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Using Tools to Improve Logistics and Production Processes in a Selected Construction Company

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Abstract:

Purpose: *This article presents the functioning of a production company in the construction chemicals industry.*
Design/Methodology/Approach: *In the article, the following objectives were indicated, analysing the course of logistics and production processes in the analysed enterprise, developing a map of the production implementation process and the production line retooling process, analysing the possibilities of implementing tools to improve logistics and production processes and developing recommendations for the enterprise. Furthermore, LM also has the task of keeping inventory at a minimum, delivering materials depending on demand based on the Kanban system, high organization and visualization of workplaces using the 5S principles and reducing machine downtime to a minimum.*
Findings: *Based on the literature research, the following thesis was formulated, the use of tools to improve logistics processes significantly improves and increases the efficiency of production processes in the analysed enterprise. In the research part, the authors proposed Lean Production improvement tools (SMED, TPM, Method 5S) to optimize logistics processes and production.*
Practical Implications: *Lean Management is one of the most popular concepts to improve the company production process, based on the principles and tools of the Toyota Production System. It is defined as a management philosophy, according to which the company strives for the optimal use of work resources, and its activities are focused on self-improvement and the constant elimination of waste.*
Originality/value: *The authors argue that it is important to introduce the proposed improvements to optimize logistics processes and production, and that they are possible to implement in other manufacturing companies.*

Keywords: *5S, construction industry, Lean Manufacturing, SMED, TPM.*

JEL codes: *M11, O14.*

Paper type: *Research article.*

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1. Introduction

Correctly organized enterprises, able to adapt to the behaviour of the free market system, can face high competition on the market and even survive the period of market crisis. The use of modern methods of improving logistics processes allows the optimization of company processes that are important for its functioning and the strategy chosen. Production logistics is treated as one of the most important fields in the sphere of logistics. A well-organized and planned production process increases profits and acquires new customers for manufacturing companies. A properly developed production system and appropriately prepared production lines result in the process progressing effectively, efficiently and without interference.

This article presents the functioning of a production company in the construction chemicals industry. Based on the literature research, the following thesis was formulated, the use of tools to improve logistics processes significantly improves and increases the efficiency of production processes in the analysed enterprise. The article points out the following objectives: analysing the course of logistics and production processes in the analysed enterprise, developing a map of the production implementation process and the production line retooling process, analysing the possibilities of implementing tools to improve logistics and production processes and developing recommendations for the enterprise. The authors proposed Lean Manufacturing and Lean Production improvement tools to optimize logistics processes and production. Companies from the construction chemicals industry are aware that a properly planned and organized production system is a key aspect to compete with the best in this sector.

Lean Manufacturing can be considered one of the most significant contributions to the history of operations management (Zhang *et al.*, 2019; Krafcik, 1988). This concept was introduced by Krafcik (Womack *et al.*, 1991) and was first used by scientists from the Massachusetts Institute of Technology. At the turn of the 90s, Daniel Roos, James P. Womack, and Daniel T. Jomes published *The Machine That Changed the World (*Abualfaraa *et al.*, 2020*)* where they compared the parameters of results and outlays in American, European, and Japanese enterprises. Toyota Motor Production has been recognized as a leader along with its Toyota Production System (Alhuraish *et al.*, 2016). The authors defined the system as the first Lean production system and referred to as Lean Production. Current references also use terms like Lean Manufacturing and Lean Thinking. In production practice, Lean Production and Lean Manufacturing are used alternatively and have the same meaning.

Lean Manufacturing refers to "a methodology designed to reduce production costs to minimize waste" (Snee, 2010). Snee defined Lean Manufacturing as "a business strategy and methodology that increases process efficiency, which translates into greater customer satisfaction and better financial results" (Szymonik, 2012). The concept of lean manufacturing stems from the use of the fewest of these factors

during the production process compared to the traditional production method (Vanichchinchai, 2019):

- half of the time spent by engineers working on newly designed products,
- half of the funds used for tools and devices,
- half of the efforts by employees,
- half of the space used in production,
- implementing newly designed products in half the time.

Lean Manufacturing as a concept leads to overcoming the number of production shortages and increasing the range of manufactured products due to maintaining only half of inventories (Womack and Jones, 1996). The organization of production, where the goal is to minimize all the resources used for various types of activities in the enterprise, provides for the identification and elimination of activities that do not provide value added in supply chain management, production, customer relations and design (Hines *et al.,* 2004).

Entrepreneurs operating according to certain rules use robots that allow them to produce larger quantities of products with an increased degree of diversity. Manufacturers at various levels of the organization also employ specialized multi-tasking employees. In lean production, several practical tips and principles must be used to reduce costs by eliminating wastefulness and simplifying service and production processes. The main principle at Lean Manufacturing is continuous improvement. Once the goals have been achieved, the efforts to improve the process should not end (Zhao *et al.,* 2019). Better solutions must be sought, and the standards of functioning must be raised, as the environment of the enterprise is constantly changing (Wu *et al.,* 2019). Toyota, which is the leading production company in the world, bases its success on this principle.

Lean Manufacturing was created based on the Just in Time system, which was later transformed into the entire enterprise management system, namely Lean Management. All this is the essence of a modern Lean Management company where one of the most important tasks is now digitization of the global business space (Koranda *et al.,* 2012). The basic principle of Lean Management is to reduce waste of resources by asking if a given task or process constitutes any value added to the enterprise (Al-Aomar, 2011). The concept of cost-effective management identifies waste as any type of process or resource that is unnecessary or increases costs or time consumption (Aziz and Hafez, 2013; Issa, 2013).

Lean Management includes organization, material order control, planning, development, and research. Tasks and procedures associated with the supply chain are viewed from a project-focused perspective, rather than from a general or standardized perspective, which makes it easier for project managers to focus on specific project results and unique customer requirements (Garcia-Acaraz *et al.,* 2019; Abdallah *et al.,* 2016). The implementation of Lean principles requires the

implementation of many typical tools that will improve the functioning of the company (Filla, 2016). In practice, these techniques are usually referred to as Lean Toolbox (Carrizo Moreira and Torres Garcez, 2013). In the research part, the authors proposed using Lean Production tools such as SMED, TPM, 5S method. Brief definitions of methods used are provided below.

SMED (Single Minute Exchange of Die) means shortening changeovers time or putting it more precisely, the impact on reducing the production batch is the basis of Lean Manufacturing and Just in Time methods (Pawłowski *et al.*, 2010). SMED is defined as improving production flexibility and a TPM element, which is designed to enable retooling of the production line in less than ten minutes (Godina *et al.*, 2018; Boran and Ekincioglu, 2017). The SMED methodology gives us three concepts, external retooling, internal retooling and retooling itself.

Retooling, i.e., introducing changes to a group of machines or a machine, involving replacing the mounting fixture, mould, matrix, tools, etc. to allow other products to be made in the manufacturing process. The time needed for retooling is counted from the last product "A" to the first product "B" in appropriate quality with standardized parameters. External retooling is part of the overall retooling, carried out during the production line or machine operation.

Usually, these are preparatory activities before stopping the production line. Internal retooling is part of the retooling performed when the production line or machine is stopped. Achieving standard performance, start time and device start-up are included in the time of internal retooling (Diaz-Reza *et al.*, 2018). This tool is increasingly used in enterprises that have variable and complex production lines (Gligorijevic *et al.*, 2016; Sayer and Williams, 2015).

TPM (Total Productive Maintenance) is one of the most important Lean Management tools and it is a global maintenance management in an enterprise (Nakajima, 1998). It is the method with which we can maximize productivity and ongoing maintenance of tools and equipment. TPM's goal is to minimize production losses associated with breakdowns or malfunctions, maximize the efficiency of production equipment, and optimize the entire maintenance program established throughout the enterprise (Bon and Lim, 2015). Equipment performance as an indicator of performance is recorded in a balanced table, especially in manufacturing companies. TPM method is divided into three areas (Imai, 2012):

Preventive maintenance - Cost control and proper people management allow predicting the occurrence of failure event by performing maintenance at the right time. Also, parts necessary to have in stock for routine and scheduled maintenance can be defined.

Autonomous maintenance - means that a team of employees performs maintenance as part of activities of the work schedule. Thus, specialized employees can focus on heavier tasks that are to prevent malfunctions and are planned in the

department work schedule. A description of maintenance work is used for tasks allowing employees to perform them regularly and on time.

Planned maintenance - heavily used or high-risk parts must be regularly replaced or maintained. This type of work must be planned because tools, parts or equipment must be out of service. In a Lean environment, maintenance planning is very important. When replacing parts, data must be downloaded to allow making predictions about possible failures.

TPM can also be defined as an approach which, due to the involvement and empowerment of employees, dramatically improves production processes (Jimenez *et al.*, 2019; Imai, 2012). The 5S method is a tool for managing the workspace and for properly maintaining the workplace in five steps according to Japanese terminology (Michalska, 2006; Dahlgaard *et al.*, 2002):

Selection (Seiri) - in Gemba (the Real Place) a distinction between unnecessary and necessary things, i.e., consistent elimination of unnecessary things.

Systematics (Seiton) - organizing the remaining items after selection.

Cleaning (Seiso) - keeping machines and the workplace clean.

Standardization (Seiketsu) - continuous practice and application of the abovementioned points as much as possible.

Self-discipline (Shitsuke) - building a habit of engaging and self-discipline by setting standards with 5S.

Nowadays, the use of 5S standards has become necessary for manufacturing companies. A perceptive and good Gemba manager determines the quality of the company in five minutes during a visit to the factory. He looks at the processes taking place in the company, including 5S and the elimination of Muda (wastefulness). In Gemba, the lack of 5S means inefficiency, and Muda poor self-discipline, low quality, inability to meet delivery times, high costs and poor morale. Suppliers who do not practice the 5S method are not taken seriously by customers.

The five elements of proper job maintenance refer to the starting point for an enterprise that would like to be a responsible producer that can apply for market leadership (Michalska and Szewieczek, 2007). The implementation of the 5S method should begin with training production department employees on method elements and the benefits of their use. It is also important that the methods used do not have to apply only to the production department as they can also apply to warehouse, office, and other employees (Sony, 2018; Ramadan *et al.*, 2020).

The result of using 5S is a well-organized, highly efficient, and clean workplace. At the same time, the method eliminates losses associated with breaks and failures that occur during the functioning of an enterprise (Sony, 2018).

2. Materials and Methods

2.1 Technical Infrastructure

The production zone together with the company high bay warehouse amounts to 3,150 m^2. The high bay warehouse is in a separate building with an area of 1,600 m^2 and is used for storing manufactured products and components for production of the enterprise. Figure 1 shows the enterprise block diagram. The production zone is in a building with a total area of 1,550 m^2. Both company buildings were made of sandwich panels with a polyurethane foam insert, which is the best insulator. With this technology, it is possible to maintain a constant air temperature and negligible air humidity. Both enterprise buildings have temperature monitoring devices, which must be maintained at 5°C-20°C, which is done using PrimoSchwank ceramic radiators and controlled with the APAR AR434 sensor system, which measures temperature every minute and sends reports to the production manager every hour. The company has 50 APAR sensors located in the production zone and high bay warehouse. The production line infrastructure includes:

- aluminium silos for loose materials for production,
- WTS double-shaft blade mixer,
- production line control module,
- conveyor engine and conveyor,
- PTE INSTEL turbine packing machine,
- SH600 bag sealer,
- temporary storage warehouse,
- Production manager's office with social facilities.

The high bay warehouse infrastructure includes:

- four-story high bay PHR shelving,
- three loading ramps,
- parking for forklifts,
- laboratory with sample warehouse.

Two enterprise halls have also been equipped with building utility systems, i.e. plumbing, lighting, ventilation and fire protection systems, which are designed to ensure safety at work and appropriate working conditions. The company has four Hyundai 45L-7A forklifts with a capacity of up to 4.5 metric tons. The trucks are powered by gas supplied from cylinders. Every production line employee working in an enterprise must undergo appropriate training and courses to be able to use transport trolleys. All transport trolleys undergo technical tests once a week performed by a machine and equipment maintenance staff. Once every six months, they are transported to the Hyundai service centre for a mandatory detailed technical inspection.

2.2 Production Employee Obligations

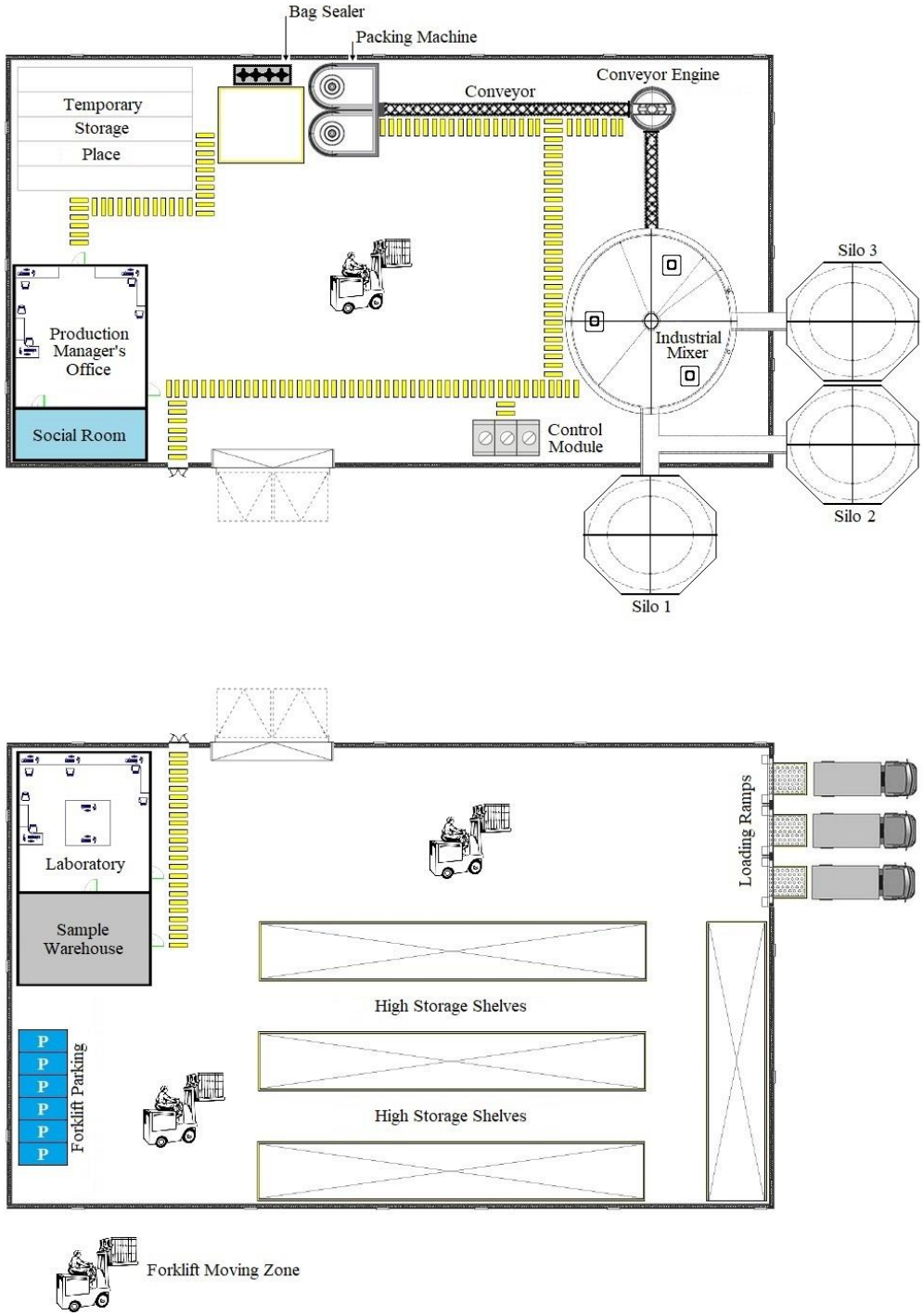
Production department employees must take appropriate courses and have training and technical skills, as they must operate equipment used for the production and storage processes. All employees of the production department must take courses run by external companies on operating forklifts with mechanical lifting drives implemented in accordance with the Regulation of the Minister of Economy of July 18, 2001, which refers to checking the qualifications required for maintenance and operation of technical devices and in accordance with the Act of December 21, 2000 on technical supervision. The course is 67 hours long. After taking the course, every employee is prepared theoretically and practically for the state examination before the commission of the Office of Technical Inspection.

After completing the course and passing the exam, a production department employee is authorized to operate forklifts in a company. Also, employees must undergo mandatory OHS training provided by an external company. The training lasts one business day.

During the training, employees learn the basic legal regulations, the obligations of employees' management, the obligations of the employer, responsibility for violation of company rules and OHS regulations, post-accident procedures for non-employees and people working in the plant, responsibility for causing an accident. A production department employee should be able to easily perform several operations at the same time, should have high mathematical skills and high accuracy, as the employee is simultaneously responsible for maintaining cleanliness, order around the production line and warehouse and for entrusted property. The tasks of a production department employee in the studied enterprise include:

- compliance with health and safety rules,
- servicing technical equipment,
- unloading suppliers' cars using transport trolleys,
- receiving goods from suppliers, initial quality, and quantity control together with confirmation of shipment from the supplier,
- entering a new product into the system and maintaining warehouse documentation,
- performing tasks necessary for the proper production process,
- ensuring high product quality,
- packing the finished product,
- maintaining cleanliness and order around the production line and in the warehouse.

Figure 1. *Diagram of the analysed enterprise.*



Source: *Own study.*

On the first day of work, new production department hires receive protective clothing after the completed courses, which is required to be worn during the work in the entire production plant.

2.3 Production Process Organization

The production process implemented in the examined company is a complicated combination of the process combining receiving the order from the customer and the process of manufacturing the product. Every employee present on a given day in the company participates in the production process. The production process begins at the sales office from the time the order is received from an individual or institution customer. Each order is carefully controlled by a logistics department employee and sent electronically to the production department manager. After receiving the order from the logistics department, the manager must check the inventory using the company computer system. If a given product in the order is in stock, the manager creates an order to release the product and sends the order to a warehouse employee. After receiving the order, the department employee must prepare a complete order to be handed over to the driver of the transport company or the customer who is scheduled to pick up the goods on a predetermined date. If the ordered product is not in stock, the manager creates a production order for the product. Production line employees check the production line settings for the adaptation of machines to the manufactured product listed in the order.

Employees must prepare appropriate semi-finished products for production. In most manufactured products, this involves the opening of two out of three silos that store bulk materials. The remaining part of materials needed for production is added in appropriate proportions through the drain to the mixer. Adding materials to production takes place only with the production line switched off. Appropriate bags for the material ordered must be loaded into the packing machine. The production manager in the production line system must enter in the control module the number of manufactured products and the mixer rotor speed adapted to the manufactured product. The machinery and equipment maintenance worker employed in the company must check the channels and the rotor of the mixer each time when starting the production line to ensure the safety of production line workers and maintain the highest quality of the manufactured product.

Next, the maintenance worker checks if the mixer motor works in compliance with the standards listed in the device operation manual, using the measurements carried out with a mixer computer. Production line workers must perform a conveyor belt test and start the packing machine. After the above-mentioned activities, the company begins production. All product components are mixed in the mixer and transported by conveyor belt to the packing machine.

Each batch of material produced is properly controlled. To this end, an employee of the factory laboratory takes a sample and marks it with the appropriate number.

Next, in the laboratory, the above-mentioned sample is examined for compliance with chemical and physical parameters appropriate for the given product and stored in an appropriate room. Workers collecting the product in bags from the packing machine must inspect each product bag using an industrial scale. The bags checked for the appropriate weight for a given product are sent to a manual sealing machine for sealing and safe closing of the product. Product bags are placed on pallets of 32 or 45 items, depending on the weight or bulk density of the material and are transported to a temporary storage place to protect the full pallet.

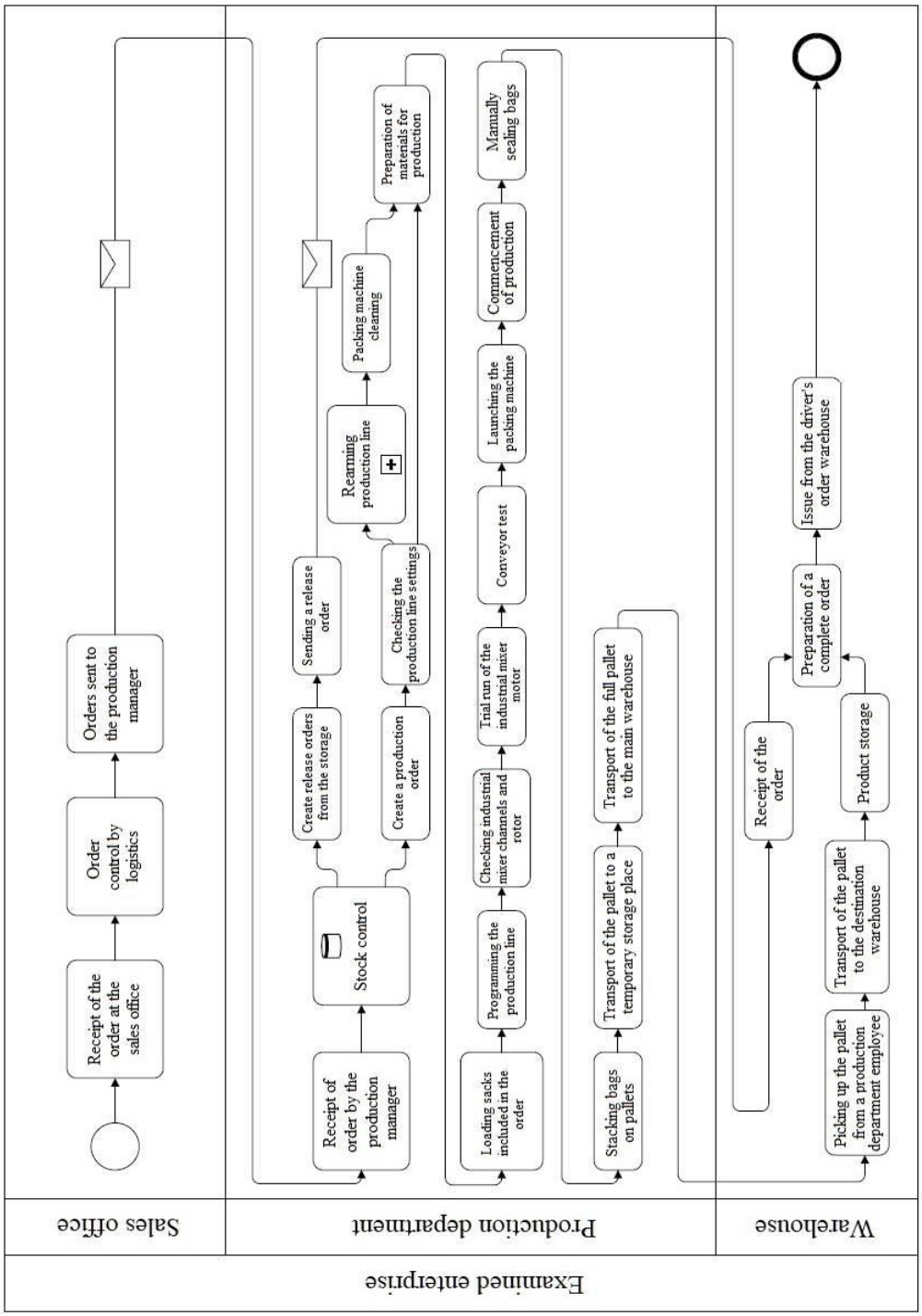
The complete pallet is wrapped in film and transported to the main warehouse where warehouse employees place the pallet in the appropriate storage place on the shelves. After producing the right amount of product listed in the order, a complete order is issued to the driver of the transport company or the customer via loading ramps. The above-mentioned process was presented using the process map in Figure 2.

2.4 Implementation of the Production Line Retooling Process

The process of retooling the production line in the examined company is a very important element that has a direct impact on the highest quality of manufactured products and their reliability. When starting the production line, no material may be present that is not part of the product's composition, which may affect its physical and chemical properties. The process of retooling the production line begins with the introduction of the Betolix waste dissolving substance into the main mixer. The entire dissolution process takes 10 minutes, and the substance can be used only once. After being pumped out of the mixer, it is sent in metal tanks to a recycling company. The equipment and machine maintenance worker must then check the mixer ducts manually, using the engine control module. All parameters should be within the standards and the operation report must not show any errors. Depending on the production line settings, the mixer rotor must be replaced for the production of the product.

The next step in retooling the production line is to replace the conveyor belt appropriate for a given product. It must be replaced in every process of retooling the production line. After the installation of a new belt, the conveyor motor must always be tested under operating conditions. The maintenance worker blows all the fifteen channels of the packing machine with compressed air to prevent unwanted substances from entering the newly manufactured product. Betolix waste dissolving substance is then being introduced into the packing machine. The packing machine is started to flush the channels. All channels must be properly dried with compressed air. During the inspection of the packing machine, the bags are also replaced with other bags, appropriate for the material subsequently produced.

Figure 2. *Production process map*



Source: *Own study.*

The production department manager archives on the disk of the production line control module the settings for previous production and uploads new settings for the next product. After programming the line, the production line must be started to check the proper functioning of all devices necessary for the production of new products. Production line employees, after receiving guidelines from the production manager, are tasked with preparing new semi-finished products that will be used during production. The times of the above-mentioned activities are presented in Table 1. The process of retooling the production line described in Table 1 is presented using the process map in Figure 3.

Table 1. *The times of tasks performed when retooling the production line*

No.	Task performed when retooling the production line	Time
1.	Introduction of waste dissolving substance into industrial mixer.	12:15 min
2.	Rising the tank of industrial mixer.	10 min
3.	Pumping down the dissolving substance.	13:10 min
4.	Inspection of channels of industrial mixer.	5:30 min
5.	Inspection of engine of industrial mixer.	12 min
6.	Replacement of the rotor for the corresponding product.	31:10 min
7.	Disassembly of conveyor tape.	14:20 min
8.	Installation of a suitable conveyor tape.	10 min
9.	Inspection of conveyor engine.	7 min
10.	Blowing with compressed air of packing machine channels.	2:45 min
11.	Introduction of waste dissolving substance to channels of packing machine.	2 min
12.	Rinsing the packing machine channels.	10 min
13.	Pumping down the dissolving substance.	2 min
14.	Desiccation of channels of packing machine.	5 min
15.	Replacement of bags in a packing machine with ones suitable for product.	15 min
16.	Saving software from the production line.	1 min
17.	Uploading new software from the production line.	1 min
18.	Test launch of the production line.	5 min
19.	Production line inspection.	5 min
20.	Preparation of materials for production.	21 min

Source: *Own study.*

2.5 Logistics Processes Implemented in the Company

2.5.1 Supply Process

The supply process in the company consists of several stages, for which designated persons responsible for performing activities related to the process of ordering the goods required for production are responsible. The process begins by the production

and warehouse manager informing the logistics department manager about the demand for specific parts for production. The demand is transmitted via e-mail or in the form of messages within the system functioning in the enterprise. The application must include the assigned material indexes for the individual items, their quantity and delivery date.

The production and warehouse manager sets the order quantity for each item included in the order and the logistics department manager selects the supplier. During this stage, the logistics specialist must make a detailed analysis of the prices of products at the suppliers of each ordered product, the time of order processing and additional costs that may have to be incurred during the whole process, such as: customs, transport, etc.

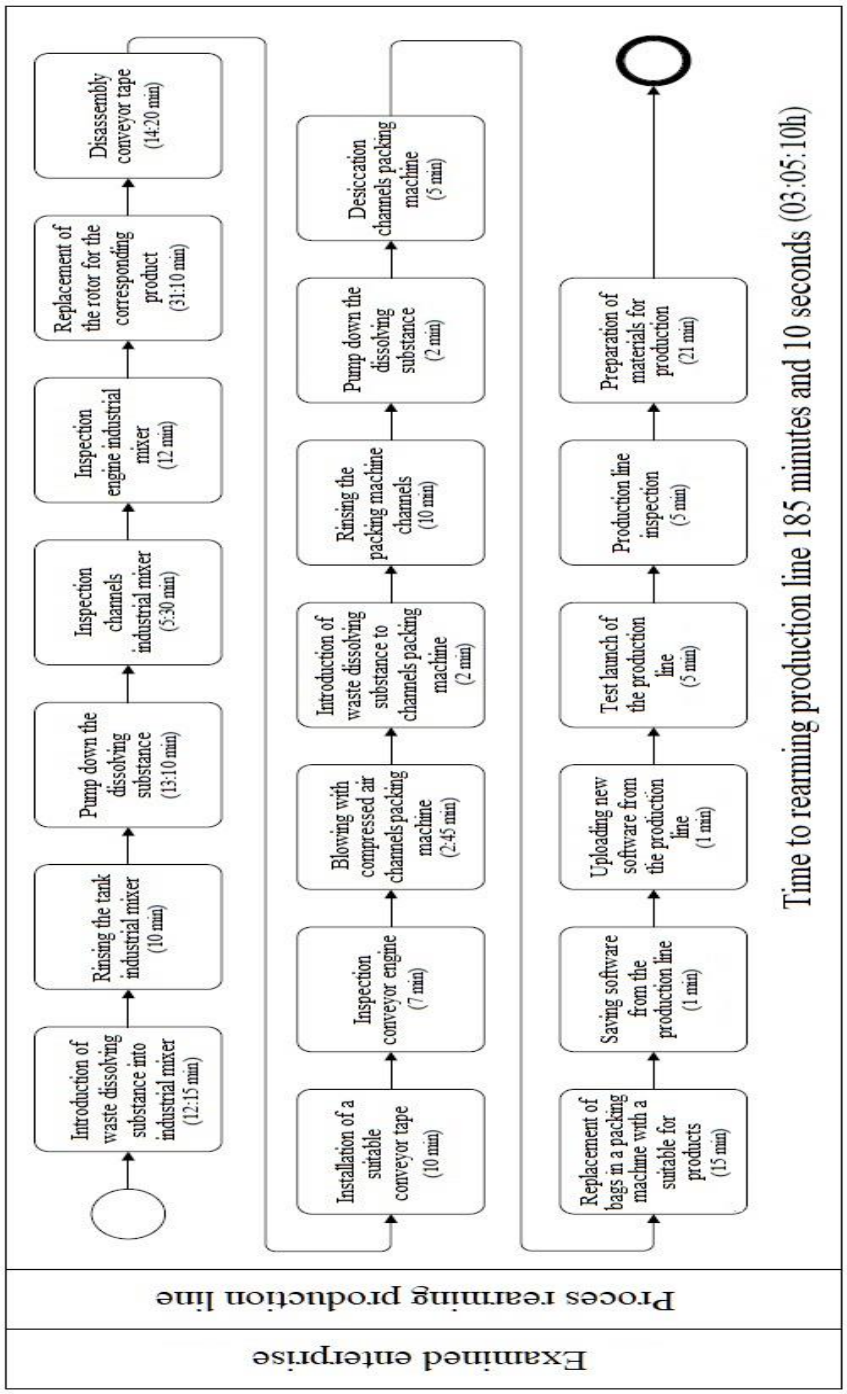
The next step in the ordering process is placing an order with the selected supplier. The logistics specialist enters the indexes of individual ordered items and the size of the order in the system. Next, the logistics employee supplies the date of shipment, delivery conditions, price, payment date and any comments to the board members of the company. The last stage during the implementation of the supply process is the verification of the received invoice for the purchased goods. The logistics department manager enters the received invoice from the supplier into the company internal system. The manager verifies the quantities and the price of each ordered item against the invoice data.

2.5.2 Warehousing Process

The technological storage process in the examined company is a set of activities that are performed during the flow of products through the warehouse. The process begins with the unloading of suppliers' cars, through acceptance and storage, completing, and ends with the loading of customers' cars. The warehouse process can be implemented due to the provided technical and organizational conditions such as storage space, machinery and equipment, personnel, flow system and inventory functioning within the company. The storage process in the examined company is complex and includes eleven stages:

- unloading suppliers' cars,
- transport to the storage area,
- qualitative and quantitative acceptance,
- sorting, de-moulding and forming warehouse loading units,
- storage,
- assembly in the warehouse,
- temporary storage in a designated place,
- completing loads for issue,
- transport to the issue zone of completed load units,
- qualitative and quantitative issue,
- loading customers' cars.

Figure 3. *Production line retooling process map*



Source: *Own study.*

2.5.3 Transport

The examined company cooperates with many shipping companies. The company does not have its own external transport; therefore, it must use the services of external transport companies. Usually, transports are organized throughout the country, while the company has also undertaken cooperation with international transport companies. Cooperation with such shippers enabled the company to expand its distribution areas to European Union countries. The cooperation has been implemented since 2016.

In 2017-2019 the company cooperates with 16 domestic and 5 foreign shipping companies. The costs of cooperation between the company and shippers involved in the export of goods and transport in the country in 2019 was PLN 169,100. The cost of cooperation with foreign market transport companies significantly exceeds the costs of cooperation of the company with shippers serving the domestic market. Figure 4 shows the quantity of goods sold in 2019.

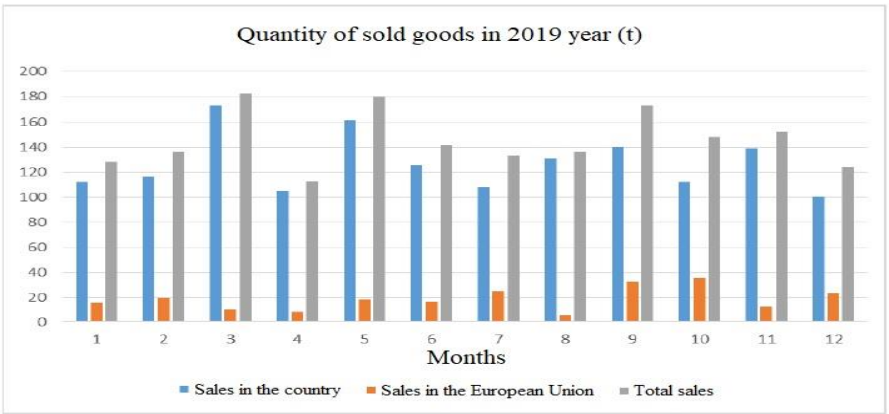
3. Results

Based on research, implementation of several process improvement tools was suggested for the examined company.

3.1 SMED – Shortening the Retooling Duration

In the studied company, the retooling process is common due to the large range of manufactured products. Currently, the retooling process is 3 hours, 5 minutes, and 10 seconds. For the company to minimize the time needed to retool the production line, it must introduce several modern solutions to the entire process. The first proposed solution is to create an installation for the introduction and pumping of substances dissolving waste from the main mixer and packing machine channels.

Figure 4. *The quantity of goods sold in 2019*



Source: *Own study based on company data.*

The use of a modern system together with a single-stage centrifugal pump can shorten operation times and facilitate the entire process. Centrifugal pumps are used to introduce and pump hydrocarbons, acids, and aggressive chemicals affecting the corrosion resistance of devices used in the enterprise. Centrifugal pumps are currently among the best and most often used in industrial plants. Due to the relatively simple construction and easy disassembly and operation, they allow access to all existing parts without the need to remove the entire pump from the system in the event of a breakdown or periodic inspections. Pumped-off dissolving liquids must be stored and prepared for transport to companies dealing with the recycling of chemical substances. The substances must be stored in IBC tanks adapted for the transport and storage of chemical, petrochemical and agrochemical liquids.

The use of IBC tanks will save space in the storage area. The tanks can be stacked due to the internal polyethylene containers, plastic pallet and external grille made of stainless steel. The IBC tank when pumping a chemical in an enterprise must be placed on a capture pallet to ensure the safety of employees posted to the process of retooling the production line. The capture pallet is equipped with removable grilles, which allow keeping the container clean and make emptying the chemical from the pallet very easy. The pallet, as it has specially made bottom, is adapted for transport using forklifts used in the enterprise.

Another solution that can save a significant amount of time is the possibility of facilitating the replacement of the main mixer rotor. Currently, rotor replacement is performed using a forklift, which is inefficient and dangerous for the life and health of the company's employees.

The company should invest in an electric crane that would be attached to the transverse reinforced concrete structure of the production zone. The crane is equipped with a 12-meter-long rope, its lifting capacity is 800 kg, it has an IP54 safety certificate and an emergency system for emergency situations, i.e. an automatic brake. The device has a torsion-resistant steel rope, which reduces the rotation of the load being lifted. With such devices used to support the retooling process, the time needed for the activities can be significantly reduced. The total time needed to retool the production line can be reduced by 40 minutes and 55 seconds. Table 2 shows the possible times for shortened retooling steps before and after upgrading.

Table 2. *Possible times for shortened retooling steps*

Retooling sequence steps	Step	Time before upgrading	Time after upgrading	Time saved
1.	Introduction of waste dissolving substance into industrial mixer.	12:15 min	2 min	10:15 min
3.	Pumping down the dissolving substance.	13:10 min	2 min	11:10 min

6.	Replacement of the rotor for the corresponding product.	31:10 min	15 min	16:10 min
11.	Introduction of waste dissolving substance to channels of packing machine.	2 min	0:20 min	1:40 min
13	Pumping down the dissolving substance.	2 min	0:20 min	1:40 min
	Total			**40:55 min**

Source: *Own study.*

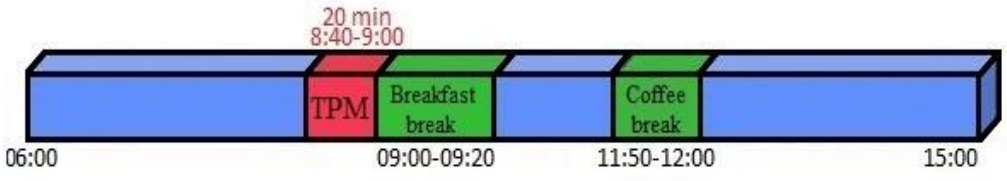
3.2 TPM - Equipment and Machinery Maintenance Carried Out by Production Staff and Operators

By organizing appropriate cooperation between production and maintenance, the examined company found it possible to significantly improve the efficiency of a utilized machine park and reduce risks to production continuity, such as unplanned downtime or production line failures. The main purpose of introducing TPM in the examined company is to reduce the costs of maintaining equipment and machinery, extend the life and increase stability during the production process. The key objectives for the examined company under TPM are:

- Involvement of all company employees in the design, use, planning, and maintenance of the equipment used in the company.
- The production line employees taking over simple activities, e.g., equipment adjustment or inspection.
- Extending the life of the company's equipment by developing a maintenance system.
- Involvement of operators of individual devices in independent reviews.
- Maximizing device performance by eliminating losses.
- Obtaining the support of all employees and the entire management of the company.

Figure 5 shows the proposed organization of changing the production time.

Figure 5. *Organization of changing the production time*



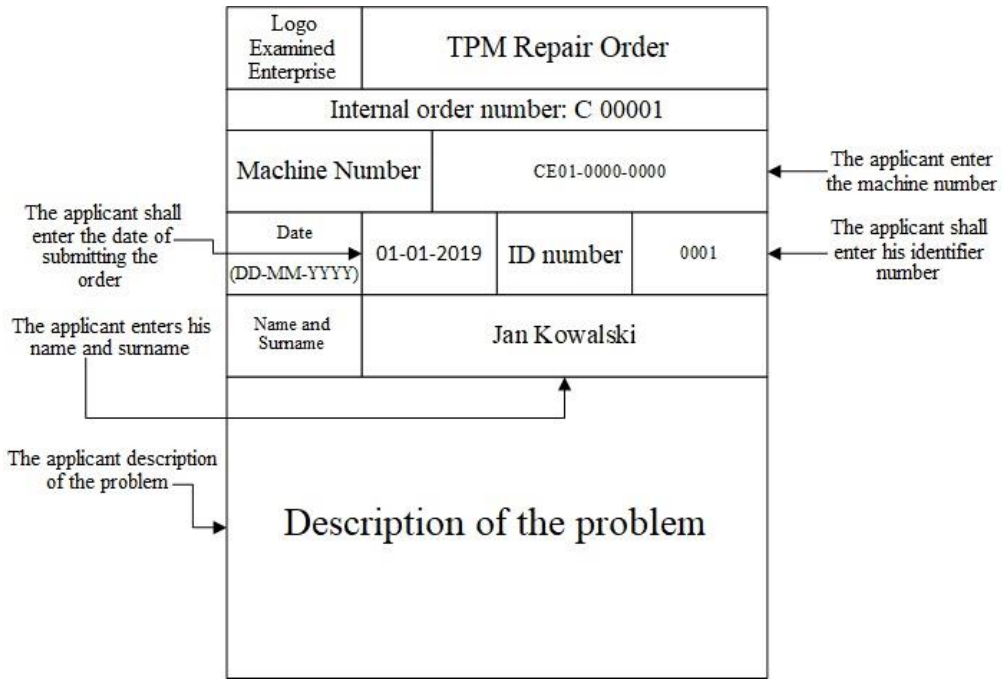
Source: *Own study.*

Elements of TPM implementation used in the company:

- Purchase of the necessary tools for employees - cutters, brushes, screwdrivers, etc.
- Creation of about 7 working instructions for the maintenance and operation of machinery and equipment.
- Allowing 20 minutes to change the production time to TPM.
- Placement of about 10 TPM boards, including a reporting system to notify of the smallest failures on TPM cards.
- Training employees in individual departments - 2 hrs on the basics of TPM operation and the operation and construction of production line equipment.

Figure 6 shows the TPM reporting card.

Figure 6. *TPM reporting card*



Source: *Own study.*

3.3 5S – Proper Maintenance of the Workstation

In the examined company, the implementation of the 5S method should be preceded by employee survey. The biggest obstacle to the introduction and use of the 5S method is resistance to changing existing employee habits. Companies should conduct two surveys to check how staff relate to maintaining order and organizing workplaces in the production zone. The first should be directed to the management

level, and the second to employees employed in production. Table 3 presents the work improvements for the examined company.

Table 3. *Work improvements for the examined company*

5S:	Work Improvement	Task (goal)
Selection	Better use of workstations, efficient and clean workstations	Cost reduction and work improvement
Systematics	Facilitating employee access to tools at the workstation, increasing safety	Quality improvement
Cleaning	Maintaining a safe and clean workstation, improving and maintaining machine efficiency	Increased security and reduced trouble with machines
Standardization	Elimination of accident causes and improvement of work environment	Increased hygiene and occupational safety
Self-discipline	Improving interpersonal relationships and reducing the number of human errors	Morale increase

Source: *Own study.*

In the process-design approach to the implementation of 5S method in the examined company, detailed planning of the projects should be assumed by setting appropriate dates and tasks. Table 4 presents the tasks and implementation times of 5S method in the company.

Table 4. *Tasks and implementation times of 5S method in the company*

Task	Time (days)
5S methodology training	10
Overview of workstations in the company	5
Determining the members of the implementation team	1
Preparation of cost estimate and expenditure plan	3
Removal of all post-production waste from the company	15
Selection of workstations requiring 5S implementation	2
Cleaning	5
Tool segregation on workstations	3
Preparation of information boards	5
Preparation of forms	1
Preparation of control cards	2

Source: *Own study.*

The training is the first stage of the 5S method and should be attended by all employees of the company. During the training, issues of operation, purpose, essence, and benefits of 5S would be discussed. After conducting the training, the

company should focus on observing employees during their work in order to check who takes care of order and whether the tools have a designated storage place. The most important step when implementing the 5S method in a company is to organize the production hall. One of the major problems of the examined company is the large amount of post-production waste. Currently, hardly any employee is posted to take out waste. Taking out the waste from the production hall will allow for the space necessary to implement the 5S method. To eliminate and identify unnecessary items, red labels should be created. In accordance with their purpose, unneeded, obsolete, and improper items will be marked on the workstations, including those too numerous, incorrectly repaired and needed items.

The proposed changes also include determining the movement route for employees, introducing the shadow method for equipment and tools of employees, indicating places for cleaning products and waste, creating instructions for each 5S activity and providing information boards so that every employee of the production hall would have at any time access to them. The introduction of the proposed changes in the company can increase the space of the production hall and improve the comfort and safety of employees.

4. Discussion

Based on the literature study and the analysis of the company, it can be stated that the main goal of the thesis has been achieved and the thesis has been verified. The following conclusions were made in the article:

1. The analysis of the organization of the production process presented the operating principles in force in the production zone and presented in detail the scope of duties of employees of the production department.
2. With the analysis of processes carried out in the production hall of the audited company, the activities carried out from the moment of commencing production through the process of changing the production line to the delivery of the finished product to the customer were reviewed.
3. The presented map of the production process and the process of retooling the production line showed the order and complexity of operations carried out in the production zone.
4. Based on the production process map, the analysis showed threats of continuity of production, such as unplanned stoppages or failures that may occur during the use of the machinery park of the examined company.
5. By analysing the process of retooling the production line, the reasons for the long duration of individual activities were identified. The main factors affecting the generation of losses during the line setup process are deficiencies in the equipment and infrastructure of the company.
6. Too long time of individual activities during the process of retooling the production line prompted improvements with the SMED improvement tool. The proposed investments can dramatically reduce retooling times and increase

employee safety. The total time needed to retool the production line can be reduced by 40 minutes and 55 seconds.

7. The proposed improvements, i.e., introducing the TPM improvement tool will significantly improve the efficiency of the depleted machine park and reduce continuity risks occurring during the production process, such as unplanned stoppages or breakdowns of machinery and equipment. The proposed TPM tool will reduce the costs of maintaining equipment and machinery, extend the lifetime and increase stability during the production process.
8. By using the 5S method in the examined company, it is possible to reduce losses that result from waste. Organizing and removing items and tools unnecessary at workstations will shorten the time needed to search for the right tools necessary during the production process, which in turn will help eliminate waste of time.

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