QUALITY AND WORK SAFETY IN METAL FOUNDRY

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Abstract

Metal foundry, despite the progressing process of implementing new production technologies - still belongs to the fields characterized by a significant level of occupational risk. In metal foundries there is a significant concentration of harmful and arduous factors at many workplaces. The degree of work safety depends, among others, on the technology, raw materials and technical equipment used. The paper presents an analysis of the accident rate based on statistical data extended by own research and results obtained from the conducted expert interview. Based on the results obtained, the most important factors harmful to health were defined and an analysis of the causes of accidents at work in foundries was carried out. Ensuring adequate in terms of quality and safety is an important element of the management process not only in the purely human dimension but also in the economic dimension.

Keywords: Quality, work safety, foundry, foundry processes

1. INTRODUCTION

Foundry next to construction [1] belongs to industries with increased occupational risk. During the entire casting production process, employees are exposed to dangerous, harmful and arduous factors that can cause occupational diseases and accidents at work. Foundry technological processes use various techniques and materials to make the model, mold and casting characterized by the diversity of their chemical composition and properties. The technological processes of making the casting used in foundries can pose a threat to the employee as well as to the environment. Most of the technological processes used in practice create problems at the workplace and for the environment. It is associated with the occurrence of: pollution, contamination, noise and other factors harmful to health and the environment. Epidemiological studies indicate an increased risk of lung and gastrointestinal, prostate, kidney and hematological cancers among foundry workers. The International Agency for Research on Cancer (IARC) concluded that there is sufficient evidence of a carcinogenic effect on people employed in the foundry industry and includes this industry as a carcinogen for humans - Group 1 [2]. The European Union includes technological processes in which there is exposure to polycyclic aromatic hydrocarbons present in carbon black, coal tar and coal tar pitch in processes that release carcinogens or mutagens [3].

The aim of the paper is to define the most important factors harmful to health and analyse the causes of accidents at work in foundries.

2. HARMFUL FACTORS FOR HEALTH IN FOUNDRY

In foundries there is a significant concentration of harmful and arduous factors at many workplaces. Depending on the type of foundry, technologies, raw materials, machinery and equipment used, this is due to:

- air pollution with dust:
    - respirable containing free crystalline silica and metal oxides,
    - containing carbon dioxide, sulfur dioxide and nitrogen oxides,
    - organic substances including polycyclic aromatic hydrocarbons, phenol, toluene and xylene derived from the addition of masses and binders.
- noise, vibration,
- high temperature,
- significant energy expenditure of employees.

Dust occurs during mass processing, forming, core making, punching, cleaning and finishing of castings - this is another important problem. The main component of dusts is free crystalline silica, which negative effects on the organisms of exposed workers must be assessed primarily from a medical point of view. In addition to the problems mentioned, there is also a factor in the form of: high labor intensity and arduousness in performing many operations [4,5] of the technological process of making the cast, e.g. regeneration and processing of molding and core sands, manual molding, melting, pouring liquid metal into the mold, breaking, cleaning and finishing castings. Foundry processes generate many hazards occurring both at the workplace and for the environment [6].

Molding and core sands used in production processes, the basic component of which is quartz sand and organic or chemical binder, after their use are transferred to the landfills of used foundries, and then to separated landfills. Because such masses often contain chemical compounds that are not indifferent to the environment, such landfills require special protection. Working environment conditions in the foundry are determined not only by the number of factors but also by the intensity of the given harmful factor. The most harmful is the occurrence of several factors at the same time - noise, vibration, dust and high temperature. In addition to the factors mentioned above, the work environment is also influenced by factors related to the organization of the workplace as well as the so-called internal logistics regarding the organization of transport routes inside the foundry. Common problems include maintaining order in the workplace, no 5S practices as well as poor lighting. Due to the nature of high concentration of technological processes and location and spatial requirements, there is a phenomenon of the spread of harmful factors between positions. The occurrence of these threats is often the cause of occupational diseases of employees in the foundry. The most common diseases are:

- pneumoconiosis,
- chronic bronchitis,
- vibrating unit,
- hearing damage,
- respiratory tract infection,
- skin diseases.

According to the assessments presented by the National Labor Inspectorate, noise in the foundry industry is one of the largest industrial threats and accounts for 45 % of all threats. In second place, only 25 % is pollination, then 6 % toxic compounds, 7 % vibrations and 25 % are other factors of the working environment (mechanical hazards, lighting, microclimate, biological pollution, electromagnetic field, etc.). Machines and devices used in the foundry industry are the loudest of all industries. These are: shock molding machines, shock grates, drum cleaners, transport lines, ventilation systems, molding machines, compressed air discharge, grinding machines, etc. The average noise level for this group of machines is 90 to 125 dB (A) [7]. That is why the noise in foundries is, therefore, the most frequently exceeding the acceptable norms element of threat to the working environment. Its occurrence, which has been proven [8,9,10], contributes to a high number of accidents and injuries, sickness absence (including non-accidental absenteeism) and, moreover, economically most important – low productivity and quality of work [11,12]. Foundries differ not only in the

technology used but also in the organization of work. **Figure 1** shows the general block diagram of foundry processes. At particular stages, we are dealing with a different level of occupational risk resulting from different levels of accumulation of harmful and dangerous factors.

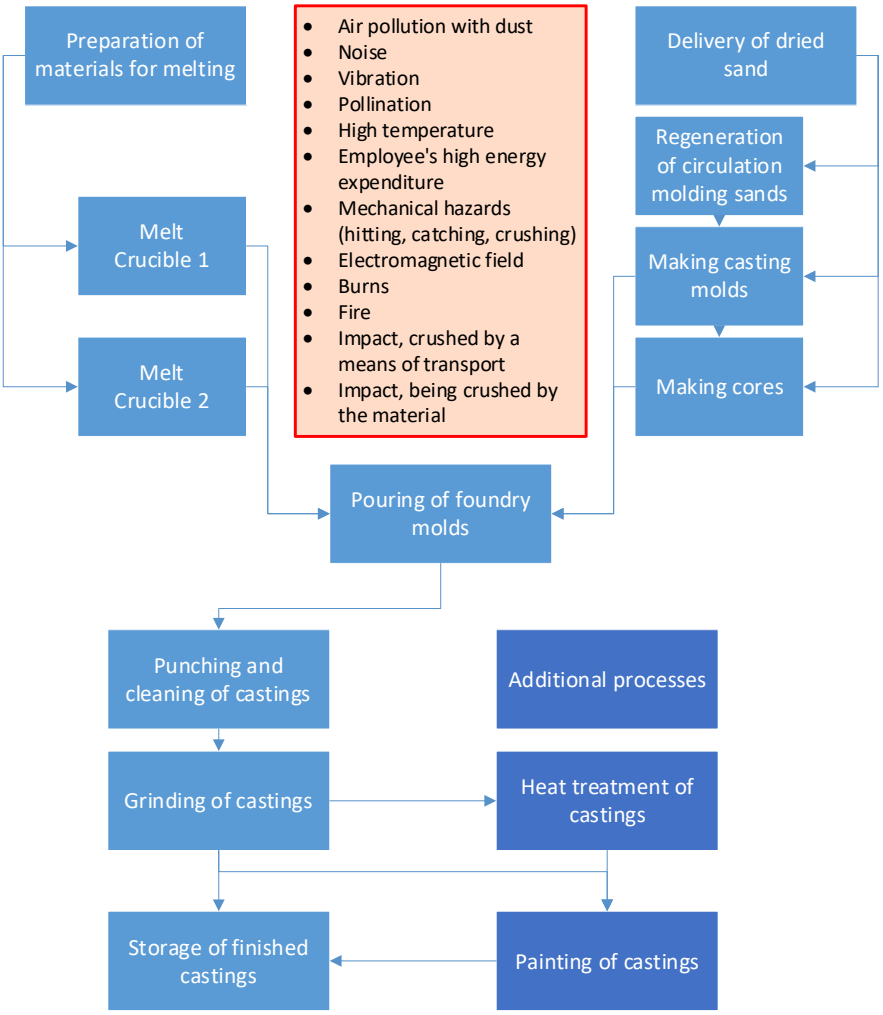

Figure 1 Block diagram of foundry processes

3. RESEARCH AND DISCUSSION

Research on the state of occupational safety and hygiene in metal foundries was carried out in 2018 in metal foundries from the Śląskie and Małopolskie voivodships in Poland. Approval for testing was granted by 10 foundries. Eight research subjects were classified as small and medium enterprises and two foundries into large enterprises employing over 250 employees.

The research was divided into several areas:

1) Analysis of recorded accidents and potentially hazardous events.
2) Documentation analysis (training, occupational risk assessment, medical examination dates, workplace control documentation, machine and equipment maintenance documentation, etc.
3) The actual state of the workplace and hygiene and sanitary facilities.
4) Assessment of the state of knowledge regarding hazards and hazardous factors in the foundry (at work stations).
5) Level of monitoring and registration of harmful factors.

In the second area, it was found that health and safety services in research facilities operate in accordance with applicable law. Employees of health and safety services conduct training in the field of health and safety for employees, assess occupational risk, control the dates of medical examinations, and carry out job control. In the investigated casts, there was no lack of health and safety training for employees, in the case of medical examinations, there was lack of 8 current medical examinations in one plant. All foundries have documented occupational risk assessments. There was no lack of health and safety instructions. Unfortunately, large quality gaps were found in the assessment of the risk as well as health and safety instructions. In the case of occupational risk assessment, the cards were prepared in a very general way without focusing on the given area of work. In many cases no harmful factors or the level of their permissible occurrence were given. In the case of health and safety instructions, there was no update compared to the actual state of the workplace, as many as 15 cases of outdated health and safety instructions/procedures were detected. The instructions referred to either non-existent devices or non-binding legal provisions.

The factor affecting the existing state is the fact that persons developing risk assessment documentation and procedures have diverse knowledge and knowledge of regulations, which has a significant impact on the quality of such studies. It should be stated that the occupational risk assessment cards are not treated in the foundries analyzed as a tool for a permanent improvement of working conditions. Unfortunately, the practice of treating work cards as a formal requirement that is not subject to analysis and updating is common. With the update, we only have to act on the recommendations of control bodies as well as in the implementation of larger investments.

In the third area, it was found that the condition of work rooms as well as hygiene and sanitary facilities meets the requirements of applicable regulations. In the case of workplaces, in several cases a condition was found that could directly contribute to a potentially dangerous event. The most common problem identified is blocking the transport / evacuation route and a permanent mess at the workplace. The reason for this is the lack of supervision over the employee, the lack of appropriate procedures and the low awareness of the employee about the effects of such a state on the level of safety. It has been found that the machines are not properly adapted to the minimum health and safety requirements regarding their use. This applies, for example, to mixers for molding and core sands as well as wood and metal processing machines. The most common problem is the lack of protection against contact of the employee with moving machine parts as well as the lack of adequate protection against contact of the employee with hazardous and harmful chemical substances (scald, corrosive).

In the fifth area, it was found that all plants conduct research and measurement of harmful factors. The data provided reveals that in half of the foundries surveyed there is a problem with the implementation of the provision regarding the reduction of concentration and intensity to NDS value (maximum allowable concentration) and NDN value (maximum allowable intensity). In the case of two of the five foundries with the problem of exceeding the threshold limits, an investment program related to the change of technology is adopted. In the other three foundries, organizational and technical programs aimed at reducing harmful factors were not developed. These foundries are subject to the use of safeguards limited only to the protection of employees with personal protective equipment. In all foundries, employers comply with the provisions on employee equipment regarding clothing, footwear and personal protective equipment. In two cases only the lack of valid attestations/certificates for personal protective equipment was found. Unfortunately, the low level of knowledge of both employees and managers regarding health and safety regulations is alarming. As a consequence, shortcomings were found in the area of water rescue showers, lack of eye wash equipment, incorrect or lack of markings, safeguards and requirements for the crane.

Based on the data obtained from the foundries tested and interviews with employees and management, it should be stated that not all potentially dangerous events and minor accidents are recorded. The following structure of accidents and potentially dangerous events in percentage terms was found for the analyzed research group:

- being hit, caught, crushed by machines and their parts, devices and tools (38 %),
- burns - human contact with liquid metal and slag (19 %),
- impact, crushing by material factors transported mechanically or manually (17 %),
- impact, being crushed by a falling, spilling material factor (11 %),
- fall from a height (7 %),
- employee contact with hazardous and harmful chemic substances (7 %),
- explosion, fire (1 %).

Analyzing the structure of accidents and hazards potentially dangerous according to the seniority of employees, it was found that in nearly 40 % of cases, they were employees with a year and less seniority. The second group were employees with experience from 2 - 3 years. The main cause of accidents is improper behavior of the employee – It accounts for 50 % of all causes of accidents, then improper operation of machinery and equipment, which is about 11 %, technical condition of devices and inadequate covers or lack of covers 9 %, improper organization of the workplace is responsible for 6 % of accidents.

The results obtained in the research coincide with the statistics of accidents for the group "metal production" in 2018 (statistical year). In Poland, 930 accidents were reported during this period, including two serious accidents and, importantly, no rare fatal accident was recorded. The cause of 767 accidents was the improper condition of the material factor, 507 improper organization of work, 588 improper organization of the workplace, 1023 improper handling of a material factor by an employee, 237 lack of protective equipment, 717 improper arbitrary behavior of an employee, 103 improper psychophysical condition of an employee and 5102 improper behavior of an employee.

4. CONCLUSION

The reason is the sum of the conditions necessary to meet the specified effect. When determining the causes of accidents, analyzes of relationships between elements of the production process are carried out and the conditions that did not affect the occurrence of the effect are rejected. This problem is considered using the human-machine model, analyzing the factors that cause interference in its functioning. Improving working conditions in castings is not always due to long-term planning of their improvement. It often happens that the adjustment of working conditions is a phenomenon accompanying investments of a different nature. Nevertheless, along with the improvement of working conditions, the company benefits in other areas. In many cases, legal requirements cannot be included in investment plans. This is due to their different release and entry dates. In order to improve the safety of foundries, it is advisable to take preventive measures, in particular to increase the emphasis on proper preparation of production processes [13,14] and to properly carry out maintenance, inspections and repairs, and to increase management's interest in issues related to preparing employees for work. It is also advisable to introduce appropriate diagnostic and control measures [15]. The transformation 4.0 is a big challenge for the foundry industry, which is also entering the foundry industry [16,17, 18]. Such approach may be useful in similar hazardous environments e.g. laser machining [19,20], biotechnology [21,22], alloys production [23,24] or waste management [25]. Mentioned risk factors should be taken into account in decision support systems [26,27] with additional uncertainty quantification and analysis [28,29].

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