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MINIMIZING OF RISKS IN THE WORKPLACE USING SIMULATION SOFTWARE

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Abstract: The purpose of risk assessment is to provide information for decision-making. It compares the resulting risk obtained from the analysis with the risk criteria based on the legislation. If the level of risk is undesirable, the organization must take measures under the legislation to reduce or eliminate the risk. There are also cases where the risk assessment leads the company to a repeated analysis and the decision to terminate the investigation due to negligible, resulting risk. The paper focuses on using simulation as a supportive tool to minimize the risk in the workplace of injection moulding plants. It was eliminated bottlenecks and designed suitable injection moulding arrangements to ensure the safety and health of workers at work.

1 Introduction

The basic goal of the proper functioning of every company is to ensure safety and health at work in the system-man - machine – environment [1]. Despite implementing all available measures to increase safety, health protection, and awareness of compliance with the organization's safety and health policy at work, it does not rule out the occurrence of an undesirable situation that leads to accidents at work. If such an undesirable situation occurs, it is necessary to follow the applicable legislation [2]. Occupational health and safety can be defined as the state of the workplace, which gives assurance that in compliance with rules such as technological procedures, safety regulations, etc., no situation would endanger workers' health [1]. To create safe work, which is required to develop and implement a system of measures such as: legislative, economic, social, organizational, technical, medical, and educational [2].

1.1 The main concepts by risk assessment

The term danger, translated from the English word "hazard", represents a source or situation that has the potential to harm: the health of the worker, i.e., damage, injury, or occupational disease, to the work environment and property, or combinations thereof [2]. Properties or capabilities of the machine, workers, material, etc., may cause damage or a negative phenomenon. It is a source of threat. Hazard identification is the process of identifying whether a hazard exists. This process also determines what the danger may be. The identified risk is then assessed, and one of the following options is selected [3]:

- interruption of the process due to a danger that is incompatible with the damage they may cause,
- take immediate corrective action to eliminate or reduce hazards arising from the hazard;
- termination of the analysis, due to negligible hazards,
- continuing to identify the risk.

A threat is any activity that leads to a dangerous situation. It represents a danger that causes negative phenomena such as injury or damage in a specific space and time in the machine–human-environment system [3]. The stage of hazard identification is followed by the identification of the threat and at the same time its analysis. This process determines the hazards that arise from the hazards and lead to an accident, damage, or another negative phenomenon, so it is important to decide on the event and manner of the probable negative hazard in the machine-man-environment system [4]. This section is important to realize that one hazard can cause multiple threats. A risk is a situation in which a negative phenomenon occurs. At the same time, when a negative phenomenon occurs, the consequences of this phenomenon occur. It is a quantitative and qualitative expression of the degree of threat. The likelihood of an adverse event leading to injury, damage to health, or harm is assessed. It involves identifying, recognizing, and assessing existing, potential, and emerging risks that are likely to lead to a negative phenomenon [1,4].

The risk identification process must consider the risks, regardless of whether the given source of risk is under the control of the organization, but also if the individual sources of risks and their causes are not obvious [3]. It

must include an assessment of the effects and consequences. It is important to consider the wide range of consequences, even if the individual sources of risks and their causes are obvious. It is also necessary to consider what may happen while considering possible adverse causes and circumstances that point to the consequences they could have [4,5]. All-important causes and consequences should be taken into account. Risk analysis is an important step in determining whether risks need to be addressed in a given system and what method to use to determine risk [1,2]. It provides information on individual sources of risk and the positive or negative consequences and probabilities that may occur. Its task is to identify the factors that affect the consequences and their likelihood [5]. A combination of consequences and probabilities most often expresses the risk. In terms of the purpose of the analysis, available resources, information, and data, the analysis can be qualitative, semi-quantitative, or quantitative [6]. The main essence of risk assessment is determining the degree of risk of the analysed risks in the machine-human-environment system [5]. The risk assessment includes an analysis of the occurrence period, hazard identification, analysis of the probability and consequences of existing adverse events [6]. The paper aims to identify the risk in the workplace of injection moulding machines using a pre-simulated process.

2 Methodology

The point method was chosen as a linear function to identify the risks at the injection moulding workplace. The chosen method is also based on the insufficient elaboration of the analysis by safety technicians and the development of a written document on risk assessment at the workplace.

2.1 Work activities of employees at the workplace of injection moulding machines

The workers at this plant are divided into two groups: a sorter and a press [7].
The main activities of the sorter are [1,3]:

- Setting up machines.
- Starting machines.
- Visual inspection of machines.
- Production process control.
- Inserting and selecting a mould from the machine.
- Relocation of moulds and materials.
- High lift truck control.

The insertion and selection of the mould from the machine are performed using a gantry crane on presses 820 S and 920 S and a forklift on other injection moulding machines. The replacement is performed by a sorter, which must perform when selecting a mould [3]:

- Ensure the connection of the moving and immovable part of the mould.
- Attach a locking panel with a holder for the permanent link of the mould.
- Disconnect the regulator used for heating and cooling the mould.
- Securing the mould against falling by crane or forklift.
- Disconnect the ejector.
- Mould release - release of clamps.
- Mould selection from the injection moulding machine.

The main activities of the press worker are [1,5]:

- Removal of mouldings.
- Visual inspection of mouldings.
- Packing and storage.
- Filling of dryers.
- Filling the tanks with granules.
- Auxiliary training for the sorter.
- Ensuring cleanliness and order in the workplace.

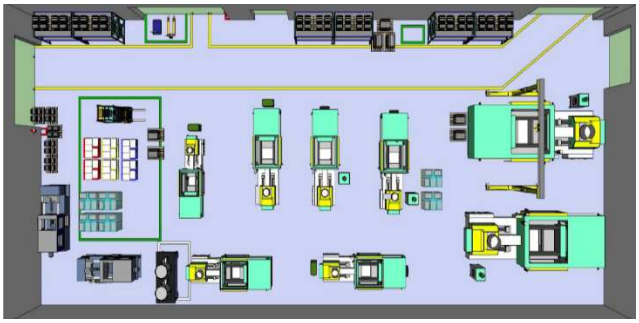

Figure 1 Current state at the injection moulding plant

At certain intervals, the press selects a container into which the finished mouldings from the injection moulding machine fall and then inserts an empty container to catch other mouldings [3]. This activity is followed by a visual inspection of the finished mouldings. It is important to check the correctness of the finished moulding in detail.

2.2 Simulation software solution

Simulation is an experimental method in which we replace an entire system with a computer model [4]. It is possible to perform several experiments on such a model, to evaluate them. Optimize and apply the results to a whole system. No other method or theory allows you to experiment with a complex system before it is put into operation [5]. No different algorithm would enable you to "play" in a few minutes of complex computer processes that last weeks or months. It is a perfect decision support tool for various levels in the enterprise [4]. The reason for using the simulation is that analytical methods (collective service theory, service networks, linear programming, etc.) have limited use in solving practical problems [1,4]. New requirements emerge for flexibility throughout the corporate organizational structure, new decentralized, modular organizational units, and new work organizations (teamwork, simultaneous engineering). One of the other reasons for using the simulation is the humanization of

workplaces [7]. The environment in production and assembly workplaces is often unsatisfactory many times beyond the tolerance of the law (working overhead, in cramped conditions, huge time stress, in unnecessary noise, and at high temperatures).

2.1.1 Tecnomatix Plant Simulation

Tecnomatix is a product line from Siemens PLM Software that includes several software tools for different production areas that can be interconnected [4,7]. The tools in the Tecnomatix series enable industrial companies to use the concept of digital enterprise in practice, i.e. plan and design production, design, verify and optimize processes and production resources in a digital environment. Accurate digital modelling, simulation, and 3D spatial visualization allow professionals working together to develop, visualize and analyse future production processes. Such an evaluation will allow key design decisions to be implemented and approved on time and on a broader understanding [4]. This will reduce errors that would otherwise occur at the start of production. Digitization allows processes to be prepared faster and more accurately, while simulation and optimization in the development phase ensure that a significant product is produced the first time, without the need for additional costly and time-consuming changes in a real factory [8]. Plant Simulation is a module for dynamic simulation-creation of a structured hierarchical model of production plants, lines, processes, transport, etc. [9]. Thanks to the dynamic design review, we can identify bottlenecks, define the workload of individual workplaces/operators, determine the system's throughput, etc.

3 Results and discussion

The riskiest situations in injection moulding machines are the fall of a load and slipping - the fall of a person [10]. They penetrate especially when using a forklift and filling dryers and injection moulding tanks. These situations can seriously harm the health of workers. Figure 2 shows a critical point in the placement of the presses.

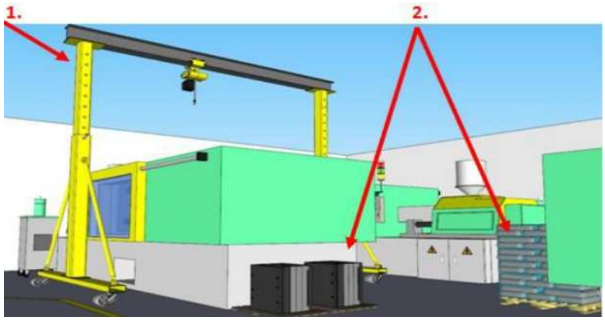

Figure 2 Demonstration of critical places in the area of injection moulding machines

Legend to Figure 2: 1. Gantry crane 2. Moulds and granules outside storage areas.

To reduce the risk of load falling, a proposal was made for the application of a bridge crane (Figure 3). With the help of this crane, all activities related to the transfer of loads can be performed, i.e., the forklift and the current gantry crane will be taken out of service.

Figure 3 Relocation of injection moulding machines at the workplace

Removing unused equipment creates space for further storage of moulds and materials (Figure 4).

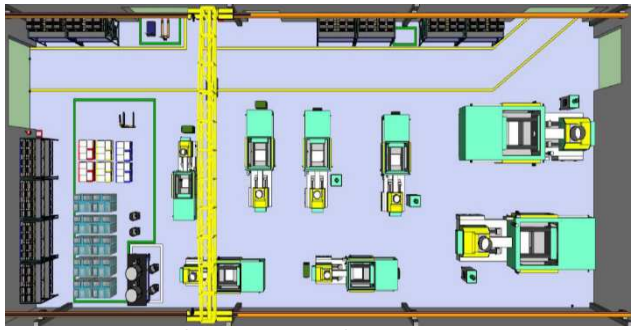

Figure 4 A view of the operation of injection moulding machines with proposed solutions

Using simulation in operation, where the simulated model of the injection moulding machine is simulated, it essentially represents a certain simplification of reality [11]. Therefore, the created model mustn't be simplified, distorted, or even completely abstracted from the system properties we want to examine using computer simulation (Figure 5).

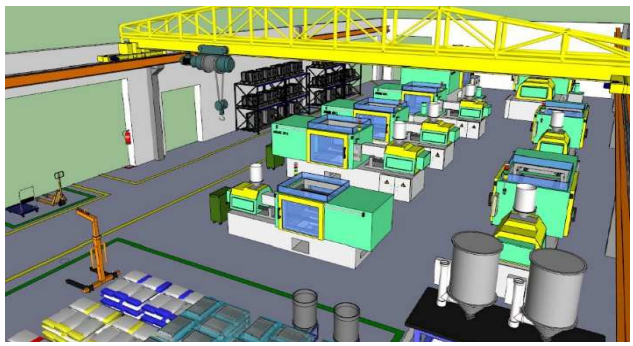

Figure 5 View of the proposed bridge crane

4 Conclusions

The simulation model serves as a template for designing and developing the actual state and results in faster and error-free commissioning. The connection of the central control computer with the simulation model will enable its commissioning before the device is deployed [12]. Behaviour during the start-up can be played out according to different scenarios. This is important when you are putting in during normal operation, and a smooth transition to the new equipment is required. With the help of the model, the company's service personnel can be trained for the new system and specifically prepared for specific equipment conditions.

The preliminary test of the daily deployment plan of the facility will draw attention to the needs of the readiness of personnel and operating resources due to the utilization of the facility. The paper aimed to use simulation software to increase the risk assessment in injection moulding machines, where, based on simulated conditions, the daily plan can be adjusted and re-tested in time if necessary. After testing the model, experiments were performed in which various options for system improvement are sought, and their impact on the modelled system is verified.

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