SIMULATION OF THE MATERIAL FLOW TO IMPROVE THE EFFICIENCY OF FIRECLAY BRICKS PRODUCTION

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Abstract

The aim of the contribution is to point out the possibilities of using computer simulation for the needs of more effective metallurgical production. Like many other tools and methods, logistics also greatly contributes to maintaining the company's competitiveness and resilience to external factors such as the crisis, inflation, falling demand, and so on. One of the key methods for maintaining balance is material planning. The term "material flow" represents an organized movement of material in the manufacturing process or product circulation. It is characterized by the direction, intensity, frequency, length and performance, structure, character of transported material and transporting and handling equipment used. The most significant group, which, at the same time, forms the most relevant part of the material flow are raw and other materials and corporate work in progress and finished products. All the types of working objects are used throughout enterprises in certain amounts, internal structure, direction and with certain frequency. For a better imagination of the production process of fireclay bricks, a simulation model for the production of fireclay bricks was developed in Tecnomatix Plant Simulation. As a basis for creating simulation served the model of the manufacturing process production of fireclay bricks. Due to the high production capacities of the production process, it has been found that for the efficient production of a limited quantity and especially the firing of the building, a narrow place of the entire production process of the fireclay is the mill.

Keywords: Simulation, model, material flow, production, fireclay bricks

1. INTRODUCTION

The process simulation models are very efficient tools for detecting the bottlenecks in the process course and for improving the process parameters. Neither costs nor negative impacts are connected with interfering in a simulation model of a production line, unlike to interfering in the operation of this line. To develop the proper simulation model, both theoretical knowledge (technique of simulation, specific simulation systems) and practical experience (description of the system, its elements and their mutual interactions and links) are necessary [1]. The course of the simulation is to be monitored in every phase. It is possible to determine impacts on total function of the system from the changes that occur at the output of the simulation model. A need for simulation models is based therefore on an opportunity for experimentation with a system without interfering in the real one. The model allows an engineer to try a number of process variants, to find the optimum process conditions and to design new process routes without any need for additional investment. The respective changes may have a significant impact on profitability of the production, market position of the company and satisfaction of its customers [1]. Simulation has a lot of applications in various branches. Simulation of systems allows to experiment within virtual objects (some of them do not exist at all). The simulation can provide answers to a lot of important questions as for example: "How will the system behave after introduction of some changes? Where are the bottlenecks in the system?" [2]. The term "material flow" represents an organized movement of material in the manufacturing process or product circulation. It is characterized by the direction, intensity, frequency, length and performance, structure, character of transported material and transporting and handling equipment used [1]. It includes the entire material movement starting with its supply to the plant through all the phases of storage, production and transportation process and ending with their dispatch or with warehouses of business organizations [1].

2. METHODS

2.1. The process analysis of production of fireclay bricks

The company manufactures its products on the basis of an order from the customer, PULL system. Depending on the assortment, the production cycles for the production of fiberglass are 1 - 2 weeks and for the production of the building 3 - 4 weeks. There is also an exception when it is produced by the PUSH system, ie in the warehouse, especially in the winter, when it is considered to be a higher requirement for an additional assortment, building fireclay, which serves for the lining of fireplaces, chimneys, etc., which is more demanding during this season. The paper deals with the manufacturing process shown in **Figure 1**. In addition to burnt production, the enterprise also deals with other types of production, which are represented in the model of the entire production process of the plant [3].

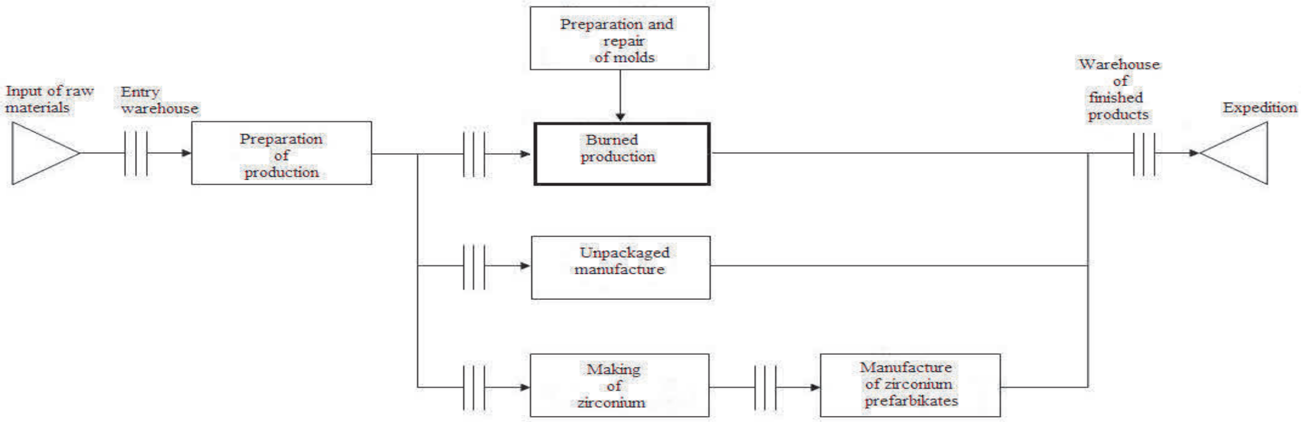


Figure 1 Formalized scheme of the company's production activity [3]

For a better imagination of the production process of fireclay bricks, a simulation model for the production of fireclay bricks was developed in Tecnomatix Plant Simulation. As a basis for the creation of the simulation, the model of the production process was used by the chamotary (see **Figure 2**). First, a basic model consisting of individual input raw materials, containers, equipment, transport routes and tunnel cars [3].

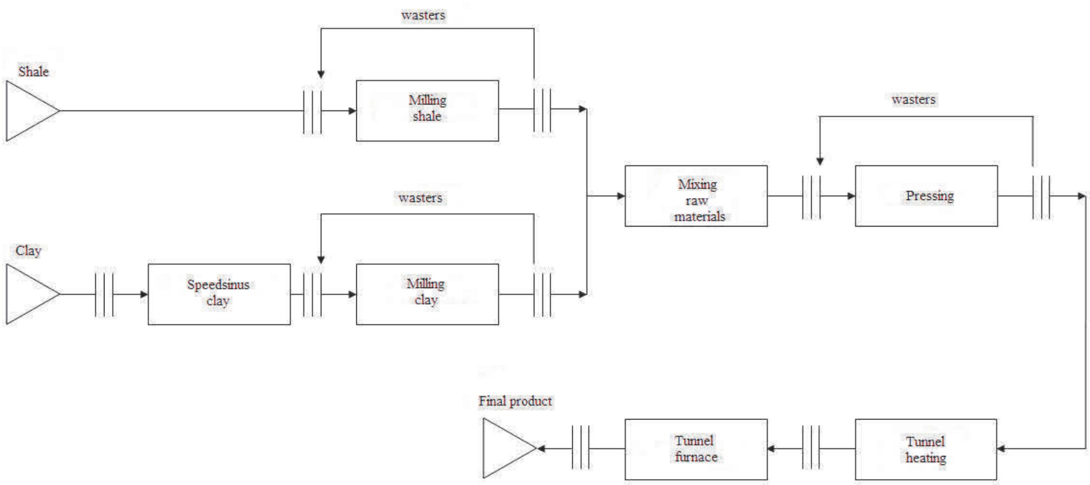


Figure 2 Model of the production process of ordinary fireclay [3]

For the production of the required products it is necessary that the feedstock is delivered to the raw materials store and then stored in the storage bins. After storage, it is necessary to have the individual feedstocks adjusted to the required moisture (clay) and the required fraction (grain thickness) [3,4]. The modification of the moisture content of the clay is carried out in the speed kiln of the clay and the treatment of the fraction of the grains takes place in the individual mills. After this treatment, the raw materials are transferred to a mixer, which mixes the feedstocks into the desired mixture [5,7]. After checking the quality of the mixture, the mixture is transported to the press where it is formed into the desired shape, using suitable molds and presses. [3,6]. After molding, the bricks are deposited on a tunnel wagon, through which the moldings are driven into the tunnel heater, where they are dried to the exact required residual moisture. After drying, the tunnels are pushed into the tunnel furnace, where the firing itself builds. After drying and burning, finished products are produced. These products are transported to the intermediate storage where quality is checked. If the quality of products meets the standards, the goods are stored in the warehouse of finished products prepared for dispatch to the consumer [3,6]. Due to the high production capacities of the process of fireclay bricks manufacturing, it has been found that for the efficient production of a limited quantity and especially the firing of the building, a narrow place of the entire production process of the fireclay is the mill. To produce 5 tons of the mixture, which corresponds to the capacity of the blender per hour, 3 tons of cake and 2 tons of clay are required for the production of common chamotte. The capacities of equipment for the production of this product are balanced up to the press, where the capacity for the original mold is 61.6 % smaller than for other devices. Subsequently, a simulation model was created, consisting of individual input raw materials, containers, equipment, transport routes and tunnels (see **Figure 3**) [3,5,7].

3. RESULTS

The simulation model is defined by a specific sequence of modeling blocks connected by lines representing the processing flow directions. The block position, icon and name, the connector blocks, the links as well as the user interface dialogues with operands and flows are the main properties of individual blocks. The blocks themselves represent individual processes or subsystems thus creating the actual representation of the real life system under examination [1,7]:

- **Input of raw materials** - Raw materials are delivered to the factory in wagons, especially bulk materials or automotive - packaged materials. Devices that serve to secure the delivery of raw materials to the raw material store: conveyor belts, gantry cranes, harrows, sliding feeder, belt conveyor, belt conveyor, reverse belt conveyor [3,8].
- **Storage of raw materials** - Loose raw materials are stored separately in the unloading area of the wagons and in the raw material depot. Packaged raw materials are stored on pallets in a separate warehouse. Raw material storage - concrete containers where individual bulk feedstocks are stored in labelled containers [9,10,11,12,13]. The capacity of the trays is 14,666 m^3 [3].
- **Treatment of raw materials - mil**ling - The input grain materials are treated in individual plants by grinding and sorting according to the required technological requirements and quality standards. The stones are dried in the RS-8 speed dial and ground by grinding and sorting. In the production of refractory materials, a binder is used, which is treated in the RS-8 quick wand to the desired residual moisture. Clay is sprinkled crane into the slicer clays from there through the belt to separate-flash, together with the flue gas, shafts and blades is moved further into the drying chamber, where it is dried. From the speed bobbin, the chain elevator is conveyed by sliding into the buffers [3,14,15]. See **Figure 3**.

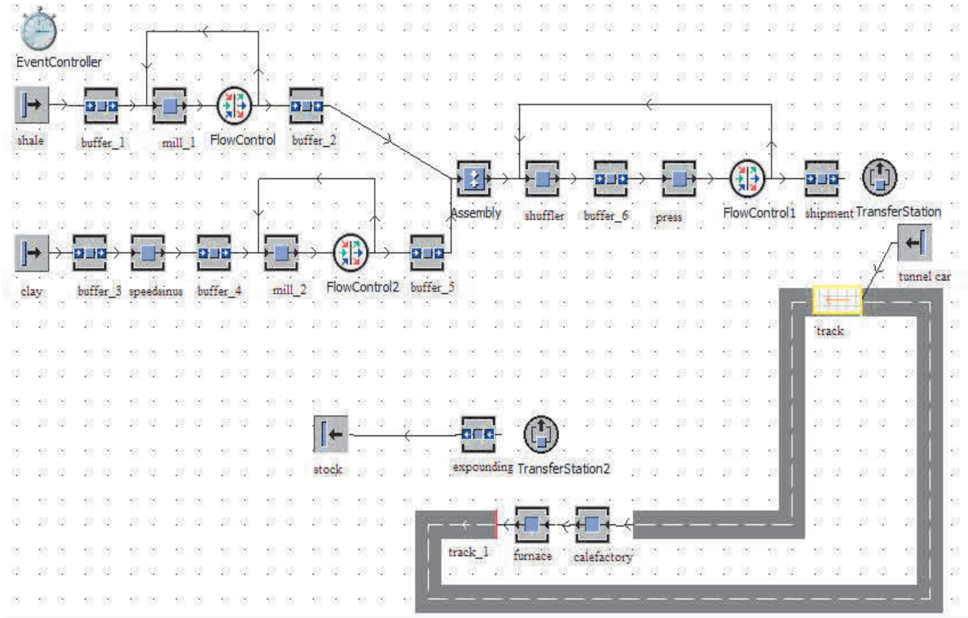


Figure 3 Simulation model of fireclay bricks production [3]

For the production of the required products it is necessary that the feedstock is delivered to the raw materials store and then stored in the storage bins. See **Figure 4** [3,17].

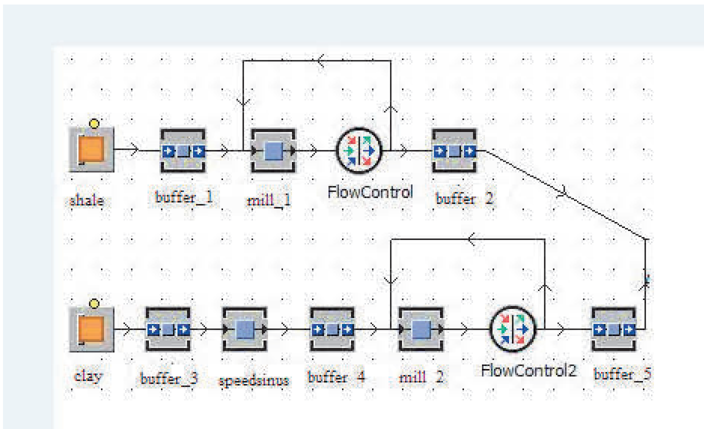
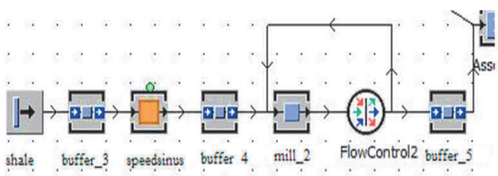


Figure 4 Input of basic raw materials from storage to production [3]



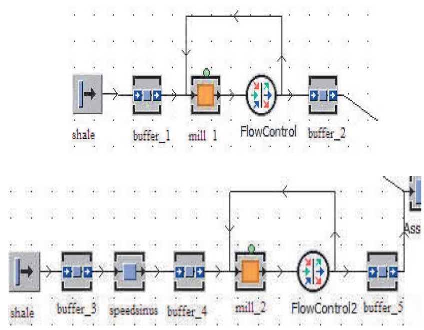


Figure 5 Drying of clay in a quick wrench [3]

Figure 6 Modification of grain fractions in individual mills [3]

After storage, it is necessary to have the individual feedstocks adjusted to the required moisture (clay) and the required fraction (grain thickness). The modification of the moisture content of the clay is carried out in the clay worm (see **Figure 5**) and the grain fraction is processed in individual mills (see **Figure 6**) [3].

After this treatment, the raw materials are transferred to the mixer, which mixes the feedstocks into the desired mixture (see **Figure 7**) [3]. After checking the quality of the mixture, the mixture is transferred to the molding mill where it is molded into the desired shape using suitable molds and presses (see **Figure 8**) [3].

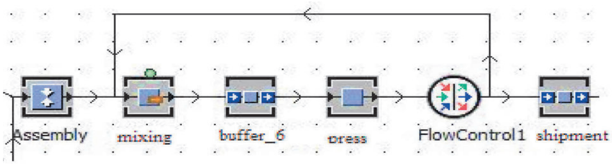


Figure 7 Mixing feedstocks in the mixer [3]

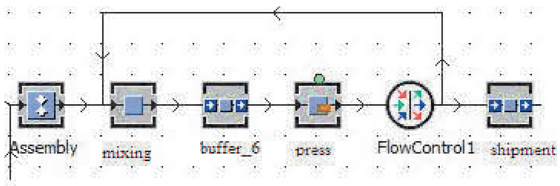


Figure 8 Compression of mixture [3]

After being pressed, the bricks are deposited on the tunnel wagon (see **Figure 9**), through which the moldings are driven into the tunnel heater, where they are dried to the exact required residual moisture (see **Figure 10**) [3].

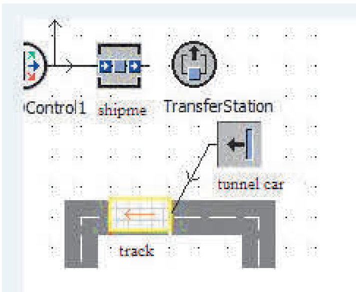


Figure 9 Tunnel car [3]

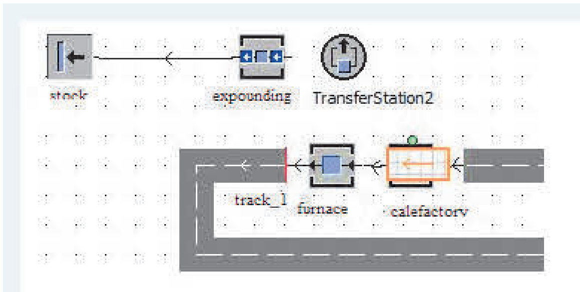


Figure 10 The laden tunnel carriage passes through the tunnel heater [3]

After drying, the tunnel cars are pushed into the tunnel furnace, where the firing itself (see **Figure 11**) takes place. After drying and burning, finished products are produced [3].

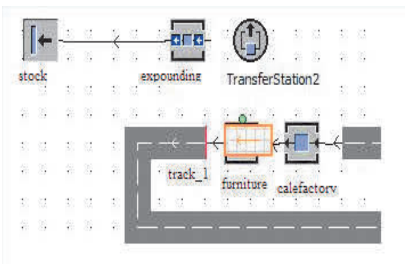


Figure 11 Burning of moldings in a tunnel furnace [3]

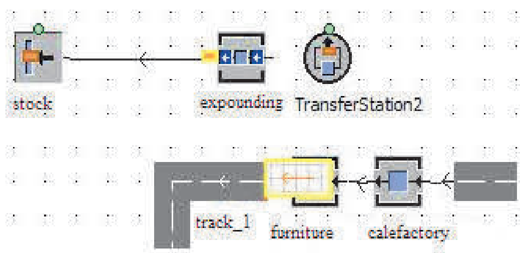


Figure 12 Unloading products from tunnel cars into finished goods warehouse [3]

These products are transported to the intermediate storage where quality is checked. If the quality of the products meets the standards, the goods are stored in the warehouse of finished products (see **Figure 12**) ready for shipment to the consumer [3].

4. CONCLUSION

The aim of the contribution was to point out the possibilities of using computer simulation for the needs of more effective metallurgical production. Like many other tools and methods, logistics also greatly contributes to maintaining the company's competitiveness and resilience to external factors such as the crisis, inflation, falling demand, and so on. After a thorough analysis of the process of fireclay bricks manufacturing, it has been found that this process can work more efficiently. Therefore, a number of measures have been proposed to reduce production costs, accelerate production, or lead to an increase in the technological level of the workplace [3,15]:

- Introducing multi-hole forms. Multi-mold forms would increase the production capacity of the mill, which would lead to an acceleration of the entire production process of the sham boiler. The design solves the introduction of a multi-bore mold at various positions and a change of the pressing surface when the original pressing surface is changed to a smaller area using a different molding area [3,16].
- Robotization of the mill workstation. By installing the robot in the press room, the technological level of the workplace would be increased, the number of non-maneuvers caused by careless handling by the workers would be reduced, and the number of staff needed to operate the press would be reduced.

Therefore, most of the proposed measures will be aimed at increasing efficiency in this section of the production process. Measures have been designed and worked to streamline the company's manufacturing process. The proposed measures serve to reduce production costs, speed up production and increase the technological level of the workplace. The benefit of the work was to point out that the company's production process can work more efficiently and with lower costs than before [3,17].

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