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AN APPROACH FORWARD TO DIGITALIZATION OF WORKPLACE RISK ASSESSMENT AND MONITORING

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Abstract. This paper presents an approach to the digitalization of the workplace risk assessment and monitoring process. Workplace risk was assessed using the "5x5" method. Workplace are spatially distributed in the observed factory. The summary risk assessment is presented visually and the high-risk workplace is marked. The map is made dynamically so that the job estimates on the diagram changes if there is a charge in the input data for any of the identified sources of risk.
Key words: workplace, risk assessment, risk monitoring.

INTRODUCTION

In the scientific and professional literature, the problem of automatic monitoring of danger and hazard in the workplace is a very current topic [3],[5],[9],[10]. However, with the development of information technologies, the model of automatic monitoring of danger and hazards in the workplace can be significantly improved. Numerous papers in scientific and professional literature testify that. Workers employed in manufacturing companies are particularly exposed to health dangers and hazards [15]. In construction as well, and therefore in the literature [4] it can be found papers of the necessity of development of the real-time safety risk assessment methodology for indentation dynamic evaluation of worker safety states on construction site.
Mayer et al. [8] as result of trans-national project for assessment and management of risk for engineered systems and geohazards conclude that appropriate simulation procedures are indispensable and gives necessary information for risk evaluation, successful risk management and communication.
With the development of information technology and the creation of the I4.0 environment, numerous papers indicate the need to develop methodologies for risk assessment online [14], [2], [8], [1].
The aim of this research is to examine the possibilities digitization of monitoring of danger and hazards in the workplace by implementing modern information technologies in order to increase the quality of the process of monitoring and risk assessment as well as increasing the safety of workers in the workplace.

METHOD OF WORKPLACE RISK ASSESMENT AND MONITORING

Workplace danger and hazard risk assessment is carried out using Kenny method or "5x5" matrix method. The methodology is based on expert identification of danger and hazard at each workplace in the observed factory. Factory INSA ad. - industry of watches, water meters and other measuring instruments was chosen as an example of application of methodologies. During the identification and assessment of dangers and hazards at the workplace and in the work environment, 85 workplaces were analyzed in the observed company. For the purpose of presenting the approach of the automated procedure of workplace risk assessment and monitoring, 10 jobs were selected. Those jobs are: president, storekeeper, foreman in the organizational unit machining, automatic lathe controller, metal lathe, auxiliary worker, grinder, technologist in surface protection, galvanizer, painter. All selected jobs were marked and coded consecutively as previously mentioned – WP – Workplace, and then entered their location on the spatial plan of the factory [6], Fig. 1.

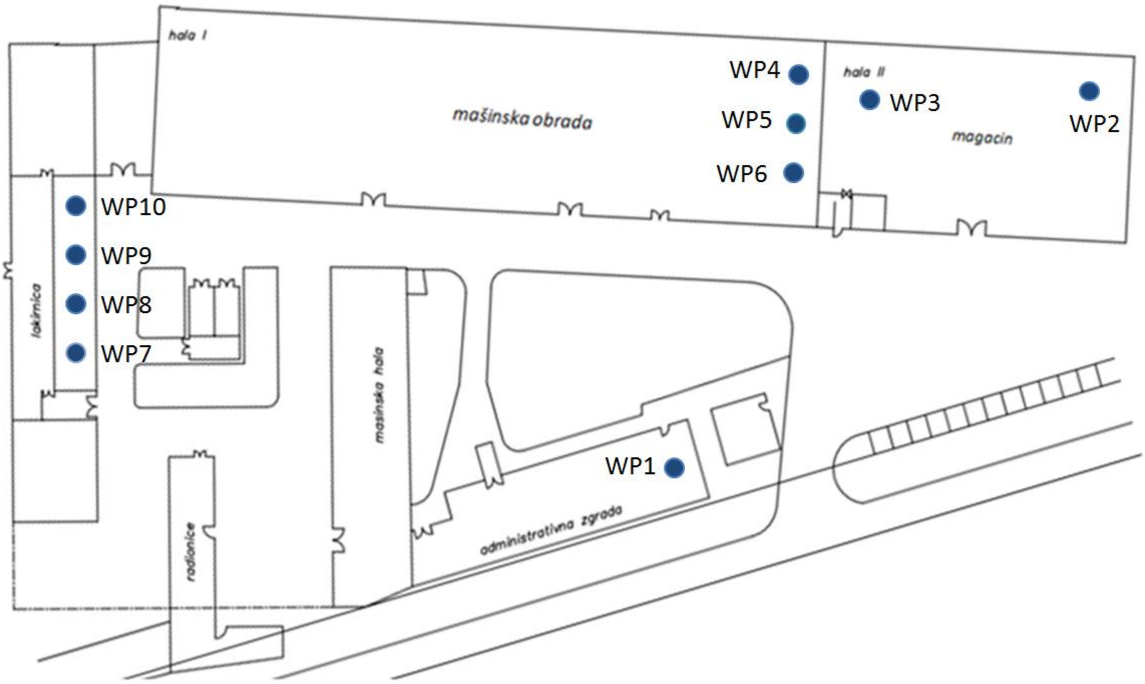

Fig. 1. Workplace spatial layout

The next step is the application of the 5x5 methodology for the identification of danger and hazard in selected workplaces. Table 1 lists and numbers the different sources of risk identified for each workplace.

Table 1. Risk numeration by workplace

WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10
1.1.1.	2.1.1.	3.1.1.	4.1.1.	5.1.1.	6.1.1.	7.1.1.	8.1.1.	9.1.1.	10.1.1.
1.1.2.	2.1.2.	3.1.2.	4.1.2.	5.1.2.	6.1.2.	7.2.2.	8.1.2.	9.1.2.	10.1.2.
1.2.1.	2.2.1.	3.1.3.	4.1.3.	5.1.3.	6.1.3.	7.2.3.	8.1.3.	9.1.3.	10.1.3.
1.2.2.	2.2.2.	3.2.1.	4.1.4.	5.1.4.	6.1.4.	7.2.4.	8.2.1.	9.1.4.	10.1.4.
1.2.3.	2.2.3.	3.2.2.	4.1.5.	5.1.5.	6.1.5.	7.2.5.	8.2.2.	9.2.1.	10.2.1.
1.2.4.	2.2.4.	3.2.3.	4.1.6.	5.1.6.	6.1.6.	7.2.1.	8.2.3.	9.2.2.	10.2.2.
1.2.5.	2.2.5.	3.2.4.	4.1.7.	5.1.7.	6.1.7.	7.2.2.	8.2.4.	9.2.3.	10.2.3.
	2.2.6.	3.2.5.	4.1.8.	5.1.8.	6.1.8.	7.2.3.	8.2.5.	9.2.4.	10.2.4.
		3.2.6.	4.2.1.	5.2.1.	6.2.1.	7.2.4.	8.2.6.	9.2.5.	10.2.5.
		3.2.7.	4.2.2.	5.2.2.	6.2.2.	7.2.5.	8.2.7.	9.2.6.	10.2.6.
		3.2.8.	4.2.3.	5.2.3.	6.2.3.	7.2.6.	8.2.8.	9.2.7.	10.2.7.
			4.2.4.	5.2.4.	6.2.4.	7.2.7.		9.2.8.	10.2.8.
			4.2.5.	5.2.5.	6.2.5.	7.2.8.		9.2.9.	10.2.9.
			4.2.6.	5.2.6.	6.2.6.				
			4.2.7.	5.2.7.	6.2.7.				
			4.2.8.	5.2.8.	6.2.8.				
			4.2.9.	5.2.9.	6.2.9.				

The following is a description of the risk assessment for workplace number 9, WP8 – galvanizer. The list of tools used by the worker in this workplace is listed first, followed by the list of protective equipment required in this workplace.

Description of galvanizing tools [7]:

- Within the galvanization department, the following equipment is present:
- Nickel plating line
- Copper cyanide and high-luster plating line
- Brass line
- Cadmium plating line
- Zinc plating line
- Brass etching line
- Line for anodizing and passivation of aluminum
- Container for removing galvanic coats

Description of equipment for personal protection [5]:

- Work suit or acid-resistant clothing
- Rubber boots or ribbed rubber-sole shoes
- Work gloves
- Safety goggles with side protection
- Protective mask over mouth and nose if needed
- Protective cap if needed

Further, the source of risk for this workplace was identified. Since the workplace is designated as WP9, all risk sources are numbered 9.1.X for danger and 9.2.X for hazard.

Recognition of risk and possible hazard in the workplace and environment -WP9

Danger recognition (9.1) [7]:

9.1.1. Danger of falling due to slipping on wet floor surfaces

9.1.2. Danger of being hit by a transportation vehicle (forklift).

9.1.3. Risk of direct contact with energized electrical components and equipment.

9.1.4. Risk of indirect contact with live electrical parts (if a fault between a live part and an exposed-conductive-part occurs).

Hazard recognition (9.2) [7]:

9.2.1. Chemical hazard caused by inhalation of various vapors, dust and fumes that occur during the work process in the galvanization department or during other technological processes that are performed near the workplace.

9.2.2. Chemical hazards that occur during work by direct contact with chemicals used in the process.

9.2.3. Physical hazards caused by noise.

9.2.4. Harmful effects of microclimate (temperature, air humidity and air flow).

9.2.5. Inadequate/Insufficient lighting conditions in the workplace.

9.2.6. Non-physiological body position (frequent standing).

9.2.7. Efforts in performing certain tasks causing psychological strain (stress, monotony, etc.).

9.2.8. Hazard related to work management (overtime work, working in shifts, night work, etc.).

9.2.9. Other possible hazards such as use of inadequate repromaterials, use of inadequate tools, instruments, change of workplace due to production process requirements.

Furthermore, for identified sources of risk, an assessment was conducted according to the “5x5” methodology.

Table 2. Risk assessment in terms of hazard and danger for galvanizer workplace [7]

Label	Hazard or danger description	Severity of injury or illness	Probability of occurrence	Risk level
9.1.1	Danger of falling due to slipping on wet floor surfaces	Moderate	Likely	Medium
9.1.2	Danger of being hit by a transportation vehicle (forklift)	Fatal	Unlikely	Medium
9.1.3	Risk of direct contact with energized electrical copmonents and equipment	Moderate	Likely	Medium

Table 2. Risk assessment in terms of hazard and danger for galvanizer workplace [7] (continued)

9.1.4	Risk of indirect contact with live electrical parts (if a fault between a live part and an exposed-conductive-part occurs)	Moderate	Likely	Medium
9.2.1	Chemical hazard caused by inhalation of various vapors, dust and fumes that occur during the work process in the galvanization department or during other technological processes that are performed near the workplace	Significant	Very Likely	High
9.2.2	Chemical hazards that occur during work by direct contact with chemicals used in the process	Moderate	Very Likely	High
9.2.3	Physical hazards caused by noise	Minor	Likely	Medium
9.2.4	Harmful effects of microclimate (temperature, air humidity and air flow)	Moderate	Very Likely	High
9.2.5	Inadequate/Insufficient lighting conditions in the workplace	Negligible	Likely	Low
9.2.6	Non-physiological body position (frequent standing)	Negligible	Very Likely	Low
9.2.7	Efforts in performing certain tasks causing psychological strain (stress, monotony, etc.)	Negligible	Likely	Low
9.2.8	Hazard related to work management (overtime work, working in shifts, night work, etc.)	Minor	Likely	Medium
9.2.9	Other possible hazards such as use of inadequate repromaterials, use of inadequate tools, instruments, change of workplace due to production process requirements	Minor	Very Likely	Medium

According to above risk assessment it could be concluded that galvanizer is a high-risk workplace. Similarly, a risk assessment was conducted for other workplaces. All sources of risk (127 in total) for the observed 10 workplaces, and their dangers and hazards estimates were entered into the database, Table 2. Conditional formatting, the classification of risk sources with the terms 'LOW', 'MEDIUM' and 'HIGH' in appropriate format.

Table 3. Workplace risk assessment

98	WP8	8.2.5.	Insignificant (no sick leave)	1	4	Likely	4	LOW
99	WP8	8.2.6.	Insignificant (no sick leave)	1	3	Possible	3	LOW
100	WP8	8.2.7.	Insignificant (no sick leave)	1	3	Possible	3	LOW
101	WP8	8.2.8.	Insignificant (no sick leave)	1	3	Possible	3	LOW
102	WP9	9.1.1.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
103	WP9	9.1.2.	Severe (long-term illness)	4	2	Rare	8	LOW
104	WP9	9.1.3.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
105	WP9	9.1.4.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
106	WP9	9.2.1.	Severe (long-term illness)	4	4	Likely	16	HIGH
107	WP9	9.2.2.	Medium (sick leave over 3 working days)	3			12	MEDIUM
108	WP9	9.2.3.	Easy (pain up to 3 working days)	2			6	LOW
109	WP9	9.2.4.	Medium (sick leave over 3 working days)	3			12	MEDIUM
110	WP9	9.2.5.	Insignificant (no sick leave)	1	3	Possible	3	LOW
111	WP9	9.2.6.	Insignificant (no sick leave)	1	4	Likely	4	LOW
112	WP9	9.2.7.	Insignificant (no sick leave)	1	3	Possible	3	LOW
113	WP9	9.2.8.	Easy (pain up to 3 working days)	2	3	Possible	6	LOW
114	WP9	9.2.9.	Easy (pain up to 3 working days)	2	4	Likely	8	LOW

Rare / Unlikely / Possible / Likely / Almost certain

Furthermore, data preparation was performed (Table 2), in which the coordinates of workplaces of the spatial distribution of the factory are given. And then the coordinates of the workplaces are linked to the table in Figure 1, by the the workplace risk assessment. Given that there are several sources of risk in one workplace, it was taken to alert the grades with highest value according to the “5x5“ methodology, as the max RNP (calculated in Table 2).

Table 4. Data preparation table for online workplace risk assessment

data preparation				
x	y	wp	Description	Max
2,95	1,50	WP1	president	9
4,65	3,80	WP2	storekeeper	9
3,75	3,75	WP3	auxiliary worker	12
3,46	3,90	WP4	controller	12
3,45	3,60	WP5	metal lathe	9
3,44	3,30	WP6	auxiliary worker	9
0,5	2,20	WP7	grinder	12
0,5	2,50	WP8	technologist	12
0,5	2,80	WP9	galvanizer	16
0,5	3,10	WP10	painter	16

Figure 2, gives the final of the estimates on the spatial layout of the factory, which is used to monitor workplace risks. Workplace 9 and workplace 10 are the workplaces with high risks, and workplaces 3,4,7,8 are workplaces with medium risk, while workplaces 1,2,5,6 are workplace with low risk.

Fig. 2. Workplace risk monitoring

In this way, risk managers can easily identify high-risk workplaces and plan priority activities events and protect employees in the workplace. Also, the software application makes it possible to show separately the workplaces with the highest risk of dangers to the health of workers.

CONCLUSION

The conducted research aims to increase the quality of the workplace risk assessment procedure as well as to more efficiently implement the procedure of protection of workers from unwanted events. Also, the proposed method of workplace risk assessment enables online monitoring of workplace risks, as well as visual representation and activation of alarm signals in order to prevent unwanted and dangerous events in the workplace, applicable for any any business-production company.

The research points to easier monitoring of workplace risk by using a database that automatically displays workplace risk assessment (low, moderate, high) as well as risk visualization by spatial layout, but the limitation of the model is the entering of input data for identified risks. Namely, the identification of risk sources for each job should be done by a professional risk assessor (this assessment is usually done on an annual basis), while the monitoring of certain risk sources can be carried out by trained staff, or automatically - through cyber physical systems for certain measurable risk sources.

However, further research should be focused on resolving the issues of entering input data (ie considering the possibility of implementing sensors for monitor parameters that affect risks at the workplace), development of expert knowledge base, data storage in the cloud, online access for the all relevant users, group decision-making in the case of multiple risk assessors and similar issues.

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