supplier specializing in prototypes. In the case of some body parts, the car maker may also carry out process engineering, build and own tools and equipment, and lend them to a supplier. In this case, the supplier is regarded as nothing more than a provider of production capacity.

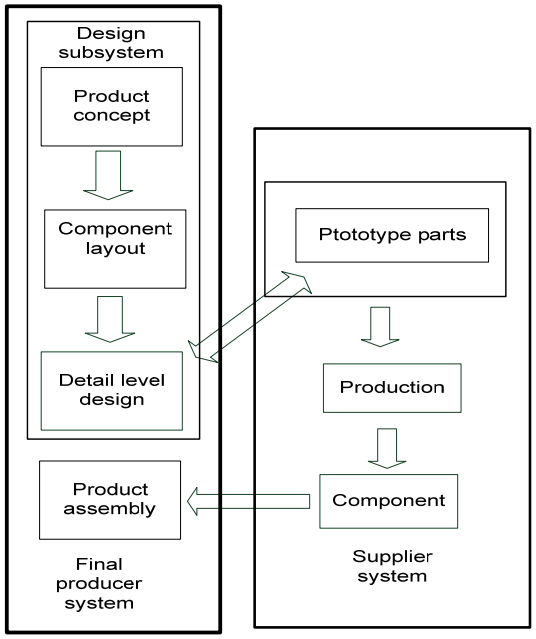

Figure 5. The system of detail controlled parts- functional parts

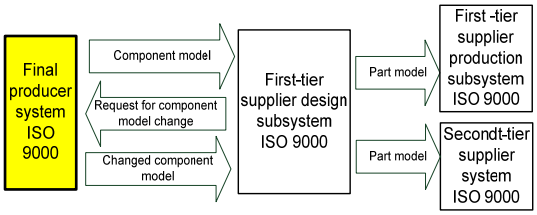

Figure 6. Information flow with Detail controlled parts

Generally, each company chooses the degree of supplier involvement component by component, which in turn determines the overall division of product design work between assembler and suppliers. It is important to note here that the

decisions regarding manufacturing vertical integration and designing vertical integration are two separate issues: for a given production in-house ratio, the designing in-house ratio could range widely. In any case, the decision on the mix of parts types depends upon the company's strategy, the nature of the component, and the capabilities of suppliers and characteristics of supplier networks [5,8,9,10,11,12,13,14].

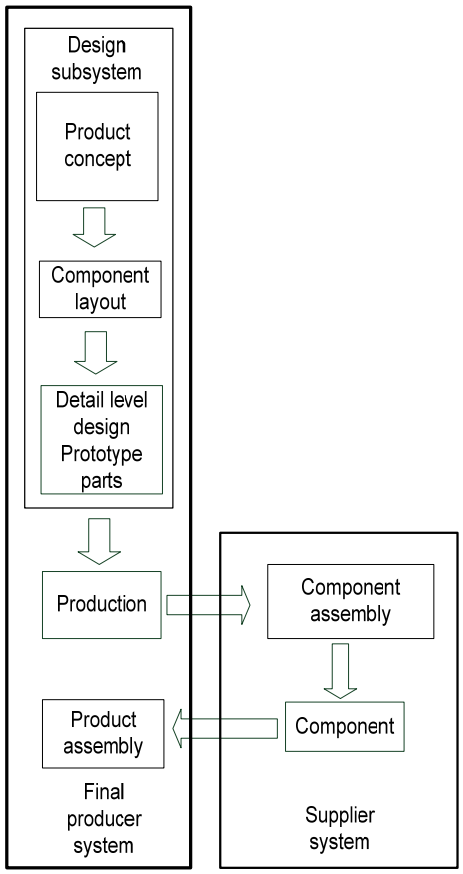

Figure 7. The system of detail controlled parts- body parts

5. CONCLUSION

Three basic design outsourcing methods were identified here: supplier proprietary parts, black box parts, and detail-controlled parts. The magnitude of supplier involvement in engineering is higher in the former method and lower in the latter.

Although the enumerated design systems are supported not only by formal procedures but also by skills, attitudes, and other factors of organizational culture, the standardized system of formal documents, such as an according to ISO 9000, should be the backbone of the systems for the purpose of efficient assurance of supplier design capability in volatile global environment.

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GENETIC ALGORITHM FOR SOLVING DUAL RESOURCE CONSTRAINED FLEXIBLE JOB SHOP PROBLEM

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Abstract. *This paper presents an application of metaheuristic approach based on genetic algorithms (GA) for solving the Dual Resource Constrained Flexible Job Shop (DRCFJS). Job Shop (JS) is a problem of scheduling the processing operations of several products on several machines. Dually constrained problem is an extension of classical JS where the operations of product transformation are constrained with the availability of two production resources, machines and workers. However, the machines and workers in a production system, may also be universal and flexible regarding the realisation of product operations. The DRCFJS is characteristic for the operational planning of highly customised, small-scale or one-of-a-kind production. The proposed GA was applied to an example of the observed scheduling problem, and the results are presented further in the paper.*
Key words: *Dual Resource Constrained Flexible Job Shop, Genetic algorithm, Production planning.*

1.INTRODUCTION

Production in SMEs is most often described as a versatile and variable production characterised by high variety of customised products made according to customers' orders, i.e. make-to-order and engineering-to-order production [7]. The scarcity and limited availability of production resources are one of the most common characteristics of manufacturing SMEs: a modest machine park, a small production capacity, a small number of workers. In the production where the customers have the opportunity to choose the type of product, its design, and the material from which the product consists, products' routes in production workshop are very diverse and variant, and production resources (workers and machines) are most often simultaneously engaged in the realisation of several jobs. These characteristics and the form of the production system, which are dominant in SMEs, make the process of operational production planning more difficult [9]. In the process of operational production planning, scheduling activities represent the most complex activities. In these activities, it is necessary to allocate resources on jobs for a specified period, while respecting one or more performance criteria [2, p. 23]. Methods of mathematical modelling and artificial intelligence are of great help in solving the scheduling problems [3]. This paper is structured as follows. After the introduction, section 2 presents the DRCFJS problem. Section 3 shortly describes the general approach of genetic algorithms and its application on DRCFJS problem. The fourth section presents the results of the GA application on a scholarly DRCFJS example. Section 5 concludes the paper.

2. DUAL RESOURCE CONSTRAINED FLEXIBLE JOB SHOP

Job Shop (JS) is a problem of scheduling the processing operations of n products on m machines, where each product may have different and predefined processing route [8]. JS problem is *NP*-hard. One extension of classic JS problem is recognized by both theory and practice, and that is the *Flexible Job Shop (FJS)*. This problem occurs when in some phases, through which products are processed, instead of one machine, there is a machine centre with a similar type of machines with the same kind of processing. The products that need to be transformed may be assigned to any of available similar machines. Unlike the classical JS, where each operation of product transformation has already defined the machine, FJS is flexible, and every operation may be realised on one machine selected from several available machines. Consequently, FJS can be divided in two sub-problems [3]. 1) **Assignment problem –** problem of determining production path by assigning any processing operation to a machine selected from a set of machines capable for processing the operation. 2) **Sequence problem** – the problem of determining the order of product processing operation by assigned machines to obtain a feasible schedule

which will optimise the desired criteria function. Considering both subproblems makes the flexible JS more complex for solving in comparison to the basic JS. Besides the machines, product processing operation may be constrained additionally with other resources (workers, special tools). JS problem where the workers and machines present the limitation for production process flow and the product sequence, is known as *Dual Resource Constrained* (DRC). Therefore, basic and flexible JS can be additionally extended with the observation of available workers in a production process.

Dual Resource Constrained Flexible Job Shop (DRCFJS) is a scheduling problem of n products $J=\{J_1, J_2,...,J_n\}$ on m machines $M=\{M_1, M_2,...,M_m\}$ with w workers $W=\{W_1, W_2,...,W_w\}$ [10]. Every product J_i $(i=1,2,...,n)$ has a predetermined order of processing operations n_i $(O_{i,1},O_{i,2},...,O_{i,ni})$. Operations $O_{i,j}$ can be realised on any machine $M_{i,j}$ from a set of compatible machines. Each machine may process only one operation at a given moment. In addition, workers that are part of the production system have different knowledge and skills to operate different machines. *Let* $M(W_k)$ be the machine set that can be operated by worker W_k. For any machines in $M(W_k)$, Wk presents a set of qualified workers. The processing time of each operation (p_{ijuk}), depends on assigned workers and machines and presents the amount of time for processing operation $O_{i,j}$ on machine M_u by workers W_k. The main goal is to obtain the optimum value of desired criteria function, by assigning workers and machines to each operation (assignment problem), as well as determining the sequence of observed product operations on each machine. Additional constrain in the scheduling problem may occur if one resource is significantly less available than other resources. For example, there are n machines and w workers where $w < n$. Presentation of the mathematical model for DRCFJS is omitted since this problem is mainly solved with heuristics.

3. GENETIC ALGORITHMS

Understanding that scheduling problems JS, FJS, DRCFJS are *NP*-hard, heuristics approach is most often used in their solving: priority rules, variable neighbourhood search [5], genetic algorithms [4, 6], heuristics based on fruit fly algorithm [10], tabu search and simulated annealing.

Genetic algorithms are a type of metaheuristics that are based on algorithms that simulate the process of genetic evolution of individuals of one population by the influence of genetic operators and the environment. The main idea of GA is to present every individual (solution) in population with chromosome structure (coding scheme) and to do crossover iteratively in order to obtain new individuals with better genetic material (new better solutions). The reasons for applying the genetic algorithm in solving scheduling problems are numerous: it generates high-quality solutions in reasonable time; there are different encoding schemes for solutions; it offers different operators to create new solutions that can avoid local minimum.

Through an application of GA on scheduling problems, the main issue presents an encoding scheme for solutions. One method for encoding that is used for a case of multi-machine scheduling is *Job sequence matrix encoding* – it is a particular type of permutation where the sequence of product processing is present separately for every machine [1]. Encoding scheme and structure of chromosome presented in this paper is obtained with structure modification, which is related to two types of assigned resources.

The chromosome structure is further presented in the form of the matrix in Figure 1 with the example of two products, three machines and two workers. Presented matrix with columns (i, j, l), where: i – index that marks processing operations of products, $i=1,..p$; j – index that marks products $j=1,..n$; l – index that marks machine $u=1,..m$ with scheduled worker $k=1,..w$, value of index l depends on number of machines and number of workers, $l=1,..m*w$. For example, in the third column of matrix (Figure 1) value six presents assignment of the third machine and second worker.

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 1 & 2 \\ 3 & 1 & 3 \\ 1 & 2 & 4 \\ 2 & 2 & 5 \\ 3 & 2 & 6 \end{bmatrix} \quad \begin{matrix} 1 & 1 & 1 \\ 2 & 1 & 2 \\ 3 & 2 & 1 \\ 4 & 2 & 2 \\ 5 & 3 & 1 \\ 6 & 3 & 2 \end{matrix}$$

$$i \quad j \quad l \qquad l \quad u \quad k$$

Figure 1: Example of chromosome structure

The process flow of executing the implemented genetic algorithm consists of the following activities:

The initialisation and generating of the initial population – in order to obtain the initial population, modified heuristics *Ini-PopGen* [1] was used. The modification in mentioned heuristics, i.e. in the process of assignment and sequence is realised with the additional resource (workers). *Ini-PopGen* heuristics obtain half of solutions randomly; another half is obtaining by considering operations processing time and availability of resources (machines and workers).

Decoding and evaluation of initial population is done according to criteria function ($C_{max} = max\{C_{ij}\}$) that presents time when all scheduled products are finished.

Binary selection – in a random way selects any two individuals from the population and compare to a value of fitness function. Fitness function of an observed individual (obtained schedule) is equal to a negative value of criteria function (C_{max}). A solution with lower C_{max} indicates higher fitness function.

Genetic operators for genetic material exchange – that are implemented were *Preserving Order-based Crossover* (*POX*), *Position Based Mutation* (*PBM*), *Machine and Worker Based Mutation* (*MWBM*). The *POX* genetic operator in order to obtain new offspring (new schedule), keeps the order in such a way that a part of genes (assigned resources and sequence of products) is taken from one parent and maintains the order from that parent, and another part (which are not included previously) is taken from the second parents. During the process of *POX*, the operation sequence of every product, which presents their transformation technology, will be respected, to generate a feasible solution.

The *PBM* is the first type of genetic mutation operator where the order of product processing is changing randomly, with respecting constraints of feasibility, to obtain a new individual in population (schedule). The *MWBM* is the second type of genetic mutation operator where the assignment of machines and workers are randomly changed. MWBM operator has next change options: change worker, change machine, and at the same time change workers and machines.

Population sorting and selection – as a result of genetic operators, new population Q_t of offspring are created. To reserve a certain number of good individuals from old population (elitism), new population R_t is formed from parent's population P_t and population of offspring Q_t. The new population has a size greater than N ($R_t = P_t \cup Q_t$). It is necessary to evaluate R_t population by sorting individuals according to fitness function ($-C_{max}$), and then to choose the best N individuals of new population P_{t+1} (where $P_{t+1} \subset R_t$). Entry to new population P_{t+1} up to N members is first reserve for individuals with the best fitness function. After the entrance of individuals with the best fitness (individuals of first rang), if there is still free space, individuals with the second rank of criteria function value (lower fitness function), are placed next. The process of creating a new population from the previous one is called the generation process. The selected members of a new population, if the maximum number of generations is not reached, switch to a new iteration.

Stopping criteria - after a series of genetic material exchange and succession of a population, the algorithm stops when the maximal number of iterations is reached (maximum number of generation). In the process of genitival evolution, the best obtain individual (schedule) is the results and solution of algorithm.

4. RESULTS AND DISCUSSION

After the GA metaheuristics explanation, its verification was carried out through solving a scholarly example of DRCFJS problem. The data (Table 1) which is used for the experiment are the examples *(DFJSP 01-10*) presented in paper [4] and on the next internet page: https://pan.baidu.com/s/1mhHfv6K. Actually, the official benchmark data for DRCFJS problem does not exist. Most authors [4, 5, 10], use benchmark example for *FJS* problem with times of duration processing operation that are modified with the data for workers (p_{ijuk}) according to different statistical distribution.

Table 1: *Benchmark* example used in heuristic application

Example	*No. of products*	*No. of operations*	*No. of machines*	*No. of workers*
DFJSP 01	10	55	6	3
DFJSP 02	10	58	6	3
DFJSP 03	15	150	8	3
DFJSP 04	15	90	8	3
DFJSP 05	15	106	4	3
DFJSP 06	10	150	15	3
DFJSP 07	20	200	5	3
DFJSP 08	20	225	10	3
DFJSP 09	20	240	10	3
DFJSP 10	20	240	15	3

Along with the examples of the scheduling problem, parameters of genetic algorithms that are used in the process of computer simulation are also defined. Parameters of the experiment and their range of values were:

- Crossover rate ($p_{crossover}$ from 0,15 to 0,9) as the frequency of crossover among individuals in the population;
- Mutation rate as a frequency of mutation among individuals in the population ($p_{mutation}$ from 0,15 to 0,7);
- Gene mutation rate as a frequency of mutation in individuals gene ($p_{gene\ mutation}$ from 0,15 to 0,7);
- Size of the population (N from 200 to 600);
- Number of generation was 300.

For the described problem, GA with criteria function (C_{max}) was developed in the environment for numerical calculation and programming language *MATLAB* 2016b. The values of C_{max}, for the solutions that are obtained with the GA are presented in Table 2 together with results of initial heuristics *Ini-PopGen.* Observing all the results in Table 2, better solutions for the improvement of C_{max} values was obtained for each example. Best improvement, in absolute value was obtained for example *DFJSP08* ($\triangle C_{max}$ = 28 [*time unit*]). If we look a relative, i.e. percentage improvement of criteria function, the best result was obtained for example *DFJSP04* ($\triangle C_{max}$ = 4.35 [*%*]), in comparison to initial heuristics *Ini-PopGen.*

The overview of one solution of *DFJSP01* example of DRCFJS problem is presented with Gantt chart by machines (Figure 2) and workers (Figure 3). Insight in Gantt chart of solutions points out that workers are much more engaged than machines. It is the obvious consequence of the less availability of one production resource (workers) than the other (machines).

Table 2: Results of genetic algorithm application on DRCFJS problem

Example	*GA parametres*				*Initial solution (C_{max})*	*Best obtained solution (C_{max})*	*Generation of obtained solution*
	$p_{crossover}$	$p_{mutation}$	$p_{gene\ mutation}$	N			
DFJSP 01	0,5	0,15	0,15	600	52	**51**	39
DFJSP 02	0,7	0,15	0,5	400	43	**42**	170
DFJSP 03	0,5	0,5	0,15	200	287	**277**	167
DFJSP 04	0,5	0,5	0,3	400	115	**110**	127
DFJSP 05	0,5	0,7	0,3	600	229	**225**	277
DFJSP 06	0,5	0,7	0,3	600	116	**113**	85
DFJSP 07	0,7	0,5	0,5	600	230	**223**	55
DFJSP 08	0,7	0,5	0,15	600	867	**839**	134
DFJSP 09	0,5	0,3	0,7	600	747	**736**	105
DFJSP 10	0,9	0,7	0,15	600	614	**607**	50

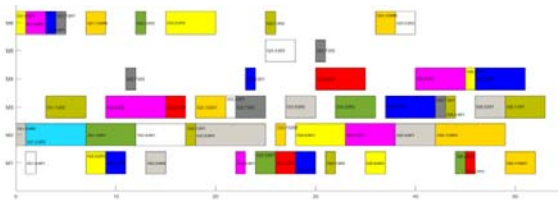

Figure 2: *DFJSP01* solution – Gantt chart by machines

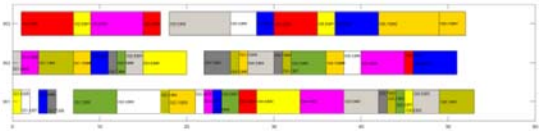

Figure 3: *DFJSP01* solution – Gantt chart by workers

5. CONCLUSION

A significant part of production enterprises still uses priority rules and the subjective experiences of individuals working on planning and scheduling tasks for solving the scheduling problem. This paper presents a scientific approach in considering and solving the scheduling problems. Resource constrained scheduling problem in operative production planning of small enterprises is firstly described. In the literature, this problem is known as *Dual Resource Constrained Flexible Job Shop*. The observed problem is then solved with metaheuristics genetic algorithms. It presents an integral solving approach for two sub-problems - assignment of resource and sequence of products is solved within one procedure, i.e. algorithm. This way of finding the solution, retains the complexity of the problem on the one hand; on the other, it provides the quality solutions.

In the literature, the dominant criteria function for DRCFJS is C_{max} that presents time when all scheduled products are finished [5, 10]. In the future work, the process of solving DRCFJS can be improved with the multi-criteria approach. In this approach, time criteria of operative plan successfulness (makespan, total completion time, total earliness and tardiness, work time of machines and total workload of machines) could be improved by observing costs criteria (earliness and tardiness costs, cost of machine and workers utilisation).

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TRANSPORT CHALLENGES IN THE ERA OF E-COMMERCE

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Abstract. *Quick distribution becomes a synonym for the modern logistics. The development of the Internet and mobile applications to a considerable extent promotes the development of e-commerce. A few years ago, online shopping was equated with the traditional computer, ppurchases were made by a typical Web page. Currently, much more transactions are made by mobile devices. The article is a discussion about the challenges of transport, which result from the increasingly inclined form of transactions: e-commerce.*
Key words: *Transport, e-commerce.*

1.INTRODUCTION

E-commerce (or electronic commerce) is a subset of e-business: any B2C contract on the sale of products or services fully or fine weather concluded by a technique for distance communication. They covers both transactions by stationary and mobile way.
E-commecre becomes more and more common. There is a graph one the Figure 1, that shows regions of Europe where this type of transaction is the most popular. Longtime access to the Internet in Western countries confirms the greater interest in e-commerce. Not without significance is also the confidence to make purchases in such a way.
Figure 2 shows the share of online purchases in Europe. It may seem surprising, however, 87% of the products bought in the UK in the year 2016, was ordered on line. Figure 3 shows the information about the popularity of the use of mobile equipment to make purchases online. As it can be seen from the statistics, ¾ all mobile device users made shopping using them, in 2016.
In this case the leader is not UK, but Turkey. Interestingly, up to 7% of the users shall buy through e-commerce on every day, and almost half of the owners of mobile devices 2-3 times per month.
By using the mobile applications today each person can buy practically everything: from clothes, shoes and toys, household up to construction machines. This availability to announcements reduces the time searching for deals, allows to faster comparison, makes easy contact to retailer and gives better analyze background before expenditurer.

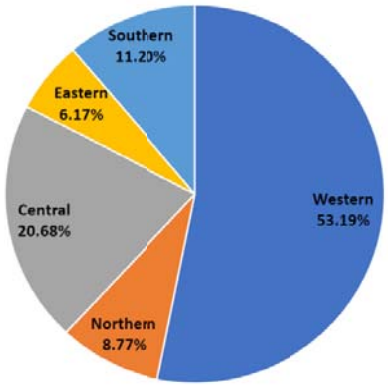

Figure 1. E-commerce market in Westenr Europe source: [1]

2. THE CHALLENGES OF "LAST MILE" CONNECTION IN RESPONSE TO CHANGES IN SOCIETY

computer. Purchases were made by a typical Web page. The shipment was sent by courier service. Usual delivery takes about the week. However, to speed up the society forced on vendors and suppliers faster response time and delivery on the second or third day after placing the order.

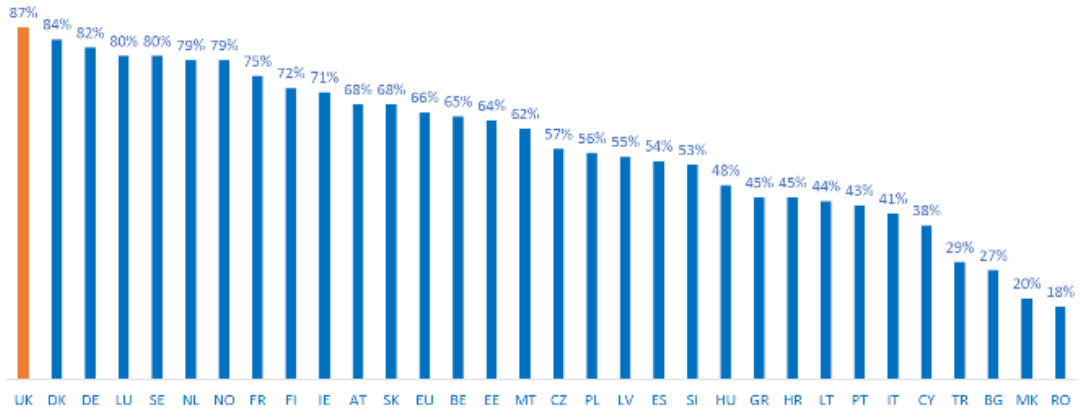

Figure 2. Online shopping rates in Europe, source: [2]

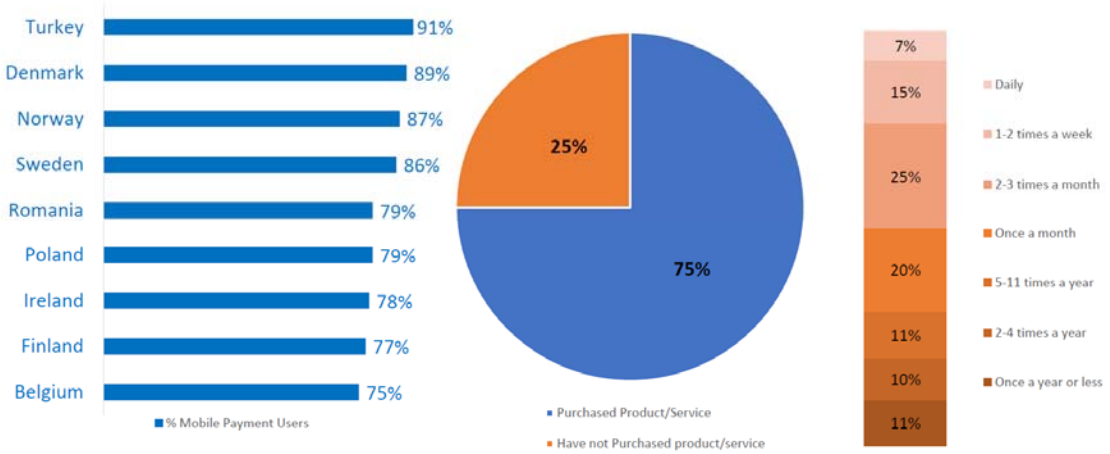

Figure 3. Mobile device usage, source: [3]

However, this trend is constantly progressing. Today's young people in European countries increasingly do shopping using mobile applications. Thanks to the wide access to online stores can immediately make purchasing decisions and place orders. Mentally, though not yet expressed, the Society also expected the delivery, which will be as fast as their decision and order.

This causes the formation of new, massive challenges modern logistics, which boils down to expose the supply also immediately.

If we look at the modern possibilities of delivery, it is clear that transport systems have not been keeping up with this trend, although some companies are trying to meet the challenges of the modern e-commerce.

In Europe is now ok. 40 companies, which are called unicorns (start-ups with over 1 Billion EUR revenew). If you take a closer look at the structure of their business are just a few of them work in the transport industry or the logistics. One of them is Lieferando/Takeaway, a company offering quick food delivery. Today, thanks to the implemented good strategy offers food delivery in time less than 1h. However, in Europe today there is no company that offers the same service in general cargo delivery. In this point Asia is different. There operate this type of business, for example Gogovan or LalaMove. Especially the second one gives you the ability to deliver cargo in urban area in less than an hour.

It seems that in this area the solution will be the phenomenon of load space sharing. In general, sharing is not a new idea, but in recent years there has been another jump, as mentioned, the term "sharing economy". The term sharing is generally defined by characteristics such as the lack of property, temporary access and redistribution of material goods or less tangible, such as money, space or time. It is also defined as a preference to pay for assets or services for consumption or on demand, instead of having assets or signing long-term service contracts. The economy of sharing can have such attributes as the availability of resources and the flexibility of their use, adapted to different needs. Communication type "peer-to-peer" seems to be its basis.

Indeed, in recent years, thanks to the idea of sharing a lot of concept found its realization. More and more is available in Europe for example. platform sharing of electric vehicles, sharing Internet networks, Office space or space vehicles (pool).

Returning to the transport and logistics and the contemporary challenges in a short distance, it

seems that the next breakthrough will be delivery in an hour or less than an hour. This is a concept that may meet by increasing the importance of sharing ideas and share your own resources (sometimes private) transport processes.

3. LONG DISTANCE DELIVERY

The development of the Internet and mobile applications to a considerable extent promotes the development of e-commerce. A few years ago, online shopping was equated with the traditional computer. Purchases were made by a typical Web page. The shipment was sent by courier service. Usual delivery takes about the week. However, to speed up the society forced on vendors and suppliers faster response time and delivery on the second or third day after placing the order.

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4. FUTURE SOLUTIONS

As previously mentioned the modern transport systems are not able to increase the speed. So be sure to look for a futuristic solutions that pass positively both Proof-of-technology principles (PoP), and then proof-of-concept (PoC). However, it need to be pointed out, that all alternative (futuristic) transport solutions is different from conventional transport – are currently at the level of the PoP. The most promising solutions include e.g.: Along or Next (Next Transportation Inc.).

Hyperloop

Looking for investor interest, plays a particularly important long-distance transport based on the movement in the tubes with reduced preasure, called Hyperloop.

An ultra-high-speed ground transportation system proposed in 2013 by SpaceX. Along with basic ride in a solar-powered, elevated air tube that for long distances would mostly follow an existing highway. To reduce resistance and low pressure environment is created within the tube. If ever built, and the 350-mile ride from Los Angeles to San Francisco would take approximately 35 minutes, reaching speeds in excess of 700 MPH [5].

In 2014, along with Transportation Technologies (HTT) was formed to create a Hyperloop in Quay Valley, California. In 2016, the first test of the along

with One over a short distance was successful. The Hyperloop Alpha concept was first published in August 2013, proposing and how the runtime locates assemblies and route running from the Los Angeles region is the San Francisco Bay Area, roughly following the Interstate 5 corridor. Along with the system would propel passengers along the 350-mile (560 km) route at a speed of 760 mph (1.200 km/h), allowing for a travel time of 35 minutes, which is considerably faster than the current rail or air travel times. Preliminary cost estimates for this LA-SF suggested route were included in the white paper-US $6 billion for a passenger-only version, and US $7.5 billion for a somewhat larger-diameter version transporting passengers and vehicles — Although transportation analysts had doubts that the system could be constructed on that budget; Some analysts claimed that the Hyperloop would be several billion dollars over budget, taking into consideration construction, development, and operation costs [5].

Figure 4. Capcule of hyperloop one, source: [5]

Next

This solution can be treated as "Urban Rapid Transit". This is the concept of energy-saving, individual urban transport or suburban. Based on a small electric vehicles (computer controlled), available on demand when you enter an address of the destination. Vehicles move on the specially prepared and secured routes, separated by a multi-level traditional streets, without stopping at intermediate stops/stations [6]. In Figure 5. shows the view Next capsule.

Movement is controlled by computer, and the number of vehicles limited, so there is no possibility of congestion (traffic) or a collision. Journeys take place continuously to the destinations chosen by the passengers. There are no timetables or designated route. The passenger shall decide on the start time and place the end of the tour. The computer is the optimal path to the destination for each passenger to avoid collisions and maintaining a safe distance between vehicles.

Figure 5. Visualization of capsule Next, source: [6]

The system monitors the number of vehicles on all stations and can automatically move the empty vehicle from the station, where these vehicles the excess (or to make room for another oncoming vehicle) to the station where they are missing.

The authors of the idea presented a physical expression of his project. Although the original system is to be used for the carriage of passengers, is the inventor of the presented analyses indicate the ability to transport cargo.

5. CONCLUSIONS

We are seeing a very dynamic changes in society and significant speed up of the way of life. It is visible in access to purchasing offers, buying proposals, ect. This fast connection to offers and easiness to place order challenging the transport: requires to speed up.

As the response – one hour delivery – seems to be quite possible to realize. Some positive responses are functioning as a real business. Transport faces real challenge in increasing speed of transport on long distance. It seems that the increase in environmental awareness and enforce legal uniquely eliminates the possibility of acceleration of means of transport over long distances. Hence, this forces the need to intensify work on the now-conventional ideas, which in the future will allow for the creation of a completely new, eco-friendly, effective and safe systems move people and cargo.

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CHALLENGES OF IMPLEMENTING A EUROPEAN BIOECONOMY BASED ON FOREST RESOURCES: NEED FOR CIRCULARITY

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ABSTRACT

Greenhouse gas emission reduction is strongly advocated within the European Union. The study of natural communities (biocenology), additionally demands inclusion of a circular economy, in which renewable products are kept in continuous circulation of use and reuse. In light of this, there arises the question whether the bioeconomy route alone, promoted by the EU, is sustainable. Using literature, based on the Delphi method, and EU documents, we highlight the importance of sustainable management of bioresources. It seems that only limited mitigation of greenhouse gas emissions can be expected.

Keywords: bioeconomy, circular economy, forest resource, biofuels, European sustainability, sustainability

INTRODUCTION

Contributing to greenhouse gas emissions reduction, is concurrently possible mainly by substitution with low carbon products, increasing energy and materials efficiency and recycling of materials and utilisation of waste. The key challenge on a global level is how to generate a sustainable approach in utilising natural resources, especially biomass neutral [4, 23]. The EU has set a milestone for cutting its carbon emissions by 2030 to levels 40 % below the levels of 1990 through domestic consumption reductions, the greater use of renewable energy sources with implementation of the bioeconomy as a means for addressing environmental problems [1, 4, 10].

The forest industry is expected to lead technological development and implement changes towards a bio-based technology by concentrating on the use of biomass, considering it to be itself renewable, thus merging the forest sector with the technology sector [2, 11, 14]. It is expected that the bioeconomy sector will create a whole new range of products via the implementation of biomaterials that utilise novel developments, such as nanocellulose, man-made fibres from lignocellulose and cellulose waste and replacement of fossil fuels-based polymers with biopolymers [15, 25].

METHODS APPLIED IN PROPOSED EVALUATION

The method used by the actors in the field for conducting the relevant analyses mainly follows the Delphi approach for data collection as an appropriate means of long-range (20–30 years) academic research, together with expert opinions. State of the art literature on biotechnology regulatory and bio-based materials development is also reviewed to help in understanding the trend in development of novel technologies.

SUSTAINABILITY DEVELOPMENT SO FAR

To reduce waste and green gas emission impact on climate change, governments around the world have started adopting so-called ‘biotechnology strategies’ with an aim to set up plans and legislation for the investment in technological development designed for the implementation of sustainably manufactured

goods and biofuels. Implementation of the EU bioeconomy emerges as a *quasi*-trade mark of the European answer to environmental problems. Its development from the idea towards defined technological and economical routing took over three decades. It has evolved through carefully planned marketing and research funding activities towards achieving bioeconomic stability [4, 5].

A visionary cycle was seen to emerge in the EU in 1993 towards development of the bioeconomy policy framework, with the EU White Paper entitled "Growth competitiveness employment: the challenges and way forward into the 21st century", which advocated the necessity for biotechnology in innovation and growth [5]. Later, the Lisbon Agenda from 2000 emphasised the need for EU leadership in the global 'knowledge-based economy', that would decrease its dependence on fossil oil [4, 10]. The 2002 EU bioeconomy strategy followed, promoting life science and biotechnology as the likely most promising of the frontier technologies, with a capacity to contribute to the achievement of the Lisbon Agenda objectives. In 2005 the 'knowledge-based bioeconomy' (KBBE) was finally established. It took until February 2012 for the European Commission to publish an action plan of bioeconomic development, entitled, "Innovating for Sustainable Growth: a bioeconomy for Europe" in which bioeconomy was portrayed as an environmentally acceptable solution to a variety of European and global problems, following the same trend *at that time* in the United States [12, 20, 25].

In the case of the forestry sector, environmental regulation has played a large role helping with the transition in the EU towards sustainable societies and green growth (see, for example, Forest Sector Technology Platform, 2015) [26]. The increased use of forest biomass for production of biofuels is expected to boost European Economy and is explicitly supported by forestry policies at EU level and especially in the Nordic and Baltic countries [11, 14, 21], considering that these regions are extremely rich in forests.

BIOFUELS FOR SUSTAINABLE REDUCTION OF GREENHOUSE GASES – current status

Factors that help promote biofuels and place them into the global fuel market are: expected increase in population and thus fuel demand, decrease in fossil fuel reserves, and already observable climate change accrued to the model of global warming [1, 24].

By 2030 the global population is expected to increase by 1.3 billion inhabitants on top of the 7.6 billion currently, with growth predominantly in developing countries, which will have a rising middle class without any proper mindset of sustainable consumption of goods and transport, which will create additional stress from pollution, inefficient land use and food production [19, 20, 23]. The global production and use of biofuels have increased dramatically in recent years, with about 85 % of their production going to bioethanol manufacture, considered the most ecologically friendly liquid biofuel, that can be produced from a variety of cheap raw materials that are sugars chemically. Theoretically, ethanol represents a closed carbon dioxide cycle because released carbon dioxide (CO_2) from ethanol burning is recycled back into plant material during photosynthesis subsequently to become biomass [26]. Sugars, such as cane and molasses, can be used directly for ethanol production via fermentation, while starches, from corn, potatoes and root crops, must be hydrolysed via enzymes to fermentable sugars, and only then ethanol can be produced [3, 8]. Cellulose, from wood, agricultural residues, waste sulphite liquor from pulp and paper mills, must likewise be converted into sugars, generally by the action of acids or cellulolytic enzymes [11]. Lignocellulose biomass has long been advocated as a feedstock for cost-effective bioethanol production in an environment-friendly and sustainable manner, and agricultural wastes/residues are advocated as abundant and renewable resources for second-generation bioethanol production [9, 11]. Therefore, to make full use of these resources for sustainable and economically feasible bioethanol production, the following difficulties still need to be overcome: (i) collection, supply and handling of bio-waste; (ii) economically feasible pre-treatment of waste; (iii) production of different economically feasible enzymes and yeast strains that will enable more efficient fermentation of cellulose in working conditions [15].

Unlike traditional ethanol production, however, biofuels derived predominantly from forest harvesting potentially lack the equilibrium in respect to CO_2 production and reabsorption. Many scientists claim that balance is only true if the calculated plant base taking up CO_2 is not cut in the first place to create the ethanol, Fig. 1, [23, 24].

Policies that will make biofuels more competitive identify the need for taxation of fossil fuels and fixed prices for biofuel-derived energy that may limit economic growth in the long run as forest biomass is only a slowly renewable source, considering the expected fast consumption of its sources [25].

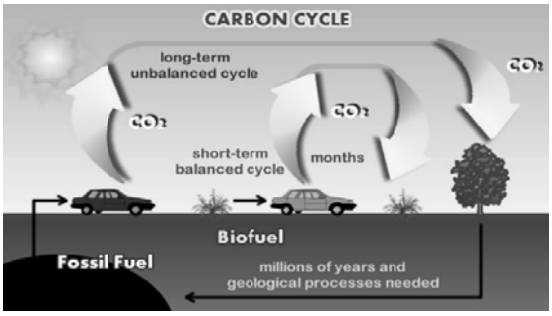

Fig. 1 Carbon cycle of transportation fuels / adopted from [56, 67] /.

MODELLING SUSTAINABLE DEVELOPMENT (SD)

Regulatory environment and megaforces

It is essential to predict the cyclical shift to a new contextual phenomenon, such as a European bioeconomy evolution, and its sustainability development (SD) model [19]. Achievement of full sustainability through SD should be cross-linked with developments of new technologies and the ability to mobilise public interest in their application [3, 10]. As it has always been in human history, a public component is always necessary to push towards technological development and industrial transformation, which form was captured in the representation of Kondratieff waves, as shown in Fig. 2, [12, 19]. On the one hand, a transition to a bioeconomy increases business uncertainty in the future, but on the other hand it is the main driver for creation of shared value of the socially accepted need for economical investment in technology and education necessary for sustainable productivity growth [23].

Taking the relationship between the nature and human species, assuming them to be distinct in a modern protected society, as a parameter that should differentiate existing approaches of SD, there are two paths: (i) conservative or "weak" sustainability, in which nature is considered as a 'resource' and in which humans are supreme above other living species on the planet, natural resources being goods that must be continuously used. The only thing that matters in a weakly sustainable society is the increase of stock and capital [22], which leads to maximising monetary compensations for environmental degradation, and (ii) the second approach, diametrically opposed, environmental preservationist, or 'strong sustainability', in which humans and nature are seen in equilibrium within the ecosystem that respects the value of natural resources and where biodiversity is essential. The proponents of strong sustainability claim that any utilisation of natural capital can never be sustainable, and that manufactured capital that requires an increase of future consumption of forest biomass for the bioeconomy needs is not an appropriate argument for destroying natural resources such as water, land, air and diverse habitat forests [26]. From a short-term temporal perspective, large investments are necessary to push for development of biotechnologies and business, with inevitable conflict between the economical and societal interests and views [11]. For downstream industries, that govern changes in biotechnology, the sustainability megaforces act to emphasise concern over vulnerability related to increasing biomass resource constraints that can cause long-term deforestation and habitat loss [25, 26]. Of increasing concern is that conflicts can arise over raw material prices, availability and sustainability acting as barriers for changing the strategic focus in the capital-intensive forest industry [5, 24, 21]. Further obstacles for strategic renewal towards sustainability are conservative organisational culture and limited financial resources [22].

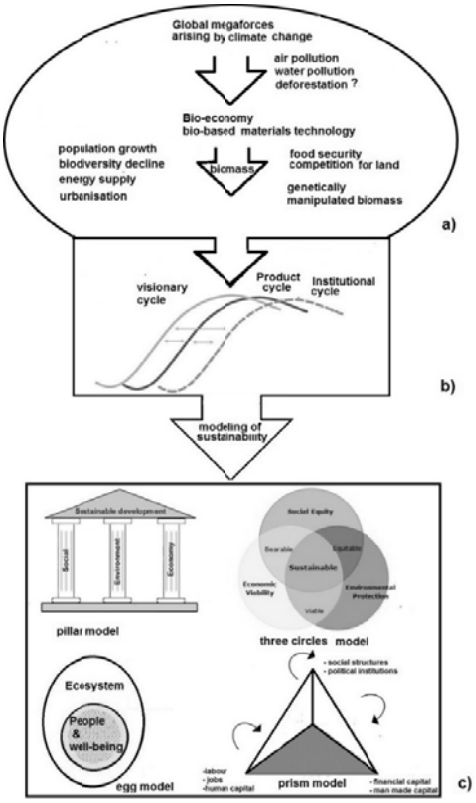

Fig. 2 Schematic presentation of global megaforces that influence changes in society towards sustainable bioeconomy / adopted from [19] /

For predicting how sustainability will act as a future megaforce in the European bioeconomy, and its leading role in the forest industry, it is necessary to understand the role of wood biomass in the production of biomaterials and biofuels, which are

being defined as zero total carbon emission products [15, 26].

Model for the European perspective

The European bioeconomy strategy focuses on: food security, natural resources, fossil fuel dependence and climate change. However, when considering the fourth aspect of a sustainability model, which is social development in combination with the research and education policy, it has been observed that the EU Framework Programme 7 (FP7) funding scheme strongly influences national research budgets through setting in motion the European Research Area [11, 13]. However, EU policy has been criticised for enabling access to patent rights from European participating companies, arising from research areas aligned with biotechnology [21]. Furthermore, critics claim that the use of renewable eco-efficient terms synonymously with sustainable gives the impression that all renewable-sourced technologies bring lower air and water pollution and reduced waste [15]. This conflation assumes that forest biomass resources can somehow replace all fossil fuel-derived chemicals, whilst organic waste automatically becomes a new renewable biomass resource, which is naturally, assumed to be always sustainable [22].

As an example, the EU (2013b) blueprint for forest-based industries challenges emphasises the significance of stimulating transition in the industry mind-set with a radical investment in research and innovation area, effecting increased production efficiency and quality of biobased products, with an aim to grow and to be competitive in different markets [24, 26]. At the EU level, the Forest Sector Technology Platform (2015) has recognised new biomaterial-based products as an important research and development area, with strong emphasis on sustainability at an overall and national level [25]. As the country with the largest wood biomass resources in Europe, for example, Finland has established its 2030 roadmap for bioeconomy development towards a carbon-neutral society [2]. The Finnish approach towards bioeconomy is, however, criticised as being too much "business as usual", in which dominant ideas and emphasis on sustainability are characterised as being economically driven and conservative [21, 22].

Over the last years, several strategies have been set forth for establishing more sustainable production patterns, and reduction of solid waste and appropriate use and reuse of natural resources using the circular economy strategy, e.g. European Commission, 2015 [5, 11]. This approach, however, requires highly sophisticated technologies and a high quality of biomass raw materials, excellent waste collection and sorting logistics regionally and internationally. In addition, for the bioeconomy strategy (BMEL, 2014; European Commission, 2012) a value-added oriented hierarchical utilisation of biomass for materials, chemicals, fuels and energy production is prioritised only after the provision of a sufficient healthy supply of food and feed to meet the basic needs of society. The cascading principle of sustainable biomass distribution in the EU bioeconomy is depicted with the "Biomass value pyramid" (Fig. 3) [12]. Key solutions and strategic actions towards a sustainable bioeconomy should include closed-loop recycling of all consumer products and materials, using the circular economy concept [13], that keeps products and materials within the biomaterials pyramid [14]. Changes in living habits are expected to be in tune with the circular economy; for example, recycling of solid-wood products can be increased with increased use of wood and wood composites in building that maintain strength over time, reduction of working and living space, and change in transportation habits, including working from home etc. [10, 23].

A recent study detailed different scenarios of biomass supply and demand in Europe (EU27) and in the world until 2050, compared to the situation in 2016, where worldwide biomass supply in 2050, based on these scenarios, would be between 12.4 and 25.2 billion tonnes of dry matter, in which wood supply would grow from about 2 to about 8 billion tonnes of dry matter, to meet demands of industry and food [20, 26].

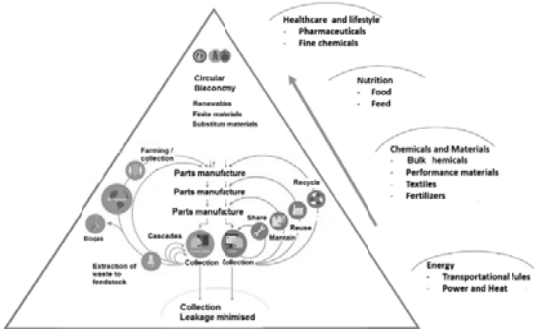

Fig. 3 Schematic illustration of closed loop concept of bioeconomy with cascading concept within the bio-mass values pyramid /adopted from [24] /

Demand for wood biomass for production of biofuels is especially high in European countries, as Europe's lack of oil resources with North Sea reserves depleted and the single dependency on Norway within the Nordic cluster, and on Russia and the Middle East outside the EU, has resulted in an emerging international trade in wood for bioenergy (primarily cut trees) [24]. That demand of wood has been largely satisfied up to now with imports from the USA and Canada, countries that are rich in wood resources and have their own interests in developing wood biofuels [16, 21] with increased investment by European companies in the forest land outside Europe (Asia, South America) with often

unsustainable planting methods that utilise exclusively genetically modified (GM) crops [6].

When considering a defined 'sustainable' approach, only the 'low' biomass supply scenario can be regarded as keeping biodiversity at a similar level as today [16, 22]. Even though it is difficult to predict trends in population growth and consumption habits of a world in 2050, it is certain that it is impossible to replace fossil fuels totally in a sustainable way, and more likely other sources of renewable energy must be developed [20].

CELLULOSIC MATERIALS IN THE FUTURE

In the light of the questionable role for biofuels discussed above, it is worth exploring the opportunities for cellulosic nanomaterials, made from renewable sources, as are likely to emerge in a range of applications that contribute to material sustainability. Advantages of low weight result in low carbon emissions in products and transport relative to other materials, whilst at the same time they bring high material strength and stiffness exceeding that of many metals. It has been demonstrated that application of cellulosic nanomaterials drastically increases concrete fracture toughness at addition levels as small as 0.5 wt%, decreasing the need for non-renewable materials use [7, 17, 18].

Speciality markets for cellulose nanomaterials already include flexible printed electronics and light emitting diode (LED) video screens, medical applications such as slow release drug delivery, incorporation in microfluid analytical devices, aerogel preparations for bone and tissue scaffolding, and 3D printing.

CONCLUSIONS

The main driving forces to increase the use of forest biomass for energy and production of bio-based materials are the international concern about climate change and, importantly, the political global imbalance of energy-rich nations as a major cause for potential destabilisation. European countries are becoming increasingly dependent on imported fossil energy. At the same time as demand is increasing, Europe needs to reduce energy costs to be able to reach economic competitiveness in the global market and to provide related social benefits, such as employment, education and health services. In Europe, where many national industries are highly dependent on fossil fuels, forest biomass is considered the solution for improving social security, providing steady material supply and thus economic growth, which will enable the EU to be competitive with the use of forest biomass providing a sustainable and unlimited resource of materials that does not contribute to increased emissions of greenhouse gases.

From the discussion in this overview, clearly the transition towards a bioeconomy is a complex process, that should be the result of concerted and simultaneous development of economic, technological and ecological awareness together with evolution of cultural values on the global scale, so that the EU can be a part of it, whilst maintaining a unique aspect to its competitiveness. This must be considered in the light of sustainability development in countries that the EU imports from or invests into, which directly influences the sustainability development of the EU itself.

The conclusion proposed here, is that a strategy toward a balanced bioeconomy needs to take account of the precepts of biocenology, which inform of the pitfall of ignoring the lack of coupling between human values and the environment occupied by the humanity. This balance can only be achieved by following the precepts of a circular economy, and not by a naïve short-term adoption of the assumption that biomass *per se* alone is sustainable.

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BEST PRACTICE OF LAUNCHING A NEW PROJECT IN INDUSTRY 4.0

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Abstract.
The purpose of the paper is to present the meaning and benefits of the new Industry 4.0 (I4.0) projects. The starting point is literary research, best practice analysis and interviews with operation managers. Qualitative research ran from 2017 to 2018 in Faurecia, but results from the experience of other organization managers with implemented I4.0 strategy were also used, particularly in the area of quality engineering and management. At this stage of research, it is about finding a suitable conceptual framework for deciding on the implementation of a new project.
Keywords: *Industry 4.0, new project, decision making, risk management, data management control*

1.INTRODUCTION

Starting a new production program requires an individual approach and professional support of research and development (R&D), manufacturing, as well as other departments within the organization. This is especially important when it comes to Industry 4.0 projects.

Industry 4.0 (I4.0) is commonly referred to as the Fourth Industrial Revolution [1] and is representing mainly Cyber-physical systems, System integration, Internet of Things (IoT), Simulation, Additive manufacturing, Cloud computing, Cognitive computing, Augmented reality, Big data, Autonomous robot, Knowledge automation.

According to Professor Klaus Schwab, author of The Fourth Industrial Revolution [2] "*in this fourth revolution, we are facing a range of new technologies that combine the physical, digital and biological worlds*".

Industry 4.0 aims to achieve a level of "smart factory" with cyber-physical systems capable of autonomously exchanging information, triggering actions and controlling each other independently [3]. This fact enables a significant improvement in processes related to research and development (R & D), materials utilization, engineering, manufacturing, performance and asset management, as well as supply chain management and overall product lifecycle. Intelligent materials and intelligent products are part of this industrial digital transformation.

The digital revolution is radically changing the traditional processes of engineering. At present, digital models, virtual prototypes and a digital replica of physical assets are expanding more and more.

The benefits of digitization are mainly in the possibilities to lean the organization [4], including simplified data management, greater possibilities of creating cheaper and more individualized solutions, automation of labour-intensive processes, or the introduction of measures that simplify these processes [5]. The benefits of I4.0 can be seen in conventional manufacturing companies as well as in companies operating in the service sector.

A majority of I4.0 projects start as a result of operation managers trying to solve problems or improve their daily work on the shop floor [6].

2.METHODOLOGY AND RESEARCH PROBLEM

We know how new projects happen in a predictable world [7].

In a predictable environment, a team is established, the market is analyzed, a forecast is created, and a business plan is written. Resources are then collected, and the plan will be launched.

Increasing the unpredictability of the environment also increases the risk of decision-making. Therefore, the research question is how to start new projects in a less predictable environment, among which I4.0 certainly belongs. The problem is to find the best way or at least a good way to achieve it in an age in which dissemination of data and opinions does not allow for a decisive analysis. Remote events have an immediate, unexpected impact and economic uncertainty cause companies to be reluctant to make big decisions in such a risky environment.

It is also difficult to find a well-established theoretical framework in this area.

Our qualitative research was conducted through a literary survey and published short examples of best practice from scholarly sources and interviews with project managers in organizations with I4.0 strategy.

The research problem is the new project launching in I4.0 in organizations that already have an implemented I4.0 strategy.

3.LITERATURE REVIEW

The topic I4.0 is relatively extensively described in the literature and is currently also discussed at conferences, discussion forums. This topic is also addressed by separate reports and organization studies, for example [8] [9] [10].

In the Emerald Insight database, the I4.0 theme appears from 2014 until now (19-7-2018), while the number of published articles and case studies by topic and keywords "Industry 4.0" is 2,724. Other related terms: "Project 4.0", "Lean 4.0", "Digital Management Control" that we searched for in this database are only rarely found. Figure 1 shows the frequency of searches for listed terms in the world over the last 12 months using google trends.

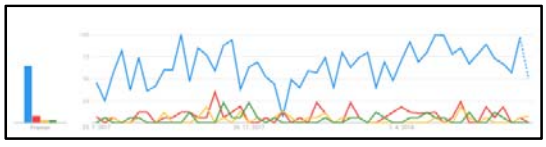

Figure 1 The frequency of search terms in 12 months [11]

Note: "Industry 4.0" – blue; "Project 4.0" – red, "Lean 4.0" – yellow; "Digital Management Control" – green.

Various evidence of the implementation of Industry 4.0 in organizations are globally growing [8]:

a) the internet is used as a primary source of information and the most important means of communication.

b) Creating and using virtual representations of the real world. Cybernetic systems that partly act autonomously and can make their choices are developing more and more.

Several authors [10] [12] [13] [14] investigated organizations, their risks and logical procedures used for projects related to new products and services. They are seeking new business models for situations where old methods of analysis, forecasting, modelling, planning, and allocation does not work.

Generalization can be found in an approach that defines acceptable loss and instead of looking for the perfect solution also allows a pretty good solution regarding win-win strategy [10] [15] and/or min-max method [16].

This approach allows different thinking and focuses more on modelling and simulating the future than on predicting it. This new logic assumes that every manager will do the same when confronted with the unknown because it is a very risky way to start new projects. Of the many exciting practices, we have chosen three, which can be summarized in simple steps. According to Jill Jusko paper published in Industry Week [10], it is essential to recognize early that the goal of new product development projects is to eliminate the difference in knowledge between when to start a new product project and when to implement it. According to Oosterwal [17], "*the whole objective is to create reusable knowledge better, faster, more efficiently and the way to be able to get products developed faster*", and the procedure according to [10] can be summarized in three steps:

(1) Agile Development→ (2) Knowledge-based Development → (3) Spiral Development

The study [8] refer to six steps which are required for success in Industry 4.0:

(1) Map out Industry 4.0 organization strategy → (2) Create initial pilot projects → (3) Define the capabilities you need → (4) Become a virtuoso in data analytics → (5) Transform into a digital enterprise → (6) Actively plan an ecosystem approach.

One of the theoretical frameworks is also a project approach based on the I4.0 strategy of Faurecia [18]:

(P1) Prerequisite anticipation → (P2) Scoping → (P3) Connectivity - Master data → (P4) DMC implementation → (P5) – Support → (P6) – Full plant roll-out

4.BEST PRACTICE EXAMPLE

Since 2015, Faurecia has been involved in the strategic transformation of its operations into Industry 4.0 or Internet of things. The emergence of new solutions such as robots for cooperation called "cobots", automated handling devices or "automated guided vehicles" (AGV) led in 2009 to a breakthrough in automation of assembly and handling in many plants. Implementation of Radio Frequency IDentification (RFID) barcodes or QR codes allows to track components and finished parts in production areas from goods receipt to product pick-up and transportation. An example of best practice in launching a new project in I4.0 is the Faurecia story based on [18] [19] [20] and interviews with operation managers.

The digital transformation of Faurecia takes place since 2015 in the following phases:

2015: Explore & Design → Experiment and Learn → Prepare Rapid Scale-Up.

The result was 200 digital use cases and **40 proofs of concept**.

2016: Core solution design and pilots. Design of the digital core solutions on the scope of selected initiatives → implementation of the solutions on pilot sites to adjust and validate the design before mass industrialization.

The result was the **first digital solutions catalogue** for operations such as Predictive maintenance, Digital Management Control, Collaborative robots, Product Life Cycle solution, digital learning platform.

2017: Deployment industrialization. Industrialization based on the large-scale deployment of the solutions available in the catalogue → Design of new digital solutions to enrich the catalogue. The result: **Massive deployment of the digital solutions** from the catalogue all over the world.

4.1 Digital Management Control (DMC)

A step forward shop floor digitalization and Lean 4.0 is a procedure of Macro planning projects:

P1: Pre-requisites and anticipation

- Team mobilization and planning
- CAR approval for Mii server and procurement

P2: Scoping

- Kick-off and site visit
- Fit Gap analysis
- Project scoping (SOW, blueprint)

P3: Connectivity & Master Data preparation

- Data preparation for Mii test
- Machine connectivity: cabling, PLC modification
- Key user training
- Translation if needed
- Master data adaptation (routings, booking point)

P4: DMC project implementation

- Material reception (devices, cabling…)
- Mii NG installation, configuration and basic test
- Non-Regression test of the solution
- End users training
- Knowledge transfer (cutover plan)

P5: Support

Post Go Live support

P6: Full plant rollout

4.2 Deployment Industrialization: Attribute data entry system

Automation of specific logistics tasks and adapting process parameters by feedback information from each produced component or product was the internal strategic goal of Košice plant in 2015.

In 2016, after the initiative of operational managers and proposing a pilot project, future users of the new attribute data entry system (ADES) defined their requirements for its features and functions. The Quality Function Deployment (QFD) application, in collaboration with the University and system vendor, has been designed and implemented by the ADES system for permanent operation of the plant.

Digital dashboards enable real-time sharing of information from pre-operational, operational and after-operational inspection and provide the opportunity for the immediate response of operating teams and in case of disagreement, drift or production line break can be immediately reacted.

After training and through permanent use of the system by personnel, after a year of use the number of nonconformities fell from 680 a month to 136. The implementation of digital management tools, along with "big data" to control manufacturing processes opens new prospects for optimizing the

operating conditions of production lines and increasingly making better use of industrial assets.
Currently, within the stages of Deployment Industrialization, several plants have implemented this system.
At present, Faurecia focuses on seamless data generation and communication, including data on the quality of manufacturing and production processes to increase efficiency and productivity while increasing visibility and control of production processes through global cloud solutions. To that end, Faurecia chose IBM [21], which has built a global cloud-based solution to collect, manage, and analyze data from every manufacturing facility in the entire company. Using cloud capabilities and analytics, poor quality can be significantly reduced, and the efficiency and performance increased [22].

4. CONCEPTUAL FRAMEWORK

Further research will jointly explore the logical procedures that are used by various organizations with implemented strategy I4.0 at new project launches.
The conceptual framework for further research is illustrated in Figure 2.

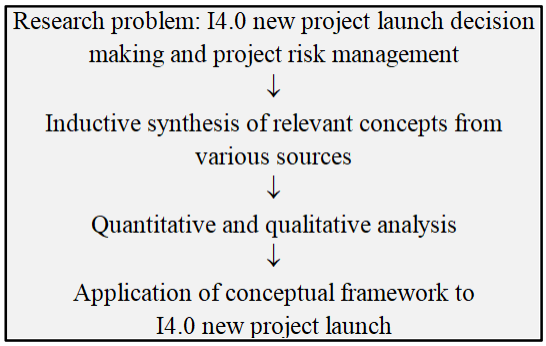

Figure 2 – Industry 4.0 research conceptual framework for the new project launch decision making and project risk management

6.CONCLUSION

The paper presents the first phase of research on the new project launch in I4.0. Three models of logical procedures are presented in the design of new projects. Best practice is taken from an organization presenting a supplier in the automotive industry and is described more detailed.
For most manufacturers, Industry 4.0 is just a dream. However, at Faurecia, it is a reality [19]. Faurecia's "digital enterprise" project is set to transform working practices in virtually every aspect of the organization [19].

Figure 3 A general view of the ADES operator application

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A YOUNG RESEARCHER'S VIEW OF AUGMENTED REALITY BASED ON QUANTITATIVE ANALYSIS OF ARTICLES AT GOOGLE SCHOLAR IN THE LAST 30 YEARS

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Abstract. *The aim of this paper is to provide insight into quantitative analysis of articles about augmented reality (AR), with the purpose to give a clearer view for future study to young researchers. In addition, potential of AR is perceived from a young researcher's point of view with the same purpose. The authors conducted a comprehensive analysis of number of articles dealing with AR on Google Scholar in the last 30 years. A comparison with number of articles mentioning virtual reality and mixed reality is conducted, too. Furthermore, the authors carried out analyses about the number of articles dealing with roles of AR in human activities, and with AR per industrial categories. The research gives reasonable ground to expect that AR is a long-term technical route which will continue developing in the next years. Accordingly, the authors provide a concise report with suggestions to young researchers.*

Key words: *Augmented reality, Article analysis, Google Scholar, Quantitative analysis, Young researcher's view*

1. INTRODUCTION

Augmented reality (AR), a new revolutionary technology that overlays digital information over real physical environment in real-time through camera-enabled devices [1, 6], brings rapid changes in various industries and human activities. Recently, AR became significant widespread technology, and it is increasingly used in various industries.

The authors of the paper realized a need to introduce a deep quantitative insight of studies about AR to young researchers, so they put themselves into a young researcher's role to have the appropriate view. It is important for young researchers because of the following reasons:

- Leading companies, governments, and institutions have been investing large resources in AR, so there is a need for engagement of young professionals in this innovative field.
- It is necessary that a young researcher form its own opinion based on relevant information and get acquainted with this area more thoroughly.
- AR has many different roles in human activities and it is related with almost all industry categories. All them have been changing over time, so it is becoming increasingly significant to keep track with the ongoing fast-paced changes and adapt the research activities.
- A profound report of research activities is essential for directing young researchers in terms of narrowing their area of interest.

2. METHODOLOGY

The authors specified an appropriate method to properly conduct a quantitative analysis of articles in a rapidly changing field such is AR, having in mind that the method should be defined from a perspective of a young researcher.

A preliminary pilot research using similar method is done on the CIRP Annals 2008-2018 [2], mostly to test and define search keywords, to recognize AR roles in human activities, to choose the proper classification of industry categories, and to comprehend the research process.

2.1. Source of data

Several sources of data are considered (Microsoft Academic, CiteSeerX, Oxford Academic, etc).

Google Scholar is chosen for the following reasons: it is a multidisciplinary search engine of scholarly sources that are available at the web; it offers a free access to advanced searching capabilities; it has a very large amount of data [5]; it is regularly updated and keeps pace with recent advance in all research fields; it covers the period of interests for this research; and it is maintained by a respected institution.

Apart from many advantages, Google Scholar has some limitations. One of them is that the articles must be present at the web and available to Google search engine to be found. The authors believe that restriction is not relevant for this research since most of scientific articles about relatively new technology like AR are present and available at the web. Some other limitations are avoided by not using Google Scholar's problematic aspects: citations are not used in this paper; Matthew and Google Scholar effects are avoided in the similar way.

2.2. Data collection

The period of interest for this research spreads over the last 30 years. It is defined by appearance of AR technology and the period when the scholarly articles have been produced.

The data are collected using the advanced search by keywords that are previously defined in the pilot research, so that they cover the searched feature unequivocally.

The keywords are defined for three general features of AR articles' appearance: 1) number of articles that appear on Google Scholar for each year in total, for AR and for related technologies – virtual reality (VR) and mixed reality (MR); 2) number of articles dealing with AR per roles in human activities, based on HBRS [3] and personal insight of the authors; 3) number of articles dealing with AR per industry categories, based on ISIC [4].

2.3. Searching criteria

Advanced search is used with exact phrases that occur anywhere in the article, for each year during the last 30 years (from 1989 to 2018).

The main searching phrases are "augmented reality", "virtual reality", and "mixed reality". Only articles strictly dealing with AR, VR or MR are considered (for example, only "augmented reality" is included, but other "augmented XYZ" are excluded, like "augmented environment", etc).

The search focus is AR, while VR and MR are used for the comparison with AR for their trends.

The options to search patents and citations are not used, so that some important Google Scholar limitations are avoided.

Search about the roles of AR is done by the next general template: "main phrase" AND "main term for the role" OR "first additional term" OR "second additional term" (for example: "augmented reality" AND "design" OR "development" is used to find articles dealing with AR role in design and development). Similar template is used to search for articles dealing with AR in industry categories (for example: "augmented reality" AND "agriculture" OR "forestry" OR "fishing"; the retrieved number of articles is put under the use of AR in the industry category "Agriculture, forestry and fishing", according to ISIC [4]).

2.4. Key historical events

The key events in the history during the last 30 years that had impact to AR are used to explain trends and changes that are found.

The data are further processed to found statistical trends, shares in totals, relations, type of determinations, and to present them in charts.

3. RESULTS

3.1. Relationship among AR, VR, and MR

The number of the articles dealing with AR, VR, and MR, and their trends are presented in Figure 1.

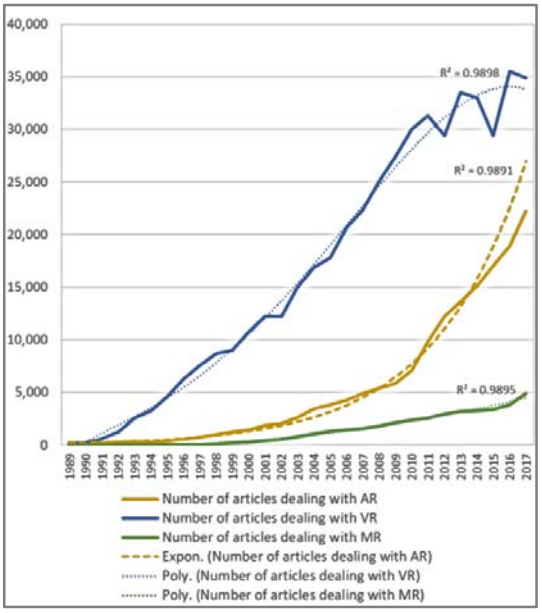

Figure 1. Number of articles dealing with AR, VR, and MR

Although the number of articles dealing with AR during the last 30 years (excluding 2018 because it still does not have the complete data) is less than for

VR, it is apparent that the AR curve increases exponentially, while the VR curve slows down after the bursting increase in the early nineties and decreases during last few years. The MR curve tells about much smaller number of articles dealing with MR, and its increase is fairly constant. All the curves have a high coefficient of determination R^2, showing a very good fit of the line to the data.

The relationship in respect the share of number of each type of articles in the sum of all AR, VR, and MR articles is shown in Figure 2.

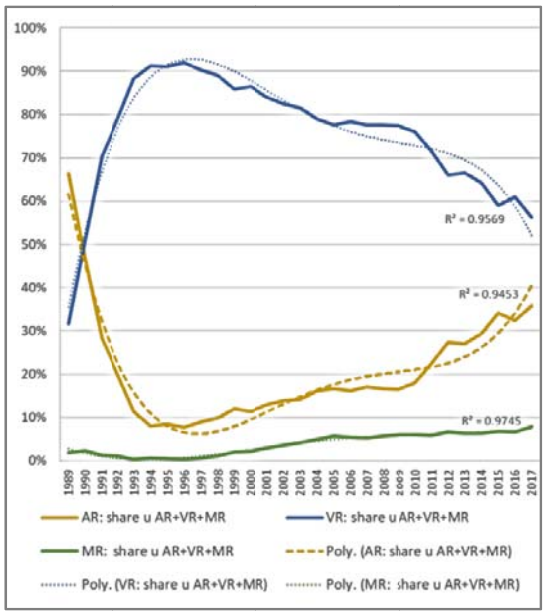

Figure 2. Share in the sum of AR, VR, and MR articles

This chart shows high values of coefficients of determination R^2 for all trendlines, too. It is obvious that AR and VR have the opposite trends, almost mirror-like, during the last 30 years. It suggests that the same researches focus their study either on AR or VR depending on technology development and the availability of technology. However, this research cannot make claims on that, and it remains for a future research.

MR has small share all the time, because it is an umbrella term covering only some parts of both AR and VR, so it is not clearly defined. Therefore, it is much less used in the literature.

The historical events that explain the presented data changes are presented in Table 1.

Table 1. Key events explaining the trends in Figure 2.

Year	Events
1989-1995	The raise of VR in the early '90 can be explained by technology advance that enabled broader use of VR.
1995-1999	The beginning of the fall of VR can be explained by technology advance enabling usage of much affordable AR technology.
1999-2001	One of the most important events for AR development of ARToolKit and release of an open-source version of it.
2001-2002	Simultaneous Localisation and Mapping (SLAM) was proven to be successful even by using a single camera.
2002-2008	Several theoretical and technical advances: US Naval Research Laboratory research program Battlefield Augmented Reality System (BARS), NASA X-38 fly using LandForm software video overlay, etc.
2008-2017	The exponential increase in the number of articles dealing with AR during last 10 years can be explained in similar way. The most prominent events are: release of Google Glasses in 2013, announcement and appearance of Microsoft HoloLens in 2015 and 2016, release of Pokémon Go mobile game for iOS and Android devices, release of Apple iOS 11 in 2017.
2018-	The similar trends continue in 2018, and it seems that it will be in the next years, because many important innovations and releases are happened and announced: Apple iPhone 8, iOS 12, ARKit 2, Google ARCore, etc.

3.2. Role of AR in articles

The numbers of articles dealing with AR per roles in human activities are shown in Figure 3.

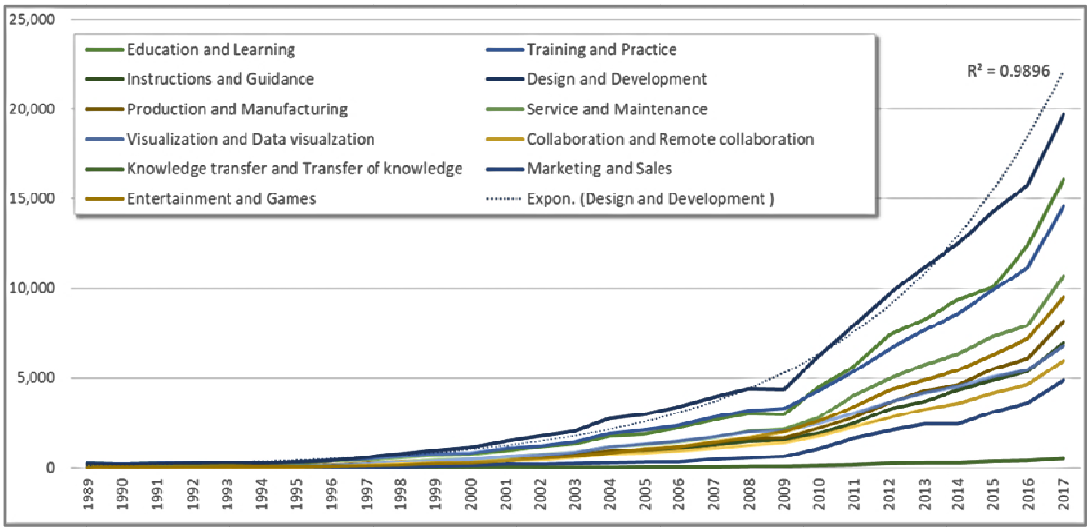

Figure 3. Number of articles dealing with AR per roles of AR by years

The sum of numbers of articles per roles can be larger than the total number of articles dealing with AR in a year, because AR appears in multiple roles in human activities. It is apparent that all roles of AR show increase all the time, and some of them, like design and development, increase exponentially (R^2=0.9896). During the last decade, number of articles dealing with almost all AR roles have exponential increase.

The current year, 2018, is excluded from the chart shown in Figure 3, because it still does not have the complete data. Therefore, the numbers of articles per roles of AR in 2018 to date (01.01.2018 - 15.08.2018) are presented separately in Figure 4.

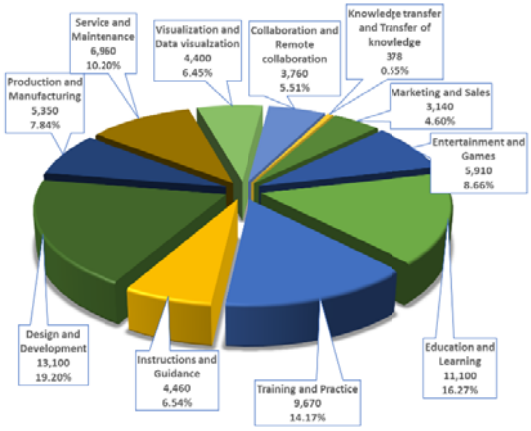

Figure 4. Roles of AR from the beginning 2018 to date (01.01.2018 - 15.08.2018)

In 2018, the articles dealing with AR and design and development are the most numerous, followed by the articles dealing with AR and education and learning, and AR and training and practice.

3.3. Number of AR articles per industry category

The curves presenting the numbers of articles dealing with AR per industry category are shown in Figure 5.

The classification of the industry categories is based on ISIC [4]. The most prominent are articles dealing with AR and *Information and communication* industry, having the largest number from 1995 to date. The articles with AR and *Professional, scientific and technical activities* industry were the leading one from 1989 to 1994, and in the last decade such articles are at the second or the third place, together with he articles dealing with AR and *Education* industry.

It is worth to mention that the high number of articles dealing with AR and *Professional, scientific and technical activities* industry is not surprising at all, knowing that this industry category comprises of sub-categories that incude professionals like architects, engineers, technicians, researchers, developers, managers and similar, who are proven to use AR and other advanced technologies in their activities.

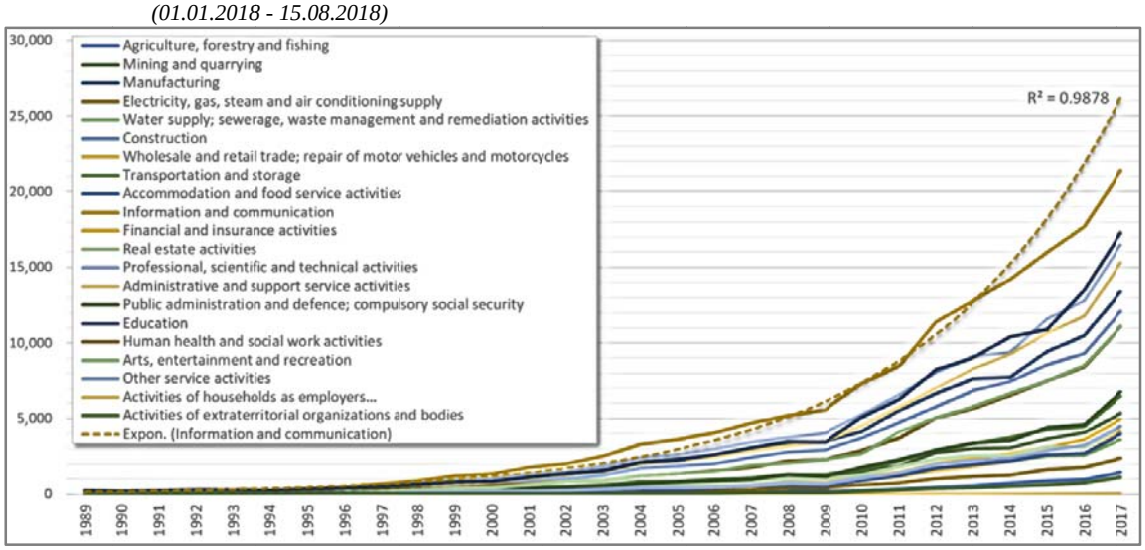

Figure 5. Number of articles dealing with AR per industry category

The share of number of articles dealing with AR per industry category by year, based on the same classification, is presented in Figure 6.

The most significant changes are visible in the first years during the observed period, when AR was in early, very intensive development phase. That period extended from 1989 to approximately 2003. From 2004 to date, the share of numbers of articles dealing with AR per all industry categories seem to be mostly stabilised.

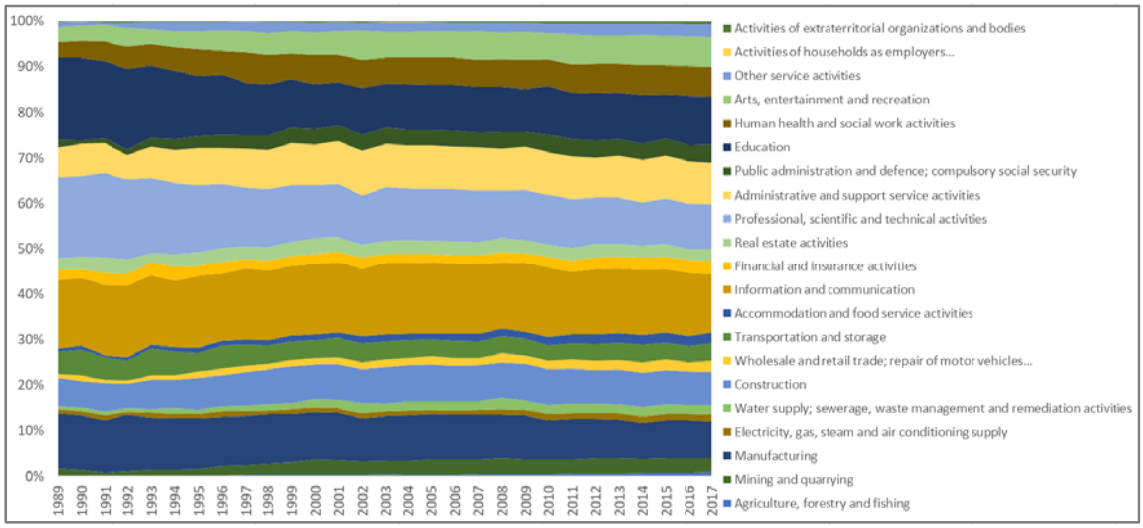

Figure 6. Share of number of articles dealing with AR per industry category

4. CONCLUSION

The results of this research give a reasonable basis to suggest the future study dealing with AR.

The quantitative analysis the authors conducted and presented in this paper, shows that AR has been found a role in almost all human activities and industry categories.

The trendlines presented in this paper have very high coefficient of determination, strongly suggesting that in the upcoming years AR will continue to be even more present in scientific articles.

Looking from the point of view of a young researcher, the results presented in this paper are of paramount importance particularly to young researchers, having in mind the increasing trends that signal similar or even greater rise of AR in the next years.

Judging by the number of articles in the last 30 years, AR becomes increasingly presented subject of research. AR shows growing share compared to related technologies, VR, and MR.

Therefore, the authors point to the most represented human activities and industry categories regarding AR and suggest to young researchers that this is the right moment to join and profile themselves in this growing area.

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