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THE USE OF IT TOOLS IN THE ACCIDENT INVESTIGATION AND ANALYSIS PROCESS BASED ON THE EXAMPLE OF FOUNDRIES

WYKORZYSTANIE NARZĘDZI INFORMATYCZNYCH W PROCESIE BADANIA I ANALIZY WYPADKOWOŚCI NA PRZYKŁADZIE ODLEWNI

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Summary: Accidents at work sooner or later affect every enterprise. It is the employer's responsibility to ensure safe working conditions by determining occupational risk at all workplaces, combating sources of danger, and providing employees with relevant information and instructions. This is one of the effective ways to reduce the number of accidents at work. The purpose of the article is to analyze accidents at work in the period 2014-2018 in a selected foundry enterprise in Wielkopolska. The scope of the article includes a summary of the data from the Central Statistical Office, the characteristics of the enterprise, and the hazards occurring in the foundry process. An analysis and assessment of accident rates at the foundry in the same period were also presented. The assessment was based on accident rates, on the basis of which the work station most vulnerable to accidents was determined.

Keywords: accidents at work, industrial foundry, safety, hazards.

Streszczenie: Wypadki przy pracy prędzej czy później mogą dotknąć każde przedsiębiorstwo. Obowiązkiem pracodawcy jest zapewnienie bezpiecznych warunków pracy przez określenie ryzyka zawodowego na wszystkich stanowiskach pracy, zwalczanie źródeł zagrożeń oraz udzielanie pracownikom odpowiednich informacji i instrukcji. Jest to jeden ze skutecznych sposobów zmniejszenia liczby wypadków przy pracy. Celem poniższego artykułu jest analiza wypadków przy pracy w latach 2014-2018 w wybranym przedsiębiorstwie odlewniczym na terenie Wielkopolski. Zakres artykułu obejmuje podsumowanie danych GUS, charakterystykę przedsiębiorstwa, zagrożenia występujące w procesie odlewniczym. Przedstawiona została

również analiza i ocena wskaźników wypadków w odlewni w latach 2014-2018. Oceny dokonano, opierając się na wskaźnikach wypadków. Na tej podstawie określono miejsce pracy, gdzie istnieje największe ryzyko wypadków.

Słowa kluczowe: wypadki przy pracy, odlewnia przemysłowa, bezpieczeństwo, zagrożenia.

1. Introduction

Towards the end of the 20th century and at the beginning of the 21st century, the very rapid development of technology in global terms was observed. This is noticeable in many areas of life, such as medicine, communication, military, astronomy and computer science. The development of technology and the associated intensive development of technology in industry, in which the production process is carried out in the "human – technical object – environment" system, where each of the system components is the source of a number of risks and disruptions that have a negative impact on human work. An unfavorable work environment occurring for a longer period of time in the form of noise, vibration, dust or heat radiation at work stations may cause reduction of employees' mental and physical fitness as well as impede their recovery. Prolonged exposure to such conditions exposes employees to various kinds of hazards, which often lead to accidents at work. "An accident at work is a sudden event caused by an external cause causing injury or death that occurred in connection with work" (Ustawa z dnia 30 października 2002…). An accident at work can be caused not only by a machine operator but also by a person spending the whole day behind a desk. The article presents the methodology of analysis and assessment of accident rates in industry using data from the Central Statistical Office (GUS) and a selected enterprise from the steel-making industry in the period 2014-2018. Accident rates were examined for the assessment and analysis. The conducted analysis shows the level of accidents at work depending on the adopted criterion. Based on the analysis, the jobs with the highest accident rate were determined.

2. Accidents at work according to Central Statistical Office data

The steel-making industry, despite the increased number of methods of protection against harmful factors that affect the quality of work, is still characterized by a significant level of accident rates. According to data from the Central Statistical Office, during 2014-2018 there were 4289 accidents in that sector, of which 48 were serious and 11 fatal. The highest accident rate was recorded in 2014. Figure 1 presents data on the number of accidents broken down into major, fatal and minor accidents. It can be seen that in 2015 the largest number of fatal accidents occurred, i.e. 19, which in subsequent years was halved, and in 2017 there were 'only' three fatal accidents (Główny Urząd Statystyczny [GUS], 2014-2018).

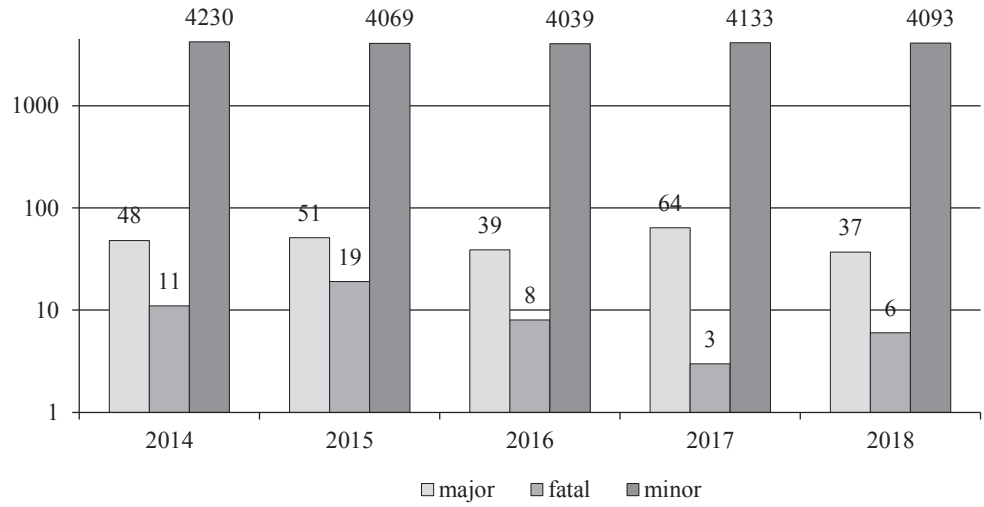

Fig. 1. The number of accidents at work broken down into fatal, major and minor in the period 2014-2018

Source: own study based on (GUS, 2014-2018).

Figure 2 presents the analysis of the number of accidents since the analyzed time (2014-2018). In 2014, 4,289 accidents were recorded, which decreased in 2016 to 4,039 accidents. However, in 2017, the number of accidents increased again (4,200). In 2018, accident rates dropped to 4,137.

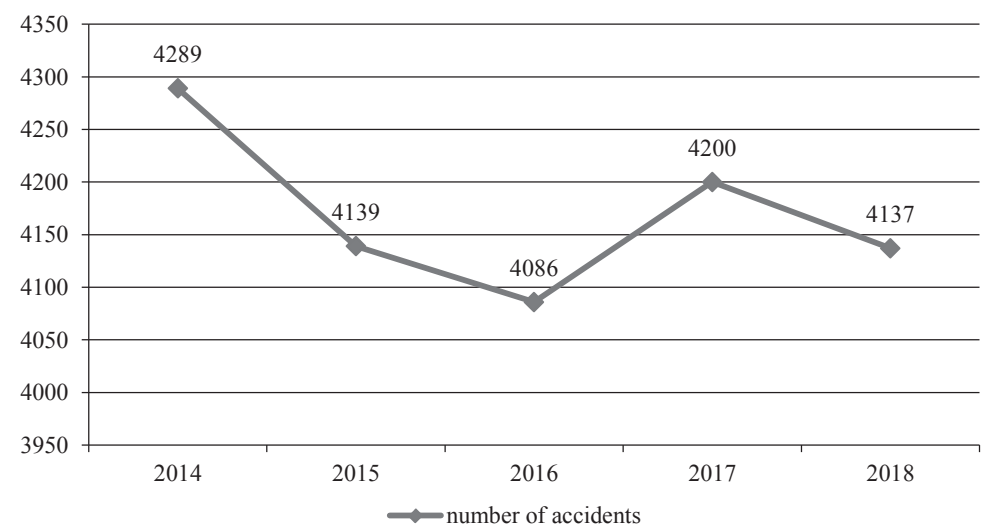

Fig. 2. Dependence of the number of accidents per year

Source: own study based on (GUS, 2014-2018).

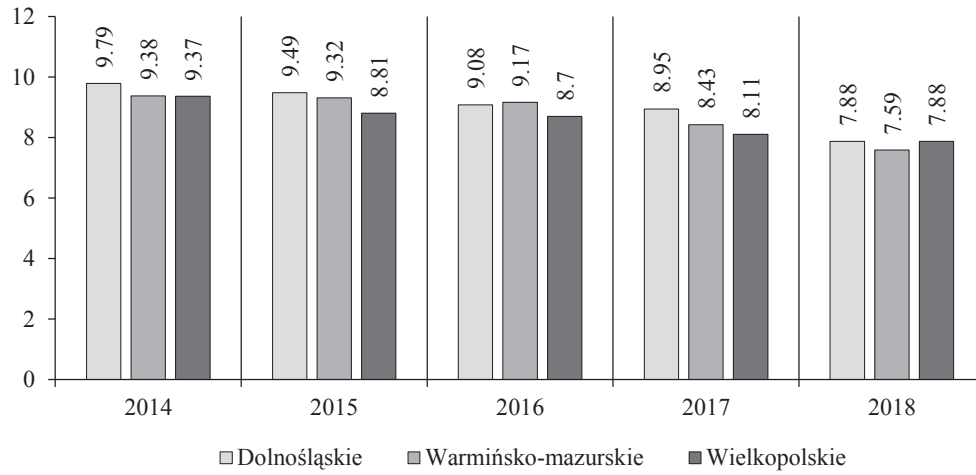

Fig. 3. The highest accident rate by voivodeships

Source: own study based on (GUS, 2014-2018).

Wielkopolska is one of the voivodeships in which the highest accident rate was recorded over the years studied, as can be seen in Figure 3.

3. Causes of accidents at work in the casting production process

The casting production process is carried out in the "human – technical object – environment" system, and the risk of an accident applies to all elements of this system. Interference in the operation of any of the elements may lead to a deterioration of human health (Rut and Pytel, 2014).

An event can be considered an accident if four conditions are met:

- the event must be sudden – an external cause must occur immediately and cause a specific effect, e.g. burns, electric shock,
- caused by an external factor – it cannot depend on the conditions of the human body, furnishings, machinery,
- occurred in connection with work – while carrying out superiors' orders, for the employer or during the employee's stay on the plant premises,
- caused injury or death, e.g. fracture, burn, amputation (Chojnicki and Jarosiewicz, 2018).

The main causes of accidents and injuries at work include technical, organizational and human reasons.

Technical reasons:

- inappropriate safety devices or lack thereof,
- incorrect operation of machines,
- insufficient stability of the material factors,

- inadequate collective protection measures or lack thereof,
- hidden material defects.

Organizational reasons:

- no or incorrect instructions for use of the machine, device or tool,
- lack of proper supervision over employees,
- lack or inappropriate training of employees in the field of health and safety,
- acceptance by the supervisors of departures from health and safety rules,
- inappropriate organization of work stations,
- excessive exploitation and improper repairs of the material factor,
- allowing an employee to work without the required tests or with contradictory indications (Siudak and Smal, 2016).

”Human causes:

- incorrect behaviour of the employee (disregard for danger and official orders, insufficient concentration of attention on the performed activity, surprise by an unexpected event, being rushed),
- incorrect, arbitrary behavior of the employee (performing activities without removing hazards, e.g. not turning off the machine or the power supply, incorrect use of limbs (arms and legs) in the danger zone, entering or entering the hazardous area without ensuring that there is no danger),
- employees' failure to use personal and collective protection equipment and safety devices (fall protection devices, ventilation devices, guards)" (Portal Asystent BHP, 2015).

4. Threats occurring in the tested foundry

The audited company has been in operation since 1989. In 1990, export production developed, and in 1991 the production and sale of grey and ductile iron castings in sand moulds became the core business. The years of 1996 to 1998 were a time of strengthening the company's position on the domestic foundry market.

Care for the natural environment and employee safety is the highest priority for the foundry's management. The guidelines of management policy are presented in the Policy for the Quality of Environmental Management and Occupational Health and Safety. The company has been awarded many certificates such as:

- Quality Management System certificate according to the requirements of the PN-ISO 9002 standard,
- Quality Management System certificate according to the requirements of the EN-ISO 9001: 2000 standard,
- certificate confirming compliance with the requirements of the Pressure Directive 97/23 / EC,
- integrated permit for operating installations for the production of iron castings,
- Microsoft SAM certificate confirming the use of legal software in the company.

The foundry's organizational structure consists of eight departments which report to the President. The construction and technology department is responsible for developing the construction and technology documentation based on the client's requirements. The foundry department is responsible for preparing production, including foundry equipment and for the process of casting grey and ductile iron castings in sand moulds. The mechanical department is equipped with modern and universally used machines (lathes, grinders, milling machines, boring machines and machining centers) to ensure the efficiency of machines, devices and the supply of technological media to work stations. The sales department is responsible for contacting the customer and proper order processing, from the product enquiry to shipping. The quality control department secures the quality of products and maintains and improves the requirements related to the integrated management system. The administrative department is responsible for staff and the secretarial office. The finance department responsible for all matters related to the company's finances. The company currently employs 227 highly qualified employees.

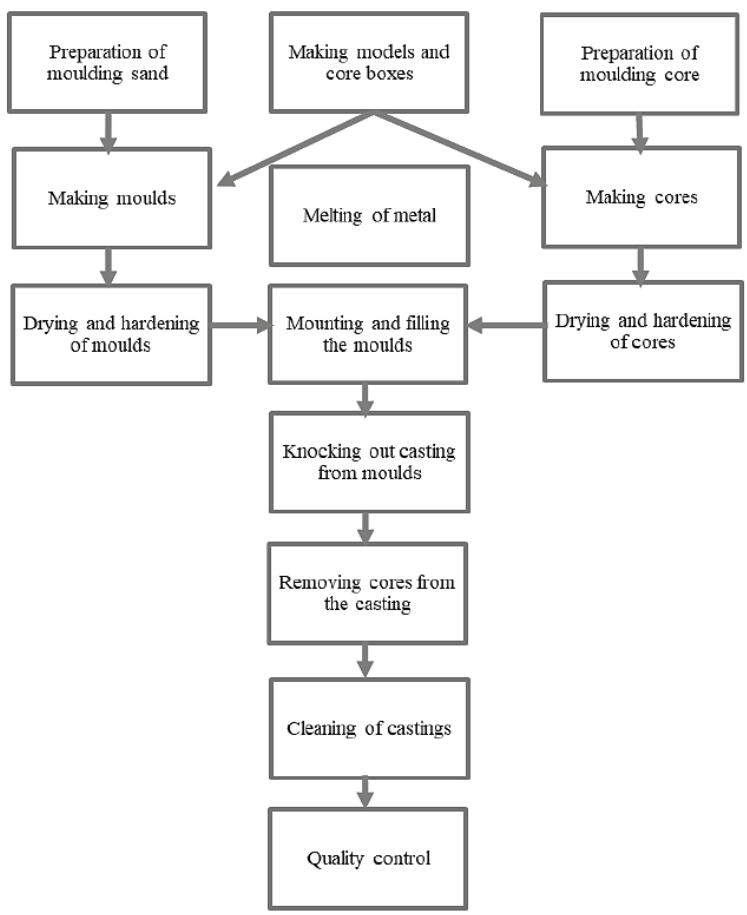

Fig. 4. Diagram of the main casting production processes in the studied foundry

Source: own study based on (Siedlecki, 2006).

The working environment of employees in the steel-making industry is associated with specific working conditions, because there are a significant number of occupational hazards. This applies especially to noise pollution - relevant for this industry, the high temperature of conducted processes, as well as the presence of harmful chemicals and dust (Rajca, 2017). Figure 4 shows a block diagram of the main production processes of grey and ductile iron castings in sand moulds.

- Making models and core boxes.

Various materials, such as wood, metals, rubbers, plastics, and foamed polystyrene are used to make models and core boxes, which are flooded with liquid metal. During this process, a large amount of harmful chemicals, gases and fumes are generated. When making models and core boxes, machines and machines for machining are used, which may pose hazards.

- Preparation of moulding and core sands.

Moulding sands, and above all core ones, are very harmful to the environment at all work stations, starting from transport, preparation of raw materials, ending with knocking out and cleaning of castings. The threat is primarily associated with the presence of harmful dust particles and gases. In the moulding sand preparation processes, there are injury hazards resulting from contact with moving drive parts or working parts of machines and devices, the risk of falling or electric shock. Most accidents occur during this process as a result of a lack of safeguards or working while the machine is moving.

- Making moulds and cores.

Automatic moulding machines and automated foundry lines are used to make the moulds, which create hazards such as noise, vibration and dust, injury hazard (overturning a stack of boxes on employees, tripping over tools, molds, hitting boxes and causing eye injuries when cleaning the models). During machine forming, however, most often accidents occur during the operation of machines.

- Drying and hardening of moulds and cores.

The drying temperature ranges from 150-600^{o}C depending on the type of binding material used. Moulding sands are also used, in which the setting takes place through hardening due to chemical reactions between the components. During this process, personal protective equipment (safety glasses and gloves) is necessary.

- Melting of metal

Various types of furnaces are used for melting metals, depending on the technological properties of the alloy, such as liquid and gas crucible furnaces, flame furnaces, electric furnaces and cupolas. Work on the smelting and preparation of metal is associated with many accidents, such as liquid metal burns, poisoning with harmful substances, electric shock (electric furnaces) or falls from a height. A large number of the alloying elements used have toxic effects.

- Mounting and filling the molds

During montage and pouring molds, typical hazards are liquid metal burns and exposure to emitted products of thermal decomposition of moulding and core

components into the work environment. Employees may also be exposed to excessive physical strain.

- Knocking out castings from moulds and removing cores from castings.

The casting process is one of the most difficult technological processes in the foundry. The knockout noise can even reach 110 dB, dust particles are released, which under the influence of machinery vibrations rise and spread throughout the hall.

- Cleaning and finishing of castings.

Finishing the surface of castings first consists of removing the filler and supply system and removing unevenness by grinding. These treatments are done manually. These are the most labour-intensive and potentially harmful to health activities. They are accompanied by noise, dust, vibrations and trauma hazards.

- Quality control.

The final stage of casting production is quality control which involves conducting tests that determine the suitability of the product that guarantees safety at work. The hazards occurring during the test occur mainly in connection with ionizing radiation, which should be kept to a minimum because it may cause irreversible effects on health (Siedlecki, 2006).

5. Accident analysis of the selected foundry

One of the basic measures, namely accident rate, was used to assess and analyze the state of safety at the foundry in 2014-2018. The analysis allowed for the presentation and comparison of accidents, determination of the prevailing safety level, identification of significant hazards and determination of the work stations most exposed to accidents.

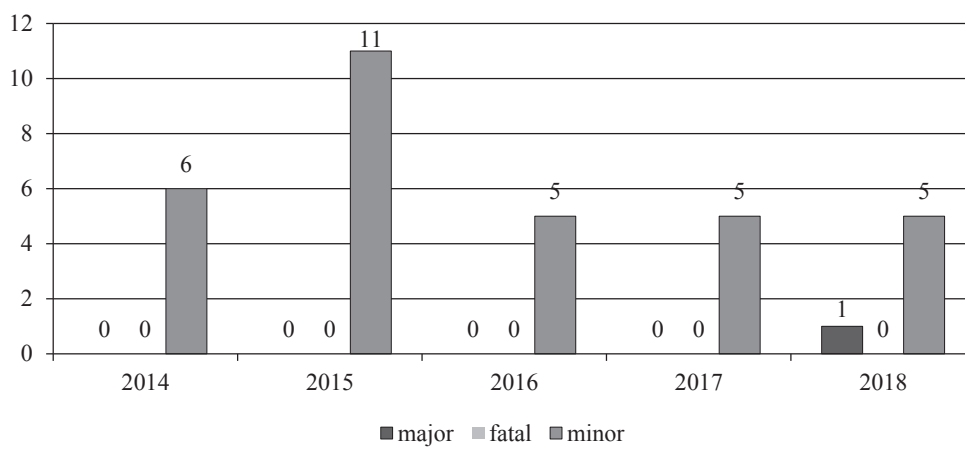

Fig. 5. Number of accidents at work broken down into fatal, major and minor in 2014-2018

Source: own study.

The analysis showed (Figures 5 and 6) that in 2015 the highest number of recorded accident events was 11. All were classified as minor accidents. In the following years the number of accidents was halved, with a major accident occurring in 2018. It can also be noted that there were no fatal accidents during the period under review, which may lead to a conclusion that the adopted methods or implementation of the continuous safety improvement program and the analysis of potential threats, which are necessary elements for effective risk management in the enterprise, did not fail.

In the next stage of research and analysis, Figure7 presents the causes of accidents at work, broken down into human, technical and organizational reasons.

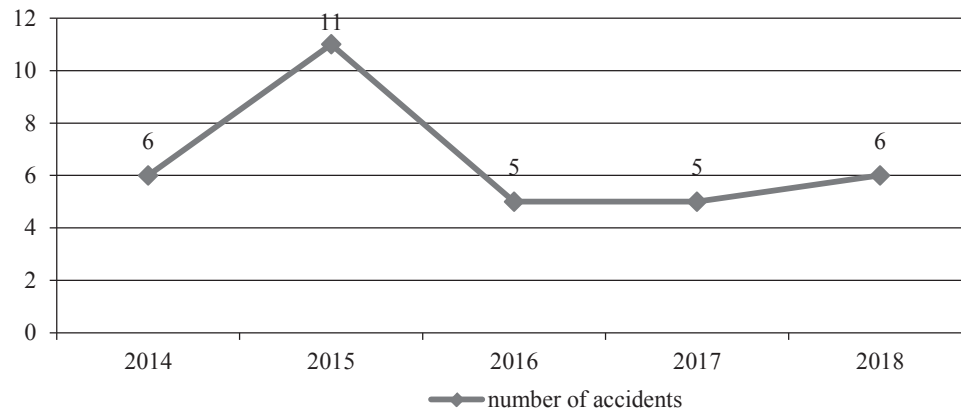

Fig. 6. Dependence of the number of accidents per year

Source: own study.

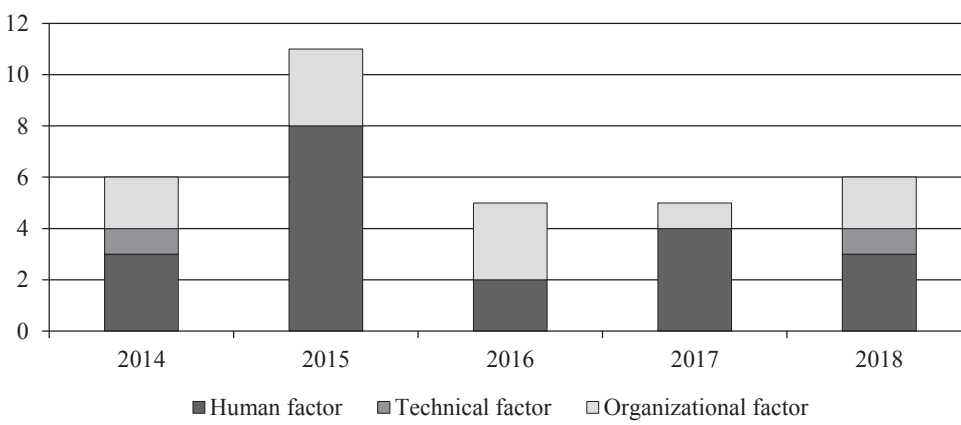

Fig. 7. Causes of accidents at work in 2014-2018

Source: own study.

The analysis of the causes of accidents at work in the period 2014-2018 allowed stating that the largest number of accidents occurred due to human and organizational reasons. The number of accidents due to these causes has dropped significantly since 2015, but it is still the dominant one. Most often, accidents due to human causes were caused by:

- insufficient focus on the activity being performed,
- disregarding danger,
- employees not using personal protective equipment,
- incorrect use of the arms and legs in the danger zone.

It was also noted that most of the accidents concerned employees with limited work experience, i.e. less than a year, and employees with more than 12 years of service. It can be stated that in the case of employees with short experience, accidents are caused by lack of experience, while in the case of long-term employees the disregard of risks and the failure of employees to use personal protective equipment.

Figure 8 shows the number of accidents at various workplaces in the steel-making enterprise. The figure below shows that the smelter is the most loaded work station in the examined plant. The employee in this position is exposed to harmful factors such as: high temperature, excessive noise, dust, physical effort, and heat radiation. The smelter's position is on the list of work stations where work is carried out under special conditions and this is in line with the list of positions of a special nature in the work stations of the department of metallurgy and machine industry. Positions least exposed to accidents are quality controller, administrative staff and driver.

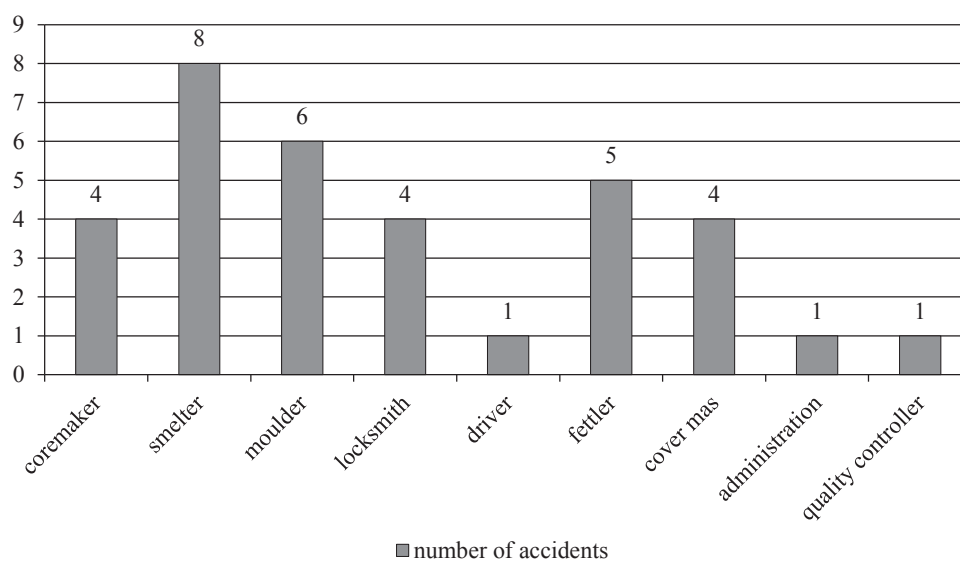

Fig. 8. Accidents in 2014-2018 according to the work stations of the victims

Source: own study.

At a later stage of research and analysis, comparisons of the status of accident were made based on the frequency and severity of accidents' indicators. The accident rate is an accepted indicator that allows to compare the level of accident rates in various enterprises in terms of employment and is calculated according to the formula:

$$W = \frac{\textit{the number of persons injured in accidents at work}}{\textit{number of persons employed in the audited enterprise}} \times 1000.$$

However, the severity of accidents is calculated from the formula:

$$W = \frac{\textit{the sum of sick leave days in the reporting period}}{\textit{number of accidents} - \textit{number of fatal accidents}}.$$

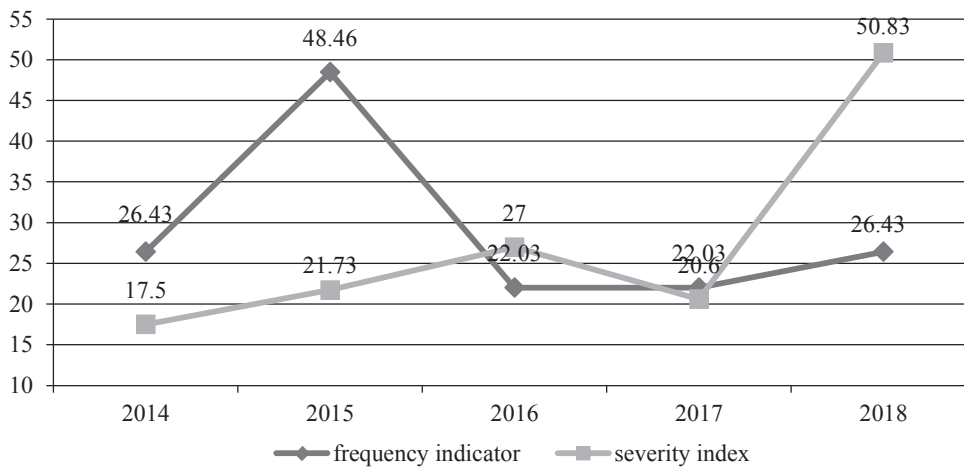

Fig. 9. Dependence of indicators on the frequency and severity of accidents in 2014-2018

Source: own study.

Data on the accident frequency index and their severity are presented in Figure 9. The highest accident frequency index was recorded in 2015 and amounts to 48.46, while the lowest was in 2016-2017. The highest severity index was recorded in 2018 at 50.83; there was a serious accident as a result of which the injured party was on sick leave for 182 days and the number of days of sick leave of all the employees was 305. The lowest severity index was recorded in 2014, in which the company lost 105 working days in total.

6. Conclusion

Based on the research and analysis carried out, it can be concluded that the most accident-prone work station in the foundry is the smelter. There are many dangers in this position, including high temperature, noise, and dust. The above analysis allows conclusions to be drawn regarding the need to apply measures that minimize or eliminate hazards through OHS training, on-the-job training and the introduction of technical innovations. The analysis also showed a downward trend in the occurrence of accidents throughout the entire period 2014-2018 there was only one serious accident, which may mean that employees are increasingly aware of the risks. Studies also show that seniority also has a significant impact on accident rates. Most often accidents are caused to young, inexperienced employees whose seniority does not exceed one year and employees with extensive experience who fall into routine. It should also be remembered that humans are not infallible and accidents cannot be avoided, however they should be monitored. Fewer accidents mean a safer working environment and fewer losses for the company.

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