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PRODUCTION PLANNING AND “DEFINE, MEASURE AND ANALYSIS“ TOOLS IN AUTOMOTIVE INDUSTRY AS PREREQUISITE OF AUTOMATION: A CASE STUDY

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Abstract: *For the production planning process to be successful, an enterprise's internal business processes must be effective and efficient, while the DMAIC cycle is important aspect of practice-based continuous improvement. In accordance to those facts, this preliminary research includes the first part of the DMAIC methodology - “define“ and “measure“ tools, applied to a case study in automotive industry, with the aim of improving production planning processes. Analysis in “define“ phase starts with SIPOC, continues with calculation of critical indicators in “measure“ phase and is followed by Pareto charts. Research shows that the existing method of manual collection of production data is not precise enough, and during two months observation period, between 14 and 52 percent of planned production time on 9 observed machines, passed as unnoticed downtime. Further data analysis showed that this time is 1.5 to 9 times higher than the total reported downtime on individual machines. Results show that the further development of data collection tools is crucial, and the recommendation is to move in the direction of automation of that process in order to make the most of available technical resources, in “improve“ phase and to “control“ it by statistical comparison of previous and new state indicators.*

Key words: *DMAIC, Automotive industry, Production data, Process automation*

1. INTRODUCTION

Produc on planning in modern systems is very sensiti e to changes of di erent factors, and a good answer to these problems can be found in adequate decision support systems (Graves, 2011). As a required base for support systems, data and informa on can be considered the primary assets of a fi m, and most organiza ons strive to collect and process as much data as possible (Bendoly, 2016; Demirkan et al., 2013). In order to increase the quality of the collected data as a result of increased business performance, it is necessary to have a desire for constant process improvement (Spasojević et al., 2020). When beĀer quality of data about productio elements and processes is available, it should be used to improve the system performance, by a constant cycle of improvement (Lee, 2018). In di erent branches of industry and di erent countries, processes improvement can be done using a variety of methods (Brkić et al.; Tomic et al., 2017), but the DMAIC (DeĀne Measure Analyse Improve and Control) method that drives Lean Six Sigma approach proved to be a good universal tool for ensuring the smooth movement in the cycle (Smetkowska et al., 2018). With its structure, DMAIC cycle provides a rigorous approach of results-oriented process management (Sokovic et al., 2010). As numerous case studies show, for resolving performance problems in automoti e industry, the most appropriate approach is implementati n of DMAIC cycle (Ani et al., 2016; Rifqi et al., 2021; Rozak et al., 2020), and the star ng point for all research is the evalua on of data collected from the producti n process.

This paper contains the fi st three phases of DMAIC tool, as it aims to explore the necessary elements for the company to successfully implement the automati n of its produc on. A er introductio of the topic explored which points out to the interrelati n between quality of data about productio , automati n and performance improvement, the next sec on describes the methodology used in this research. In the third part the results are presented and later on, aĀer discussion part, is concluded that the recommendati n is to move in the direc on of automati n in order to make the most of available technical resources, in “improve“ phase and to “control“ it by stati cal comparison of previous and new state indicators.

2. METHODOLOGY

The fi st 3 phases of the DMAIC cycle, “defi e“, “measure“ and “analyse“, were applied to a case study in medium sized company which deals with the productio of automoti e components. Out of 35 installed machines, 9 of them were selected according to their capabilities for interconnecti ity and ful lling the demands that Rubmann et al., (2015) suggest . Data collec on was performed using a manual method, in manner that aĀer removing the cause of the stoppage, the worker on machine recorded the reason for the stoppage and its durati n. Such a method was applied for a long period of ti e in this sector, and the aim of this paper is to examine the e ecti eness of this method.

3. RESULTS

The fi st step towards system improvement is comprehensive analysis of the problems that appear in standard everyday work. Figure 1 shows the SIPOC diagram of the improvement process, where input data and their suppliers, as well as output data and their users are presented. This diagram makes a good starting point for “defi e“ phase of the DMAIC methodology, as it provides a comprehensive overview of the flow of data through the process.

S	I	P	O	C
Suppliers	**Inputs**	**Processes**	**Outputs**	**Customers**
Production sector Machine workers Sector of maintenance External partners Sector of quality	Capacity plan Production plan Congestion tables Information obtained from machine workers Written reports on machine operation Report on defect products	Data collection Analysis of machine efficiency Data accuracy analysis Determining the type and frequency of downtime Identification of the cause of the stoppage Ranking of causes by priority for solving	Weekly and monthly machine performance reports Proposal of measures for process optimization Work instructions Training plan Investment justification report	Machine workers Sector of production Logistics sector Sector of maintenace Higer management

Figure 1: SIPOC diagram for process of improving production

This paper is focused to the fi st element of output secti n of SIPOC, namely monthly machine performance reports. An example of one monthly report is shown in Figure 2, on which it can be seen that 53.3% of planned machine working ti e, machine was in stoppage. The problem appears in the part where more than half of that period (28.45%) belongs to unnoted down me, about which no data is recorded.

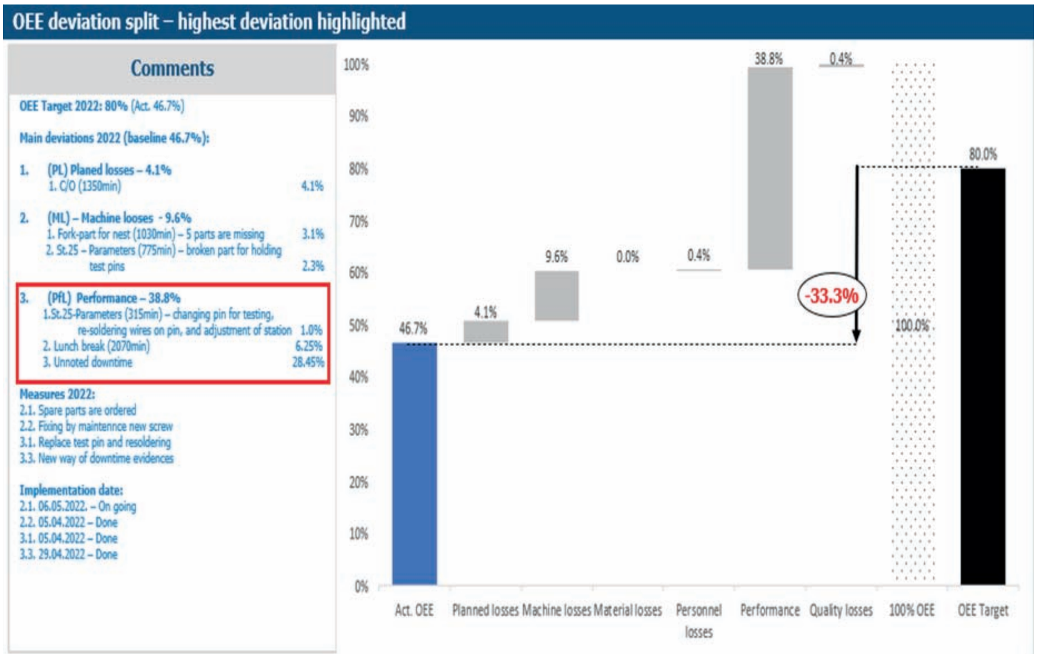

Figure 2: Monthly report for machine no. 2

In order to confi m this deviati n, the operati n of another 8 machines was monitored in 2 consecuti e months, resulting in data collectio from 9 machines in total. Obtained results for the fi st month are shown in Table 1 and for second month in Table 2. Parameters that are recorded are:

- Number of good parts (*OK*)
- Number of bad parts (*NOK*)
- Total planned productio ti e of machine (T_{pl})
- The actual working ti e of the machine (T_{pr})
- Time out of producti n (T_{pl} - T_{pr})
- Time of recorded stoppages (T_z)
- Share of unde ned Āme in planned producti n ti e (T_u).

Table 1: Recorded parameters for the first month

	OK (pc.)	*NOK* (pc.)	T_{pl} (min)	T_{pr} (min)	T_{pl} - T_{pr} (min)	T_z (min)	T_u (%)
Machine 1	423400	1472	33120	19119	14001	5465	19.5%
Machine 2	367900	3522	33120	15476	17644	5995	28.9%
Machine 3	623000	2072	33120	18752	14368	3490	26.6%
Machine 4	606700	3747	37440	25944	11496	2100	18.8%
Machine 5	197400	1369	29760	9143	20617	8125	35.7%
Machine 6	352700	1639	29760	14174	15586	2700	37.1%
Machine 7	542300	2683	32160	21799	10361	1415	21.6%
Machine 8	532980	3969	32160	21478	10682	2010	20.7%
Machine 9	568000	1407	32160	22776	9384	2140	16.3%

Table 2: Recorded parameters for the second month

	OK (pc.)	*NOK* (pc.)	T_{pl} (min)	T_{pr} (min)	T_{pl} - T_{pr} (min)	T_z (min)	T_u (%)
Machine 1	493600	2692	34560	22333	12227	2450	22.0%
Machine 2	331000	2971	34560	13915	20645	4115	41.6%
Machine 3	562200	1941	34560	16924	17636	3195	35.5%
Machine 4	543800	5667	40320	23352	16968	3280	27.7%
Machine 5	190320	1583	28800	8828	19972	3315	51.6%

Machine 6	238000	1105	19200	9564	9636	2260	32.2%
Machine 7	428600	2790	34560	17256	17304	5045	29.2%
Machine 8	581360	3978	34560	23414	11146	1145	22.7%
Machine 9	618000	1473	34560	24779	9781	2660	14.4%

The parameter of undefin d Āme in planned produc on Āme is calculated using a formula:

$$Tu = \frac{(Tpl - Tpr) - Tz}{Tpl} * 100\% \quad (1)$$

The represented collected data shown above mark the end of the “measure“ phase. The data of total machine working ti e and total downti e recorded per month are presented on Figure 3.

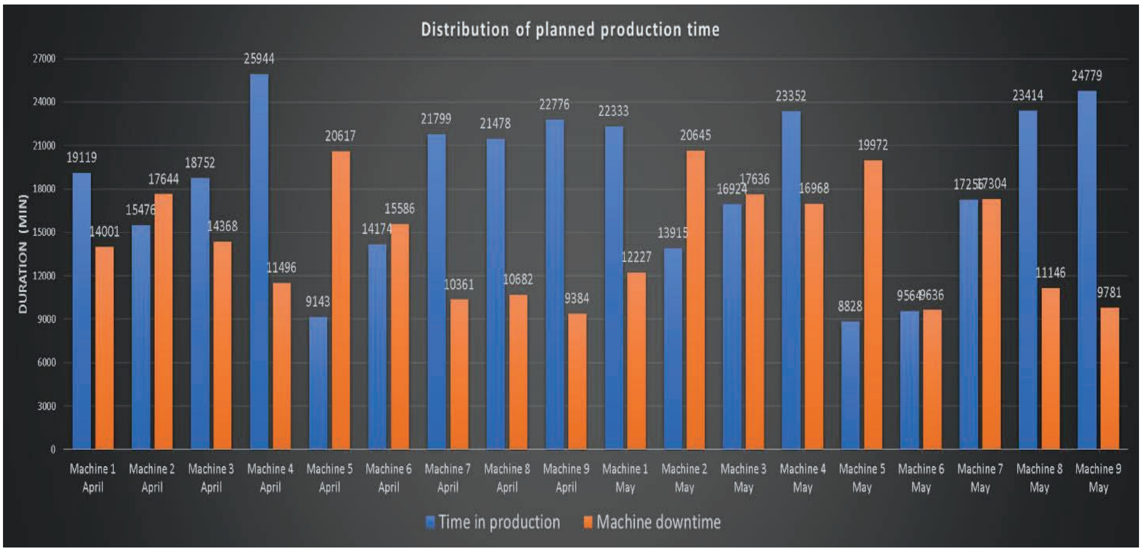

Figure 3: Distribution of planned production time

In order to have beĀer understanding of collected data, the recorded downti es are grouped by the statio on the machine where they occurred and presented by Pareto diagrams. The example of Pareto diagram for downti es that occurred during the fi st month on machine no. 7 is shown in Figure 4.

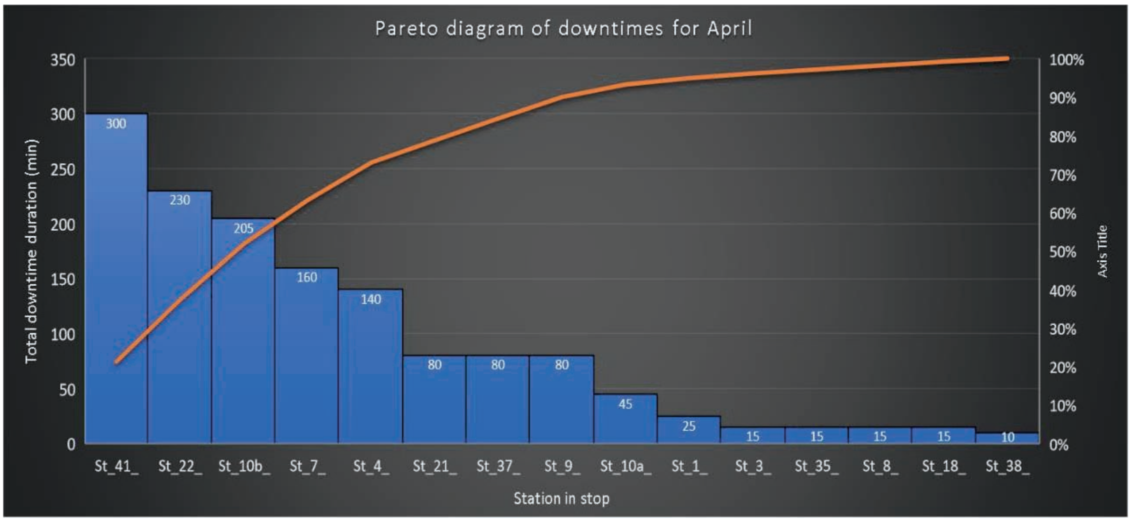

Figure 4: Pareto diagram of downtimes on machine no. 7

The ra o between recorded downti es and unidentifie downti es in both observed months are shown in Figure 5.

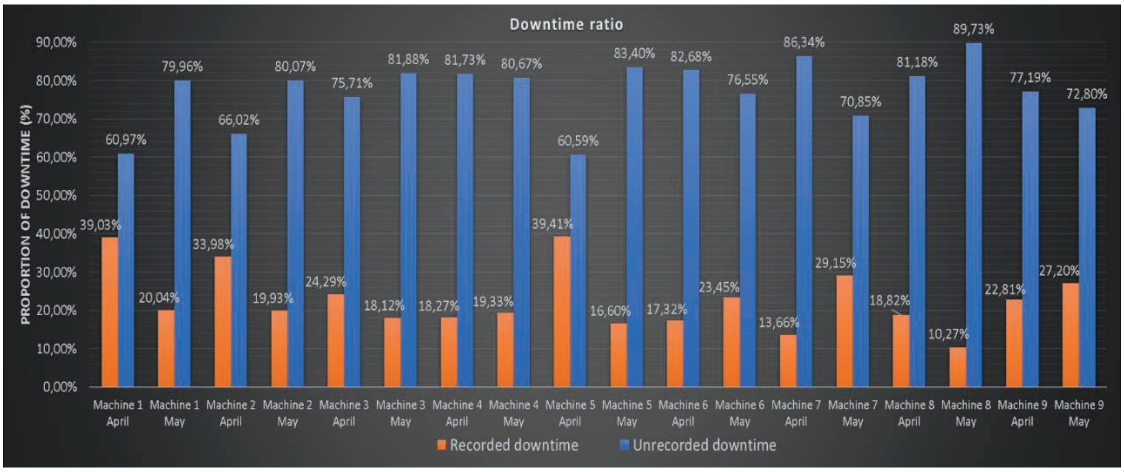

Figure 5: Downtime ratio

4. DISCUSSION

In order to successfully apply the DMAIC cycle, the fi st and the most demanding step is to define the problem of interest that requires solving. It is done by comprehensively looking at the di erent parts of the process, its inputs and outputs as well as the suppliers of inputs to the process and users of outputs from process. In this case, according to the process output, monthly reports, it can be seen that data collectio , analysis of machine e ciencies, data accuracy analysis, determining type and frequency of downti e and identi catio of the cause of downti e, have problems with data reliability. The measurement phase that was conducted over the period of two months, confi med that with manual reporting and recording of downti e, between 14 and 51 percent of planned produc on ti e is spent in machine downti e, which is not recorded (Table 1 and Table 2). The whole problem can be beĀer seen when data is displayed on diagram. For example, on Figure 3 it can be seen that during observed period some machines had more downti e than work ti e, and because decisions for improving elements of productio process are made according to Pareto charts, it is of crucial importance, that all causes and durati ns of downti e are available in the decision-making process. The potentia and benefit of the improvement can be seen in Figure 5, which shows that only 10 to 40 percent of total machine downti e is reliably recorded.

5. CONCLUSION

Previous researches that included the applica on of DMAIC cycle for process improvement has shown signi cant increase in business performance, pointi g out importance of reliable collected data for good quality management (Godina et al., 2021; Karout et al., 2017; Kaushik et al., 2009).
A er analysis and presentati n of the collected data, which as pointed out in the discussion part of this paper, unequivocally confi m the existence of the deviati n in process data, further research was conducted with the company's senior management, and the conclusion was drawn that due to size of the producti n system and the number of visible problems, there are not enough resources left to carry out a detailed research on data quality, so decisions are made on the basis of available data.
In that aim, the main purpose of this paper is fulfil ed. It confi med the necessity of improving data collectio tools and iden fy the weak points of the current collecti n process and with eliminati n of manual downtime recording and the introduc on of a more automated system, plant producti ity can be dras cally increased. This solutio can be designed through the remaining stages of "improvement" and "control" of the DMAIC cycle, which would be recommended for further research.

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