Workplace Optimization in the Manufacturing Enterprise Supported by Digitalization Software

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***Abstract* – The aim of the proper functioning of each manufacturing enterprise is to ensure safety and health protection at work in the system man-machine and environment. Despite the implementation of all available measures to increase safety, health and awareness by adhering to the organization's occupational safety and health policy, it does not preclude the occurrence of an undesirable situation leading to occupational accidents. A system of measures such as legislative, economic, social, organizational, technical, health and educational needs to be developed and implemented to create safe work, with respect to worker health protection. It is the last mentioned educational measure that we want to point out in the present paper on the use of the Tecnomatix Plant Simulation software in the teaching process and thus participate in the intersection of theory and practice.**

***Keywords* – manufacturing, optimization, digitalization, simulation software, enterprise**

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1. Introduction

The basic objectives of simulation, such as methods of studying the behaviour of a particular system using a computer or other model and experimenting with it, can be divided into:

- analysis of existing production systems to improve them,
- designing or verifying projects for new production systems [1].

The area of analysis of existing production systems can be divided into:

- determining the appropriateness of rebuilding or modifying an existing production system,
- analysis of the behaviour of the production system under different production conditions,
- investigating the impact of different control algorithms on production system operation[2]

The identification of risks in the injection moulding workplace was realized in a company that focuses mainly on the production of components for the automotive industry [2],[3]. Other equipment used for mould handling and material transfer, such as forklift truck as well as gantry crane with load capacity up to 5000 kg. For other injection moulding machines, a forklift is used to change the mould.

A very important task is also to dry the material called granulate [2]. Dryers are used for drying the granulate. These dryers must be filled manually and the granulate is then automatically transferred to the injection moulding container. Their use also depends on the type of the contract [1],[2],[4]. The reservoirs of the other injection moulding machines are filled manually, but previously the granulate is dried in ovens that do not fulfil the function of automatically transferring the granulate to the reservoir. The following Figure 1. shows the current state of machine layout at the injection moulding station.

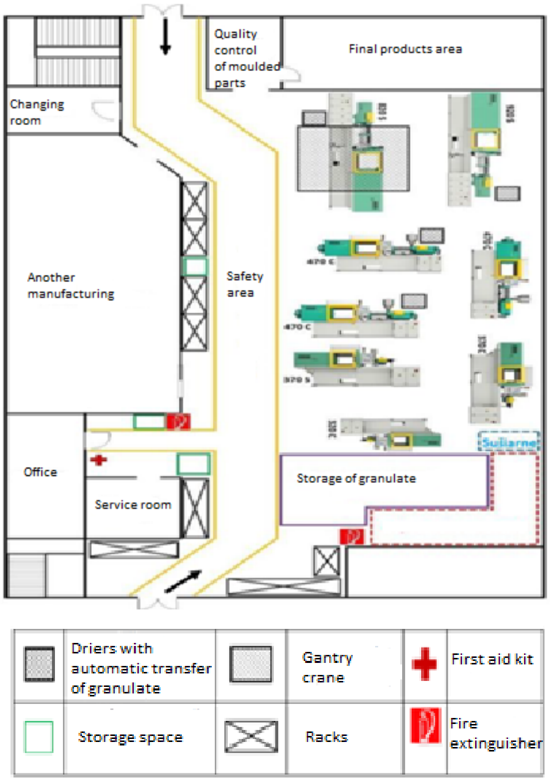

Figure 1. The current state of deployment of injection moulding in the workplace with legend

2. Technological Process of Moulded Plastics Parts

The main principle of the production of plastic mouldings is the injection of granulate into the mould [2].

Plastic moulding production process:

1. Inserting the dried granulate into a container
2. Closing the mould
3. The granulate is fed via a screw to a heating unit in which it transforms into a liquid state and passes through a nozzle into a mould.
4. Cooling of the liquid granulate into the mould
5. Cooling of the compact is followed by opening the mould
6. The last part is to extrude the moulded parts using an ejector

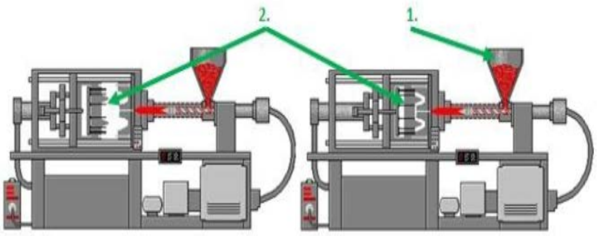

Figure 2. Scheme of the open and closed mould form [5].

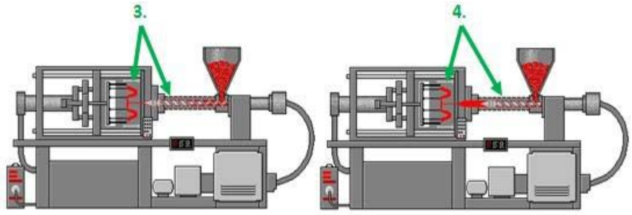

Figure 3. Scheme of granulate feeding and moulding parts cooling [5]

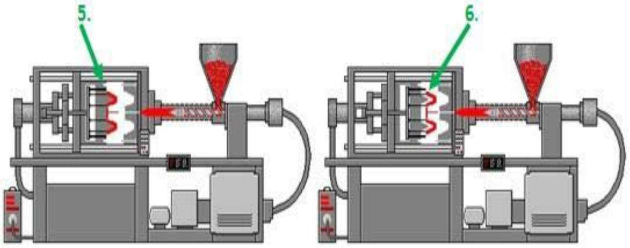

Figure 4. Scheme of the open mould and extrusion of the moulded plastics part [5]

Workers in this operation are divided into two groups: a shifter and a press.

The main activities of the marshaler are:

- setting up the machines
- starting the machines
- visual inspection of the machines
- process control
- inserting and selecting a mould from the machine
- relocation of forms and materials
- forklift control [1], [3].

The insertion and selection of the mould from the machine are carried out using a gantry crane on presses and a forklift on other injection moulding machines [4].

The replacement is done by a spooler, who must select the mould:

- ensure the connection of the movable and stationary mould parts
- attach the securing panel with clamp for permanent mould connection
- disconnect the regulator for mould heating and cooling
- securing the mould against falling by crane or forklift
- disconnect the ejector
- removing the mould - removing the stubs
- mould selection from injection moulding [5]

The main activities of the press are [5]:

- removal of mouldings
- visual inspection of mouldings
- packaging and storage
- filling driers

- filling the containers with granulate
- ensure cleanliness and order in the workplace

At certain intervals, the die removes the container into which the finished mouldings fall from the injection moulding and then inserts an empty container to retain further mouldings. [5] This activity is followed by visual inspection of the finished mouldings. It is important to check the accuracy of the moulded part in detail. [7]

Filling of drying and injection moulding tanks is done manually. In dryers the filling is manual, but the transfer of granulate to the injection moulding container is automatic [6]. The filling of these dryers is complicated and there is also a risk of falling of the load of the particular upper part of the dryer, which must be lifted during filling [7]. This part is held by another worker from the other side [8].

There is a danger of the worker falling, which may be caused by loss of balance, inattention, etc.

Problem definition:

The hazard comes from threats such as:

- Inappropriate coordination of works
- Dangerous activity
- Inadequacy of working procedures
- Inappropriate machine layout
- Poor ergonomic conditions

3. Workplace Optimization Used a Simulation Software

The riskiest situations in the operation of injection moulding are the fall of the load and slipping - the fall of the person. They arise especially when using a forklift and filling driers and injection moulding tanks. [8] These situations can seriously damage the health of workers.

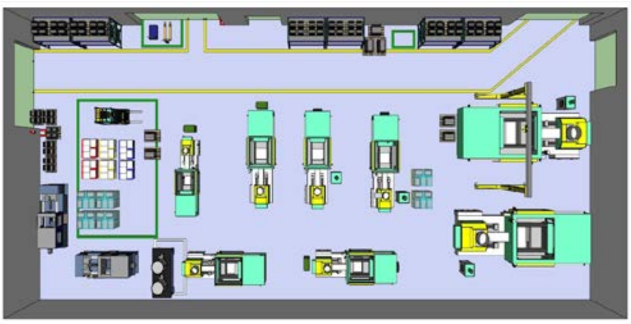

Figure 5. Model of the current state of the injection moulding operation station [5]

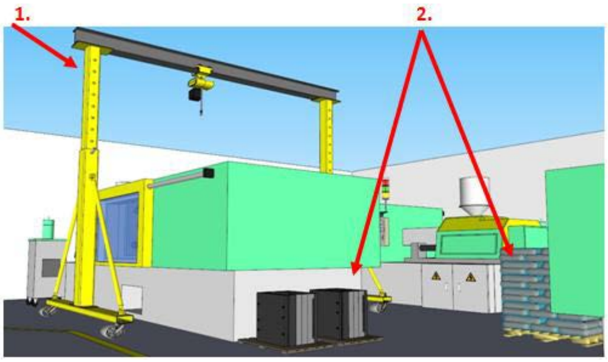

Figure 6. View of the current gantry crane [5]

Legend to Figure 6:

1. Gantry crane
2. Moulds and granules outside storage areas

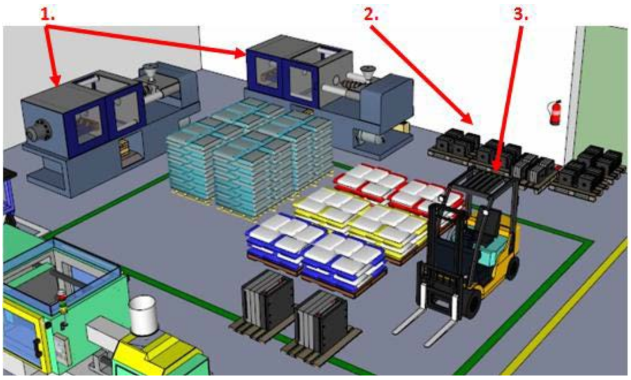

Figure 7. View of the current storage area [5]

Legend to Figure 7:

1. Unused machines
2. Moulds outside storage areas
3. Forklift equipment

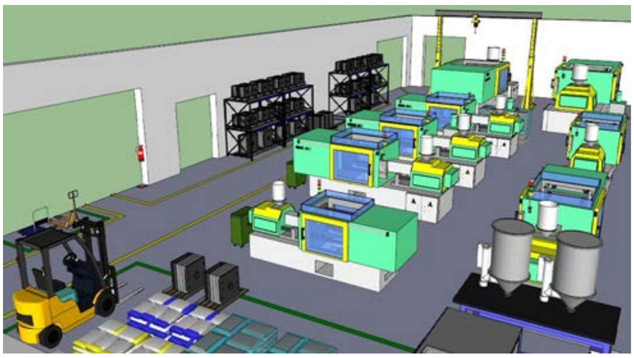

Figure 8. View of the injection moulding operation [5]

To reduce the risk of falling the load, a proposal was made to apply a bridge crane. With this crane, all activities related to the transfer of loads can be performed. The forklift and the current gantry crane will be removed from service.

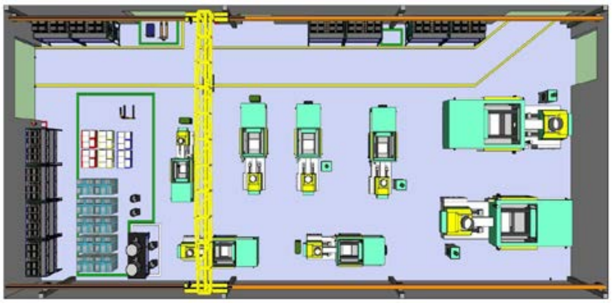

Figure 9. View of injection moulding operation station with proposed solution used a Tecnomatix Plant Simulation [5]

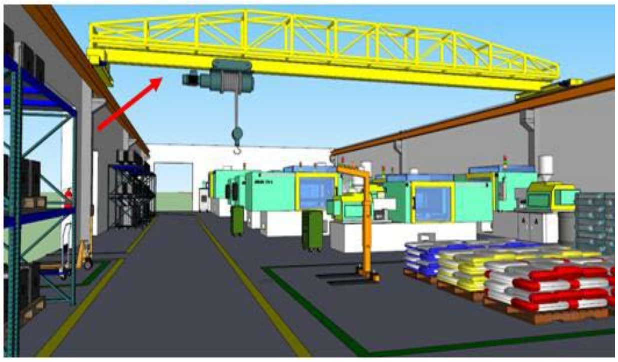

Figure 10. View of the proposed gantry crane [5]

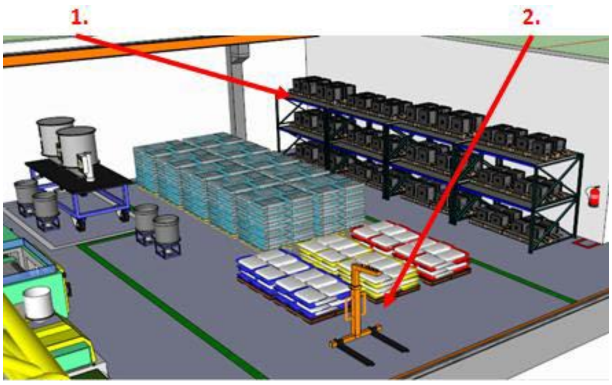

Figure 11. View of optimizing used a storage area [5]

Legend to Figure 11:

1. Removal of unused equipment creates space for further storage of moulds and materials
2. Manual load handler for overhead loads

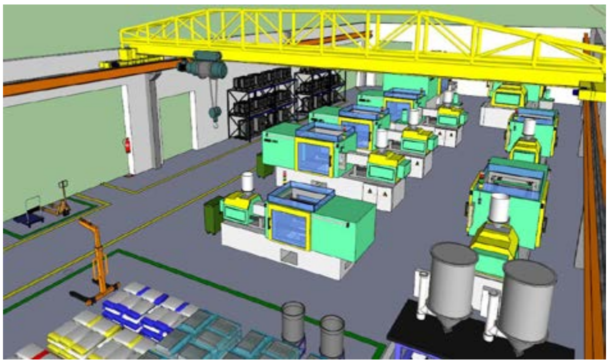

Figure 12. Proposed solutions used simulation software [5]

One of the main advantages of today's computer simulation software products is the ability to simulate the above processes to the user's desired time. Simulation of the required real-time in computer simulation takes only a few minutes [9].

After running the simulation run, each of the current simulation programs provide a sufficient number of reports (so-called reports) to verify the validity of the desired main objective of the simulation [10].

With the help of superstructure models, it is possible to find the optimal solution under the specified constraints within a short time.

4. Conclusion

In the process of using simulation, we have to keep in mind that simulation, like other methods, has its advantages and weaknesses.

The strengths of using the Tecnomatix Plant Simulation program are to solve real sieves in a manufacturing plant:

- allows solving analytically insoluble tasks
- makes it easier to solve difficult tasks
- standardizes some quantitative parameters
- the modelling process helps to identify and specify new facts
- extension of the possibility of prediction to areas where it is not correct to use deductive methods or deterministic models

In the context of the present issue of the potential hazards arising from the current deployment of injection moulding in the workplace, we can state that the simulation allows:

- predicting behaviour
- decision support
- understanding how it works
- cost savings

However, the simulation does not allow:

- automatic optimization
- complete production management
- replacement of man in decision making
- finding the right solution for incorrect data

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