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SYSTEM SAFETY: HUMAN - TECHNICAL FACILITY – ENVIRONMENT
6(1), 2024, pp. 485-492

OCCUPATIONAL SAFETY MANAGEMENT IN STEEL MILLS DUE TO INTER-BRANCH TRANSPORT

DOI: 10.2478/czoto-2024-0049
Received: 13/11/2024
Accepted: 31/12/2024

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Abstract: The article is devoted to the subject and management of occupational safety in steel mills in connection with interdepartmental transport. The risk of accidents at work related to interdepartmental transport in steel mills is very high, therefore in the first part of the article, literature research was undertaken to determine the specificity of the steel production process. The second part uses research in the form of environmental interviews and determines the risk of inter-work transport on individual epaps and indicates actions that may reduce the risk of accidents at work in the steelworks in the future. The last part contains recommendations to increase safety in steel mills based on field research.
Keywords: safety management, risk, steel mills, accidents at work, hazards

1. INTRODUCTION

Intra-faculty transport in the areas of the station is a very risky task. Due to its specificity, this transport poses many challenges to logistics operations in terms of safety (Niciejewska, 2017).. Effective management of the safety of logistics processes is aimed at minimizing accidents at work, loss of goods, as well as downtime related to the consequences of accidents at work (Venkataraman, 2022).

The main objective of the article is to indicate the greatest hazards occurring in inter-mill transport in steel mills. The main novelty is field research of employees from various professional groups and the analysis of threats in order to determine their key indications. Further in the article, literature research was undertaken, extended by community interviews, in order to determine the greatest risks resulting from inter-mill transport in steel mills.

The steel production process is very complex because it consists of many very specialized processes in which five main phases of the production process are distinguished. The diagram is shown in Figure 1.

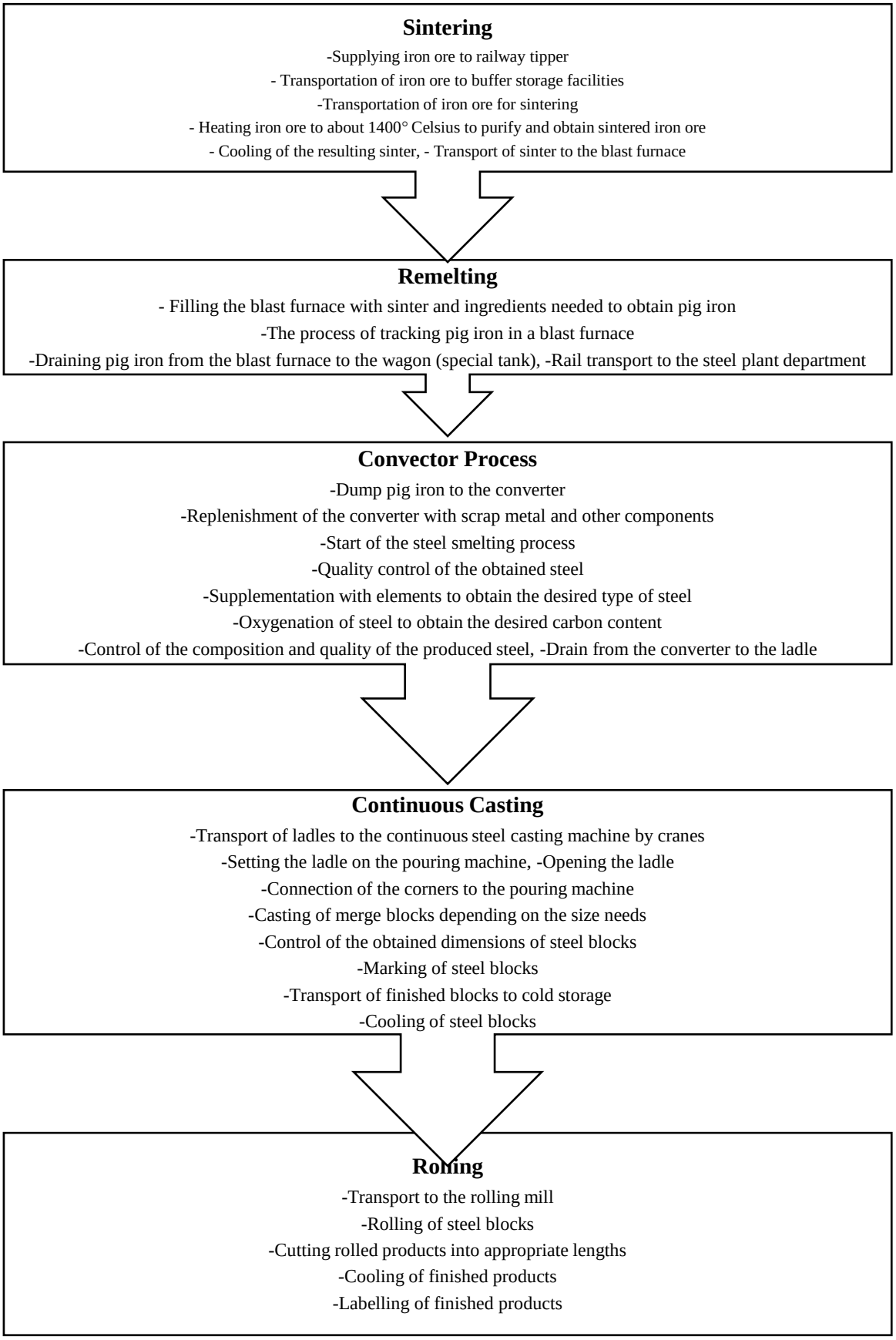

Fig. 1. Steel production process flow

Source: Author's own elaboration

The first stage of steel production is the sintering of iron ore. This process is carried out with the use of gas on a moving grate. The main task of additives at this stage is, among other things, to remove impurities.
Smelting takes place in a blast furnace, where the previously formed charge is melted into pig iron. It is a liquid mixture of iron and other impurities At this stage, pig iron still has too many impurities to be suitable for production. The carbon content at this stage is more than 3% (Singh et al., 2014).
The convector process ensures the separation of undesirable by-products from the liquid pig iron. The previously produced charge is applied from the top of the tank. The process involves blowing the mixture with air at a temperature of 900 to 1100 degrees Celsius. As a result of the process, the coal is burned out, resulting in steel (Iu, 2021). At this stage, in order to obtain steel with the desired parameters, alloying additives are added, which are variable depending on the required parameters, such as:

- hardness of steel,
- tensile strength,
- extensibility and ductility

The next stage is still casting steel. The resulting steel is poured into a catalyst, which allows it to solidify and maintain its specific shape. After being pulled out of the mold, the resulting block is cut to the desired length and then cooled. The resulting steel blocks are transported to the rolling mill.
The last stage is rolling, which consists in shaping the steel into the desired shape by rotating rollers. Rolling can be done cold or hot – after the steel has been warmed up).
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The last stage is rolling, which consists in shaping the steel into the desired shape by rotating rollers. Rolling can be done cold or hot – after the steel has been warmed up).
It is worth noting that between the melting process and the convector process, pig iron is transported using special transport tanks mounted on the railway tracks leading between the departments. This is a very dangerous process, because the liquid pig iron is

transported very quickly to the convector tank in order to reduce the temperature loss as much as possible. With the longer transport time, the pig iron cools down and reheating it generates very high costs. Waiting too long for the consequences will lead to its complete freezing. Both in the process of loading and unloading liquid pig iron, there may be many hazards resulting mainly from high temperatures. The next transport takes place between the convector process and the continuous casting. Once the liquid steel is properly prepared and contains any alloying additives, it is transported through the tank by means of a gantry. You are more likely to risk the expense of the process because the steel is heated to such a temperature that a small amount of water can cause an explosion. The metallurgical industry poses many challenges in terms of safety in transport. Due to the characteristics of the industry and the high temperatures, as well as the weight of the materials to be transported, machinery and transport equipment must meet a number of requirements (Rushton, et al., 2022).

2. EXPERIMENTAL

After an in-depth literature analysis, field research was proposed to verify the hazards occurring in the areas of steel mills. The research was carried out using the method of community interviews. They were carried out from 4 to 7 March 2024 on the premises of steelworks x. The entity has not agreed to disclose its name and location, which is why it is referred to as x in this publication. The study was conducted with six employees from different departments:

- The operator of it casts steel, whose main task is to operate the continuous steel casting machine. He works in an eight-hour system in three shifts.
- The head of the steel plant department, who is responsible for managing human resources and machinery in order to maintain the continuity of production,
- crane worker of the continuous steel casting hall whose main task is to operate the crane and transport the steel ladle to the continuous casting machine,
- Head of the Occupational Health and Safety Department of the Steel Mill, who is responsible for maintaining occupational health and safety in all departments of the audited steelworks,
- operator of healing machines, whose main task is to properly set and maintain the production rate of steel casting,
- Head of the Continuous Steel Casting Department, who is responsible for maintaining the appropriate production efficiency and maintaining the quality of the steel produced.

The research was carried out in order to identify hazards and propose solutions to reduce the risk of accidents at work. After conducting all the community interviews, table number one was developed, which presents the indicated threats and the indicated solutions of individual employees.

Table 1. Field Studies with Steel Mill Workers

Interview number	Position	Identified risks	Recommended solutions
1	Continuous Steel Casting Machine Operator	- high temperature, - risk of crane ropes breaking, - the risk of unstable placement of the ladle in the pouring machine,	- higher quality protective clothing, - periodic inspections of machines,

		- crushing -noise	-employee turnover -hearing protectors
2	Head of the Steel Plant Department	- the risk of improper gripping of the ladle by the crane, - improper placement of the ladle to the pouring machine, - human error - burns - Being caught by moving parts of machinery and equipment --noise	- employee turnover, - periodic trainings, - use of accident protection systems, -hearing protectors
3	Crane worker of the continuous steel casting hall	- breaking of crane ropes, - failure of security systems, - employee inattention, - uncontrolled lifting and/or lowering of the ladle -noise -chemical hazards (sulphur teloxides, nitrogen oxides)	- periodic inspections, -employee training, - employee turnover, - Use of safety signs, -hearing protectors **- Electro filtration**
4	Head of the Occupational Health and Safety Department of a steel mill	- burns, - moving elements of machinery and equipment, - crushing, - rapture, - cut, - Death of an employee -noise	- use of personal protective equipment, - periodic employee training, - shaping the occupational health and safety culture among the employees of the steel mill, -hearing protectors
5	Hopper Operator	- tiredness - lack of concentration, - dispersion - high temperature -noise	- increased interruptions in work, - frequent changes in position, -hearing protectors
6	Head of the Continuous Steel Casting Department	- damage to crane ropes, - incorrect installation of the ladle, - human error -noise	- periodic inspections of the crane's technical condition, - employee training, - application of occupational health and safety audits, -hearing protectors

Source: Author's own elaboration

As the field tests of the employees showed, the greatest number of hazards were indicated in the transport of steel at the stage of transporting steel refined with alloy additives to the continuous steel casting department. This transport is carried out with the use of overhead cranes. From a field study with a crane operator, he identified four main areas of potential risk from an accident involving cranes:

- Mechanical damage associated with intensive use of cranes, especially in industrial conditions, can lead to increased wear and damage to mechanical

components such as hooks, chains and lashing ropes. This damage can increase the risk of an accident by failing to cause equipment during its use.

- Operators' errors related to improper operation of cranes, as well as their use at a significant speed, overloading and/or insufficient securing of the load can lead to uncontrolled crane movements and, as a consequence, to an accident during loading, unloading or transport of finished pig iron.
- Non-compliance with safety regulations due to lack of regular technical inspections or inadequate training of staff and neglect of safety-related procedures,
- Environmental conditions that may contribute to increased erosion of crane components, such as increased humidity, dust, corrosion, high temperatures, can directly affect safety, causing failure or accidents at work (Niciejewska and Kiriliuk, 2020),

Therefore, one of the most important elements of safety is strategies aimed at reducing accidents with the use of cranes. Regular technical inspections are a very important aspect (Sadeghi, et al., 2021). Regularly carried out, they ensure efficiency and safety. Damaged elements or subassemblies should be repaired or replaced immediately, and once they are detected, the work should be absolutely stopped. Another very important aspect is the human factor (Greeff, et al., 2023). Crane operators should be periodic in terms of safe working procedures, crane operation, and identifying and responding to any potential hazards associated with their use. Regular training is aimed at maintaining a high level of security and shaping the organizational culture. Monitoring systems can be implemented to manage occupational safety and health more effectiv (Pacana and Czerwińska, 2023; Asadzadeh et al., 2020). They should be based not only on monitoring, which consists in recording an image of the work and saving it on memory cards, but also on the installation of safety sensors, which can significantly prevent accidents by warning operators of overloading. Every operator should have a stop button to stop crane operation in the event of a potential hazard in order to prevent industrial accidents, collective accidents or, in the worst case, an industrial disaster (Im and Park, 2020). A key aspect is the analysis of accidents and incidents that have occurred in the past in order to define the causes and circumstances in order to introduce preventive measures to prevent similar situations in the future (Vögele et al., 2020). It is also worth mentioning that steel mills should work with crane manufacturers and report any failures and periodic inspections in order to function properly. In the event that the crane does not pass the periodic inspection or its technical condition is not suitable for further use, all work with its use should be stopped and secured so that it is not used by mistake. It is also worth remembering about measures to prevent operator fatigue, as long hours and monotony related to work can lead to fatigue, but consequently can lead to a higher risk of accidents at work. It is worth using rotational systems and such regular breaks, which can significantly prevent fatigue and improve the concentration of crane operators (Sadeghi, 2021).

3. RESULTS AND DISCUSSION

Reducing the accident rate associated with the use of overhead cranes in steel mills requires the involvement of both employees and managers, as well as the occupational health and safety unit. In order to reduce it, safety procedures should be continuously improved, as well as employee training by increasing hazard awareness, proper monitoring of the technical condition and cooperation with the suppliers of the cranes

themselves in order to create a safer and more productive working environment for all steel mill workers (Albrechtsen, 2019).
In order to reduce the accident rate in the metallurgical industry, it is necessary to carefully plan routes, analyze them, and adapt them to the specifics of the goods and the existing infrastructure. Regularly inspect the technical condition of all equipment and machinery, as well as means of transport, in order to reduce the accident rate related to intra-departmental transport. Another very important aspect is employee training. Each employee performing their tasks should be adequately trained in safe working procedures for operating the equipment on which they perform their duties (Wołowczyk et al., 2023). It is also necessary to develop awareness of hazards and the ability to cope with situations that may potentially threaten the occurrence of an accident at work, so that the employee is able to minimize the risk of an accident at work in a crisis situation (Maszke et al., 2018). The last very important aspect is the monitoring and control of fire risk. Before transporting liquid pig iron, the fire risk must be carefully determined and all measures and preventive measures must be taken to reduce the risk of fire (Brauer, 2022).

4. CONCLUSION

The safety of steel products and steel processing requires cooperation between different departments. Improving awareness, training of personnel and investments in the best quality materials and transport infrastructure can significantly contribute to reducing the risk of accidents at work and ensuring smooth production processes and continuous steel casting, as well as safety in the transport of this key industrial raw material. Management of intra-faculty transport safety in steel mills is a very important part of the steel production cycle. (Patel et al., 2022). Each element of the inter-shipment transport should be described in detail and employees should be trained in the applicable safety standards and rules in order to reduce the accident rate. The safety system should be constantly improved. Improvement of the safety system can take place at any stage of transport and at every level of the company's organizational structure. It is necessary to collect information and suggestions from employees in order to increase safety and undertake an analysis of their implementation into the company's structures. Such activities can also increase the level of safety in the chuting industry not only in the audited company, but also in other steel mills. Horizontal signs can also be used to increase the level of safety.

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