M. SPILKA

ISSN 0543-5846
METABK 60(1-2) 129-132 (2021)
UDC – UDK 669.011-061.5:658.531:351.78:368.025.6=111

SHAPING WORKPLACE SAFETY IN THE METALLURGICAL INDUSTRY

Received – Primljeno: 2020-08-27
Accepted – Prihvaćeno: 2020-11-03
Preliminary Note – Prethodno priopćenje

Shaping workplace safety is determined by the organization of work in a way that does not endanger the employee during its performance. It consists of such aspects as occupational risk assessment and determination of the workload, as well as its impact on the employee. At workstations in the metallurgical industry, activities are performed in conditions harmful to health, hence the article presents the results of the workload assessment related to the physical load on employees at selected workplaces in the metallurgical industry. The occupational risk was also estimated and corrective actions were indicated to increase work safety.

Keywords: metallurgical industry, workplace, safety, occupational risk, work nuisance assessment

INTRODUCTION

Ensuring an adequate level of occupational health and safety and work protection in the company is regulated by many legal acts, the most important of which is Directive 89/391/EEC – OSH on the introduction of measures to encourage improvements in the safety and health of workers at work. This legal act obliges the employer, among others, to ensure safe and hygienic working conditions, identify hazards at the workplace, assess occupational risk, inform the employee about the results of such assessment and apply preventive measures reducing occupational risk [1]. Occupational risk assessment is also one of the basic requirements of occupational health and safety management, formalized by ISO 45001 Occupational Health and Safety Management Systems [2].

When estimating the occupational risk, many methods can be used, depending on the degree of traceability of the processes concerning the assessed position, as well as any potential threats that occur [3]. When carrying out an occupational risk assessment, it is worth considering the aspect of assessing work related nuisance, e.g. physical load, which correlates with potential ailments from the musculoskeletal system.

The working environment of people employed in the metallurgical industry is associated with specific working conditions, because there is a significant number of occupational hazards (including noise, high temperature of the processes, presence of harmful chemicals and dust), which may cause injuries or occupational diseases [4]. Proper identification of hazards and associated risks is the basis for taking various preventive actions, resulting in increased safety at workplaces.

M. Spilka, e-mail: monika.spilka@polsl.pl, Silesian University of Technology, Gliwice, Poland

METHODOLOGY

The main objective of the research was to assess the safety at selected workplaces in the metallurgical industry and to eliminate activities involving significant risk. The analysis focuses on the positions of steel scatterer and supervisor of the continuous casting of steel in the electric steelworks department.

An assessment of work nuisance in terms of physical load was carried out, evaluating the physical effort using the chronometric-tabular method of energy expenditure proposed by Lehmann [5]. The expenditure is calculated on the basis of a thorough analysis of all activities performed during the working day and is expressed as the sum of the energy needed to maintain the body's position and its movement, as well as the energy required by individual muscles during work.

The possibility of ailments from the musculoskeletal system was determined by the Rapid Entire Body Assessment (REBA) method [6], which is recommended for risk assessment, especially at workplaces where work is performed in a standing position. The method takes into account body position, external strength, muscle work dynamics, type and quality of the grip.

In order to reduce the number of accidents at work and improve working conditions, mental load of employees was assessed using an estimation method, which consists of two stages: determining the physical effort and the monotony load on a point scale from 1 to 5, where 5 means the most.

Moreover, occupational risk was assessed using the Risk Score method [7], in which the risk is estimated by calculating the R index, which is the product of three parameters: the probability of a hazard (P), its effects (S) and the exposure time (E).

RESULTS AND DISCUSSION

In order to assess the physical effort in the analyzed workplaces, the working time schedule was created in a typical working day, and then the components of the assessment of energy expenditure w_a, w_b, w_c were calculated (Tables 1,2).

Subsequently, the point and verbal evaluation of the physical effort components (energy expenditure, static load, repetition of movements) were performed, the estimated point values of these components were summed up and the calculated physical effort was classified to the appropriate category of physical load. The results are presented in Table 3.

The analysis using the REBA method of the possibility of ailments from the musculoskeletal system showed that, for the steel scatterer position, the risk of ailments is at an average level (activities: ladle fitting (7 points) and ladle handling (4 points)), while in the position of supervisor of the continuous casting of steel, the risk was assessed as low (< 3 REBA points).

The mental burden of employees at the analyzed workplaces is presented in Tables 4-6. Using the estimation method, the level of mental burden at the steel scatterer position was assessed as average. The information load component – performed activities – has the greatest impact on the size of this load. This is due to the typically working-class nature of the workplace. In turn, the mental burden in the position of the supervisor of the continuous casting of steel was determined as high, which is mainly influenced by two components of the information load, namely information reception and decision making.

The estimated occupational risk using the Risk Score method at the steel scatterer position is very high.

Table 1 **Analysis of the physical load on the steel scatterer position using the Lehmann method**

Gender – male		Time / min.	w_a		w_b		w_c / kJ
No.	Action performed		kJ/min	Body position	kJ/min	Type of work	
1	Ladle fitting	30	4,2	standing inclined	8,4	average, both arms	378
2	Ladle transport from and to CCS	120	2,5	standing	6,3	light, both arms	1 056
3	Break	30	1,2	sitting	1,2	light, forearm	72
4	Ladle control	120	2,5	standing	5,0	light, one arm	900
5	Ladle operation	30	2,5	standing	6,3	light, both arms	264
6	Ladle transport to the furnace	150	2,5	standing	6,3	light, both arms	1 320
						Total	3 990

where:
w_a – energy expenditure due to the torso position,
w_b – energy expenditure due to the limbs work,
w_c – energy expenditure being the sum of w_a and w_b.

Table 2 **Analysis of the physical load on the position of supervisor of the continuous casting of steel using the Lehmann method**

Gender – male		Time / min.	w_a		w_b		w_c / kJ
No.	Action performed		kJ/min	Body position	kJ/min	Type of work	
1	Inspections of CCS billet elements (documentation photographic)	45	7,2	walking	2,5	light, forearm	436,5
2	CCS process supervision	90	7,2	walking	5,0	light, one arm	1 098
3	Break	30	1,2	sitting	1,2	light, forearm	72
4	Office work	225	1,2	sitting	1,2	light, forearm	540
5	Process supervision billet cooler	90	7,2	walking	2,5	light, forearm	873
						Total	3 019,5

Table 3 **Assessment of components of physical effort at the analyzed workplaces**

Component of effort	Scoring		Verbal rating	
	steel scatterer	supervisor	steel scatterer	supervisor
Energy expenditure	28	21	average	low
Static load	41	30	average	average
Repeatability of movements	7	3	low	low
Total workload	76 Average effort	54 Low effort		

This is due to the occurrence of a factor that may cause a hazard, namely high temperature. Factors with a high level of risk include noise, non-ionizing infrared radiation, industrial dust and falling objects transported by means of handling equipment. In the case of position of the supervisor of the continuous casting of steel, a very high risk factor is the possibility of being hit by motor vehicles and moving objects. Factors for which the assessed risk is high are: high temperature and hot surfaces, danger of burial and electricity. A section of the risk assessment for significant hazards identified at the analyzed workplaces is presented in Table 7.

CONCLUSIONS

Shaping workplace safety comes down to taking actions to ensure safe and hygienic working conditions. Estimating occupational risk and the assessment of workload, as well as the use of preventive measures, protect the health and life of employees directly and indirectly – by raising awareness of hazards in the workplace and promoting safe work.

The physical load assessment carried out at the exemplary workplaces of the electric steelworks department of one of the metallurgical industry companies showed the risk of physical effort on an average level for an employee performing manual work and low in the case of a supervising position.

The occupational risk assessment carried out using the Risk Score method showed that the occupational risk for the analyzed workplaces is very high, therefore corrective actions were proposed. Despite the estimated very high risk in the position of the supervisor of the continuous casting of steel, the actual work activities performed in this position were classified as safe or almost safe. In the case of the steel scatterer position, for

Table 4 **Assessment of the information load at the analyzed workplaces**

Stage	Receiving information		Decision-making		Activities performed	
Feature of information	steel scatterer	supervisor	steel scatterer	supervisor	steel scatterer	supervisor
Inflow frequency	2	4	2	3	3	2
Volatility of information	2	4	1	2	3	3
Uncertainty	2	3	2	5	3	3
Information complexity	2	4	2	4	3	3
Inaccuracy	2	2	2	4	5	2
Validity of information	3	5	1	5	4	3
Time stress	2	5	3	5	3	3
Total	15	27	13	28	24	19
Total score 52 points – average load (at the steel scatterer position) 74 points – high load (at the position of supervisor of the continuous casting of steel)						

Table 5 **Assessment of the monotony load at the analyzed workplaces**

Component of monotony	Point note	
	steel scatterer	supervisor
Uniformity of the work process	2	1
Uniformity of environmental conditions	1	1
Great ease of work, not involving the intellect	1	5
The need for constant tension of attention	2	5
Total	6 (average load)	12 (average load)

Table 6 **Summary evaluation of the mental load of employees at the analyzed workplaces**

Type of load	Point note	
	steel scatterer	supervisor
Information burden	52	74
Monotony burden	6	12
Total burden	58 (average load)	86 (high load)

Table 7 **Section of the risk assessment for significant threats identified at the analyzed workplaces**

Work environment factors causing threat			Risk level				Preventive actions
Factor	Source of the threat	Possible effects of the threat	P	E	S	R	
high temperature	slag during ladle emptying, liquid metal during ladle transport, hot surfaces, firing the drain hole, burning of the clots	body burns, eye injuries, death	5	6	15	450 Very high	use of personal protective equipment, increased caution during work, compliance with the workplace instructions
danger of burial	slipping of billets	internal injuries, contusions, cuts, fractures, death	3	6	15	270 High	correct billet storage, a ban on passing between prisms

most of the time during a typical working day, the activities performed by employees are dangerous or particularly dangerous. In this case, urgent corrective actions are needed, to increase the work safety level of employees.

Acknowledgements

Author thanks Mr. Adrian Marzec, MSc. for data collection.

REFERENCES

[1] Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, Official Journal L183, 29.06.1989.

[2] ISO 45001 Occupational health and safety management systems, ISO, Genève, 2017.

[3] A. Kiljan, M. Spilka, A. Kania, P. Sakiewicz, T. Karkoszka, M. Roszak, Proactive shaping of work safety in manufacturing processes, Book of good health and safety practices, Higher School of Labour Protection Management Publishing House, Katowice, 2018 (in Polish).

[4] P. Rajca, Analysis of hazards in the metalurgical industry on example of selected positions of steel works, Research works of the Jan Długosz Academy in Częstochowa 5 (2017), 53-65 (in Polish).

[5] M. Dębowski, M. T. Spioch, Chronometric-tabular method of evaluating energy expenditure, Applications of Ergonomics 3 (1992), 67-77 (in Polish).

[6] M. Joshi, V. Deshpande, Investigative study and sensitivity analysis of Rapid Entire Body Assessment (REBA), International Journal of Industrial Ergonomics 79 (2020), 103004.

[7] E. Matuszewska-Majcher, The overview of applied methods for occupational risk assessment, Support systems in production engineering 6 (2017) 4, 63-68.

Note: The responsible translator for English language is ITAMAR Group Sp. z o.o., Gliwice, Poland