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Modernisation of the workplace as a result of the outbreak of the pandemic

A. Kania*, M. Polok-Rubiniec, A. Włodarczyk-Fligier
Department of Engineering Materials and Biomaterials, Faculty of Mechanical Engineering, Silesian University of Technology, Konarskiego 18a, 44-100 Gliwice, Poland
* Corresponding e-mail address: aneta.kania@polsl.pl
ORCID identifier: https://orcid.org/0000-0003-0337-1344 (A.K.)

ABSTRACT

Purpose: of this paper is to propose modernisation activities, including the improvement of machines and devices that will increase work safety during the epidemic state for the workplace of an injection moulding machine operator in a selected manufacturing company.

Design/methodology/approach: In the work brief analyses of a production line and a workplace of an injection moulding machine operator were carried out. Then the threats that occur at the analysed workplace were identified. The risk assessment was done using three methods: matrix according to the PN-N-18002:2011 standard, Risk Score and PHA.

Findings: The results of the occupational risk assessment obtained by the three assessment methods were similar and gave similar results. The greatest and unacceptable risk has occurred for the threat of SARS-CoV-2 virus infection. Therefore, the following modernisation solutions were proposed: the introduction of mandatory epidemiological questionnaires, online training for company employees, the use of a three-axis robot, replacement of traditional disinfection dispensers with automatic ones.

Practical implications: The results of re-assessing the occupational risk after introducing the proposed improvements showed that the occupational risk was significantly reduced – mainly to the low or very low levels.

Originality/value: The proposed modernisation solutions at the workplace of an injection moulding machine operator can be used for each workplace and each epidemiological state.

Keywords: Materials manufacturing and processing, Safety and health management, Occupational risk assessment, Injection moulding operator, COVID-19

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INDUSTRIAL MANAGEMENT AND ORGANISATION

1. Introduction

Each company employee, regardless of their duties, is exposed to various types of threats that may lead to the deterioration of their health or life. These threats include dangerous, harmful and burdensome factors. Dangerous factors cause injuries or immediate deterioration of human health and even death. Harmful factors affect the

deterioration of human health. Burdensome factors make work difficult or contribute to assessing workability and efficiency [1,2].

Employee's contact with these hazards, the time of exposure and exceeding the acceptable concentration and intensity of factors are important. It is defined as an occupational exposure. Actions limiting occupational exposure reduce the occurrence of occupational risk by reducing the probability or frequency of undesirable factors [3,4].

Thus, occupational risk occurs in the working environment while performing mandatory professional activities [5,6].

One of the ways to improve occupational health and safety in a given enterprise is the implementation of occupational risk assessment. Its task is to identify individual threats and determine their risk level. This can be done through verbal descriptions or numerical indicators per the assumed methodology of occupational risk assessment. Determining the level of risk depends on examining the probability of threats, possible consequences and exposure to these threats [7].

Due to the outbreak of the COVID-19 pandemic in Poland, in addition to the threats related to the work performed, new threats have appeared, such as:the possibility of being infected with the SARS-CoV-2 virus and the fear of being infected. Both hazards have a negative impact on the worker. Such risks should be eliminated or reduced as much as possible by introducing appropriate modernization measures on the production line. As a result of the crisis, enterprises had to adapt to new market realities and new procedures regarding work safety.

The work aims propose modernization activities, including the improvement of machines and devices that will increase work safety, for the workplace of an injection moulding machine operator in a selected manufacturing company.

2. Guidelines for the functioning of industrial plants during the occurrence of an epidemiological threat

At the beginning of 2020, a large part of society heard about the 'coronavirus'. The appearance of a new SARS-CoV-2 strain from Wuhan in Poland has given the term 'ccoronavirus a new and dramatic meaning.

As in the case of other viral and bacterial diseases, there may be two risks associated with the possibility of an employee contracting COVID-19 [8]:

1. Related to the performance of a specific job.
2. Caused by general epidemiological conditions.

The first type of risk is directly related to the type of industry, services, research or medical activity in which there is intended or unintended contact with biological agents.

In accordance with the Regulation of the Council of Ministers of 2 May 2020 on the establishment of certain restrictions, orders and prohibitions due to the pandemic state (Polish Journal of Laws, item 792), these guidelines contain general information on precautionary measures to be taken during the epidemic period in any workplace, including [9]:

- an action plan to protect the health of employees during the epidemic,
- means that can be taken to reduce the possibility of SARS-CoV-2 infection at work,
- communication-related to the actions taken to reduce the possibility of SARS-CoV-2 infection at work,
- appropriate procedure when a person is suspected of COVID-19 disease.

Maintaining a certain physical distance between employees is one of the main ways to reduce the probability of SARS-CoV-2 virus infection in the work environment. To do this, you should [10]:

1. Limit the number of people who are at the same time:
   a) at the workplace; it is advisable to introduce an individual work schedule,
   b) in toilets, cloakrooms, and rooms by introducing rotating breaks and a board informing about the number of people in the space.
2. Arrange workstations to ensure a minimum distance of 1.5 m between them, if possible. If this is not possible, it is recommended that workers have their backs on each other.
3. Establish rules for using the communication routes such as stairs, corridors, and elevators, e.g. by introducing one-way traffic or reducing the number of people allowed in the elevator.
4. Define a code of procedures in places where people gather, e.g. when entering the workplace, when checking in, when leaving the building after a shift. It is recommended that these places be properly arranged and marked.

3. Results and discussion

3.1. Characteristics of the selected production line

The line for the production of protective visors will be analysed. The proposed changes are aimed at improving occupational health and safety in the position of the injection moulding machine operator.

The production line consists of two injection moulding machines with injection moulds, belt conveyors, a box to which ready-made elements are transported, a box with injection branches (elements formed from channels supplying liquid plastic), a crusher for plastics, a packaging room and a warehouse for finished products.

The production process of protective visors begins with feeding the raw material, in the form of polypropylene (PP), into the hopper of the injection moulding machine. Then the material is transported to the heated cylinder, which is plasticized and injected into the injection mould cavity using a nozzle. The material solidifies in it, takes the shape of the mould cavity and is removed from it.

The finished elements are transported to the box using a conveyor belt. There, an employee manually separates the finished element from the injection branch and sorts it into the appropriate boxes. A conveyor belt transports the box with ready-made elements to the packing plant, where quality controllers check the product and then pack it into cardboard boxes, 200 pieces each.

The cartons are then picked up by the forklift operator and transported to the warehouse. The waste box is moved manually by the injection moulding machine operator to the crusher, which processes the plastic waste into granulate, which is the raw material for the next production.

3.2. Brief analysis of the injection moulding machine operator's workplace

The tasks of the injection moulding machine operator include:

- feeding the raw material in the form of polypropylene,
- supervision and control of the moulding process and the quality of the manufactured products,
- separating semi-finished products from the injection branch,
- sorting semi-finished products and injection branches to appropriate conveyors,
- transferring transports boxes with injection branches to plastic crushers,
- handling technological documentation,
- maintenance and cleaning of operated machines and devices,
- controlling the control equipment supervising the technological process,
- reacting to errors in the process.

The injection moulding machine operator works in a 3-shift system, 8 hours a day. This is due to the need to leave the machines in continuous operation. During the shift, the worker maintains a mainly standing position.

During work, the employee is entitled to two breaks: 10 and 20 minutes.

Due to the epidemiological situation, a rotational system of breaks was introduced to minimize crowds of people in places such as bathrooms, cloakrooms, and canteen.

In order to reduce the effects of possible hazards, the injection moulding machine operator is required to wear the following:

- protective clothing against entanglement in moving machine elements,
- footwear with a non-slip sole and equipped with toes or soles to protect against puncture,
- glasses, goggles or face shields protecting against fragments of solid objects,
- gloves protecting against light mechanical injuries and contact with hot machine elements,
- earmuffs or inserts protecting the hearing organ,
- protective masks or visors,
- disposable gloves,when it is not required to wear protective gloves.

3.3. Occupational risk assessment at the injection moulding machine operator's workplace

In order to thoroughly analyse the workplace of the injection moulding machine operator and increase occupational health and safety, the occupational risk assessment was carried out with three selected assessment methods: matrix in accordance with the PN-N-18002:2011 standard, Risk Score and PHA (Preliminary Hazards Analysis) [11-13] (Tables 1-4).

The results of occupational risk assessment obtained by three methods (matrix according to PN-N-18002 standard, Risk Score and PHA) are very similar (Tab. 4). A slight difference concerns the noise hazard – in the matrix method, according to PN-N-18002:2011, the risk for this hazard was estimated at a high level; in the other methods, the risk is medium. After a deeper analysis of the results, it can be concluded that for the analysed job position - the injection moulding machine operator – the Risk Score method is more accurate because the obtained results are more accurate. Unlike the other two methods, the Risk Score considers three risk parameters in the estimation, including exposure to the threat. This parameter is very important because it allows you to determine how often a given hazard may occur at the workplace, which is very important from the point of view of the probability of contracting the COVID-19 virus. In addition, the Risk Score method and the method according to PN-N-18002:2011 standard estimate risk at five levels (very low, low, medium, high and very high), while the PHA method uses only three levels of risk estimation (low, medium, high).

Table 1.
Occupational risk assessment by PN-N-18002:2011 standard

No.	Threat name	The probability of the threat occurring (P)	The severity of the consequences (S)	Risk estimation (R)
1.	Noise	high	low	medium
2.	Lighting	high	low	medium
3.	Industrial dusts	high	low	medium
4.	Sharp tools and protruding parts hazards	medium	medium	medium
5.	Hazards associated with the movement of workers	medium	medium	medium
6.	Electric shock hazard	low	high	medium
7.	Fire hazard	low	high	medium
8.	Static physical loads	medium	medium	medium
9.	Dynamic physical loads	medium	medium	medium
10.	Lower limb crushing	medium	medium	medium
11.	Hazards related to technological machines	low	high	medium
12.	Hazard related to spilt raw material	medium	medium	medium
13.	Contact with hot parts of the injection moulding machine	low	medium	low
14.	Virus SARS-CoV-2	medium	high	high
15.	Stress, depression, fear of infection	medium	medium	medium

Table 2.
Occupational risk assessment using the Risk Score method

No.	Threat name	Potential human losses (S)	Exposure to the threat (E)	The probability of the threat occurring (P)	Risk estimation (R)
1.	Noise	3	10	6	180
		absent	continuos	quite possible	
2.	Lighting	3	6	6	108
		absent	frequent (daily)	quite possible	
3.	Industrial dusts	3	6	6	108
		absent	frequent (daily)	quite possible	
4.	Sharp tools and protruding parts hazards	7	6	3	126
		severe body injury	frequent (daily)	practically possible	
5.	Hazard associated with the movement of workers	7	6	3	126
		severe body injury	frequent (daily)	practically possible	
6.	Electric shock hazard	15	3	3	135
		fatal victim	sporadic (once a week)	practically possible	
7.	Fire hazard	100	1	1	100
		a lot of fatal victims	sporadic (a few times per year)	unlikely	
8.	Static physical loads	3	6	10	180
		absent	frequent (daily)	very likely	
9.	Dynamic physical loads	3	6	10	180
		absent	frequent (daily)	very likely	

No.	Threat name	Potential human losses (S)	Exposure to the threat (E)	The probability of the threat occurring (P)	Risk estimation (R)
10.	Lower limb crushing	3	6	6	108
		absent	frequent (daily)	quite possible	
11.	Hazards related to technological machines	7	6	3	126
		severe body injury	frequent (daily)	practically possible	
12.	Hazard related to spilt raw material	3	6	6	108
		absent	frequent (daily)	quite possible	
13.	Contact with hot parts of the injection moulding machine	3	6	3	54
		absent	frequent (daily)	practically possible	
14.	Virus SARS-CoV-2	40	6	1	240
		few fatal victims	frequent (daily)	unlikely	
15.	Stress, depression, fear of infection	3	6	6	108
		absent	frequent (daily)	quite possible	

Table 3.
Occupational risk assessment using the PHA method

No.	Threat name	Damage degree (S)	The probability of the threat occurring (P)	Risk estimation (R)
1.	Noise	2	3	6
		minor injuries, measurable damage	ad hoc events that happen once a year	
2.	Lighting	2	3	6
		minor injuries, measurable damage	ad hoc events that happen once a year	
3.	Industrial dusts	2	4	8
		minor injuries, measurable damage	fairly frequent events, occurring once a month	
4.	Sharp tools and protruding parts hazards	2	4	8
		minor injuries, measurable damage	fairly frequent events, occurring once a month	
5.	Hazards associated with the movement of workers	3	3	9
		severe injuries, significant damage	ad hoc events that happen once a year	
6.	Electric shock hazard	4	2	8
		single fatal accidents, severe damage	unlikely, occurring once in 10 years	
7.	Fire hazard	6	1	6
		collective fatalities, large-scale off-site damage	very unlikely	
8.	Static physical loads	2	4	8
		minor injuries, measurable damage	fairly frequent events, occurring once a month	
9.	Dynamic physical loads	2	4	8
		minor injuries, measurable damage	fairly frequent events, occurring once a month	

No.	Threat name	Damage degree (S)	The probability of the threat occurring (P)	Risk estimation (R)
10.	Lower limb crushing	2 minor injuries, measurable damage	4 fairly frequent events, occurring once a month	8
11.	Hazards related to technological machines	3 severe injuries, significant damage	3 ad hoc events that happen once a year	9
12.	Hazard related to spilt raw material	2 minor injuries, measurable damage	4 fairly frequent events, occurring once a month	8
13.	Contact with hot parts of the injection moulding machine	2 minor injuries, measurable damage	3 ad hoc events that happen once a year	6
14.	Virus SARS-CoV-2	4 single fatal accidents, severe damage	4 fairly frequent events, occurring once a month	16
15.	Stress, depression, fear of infection	2 minor injuries, measurable damage	4 fairly frequent events, occurring once a month	8

Table 4.
Summary of the results of occupational risk estimation using three selected assessment methods

No.	Threat name	Hazard, according to the PN-N-18002 standard	Hazard according to the Risk Score method	Hazard according to the PHA method
1.	Sharp tools and protruding parts hazards	medium	medium	medium
2.	Hazards associated with the movement of workers	medium	medium	medium
3.	Electric shock hazard	medium	medium	medium
4.	Fire hazard	medium	medium	medium
5.	Lower limb crushing	medium	medium	medium
6.	Hazards related to technological machines	medium	medium	medium
7.	Hazard related to spilt raw material	medium	medium	medium
8.	Noise	high	medium	medium
9.	Industrial dusts	medium	medium	medium
10.	Contact with hot parts of the injection moulding machine	low	low	medium
11.	Virus SARS-CoV-2	high	high	high
12.	Stress, depression, fear of infection	medium	medium	medium
13.	Static physical loads	medium	medium	medium
14.	Dynamic physical loads	medium	medium	medium
15.	Lighting	medium	medium	medium

Comparing the results of the occupational risk assessment results with the three selected methods, it can be unequivocally stated that the greatest risk is associated with SARS-CoV-2 virus infection; , it is necessary to focus on taking measures to reduce the risk of virus infection at the analysed workplace. It is the employer's responsibility to introduce both preventive and modernization measures.

3.4. A proposal for modernization activities, including those reducing the effects of the pandemic

One of the preventive measures to reduce the risk of SARS-CoV-2 virus infection is the preparation of an epidemiological occupational risk assessment questionnaire for each employee. Before entering the workplace, employees will have to complete it. Such a questionnaire should include questions about the symptoms typical of the disease and about contact with people infected with COVID-19.

Many production line downtimes are caused by human error. Frequent failures and incorrect operation of machines and devices may result from the employee's lack of sufficient knowledge and training. It is necessary to ensure that operators are properly qualified and that they follow the recommendations contained in the guidelines. Each emergency should be described in detail, considering the elements and subassemblies of the machine and the time in which the failure may occur. As a solution, additional training for employees should be introduced. However, in order to reduce the risk related to the possibility of SARS-CoV-2 virus infection, employee gatherings should be limited, therefore training should be held remotely.

When planning a production line upgrade, it itis important to determine the difference between expected and actual capacity, so you estimate how the upgrade will increase productivity. Acceleration and improvement of work in producing elements for protective visors can be achieved by using a three-axis robot that pulls injection branches from the mould and puts them into a waste container. Thanks to this, manual tasks are optimized, errors are minimized, which translates into increased production efficiency. The robot can be assembled above the injection moulding machine, where when the mould is opened, it slides down and, using a gripper, takes the injection branch and transfers it to the waste conveyor. The use of an integrated manipulator with an injection moulding machine creates an efficient and efficient system.

Taking into account the restrictions related to COVID-19, the company must introduce changes to the workplace. Therefore, in addition to disposable gloves, the injection moulding machine operator should have a disinfectant so that the employee does not spread the virus to tools or devices. The solution could be touchless dispensers with disinfectant liquid to minimize physical contact with the surface of the container and reduce the likelihood of spreading viruses. Automatic feeders are designed for wall installation.

3.5. Reassessment of occupational risk after the introduction of modernization measures

After introducing the proposed modernization measures, including those reducing the risk due to the possibility of COVID-19 infection, the occupational risk was re-estimated using three selected assessment methods. The results of the occupational risk assessment before and after the introduction of corrective measures are presented in Table 5. The table presents only those hazards that have changed as a result of the implementation of modernization measures.

Table 5.
Results of occupational risk assessment with three selected assessment methods before and after the introduction of corrective measures

No.	Threat name	Risk assessment					
		PN-N-18002 standard		Risk Score		PHA	
		before	after	before	after	before	after
1.	Dynamic physical loads	medium	low	medium	very low	medium	low
		acceptable	unacceptable	unacceptable	unacceptable	unacceptable	unacceptable
2.	Lower limb crushing	medium	low	medium	very low	medium	low
		unacceptable	unacceptable	unacceptable	unacceptable	unacceptable	unacceptable
3.	Virus SARS-CoV-2	high	medium	high	low	high	medium
		unacceptable	unacceptable	unacceptable	unacceptable	unacceptable	unacceptable
4.	Stress, depression, fear of infection	medium	low	medium	very low	medium	low
		unacceptable	unacceptable	unacceptable	unacceptable	unacceptable	unacceptable

After analysing the results of the occupational risk assessment, before and after the introduction of corrective actions, it can be seen that the risk level for the four identified hazards has been significantly reduced. By applying both the proposals for modernization activities and legally regulated guidelines, in connection with the restrictions caused by the outbreak of the CO-VID-19 pandemic in Poland, the risk at the workplace of the injection moulding machine operator in the analysed company was reduced to an acceptable level, which greater employee safety and less probability of being infected with the SARS-CoV-2 virus.

4. Conclusions

The work aimedto carry out an occupational risk assessment and to introduce corrective actions at the workplace of the injection moulding machine operator. Improvement proposals concerned machinery and equipment, as well as improving occupational hygiene as a result of the outbreak of the pandemic. To increase the accuracy of the analysis, the risk assessment was carried out using three methods: according to the PN-N-18002:2011 standard and Risk Score and PHA. The study was preceded by an analysis of the injection moulding machine operator's work environment, including the identification of hazards to which the employee is exposed.

The results of the occupational risk assessment obtained by the three assessment methods were similar and gave a similar conclusion. The greatest and unacceptable risk occurs in the case of the threat of SARS-CoV-2 virus infection, which forces the employer to take appropriate action in this direction. Slight differences in the results of the risk assessment of other identified threats may result from different risk parameters and levels of risk evaluation that are taken into account in each of the methods.

It should be noted that there is a high probability of an employee's contact with the SARS-CoV-2 virus during a work shift. On the production line, the injection moulding machine operator has contact with other employees, tools and devices that pose a potenpotentially threaten context. Although the occupational risk associated with other hazards is kept at an acceptable level, it is advisable to strive to reduce its level constantly. Therefore, the following modernization solutions were proposed:

- introduction of mandatory epidemiological questionnaires,
- online training for company employees,
- the use of a three-axis robot,
- replacement of traditional disinfection dispensers with automatic ones.

The results of re-assessing the occupational risk after introducing the proposed improvements showed that the occupational risk was significantly reduced.

References

[1] Work safety: harmful factors. Research and measurements (in Polish). Available from: https://www.pip.gov.pl/pl/f/v/198526/3220BHP20CZYNNIKI20SZKODLIWE2200internet.pdf

[2] O. Kruzhilko, O. Polukarov, S. Vambol, V. Vambol, N.A. Khan, V. Maystrenko, V.P. Kalinchyk, A.H. Khan, Control of the workplace environment by physical factors and SMART monitoring, Archives of Materials Science and Engineering 103/1 (2020) 18-29. DOI: https://doi.org/10.5604/01.3001.0014.1770

[3] B. Rączkowski, OHS in practice, XII edition, Human Resources Consulting and Improvement Center, Gdansk, 2009 (in Polish).

[4] A.P. Bochkovskyi, N.Yu. Sapozhnikova, Development of system of automated occupational health and safety management in enterprises, Journal of Achievements in Materials and Manufacturing Engineering 107/1 (2021) 28-41.
DOI: https://doi.org/10.5604/01.3001.0015.2454

[5] O. Kruzhilko, V. Maystrenko, I. Tkalych, Yu. Polukarov, V.P. Kalinchyk, I. Neklonskyi, O. Ryzhchenko, Study of the harmful factors influence on the occupational risk level: the example of the Ukrainian mining industry, Journal of Achievements in Materials and Manufacturing Engineering 110/1 (2022) 35-41.
DOI: https://doi.org/10.5604/01.3001.0015.7029

[6] A.P. Bochkovskyi, Elaboration of occupational risks evaluation models considering the dynamics of impact of harmful factors, Journal of Achievements in Materials and Manufacturing Engineering 102/2 (2020) 76-85.
DOI: https://doi.org/10.5604/01.3001.0014.6777

[7] M. Krause, Practical aspects of the selection of occupational risk assessment methods, Scientific Journals of the Silesian University of Technology 59 (2011) 173-190 (in Polish).

[8] D. Smoliński, How to work more safely. SARS-CoV-2 risk assessment, Labor Inspector 10/452 (2020) 6-10 (in Polish).

[9] Regulation of the Council of Ministers of 2 May 2020 on the establishment of certain restrictions, orders and prohibitions due to the pandemic state, Polish Journal of Laws, item 792 (in Polish).

[10] Guidelines for industrial plants during the COVID-19 epidemic in Poland (in Polish). Available from: https://psseproszowice.wsse.krakow.pl/index.php/obszarydzialan/109-koronawirus-sars-cov-2/953-wytyczne-dla-zakladow-przemyslowych-wtrakcie-epidemii-covid-19-w-polsce
[11] PN-N-18002:2011. Occupational health and safety management systems – General guidelines for occupational risk assessment.
[12] S. Wieczorek, P. Żukowski, Organization of safe work, Tarbonus Publishing House, Tarnobrzeg, 2022 (in Polish).
[13] https://ryzykazawodowe.pl (in Polish).