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THE OPTIMISATION OF THE PRODUCTION PROCESS BASED ON THE 5S LEAN PRODUCTION TOOL ON THE EXAMPLE OF THE ESTOLUMBER COMPANY

Bachelor Thesis

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I have written this Bachelor Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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Introduction

Today more and more factories producing of a certain type of goods are appealing to the process optimization to reduce the company's costs and increase the output of the enterprise. One of the crucial concepts in terms of process optimization is the lean production concept. Lean production is a management technique that allows the company to reduce costs and accumulate as much resources as possible for bringing the value of the product to the customer (Irani, 2020). With the help of this concept, the company can optimize its internal production processes and eliminate several wastes to increase the efficiency and profitability of the company. The lean production process includes several practically applicable tools that allow the company to improve the production process. It should be noted that these tools are aimed not only at the reduction of costs but also at bringing an additional value to the final product. Still, the concept of lean production has been applied many times over its long history, and there are many examples of the introduction of one or another technique into the production process.

The benefits of the application the lean production concept to the manufacturing process can be observed in the history by the Japanese economic miracle (Crawford, 1998). Lean production tools refer to the Japanese phenomenon of a significant increase of the rate of economic development (Crawford, 1998). Many years ago, car production company Toyota was the first company that introduced this concept to the operation process (Borris, 2006). For today, the problem of process optimization remains even more relevant than ever due to the economic crises caused by the pandemic and a significant increase in prices for raw materials in the wood processing industry (Popken, 2021). During the pandemic, many enterprises were forced to stop the production process. In connection with this situation, recovery of the production with the lowest minimal costs became a crucial issue. Thus, in the modern situation of uncertainty, it is essential for companies to optimize costs most efficiently, and the use of the lean production concept for manufacturing companies becomes a useful tool. Since the 5S is one of the most widespread and versatile tools of the lean production concept, its application becomes a solution to the problem of optimizing production and reducing costs (Kobayashi, 2008).

The research gap of this study lies in the fact of application of the 5S lean production tool in the wood processing industry aiming at the resolving of the material transportation problem. In this regard, the further application of the studied topic will be relevant for the manufacturing companies in term of the application of the 5S lean production tool and, therefore, optimization the production process.

The aim of the bachelor thesis is to investigate the current production situation and to offer the optimisation possibilities based on the 5S lean production tool at the Estolumber company. In this bachelor thesis, it is necessary to consider the application of the certain tool of the lean production concept in an SME and identify the possibilities of elimination the transportation waste on the example of a company producing wood products. In this regard, material transportation issue is closely related to the specific waste of unnecessary transportation of raw materials and finished products (Borris, 2006). Therefore, the application a certain lean production tool can be a solution for material transportation issue of the studied company. It is important to note that in this bachelor thesis, the concept of lean production will be considered as an approach of solving the specific problem the company currently has through the application of the lean production tool, but not an attempt to application the entire concept of lean production in the specific company. The application of the whole concept requires the adoption of the specific strategic goals aimed at the withdrawal of all wastes of the company, changing the strategy, and making it aimed at continuing deleting these wastes of the company (Liker & Meier, 2006). Besides, in the case of this study, the main aim is to apply the lean production tool for the production process to optimize it, but not to achieve the continuing improvement of the production process through the application of the entire lean production concept.

Thus, to achieve the aim of the bachelor thesis it is necessary to perform the following tasks:

- Define the lean production concept and lean production tools
- Identify the type of production of the studied company and explain the choice of the 5S lean production tool for the solution of the material transportation problem.
- Analyze the previous application of the 5S lean production tool to the optimization the company’s production process.
- Describe the essence of implementation of the 5S lean production tool within the studied company
- Evaluate the material transportation process performance before the implementation of the 5S lean production tool within the studied company
- Offer the optimisation possibilities based on the 5S lean production tool at the Estolumber company

From the structural point of view, the study consists of two chapters. The first chapter introduces definitions of the lean production concept and lean production tools. It is important to find the most suitable way of explaining this concept since the method of its application depends on it. This chapter also contains a detailed analysis of the 5S lean production tool and its previous applications. The second chapter describes the process of applying the 5S lean production tool to a studied company in the connection to the material transportation problem, production situation analysis, the results of the study, and the list of optimisation possibilities based on the application of the 5S lean production tool.

Keywords: lean production, 5S, lean production tool, production optimization.

1. The production optimization based on the 5S lean tool

1.1 The concept of lean production and lean process improvement tools

In this chapter the definitions of the lean production concept and the possible uses of lean production tools will be discussed. In addition, in this part, the possible types of production organization will be explained, and the most suitable lean production tools for optimization will be mentioned.

The research about process optimization and the application of the lean production concept requires the definition of lean production and choosing the most efficient strategy of the application of lean production tool. Thus, the understanding of the meaning of the concept is necessary for the correct application within the production process. Depending on the purposes of implementation of the lean production concept, different authors defined this concept differently. Besides, the use of lean production tools has changed over time along with production methods

Initially, lean manufacturing was invented in Japan and called the Toyota Production System (TPS) (Borris, 2006). The essence of the TPS lies in the fact of continuous improvement of operations of the production process, and the overall success of the application of this system happened due to the use not of individual tools of lean production but of the entire system allowing continuous innovation (Spear & Bowen, 1999). In this regard, it is possible to conclude that the lean production concept implies more than a set of different tools to increase production productivity, but a certain flexible system that allows to constantly modernize production processes and at the same time adhere to lean production tools. One of the first definitions of lean production as a concept was formulated by James P. Womack et al. (1990) in the "The machine that changed the world" book. The lean production there represented as the special way of organizing the production process considering economic circumstances, failure of the attempt to adopt an already working mode of production and aiming at the optimizing the production process step by step applying different methods (Womack, 1990). Regarding the workshop application of the lean production concept, it can be characterized as a way of the application of several lean production tools for making the production process efficient (Irani, 2020). In this case, the author makes a bias towards the use of lean production tools based on the values that the company adheres to at the current stage of development and considers the lean production concept as a set of lean production tools to achieve the company's strategic goals. At the same time, according to Jeffrey K. Liker and David Meier (2006), the Toyota way of production is related to "identifying and eliminating waste in all work activities" (p26). Thus, considering the topic of the application of the lean production tool, it is necessary to recognize the weak point of the company and later find a way to solve the existing problem.

When discussing the principles necessary to optimize the understanding of the principle, for a better presentation, it is required to highlight specific points in each definition of the authors to understand the whole lean production concept. Table 2 shows the essential parts of definitions of different authors and whether these authors understand the use of the entire lean production concept or its individual tools to solve a specific problem.

Table 1

Keywords of the lean production concept terms

Source of definition	Keywords	Type of definition
Spear and Bowen, 1999	Continuous improvement of operations of the production process	The entire concept
Womack, 1990	Optimizing the production process step by step applying different methods	Several lean production tools
Irani, 2020	The application of several lean production tools for making the production process efficient	Several lean production tools
Jeffrey K. Liker and David Meier, 2006, p 26	“Identifying and eliminating waste in all work activities"	The entire concept

Source: Compiled by author based on sources mentioned in the table

Therefore, in terms of this bachelor thesis, the lean production concept should be defined as a concept that consists as a set of certain lean production tools used to solve a specific company’s problem.

Initially, it is necessary to identify the type of production, to correctly choose the lean production tool necessary for solving the problem in the most efficient way. There are several ways of organizing the company’s workshop. According to Hayes and Wheelwright (1979), it is possible to define several types of production such as jumbled flow, disconnected line, connected line, continuous flow. The production of the studied company can be described as disconnected line. The workshop of the company has several machines and at the same time there are limited number of options passing the pack of raw material through the workshop. This type of production can be characterized by certain number of ways the materials can move through the workshop and, therefore, during this process the materials may accumulate between different levels of production (Hopp & Spearman, 2008). Thus, the problem of the proper transportation of raw materials to the workshop and between machines appears. Considering the disconnected line as one of the job shop ways of the production, there are multiple lean production tools that are suitable for process improvement (Irani, 2020). For example, according to Shahrukh A. Irani (2020) such tools as 5S, Total Productive Maintenance (TPM), Setup reduction (SMED), error-proofing (Poka-Yoke), quality at source, etc. are suitable for the most job shops. Besides, it is important to note that these tools are designed to improve various levels of the production process and not all can solve the problem of unnecessary transportation of materials.

Another subject that should be defined within this bachelor thesis is the essence of lean production tools. From author-to-author lean production tools can be considered either as an attempt of consistent application of the whole lean production concept by continuing waste elimination, or the way of solving the company’s specific problem. For example, according to Jeffrey K. Liker and David Meier (2006) the key factor influencing the application of the lean production concept is the focus on the waste eliminating philosophy, but not on the separate application of the lean production tools. Besides, it is important to note that in this bachelor thesis lean production tool will be considered as a way of eliminating the waste related to the material transportation. According to Peter Hines (2004), the lean production implementation is a “highly prescriptive application of a set of tools and methods” (p 1001). In this context, this is the most correct definition, because the solution of a certain problem (transportation waste elimination) is associated with the use of a specific set of lean tools and, therefore, lean tools act as a tool to achieve the goal. In general, there are multiple lean production tools that address multiple production challenges. According to Jeffrey K. Liker and David Meier (2006) there are value stream mapping, 5S, pull production, Kanban. All these methods of eliminating production wastes can be considered as lean production tools applicable for unnecessary material transportation problem. For example, value stream mapping approach that consists of a description of the steps in production to create value and unnecessary waste elimination associated with unnecessary actions (Jeffrey

K. Liker & David Meier, 2006). 5s, in turn, is a set of principles for waste elimination aimed at organizing the workplace and the production process (Patel & Thakkar, 2014). Pull production is a certain system of satisfying consumer demand in which each subsequent action is determined by the previous one and, therefore, unnecessary actions are excluded from production (Jeffrey K. Liker & David Meier, 2006). All these tools can be applied at the unnecessary transportation of materials problem depending on the type of production discussed above. It is also necessary to consider the meaning of lean production tools precisely on the example of these tools because they all apply for different waste elimination and in the context of different types of production. Nevertheless, in the study these tools will be considered in the relation of the solution of the specific material transportation problem. Besides, it is important to note that for the application of the entire lean production concept, all production processes should be spared from different wastes and, therefore, all lean production tools are aimed at eliminating the specific type of waste, but the application of the entire lean production concept assumes the combination of different tools continuous process improvement. Within this bachelor thesis it is necessary to choose the specific tool for eliminating the waste related to the unnecessary transportation of materials.

As was mentioned above there are also several wastes of the production process the company may face. Since the aim of these research is to solve a particular problem related to the transportation, lean production tool for resolving this problem should be chosen considering its applicability to this issue. There are multiple lean production tools that can resolve the transportation of raw materials problem or eliminate the waste related to the inefficient transportation of materials. The most often used tools such as pull production together with kanban system can resolve the operation matching problem and the, therefore, this system can eliminate the waste of unnecessary transportation (Liker & Meier, 2006). The essence of the pull production lies in the fact that each previous operation defines the next one, and the kanban system is a set of special designation cards on which denoted a sigh represents the next step of production (Liker & Meier, 2006). However, a pull system must be applied in a focused manner, because it is a complex system that often requires re-tuning production, introducing additional stages, training workers, etc. In this regard, the use of a pull system in conjunction with Kanban is not suitable in the case of this type of production as disconnected line or in case any the production process related to the production with comparatively low volume and a certain diversity of products. In this case it is important to choose lean production tool that is in one hand suitable for the type of production that the company currently has, and in the other hand solves the problem of unnecessary material transportation in the most efficient way.

The Table 2 represents the correlation between the lean production tool and the discussed above type of the production.

Table 2

Lean production tools corresponding to the type of production

The type of the production	Corresponding lean production tool
Job shop	5S
Conveyor line	Kanban, Pull production

Source: Compiled by author

With the use of a particular lean production tool, it is essential to note that the methods listed in the table are applicable to the solution of the transportation of materials problem. The solution to this problem involves choosing the most preferred lean production tools to optimize the specific type of the production. Besides, the most suitable tool for that solves the problem of transportation of raw materials and matches the disconnected line type of production is 5S. According to the theory of different authors presented above, the 5S lean production tool is not only a universal tool for solving various kinds of difficulties in production, but also fits a certain type of production to the advantage of the studied company. In addition, the 5S lean production tool was also chosen because of its ability to solve the transportation of materials problem.

1.2 The 5S lean production tool

In this part of the study, the 5S lean production tool will be considered from the point of view of its definition, the constituent principles, and possibilities of applying in the relative types of production and the different structures of the company’s.

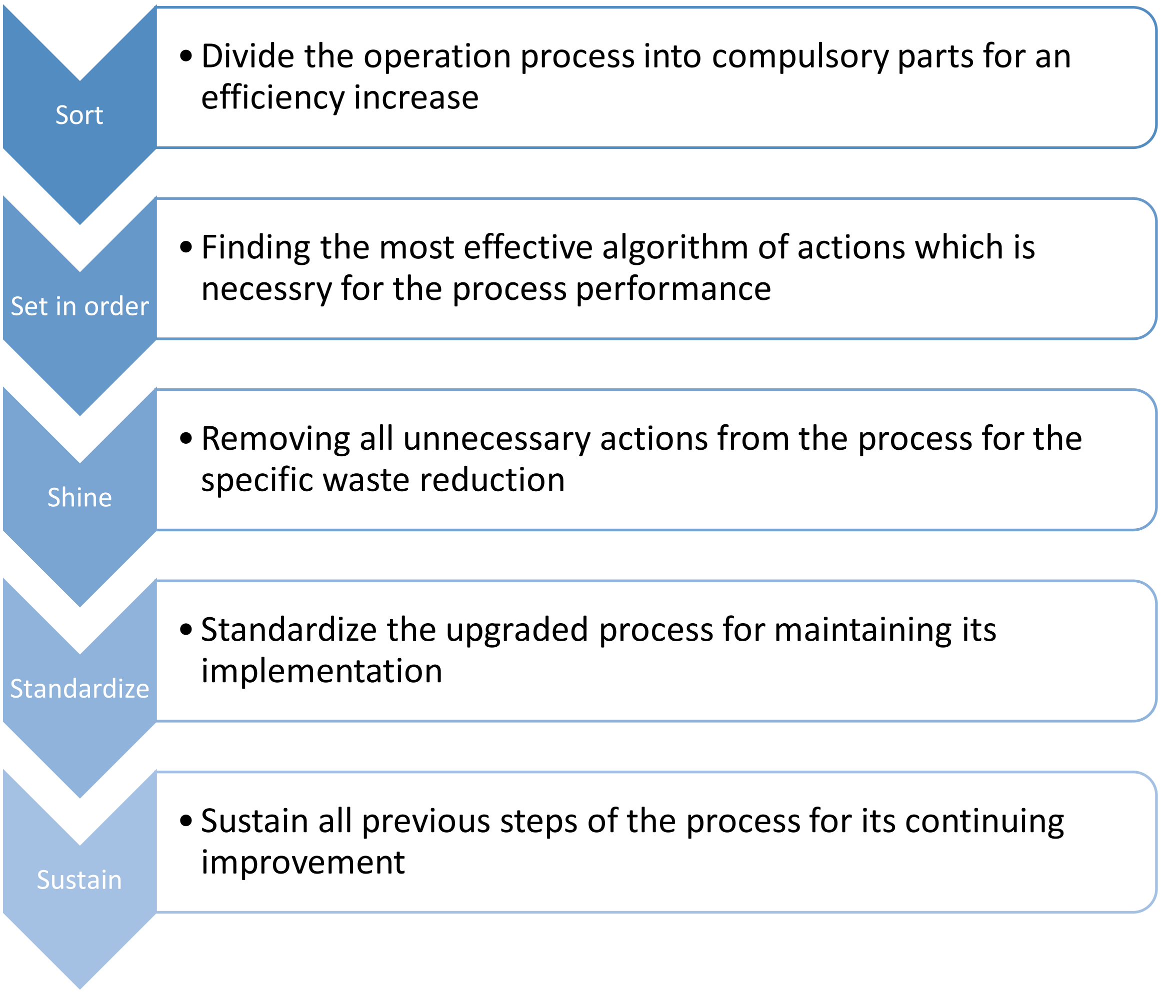
One of the most common lean production tools is the 5S tool. In order to understand the application of a particular tool of lean production concept, it is necessary to take into account its implications for the company and for the lean production concept implementation. Depending on the method of using this tool, its meaning may differ significantly, although the very principle of using this tool remains unchanged. Considering the significance of the whole lean production concept, it is also necessary to determine the meaning of this 5S lean production tool for the most effective application. According to Patel and Thakkar (2014), 5S represents a specific approach to solving organizational problems, involving the application of several principles such as sort, set in order, shine, standardize and sustain. However, it is essential to note that since 5S is an acronym for Japanese words, there are other ways to decipher this lean production tool. For example, Kobayashi (2008) describes 5S as one of the lean production tools, consisting of principles such as organization, neatness, cleaning, standardization, discipline. In this work, the analysis will use the method of translation according to Patel and Thakkar (2014) because this is the most common way of understanding these principles.

In the process of the practical application of the 5S lean production tool, based on previous experience and research, each principle of which the 5S consists of should be applied consistently in relation to a specific production situation. The principles that make up this lean production tool will be discussed below, and thus the steps for applying the whole 5S lean production tool will be presented. The first principle, which stands for "sort", is to sort and divide the work process into parts to increase efficiency (Patel & Thakkar, 2014; Mohan Sharma & Lata, 2018). A distinctive feature of the first step is the identification in the process of separation of everything that could reduce the efficiency and effectiveness for the subsequent elimination. The second principle or second step of applying the 5S lean production tool stands for "set in order" is to find the most correct and effective course of action and strengthen existing company processes (Patel & Thakkar, 2014). It is important to note that the second step of the application of the 5S should be aimed at finding and applying the correct strategies for conducting the company company's processes after the processes themselves have been sorted out in the first step using the "sort" principle. The next step in the application of the 5S lean production tool stands for "shine" and is to clean the processes of all unnecessary contaminants that do not affect the production of the final product (Patel & Thakkar, 2014; Mohan Sharma & Lata, 2018). This principle or step is important for applying the results obtained in the previous stages and achieving process improvement. The next step stands for "standardize" and according to this principle, in order to apply the 5S lean production tool, it is necessary to standardize the process improved and cleaned in the previous application step (Patel & Thakkar, 2014; Mohan Sharma & Lata, 2018). Because all of the previous steps listed must be applied consistently to achieve the most effective result, the standardization of improved processes is an important basis for process improvement. The last of the principles that the 5S lean production tool includes is "sustain," and this step includes a summary of all previous principles and steps to achieve continuous improvement of the process (Kobayashi, 2008; Patel & Thakkar, 2014).

Figure 1 reflects the implementation of the 5S lean production tool to the company’s operation process. The necessary steps and their descriptions are represented in the figure.

Figure 1

The 5S lean production tool implementation steps



Source: Compiled by author based on Patel & Thakkar, 2014; Mohan Sharma & Lata, 2018; Kobayashi, 2008 sources

Analyzing this lean production tool, one cannot but say that it most closely corresponds to the waste elimination idea of the whole lean production principle. For example, Liker and Meier (2006), in their work to understand the meaning of this term, focus their attention on the fact that 5S is not only cleaning the workplace to obtain an appropriate result but organizing certain work items to eliminate losses associated with their movement. In this definition, it is important to note that the authors focus their attention precisely on the result, which should be aimed at waste elimination. With this approach, the use of 5S or other lean production tools is most effective because it takes into account the value of the application and its focus on the bottom line.

For the better understanding of the application of the 5S lean production tool, it is also necessary to disassemble its application over the time of use in an organization in the production process. Initially, 5S as one of the tools of the lean production concept was widely implemented within the framework of the application of the lean production principle in the Japanese company Toyota as part of the application of the entire Toyota Production System, during which it showed significant results (Suárez-Barraza & Ramis-Pujol, 2012). In the context of applying the entire lean production principle, this approach of combining several lean production tools is the most effective since it involves continuous improvement of the processes within the organization. Besides, the general application of this 5S is also widely studied. Although to date, the basic principles of this lean production tool have not changed completely, as a result of research into various applications of the 5S lean production tool, it demonstrates a positive impact on production today (Patel & Thakkar, 2014).

As mentioned earlier, the 5S lean production tool consists of several parts or principles used to implement the lean production concept. It is also important to take into account that the specifics of the activities of a particular company, its production process affect the application of the principles of this lean production tool, but first of all, it is necessary to consider the individual principles that make up this tool, because they can be applied differently depending on the specific situation. Nevertheless, the idea of combining all these principles is in the last “S” in the abbreviation of the 5S because by how much the result of sustain can be judged on the consequences of applying the entire 5S tool (Kobayashi, 2008). It should be noted that for the consistent application of 5S and the consolidation of the result of continuous improvement, it is important to combine a clear understanding of the principles together and also apply their focus on a specific result.

When discussing possible ways of applying this principle, it is also necessary to consider the specifics of the production of an individual company or the type of its production. However, in this respect, 5S is one of the most versatile lean production tools suitable for various production types, from the job shop to the conveyor line (Irani, 2020). It is also important to note that the principles of this lean production tool are applicable in various company activities, namely both in the production process itself, in the preparatory stages for production, as well as at the organizational management level of the company (Mohan Sharma & Lata, 2018). This makes it possible to conclude that the 5S lean production tool is suitable for organizing the direct production process of a company, which can take various forms, and for waste elimination on the organizational level of the company’s activity. However, in the context of this study, it is necessary to consider the application of the 5S lean production tool to the manufacturing process related to the material transportation actions of the loader.

1.3 Previous application of the 5S lean production tool

The lean production tools application theme has proven its effectiveness over many years of the use. The usage of specific strategies for optimizing production operations entails many positive aspects, such as reducing setup time, reducing company costs, and, in general, eliminating wastes of the company related to defects, overproduction, waiting between process steps, unnecessary transportation of materials, overprocessing of parts, unnecessary inventory, unnecessary operator movement (Borris, 2006). Therefore, to be sure of the effectiveness of lean production tools, it is necessary to review previous applications of them, and consider the 5S tools as a basis of the analysis of empirical studies.

One of the studies analyses the use of the lean production concept by applying lean production tools to a small and medium enterprise of the carton company (Roriz et al., 2017). Implementation of several tools at once is determined by an attempt to solve several problems at once that the company faces in the production process. Besides, in this bachelor thesis, the studied company can also be referred to as SME, and the type of production can be described as a workshop, not the conveyor line. All these facts make companies very similar, and the implementation of lean production tools follows the same principle. In this work, one such methods aimed at waste elimination as SMED and 5S were applied. This study represents the solutions the setup time problem organization of working area, etc using lean production tools. It is important to note that this study does not a case of the implementation the entire lean concept to the company’s production process, but an attempt to solve the company’s existing problems. In this regard, this study has the similar goal with this bachelor thesis, since the main aim is to implement the lean production tool in order to solve the material transportation problem.

During the application of lean production tools, a technique was used to determine the existing weak points of the company, measure indicators, use the lean production tool and then analyze the data with the calculation of the final amount of costs that were saved through optimization (Roriz et al., 2017). In addition, in the process of solving the assigned tasks, the company also conducted a survey of employees regarding improvements and their opinions regarding the improvement of the company's work were also taken into account. It is important to note that companies that do not have a conveyor line or most of SME, should also take into account the productivity of workers during lean production tools implementation. As for the results of the lean production concept implementation, which consisted of SMED and 5S lean production tools, the company managed to significantly reduce costs and at the same time increase productivity (Roriz et al., 2017).

The next study that can be analysed from the point of view of 5S lean production tool implementation is a case study of the company produces the scientific equipment (Gupta & Chandna, 2020). Shaman Gupta and Pankaj Chandna (2020), in their research dedicated to 5S implementation in the manufacturing company in India, found, that the 5S tool implementation has resulted benefits of the workplace. Especially, researchers discovered, that the searching time for the tool in the workplace has been improved as well as the safety level was increased and, therefore, it possible to make a conclusion regarding the effectiveness of the 5S lean production tool. Overall, the audit score has been improved from the level of 6 scores (in week 1) to 72 score (in week 24) (Gupta & Chandna, 2020). Besides, the major objective behind conducting the research was to ensure that the 5S method is successfully implemented in the company's shop floor (Gupta & Chandna, 2020). Since the studied in this paper company can be described as SME, and the 5S tool was applied on the workshop floor, furthermore the company does not have the conveyor line, the results of the application the 5S lean production tool are relevant for the research.

One of the questions, stated in the research, was dedicated to the way of incorporation of lean structure into the routine-based operation of employees. The implementation of the 5S was conducted in 10 steps such as top management's support in implementing 5S, launching an education and training program, organizational structure plan, formulating 5S policies and goals, master plan for 5S deployment and its presentation, feasibility study and its presentation, pilot installation, plant wide installation, progress audit, 5S certification and award (Gupta & Chandna, 2020). Some of these steps are a reflection of the standard implementation of the new technology, which includes, in addition to implementation, auditing. In this study, the algorithm for making changes in the company's work process, starting with preparatory actions and ending with the use of the 5S lean production tool is presented. The process of direct implementation of 5S in relation to existing operations is different. It includes the consistent implementation and performance of all 5S principles considered and described in the theoretical part of this bachelor thesis.

As research stated in their study, "the success of the 5S initiative depends primarily on its maintenance", therefore, taking this into account, assembly employees in the given company, were responsible for conducting weekly audits to point out activities which needed improvements (Gupta & Chandna, 2020, p 354). Results were put up on information boards so that workers could be made aware of the improvements required in their workstation and, at the same time, it allowed workers improve their workstations themselves. Thus, it is possible to make a conclusion that the effectiveness of the application of the 5S lean production tool in the case of job shop depends on the employees, since the company does not have an automatization that allows to apply different tools without involvement of job shop workers.

The next study also shows the implementation of the 5S lean production tool to the company's manufacturing process. The target of a given company producing prefabricated products, such as budlings, offices, etc. as for the two previous companies, there was a reduction in costs along with an increase in productivity and the general work attitude in the workshop (Al-Aomar, 2011). However, unlike the two previous companies, one of the goals was also to achieve a continuous process improvement, not just to improve the current situation regarding the workshop of the company. In the process of applying the 5S lean production tool, the company applied a systematic approach to solving existing problems, and all processes were deconstructed for the most accurate waste elimination within the workshop. (Al-Aomar, 2011) However, a significant difference between this study and the two previous ones is not only the implementation of the 5S lean production tool for continuous process improvement but the lack of calculations regarding cost reduction. This study has resulted in recommendations for work performance and overall shop floor maintenance since the 5S lean production tool-related the setting different actions or tools in a specific order for an increasing inefficiency.

Table 3 is a summary table that in a short form gives an idea of the research method, sample and the result of the 5S tool applications.

Table 3

Summary of the 5S lean tool previous applications

Authors of the study	Methods	Sample	Results
Roriz et al. (2017)	Estimation of time, costs, and profits	Internal operations of the carton company	Decrease in costs and increase in profits
Shaman Gupta, Pankaj Chandna (2020)	Questionnaire	Employees of the scientific equipment manufacturing company	Decrease in time for tools searching, increase in the level of industrial safety
Al-Aomar (2011)	Questionnaire, visual estimation	Company personnel involved in the construction of modular cabins	Increase in efficiency, decrease in wastes and pollution in the workshop

Source: Compiled by author based on sources mentioned in the table

Thus, according to presented previous studies, the use of the 5S lean production tool in the workshops yields positive results such as cost savings and increased production efficiency. On the example of companies working in various fields such as the production of scientific equipment, cabin construction, or carton company, one can judge the positive impact of this tool on the production process of firms with such a production organization as job shop. None of the listed companies had a conveyor line, and for the application of one or another lean production tool, the type of production is necessary. Although the primary method of previous research was to survey employees about the workplace organization or the production process, the empirical part of this study will quantify the operation time and cost savings, as well as interview the employee on the topic of material transportation and the 5S lean production tool application. Such indicators as time and costs were selected for analysis because the purpose of this work is to optimize one of the production processes related to the material transportation problem, which is to reduce the operating time of the truck and thereby reduce costs. The interviews and not the surveys method were selected as a primary qualitative because interviews with employees related to the process can most accurately describe the situation and at the same time most accurately identify existing weaknesses in the process and develop effective practical recommendations for the process optimization.

2. Empirical study on the implementation of the 5S lean production tool

2.1 Description of the study

In the empirical part, the process of implementation of the 5S lean production tool at Estolumber will be considered. In this part of the study, a description of the company will be presented, as well as research methods on which the analysis will be based, and practical recommendations will be developed in order to offer the optimization possibilities for the solution of the material transportation problem.

The company Estolumber works in the sphere of production and sale of pine, spruce, and birch sawn timber. The company's primary goal is to provide buyers with high-quality products and establish long-term and productive relationships to improve the efficiency of the company. One of the company's advantages is the many years of experience in producing and selling sawn timber from its managers and mutually beneficial partnerships with suppliers and buyers (Estolumber, 2021). The finished products manufactured by the company are in demand in such areas as construction, furniture production, repairs, as well as other areas of application of wood products. The company is located in Jõhvi city, and the company's office and workshops are located on the same territory in close proximity to each other. The enterprise can be classified as SME having approximately 20 employees working in shifts, more than half of whom are directly involved in the production of finished products on the shop floor. The company also employs a production manager, sales manager, accounting specialists, bookkeeping specialist, and the document management specialist. In addition, the company's key employees directly related to the material transportation problem are the loader driver and the production manager. The choice of this company from a research point of view is the understanding of changes in the current situation in the sawn timber market and a significant upward change in prices for some items of raw materials. This company is engaged in the production of many types of wood products and the optimization of the production process through the implementation of the 5S tool is necessary for one of the workshops producing roofing battens. Roofing battens is a building material, one of the product types that is the most significant item in the company's product line, as it brings the greatest margins in relation to the company's costs of production and the price of finished products.

The material transportation problem in this study can be recognized as the problem of transporting raw materials from warehouse to workshop, transportation of finished products from workshop to warehouse, as well as materials transportation within the workshop of the company. All these actions and their execution time affect the costs of the company and the volume of products produced per unit of time. In this regard, the material transportation problem should be solved by applying the principles of the 5S lean production tool.

Since the purpose of this study is the investigation of the current production situation and to offer the possibilities of optimization, it is necessary, on the basis of the existing situation with the material transportation, to draw a conclusion to what extent the principles or steps will be applied to optimize the work of the loader. Besides, for the full implementation of the 5S lean production tool each of the principle should be applied in order to achieve the continuous improvement of the process. In particular, such a 5S tool principle as “sort”, which implies the separation of necessary actions, should be used in such a way that the loader performs only the actions necessary for the work, as this affects the work time. In addition, the “set in order” principle should be organized around the most important transportation actions that must be performed in a specific order to ensure the greatest efficiency or the least time and cost. Thus, in this part of the study, it is necessary to apply principles of the 5S lean production tool in the most effective way.

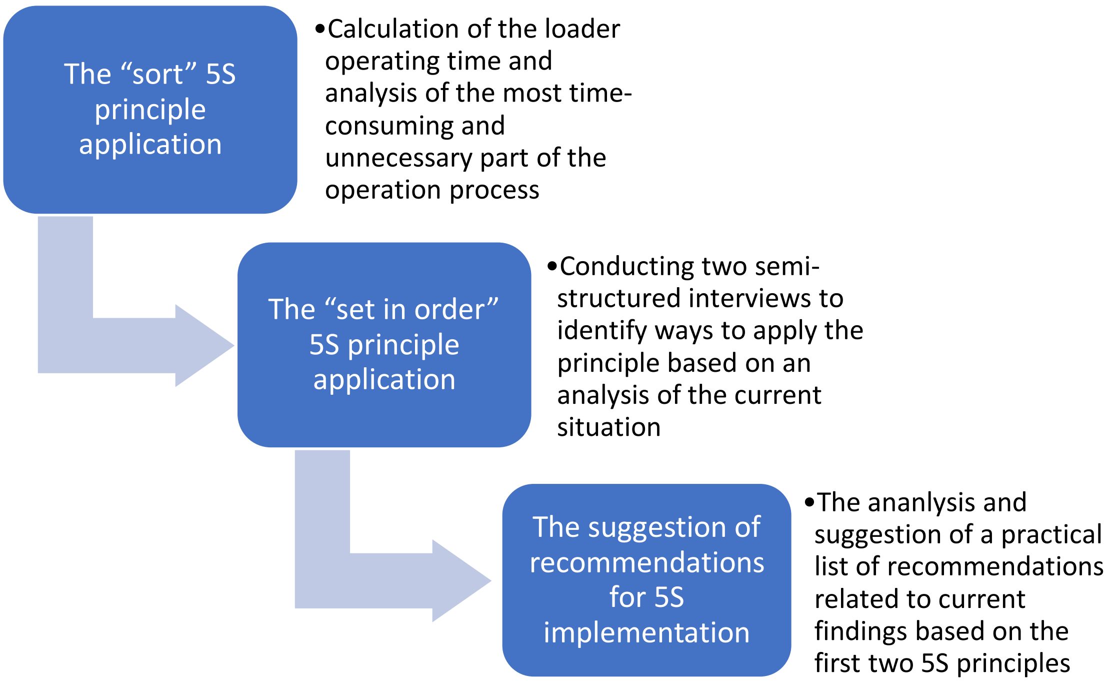
In this part of the study, it is necessary to discuss the research methods that will be applied in the empirical part. The empirical study of the thesis consists of qualitative methods. The main method of empirical research related to the “sort” principle will be the measuring of the time that takes for a loader to transport raw materials to the workshop and inside the workshop before applying the principles of the 5S lean production tool or the structured observation method. Structured observation is used in various fields of studies and allows data to be collected in a systematic manner in order to most accurately characterize the phenomenon under study (Turnock, 2001). Measurement of time will be carried out by the author of the study. For optimization purposes, it is necessary to evaluate the specific actions of the loader before the implementation of the 5S lean production tool in order to identify the weak points of the process where the loader operating time can be reduced in accordance with the 5S lean production tool. The qualitative research of the study related to the ”set in order principle” is based on semi-structured interviews with the production manager and the loader driver. The semi-structured interview was chosen as one of the research methods because several authors stated its usefulness and applicability to such research. The semi-structured interviews can be applied in very specific areas where well-structured questions do not reflect the essence of the study and cannot be accurate initially (McIntosh, 2015). The target of this research is to review the material transportation process in detail and to identify the loader action that can be optimized by the application of the 5S lean production tool. Among all the qualitative research methods, the interview was chosen because this method allows you to give the most specific and detailed idea of what is happening in the company in relation to the material transportation problem.

Thus, the process of implementation of the lean production tool will consist of calculating the operating time of the loader prior to the implementation of 5S, conducting interviews related to the material transportation process optimisation, identifying certain places in the operation of the loader in which it is possible to apply the 5S principles. Also, based on the investigated actions, a list of recommendations for optimizing this workshop using the 5S lean production tool will be provided. It is assumed that the developed production optimization strategy, supported by quantitative and quantitative methods of assessment, will reduce the operating time of the loader as well as the associated costs and thereby resolve the material transportation problem related to the workshop.

Figure 2 shows the research steps implemented in this thesis. In addition, the figure also reflects a short description of each research step.

Figure 2

The research steps applied within the thesis



Source: Compiled by author

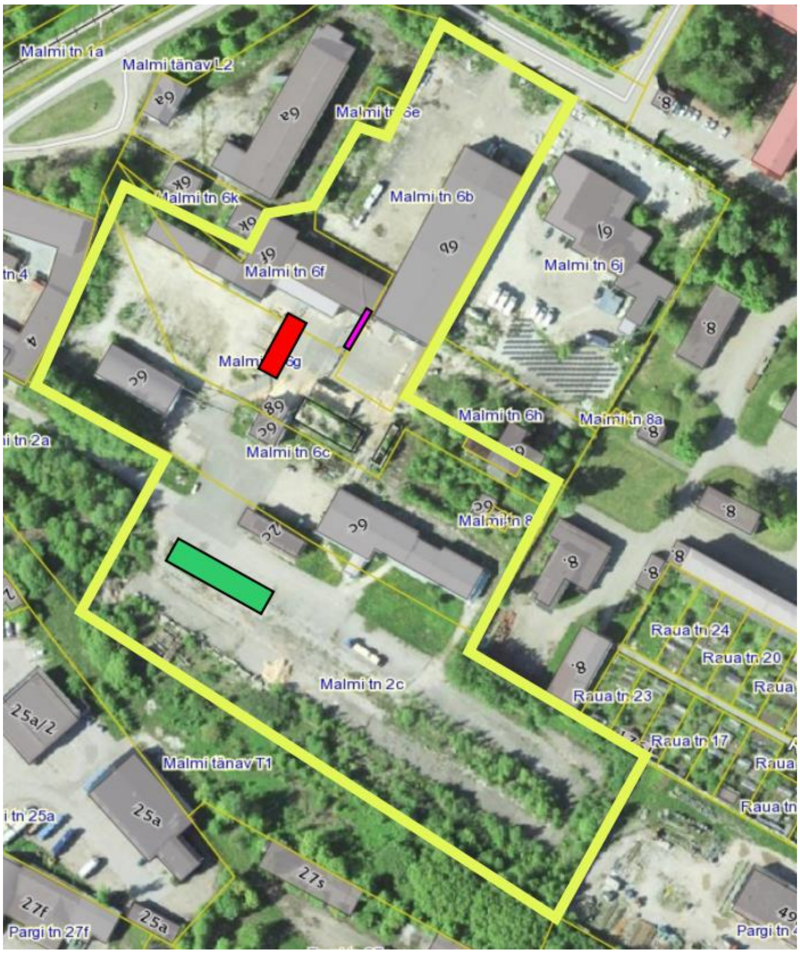
2.2 Quantitative study related to the material transportation process

For the application of the 5S lean production tool, the process of material transportation should be described. Calculating the time as well as dividing the loader operation process into parts is necessary to apply the first step of the 5S lean production tool, which stands for “sort”. In this part of the study, actions of the loader and operating time and distance calculations will be presented. This process can be divided into moving material inside the shop and outside the shop. The movement of material within the workshop is closely related to the production process and thus directly affects the company's production process. It is also important to note that materials are moved inside and outside the workshop by a Nissan forklift with a serial number J1F4A45LY. The load capacity of this loader is 4500 kg which means the maximum load capacity is 2 packs of desks, its average speed is 4000 m/h, and the loading and unloading time equals approximately 15 seconds. The load capacity of this forklift as well as its average speed and loading and unloading time were found out through physical measurements during the production process. The loader operation process was observed over 1 working day and is based on several measurements of time and its average value. It also necessary to note that the calculations take into account the average speed of the loader (loaded and unloaded) and the load capacity related directly to this production.

For the calculation of the loader operating time, it is necessary to describe the process of moving materials outside the shop and also to understand the location of raw materials and finished products on the territory of the enterprise. Scheme 1 represents the location of raw materials and finished products on the premises of the enterprise and the location of the workshop where the products are manufactured.

Scheme 1

Schematic representation of the territory of the enterprise



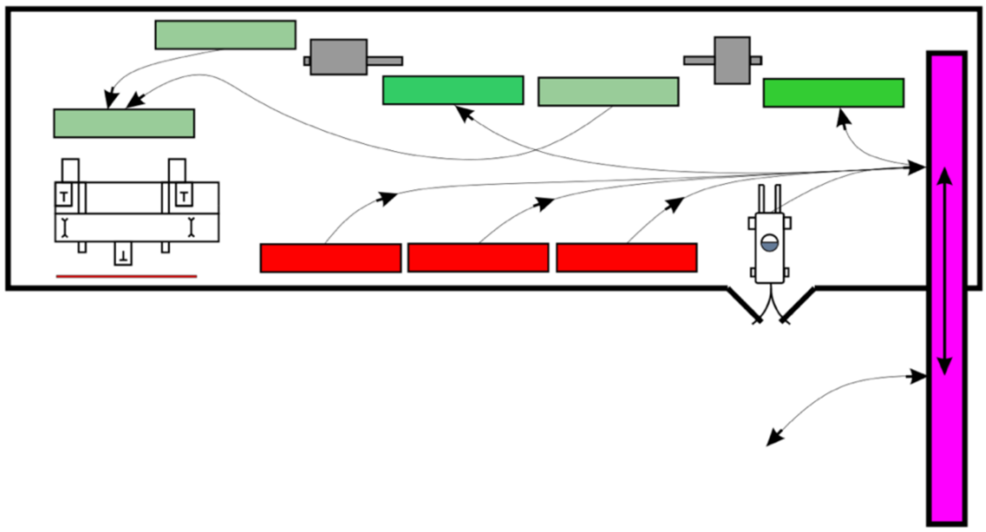
Source: Compiled by author based on X-GIS2 map

In Scheme 1, the territory of the enterprise is marked with a yellow outline, and the building Malmi tn 6f represents the workshop where the products are manufactured. In the immediate vicinity of the workshop, the area where the company's finished products are stored is highlighted in red on the diagram, and the location where raw materials are stored is highlighted in green. The purple color in the scheme indicates the place where raw materials are transported for delivery inside the workshop and from where finished products are taken for delivery to the warehouse, highlighted in red. The transportation of material within the territory of the enterprise is provided by the loader which capacities (the average speed and load capacity, loading and unloading time) were described above.

Another part of the loader operating process is its actions inside the workshop. Scheme 2 represents the movement of the loader within the workshop, and also reflects the layout of the machines, raw materials, and finished products.

Scheme 2

Schematic representation of the workshop of the enterprise



Source: Compiled by author

In addition to the location of the material on the diagram, the arrows also indicate the movement of the loader. The purple colour in the diagram indicates the line that transports raw material to the workshop, as well as finished products from the workshop, the red colour in the diagram indicates packs of finished products that are stored one on top of the other in the amount of three pieces. The bright green colour on the diagram indicates raw materials that were purchased by the company and have not yet been put into production. Dimly green in the diagram indicates those raw materials that have already passed one of the stages of production.

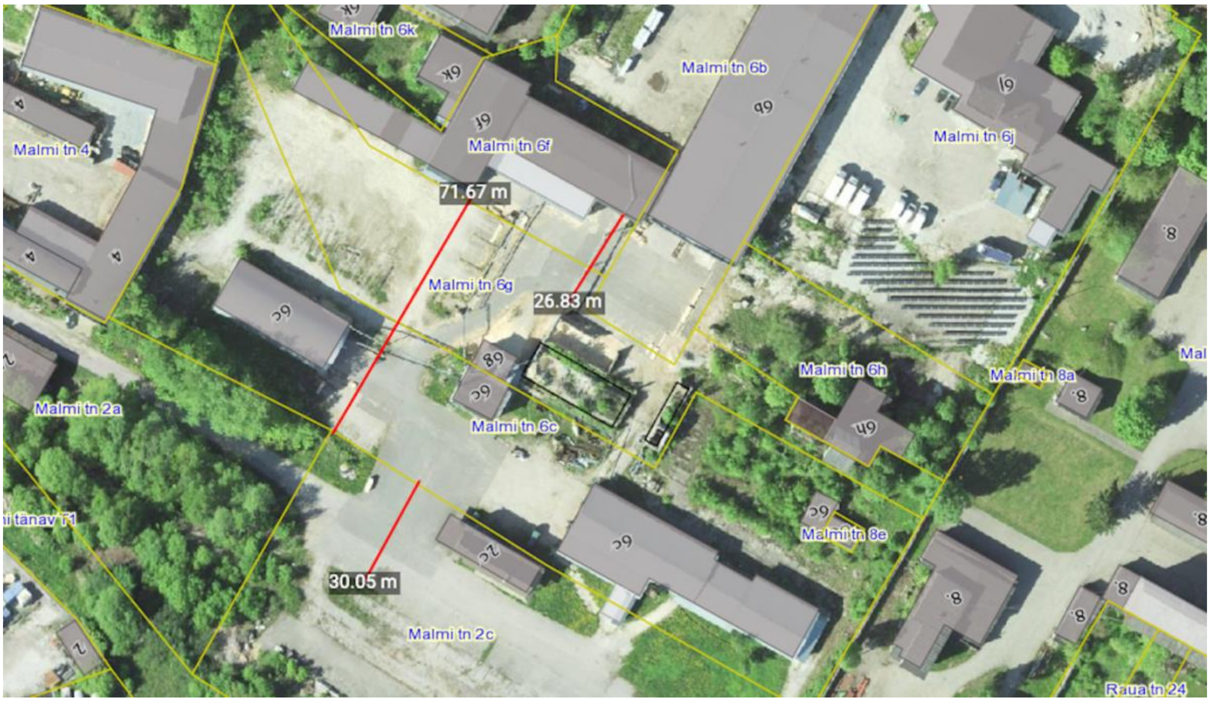
The production process in this workshop is directly related to the movement of materials around the workshop and consists of several stages. It is important to note that during the production process, the boards are stacked in packs, and after that, they are moved around the workshop. The first stage of production begins with the loader transferring the packs of boards to the line outside the workshop, highlighted in purple. Then packs of boards one by one transported inside the workshop with the help of the line’s driving mechanism.

After that, packs of boards are delivered by the loader from the line to one of the machines to the places highlighted in bright green. Subsequently, after processing, packs with boards are formed in places located in close proximity to the machines highlighted in dull green. Further, at the second stage of production, the packs are moved to the end of the workshop (left side of the diagram), where they pass through the machine and are formed into a pack of finished products marked in dull green, which is subsequently transported to the places of storage of finished products highlighted in red. Subsequently, packs of finished products are transported one by one to the line marked in purple for removal from the workshop to the warehouse of finished products which is presented in Scheme 1.

For the calculation of the operating time of the loader, it is necessary to know the distance that the forklift travels inside and outside the workshop when transporting materials. Scheme 3 reflects the distance a loader travels across a facility.

Scheme 3

Schematic representation of the territory of the enterprise with distances



Source: Compiled by author based on X-GIS2 map

The scheme shows that the distance from the line transporting materials to the workshop to the storage of raw materials is approximately 115 meters. When considering the return road, the loader travels 230 meters when transporting raw materials to the workshop. Thus, the time of transportation of raw materials to the workshop, considering the loading and unloading time, equals:

$$\frac{\text{Distance}}{\text{Speed}} + \text{Loadind time} + \text{Unloading time} = \text{Loader Operating Time}$$

$$\frac{230\text{m}}{4000\text{m/h}} \times 3600\text{s} + 15\text{s} + 15\text{s} = 237 \text{ seconds}$$

Scheme 3 also shows that the distance from the line transporting materials to the storage of finished products is approximately 25 meters. In consideration of the return road, the loader travels 50 meters when transporting finished products from the workshop. Therefore, the time of transportation of the finished product to the place of its storage, considering the loading time, is:

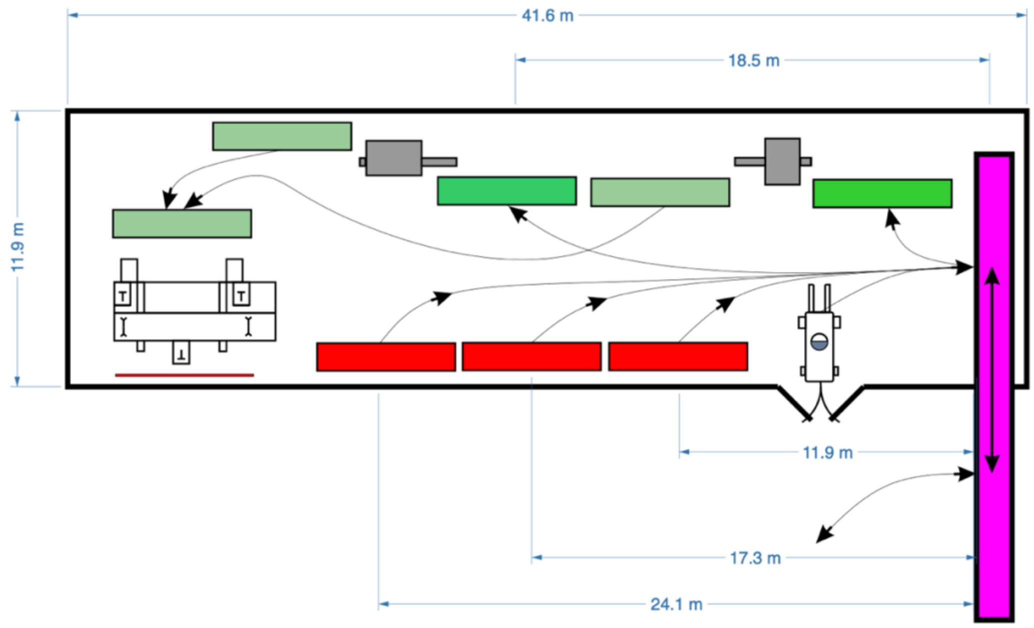
$$\frac{\text{Distance}}{\text{Speed}} + \text{Loadind time} + \text{Unloading time} = \text{Loader Operating Time}$$

$$\frac{50\text{m}}{4000\text{m/h}} \times 3600\text{s} + 15\text{s} + 15\text{s} = 75 \text{ seconds}$$

For the calculation of the operating time of the loader inside the workshop, it is necessary to consider and calculate the distance that the forklift travels during the entire production cycle. In Scheme 4, in addition to the movement of the loader during the transport of materials, the distances necessary for calculating are also marked.

Scheme 4

Schematic representation of the workshop of the enterprise with distances



Source: Compiled by author

Thus, considering the first stage of production, the distance from the entrance to the building to the place on the line where the raw material is located is approximately 6 meters. The distance from the material on the line to the conveying point of the first machine is approximately 2 meters, and the distance from the conveying point to the second machine is 18.5 meters. Considering the second stage of production, the distance from the transport site of the first machine to the machine of the last stage of production is approximately 26 meters, and the distance to the second machine is approximately 2 meters. The final stage of the loader's work is the transportation of finished products from the last machine to the storage place for finished products, marked in red in the diagram. The distance of this transportation is approximately 10 meters. The last action of the loader is the transportation of the finished product from its temporary storage to the line marked in purple in the figure. This transportation distance is approximately 17.3 meters depending on the specific storage location.

Therefore, the distance that the loader travels when used for the production of the first machine is:

$$6\text{m} + 2\text{m} + 26\text{m} + 10\text{m} + 17{,}3\text{m} = 61{,}3\text{m}$$

Thus, the distance that the loader travels when used for the production of the first machine is:

$$6\text{m} + 18{,}5\text{m} + 2\text{m} + 10\text{m} + 17{,}3\text{m} = 53{,}8\text{m}$$

Based on the calculated data, it becomes possible to calculate the operating time of the loader in the case of using the first or second machine. When using the first machine, the operating time of the loader with a full production cycle, considering the time of loading and unloading, equals:

$$\frac{\text{Distance}}{\text{Speed}} + \text{Loadind time} + \text{Unloading time} = \text{Loader Operating Time}$$

$$\frac{61{,}3\text{m}}{4000\text{m/h}} \times 3600\text{s} + 60\text{s} + 60\text{s} = 175 \text{ seconds}$$

In case the company produces boards using a second machine, the loader operating time, considering loading, and unloading, equals:

$$\frac{\text{Distance}}{\text{Speed}} + \text{Loadind time} + \text{Unloading time} = \text{Loader Operating Time}$$

$$\frac{53{,}8\text{m}}{4000\text{m/h}} \times 3600\text{s} + 60\text{s} + 60\text{s} = 168 \text{ seconds}$$

Therefore, describing the material transportation problem within the enterprise, the transportation time of raw materials and finished products outside the workshop is 237 seconds and 75 seconds, respectively. In the case of transporting materials inside the workshop, using the first machine is 175 seconds, and using the second machine is 168 seconds.

Thus, according to the study, the first step in the application of 5S, which is sorting processes, was performed based on the calculations of the loader's operating time and based on this, we can conclude that the most significant amount of time that the loader spends on delivering raw materials to the workshop for subsequent processing and this time according to the calculations as already mentioned above is 237 seconds. At the same time, based on these data, it can be concluded that this time should be reduced and approached as the time of transportation of finished products outside the workshop for the most influential work of the enterprise.

Besides, analysing the operation of the loader inside the workshop, the main work time is spent on moving materials in the event that the first machine is used and not the second, and the loader performs actions related to transporting materials to the first machine, the total time of which is 175 seconds. However, the separation of these processes is necessary for analysis as well as for the subsequent development of practical recommendations and understanding of how important each of the actions of the loader is and performed in the most effective way. It is important to note that this calculation was also made based on one cycle of the loader and a general understanding of the situation in the production. In the course of the workshop, both machines are usually involved, and in this regard, it is essential to identify specific actions of the loader and reduce the execution time of individual ones in order to reduce overall work time.

As for the analysis of the positions of products, it is necessary to consider them from the necessity point of view. In other words, it is necessary to understand how certain materials are needed for production at a particular moment and place them as close as possible to the place where they are needed (machine or warehouse). Thus, it will be possible to conclude the current arrangement of materials. In addition, it is important to understand which packs are misplaced and where they should and can be moved, given the current location of the machines and the layout of the shop.

In order to understand the issue of the “sort” principal application, it is possible to divide all current materials into those that are used often and less often, and this will allow us to divide the actions of the loader into value-adding and not for the correct implementation of the “sort” 5S principle. Thus, if we consider the movement of materials within the workshop, then the materials in the process of production are located as close to the machines as possible. Scheme 4 reflects the optimal layout most accurately, with materials in production highlighted in green and finished products highlighted in red. Thus, a reduction in the loader operating time in the case of an optimal arrangement of materials can be achieved with the help of the accompanying processes of cleaning the workshop and adjusting the loader (its timely maintenance). When considering forklift operation outside the workshop, both the location of the finished goods warehouse and the location of the raw materials warehouse must be taken into account. On analysing the location of finished products and raw materials in Scheme 1, it can be concluded that their location is not optimal according to the principle that materials should be closest to the place of need. As a result, the loader performs unnecessary actions, and thus it becomes possible to “sort” its action on value-adding and not according to the 5S lean production principle. Based on Scheme 1, we can conclude that the current location of raw materials requires the longest loader operation time, and in this regard, we can conclude that the path taken to transport them to the workshop is not value-adding from the point of view of the “sort” principle of the 5S lean production tool. Thus, according to the mentioned above lean production tool, it is necessary to change the location of raw materials outside the workshop. In addition, the location of finished products can also be changed due to the fact that there is much more space outside the workshop to place them. According to the 5S lean production tool, the removal of finished products can also be optimized by placing finished products closer to the conveyors marked in purple in Scheme 1. As a result, not the value-adding actions of the loader will be leveled. These conclusions that were made based on the calculations and the analysis should be taken into account while preparing the list of recommendations as a final path of the thesis.

2.3 Qualitative study related to the material transportation process

In addition to the loader operating time calculations, it is necessary to consider and evaluate the current situation in production based on the opinions of the managers of the production and the loader driver. In this part of the study, questions of the interview with the production manager and the loader driver will be presented, the results of the interview will also be reflected and conclusions will also be drawn based on the answers of employees regarding the optimization of production in general, and in particular the application of the second “set in order” step of the application of the 5S lean production tool. The opinions of these employees were selected for the analysis since they are crucial in terms of the application of the 5S lean production tool to the material transportation problem. The job responsibilities of the production manager include organizing the work of the production process as well as the work of the loader itself in terms of transporting the necessary raw materials to the workshop and timely removal of finished products to the warehouse. The loader's driver is also directly related to the process of transportation of materials. The employee was selected because with the help of the interview it is possible to accurately identify the weaknesses of the process since the worker is directly involved in it. The main aim of the interviews is to develop ideas that correspond to the second principle of the 5S lean production tool. The “set in order” principle should give the very practical ways of the necessary actions of the loader which should be done in order to reduce the waste of time and thus reduce the costs of the company.

Table 4 shows basic information about the conducted interviews. At this stage, it is essential to note that both interviews were conducted in Russian and subsequently were manually transcribed and translated into the English language.

Table 4

The interviews information

An employee	Date	Place	Duration	Language
The production manager	07.04.2022	Johvi, Ida-Viru County	43 minutes	Russian
The loader driver	08.04.2022	Johvi, Ida-Viru County	36 minutes	Russian

Source: Compiled by author

The interview questions for the production manager and the loader driver will also be presented in this part of the study. The questions were designed in a way to reflect the essence of the lean production concept, the subsequent application of the 5S lean production tool, and the “set in order” principle of the 5S tool most accurately. In the introduction, it should be said that the order of questions also matters. This sequence of questions was chosen for the most accurate expression of the opinion of the interviewees and for the exclusion of the possibility of answers that are not relevant to the situation. Interviews of the production manager and loader driver consist of two parts. In the first part of the interview, general questions for the production manager and loader driver regarding changes in the production process, the lean production concept, and the 5S lean production application will be asked. In the second part of the interview, the questions asked of the two employees will be different. For the production manager, the questions will focus on changing the process and the 5S “set in order” principle application in terms of efficiency gains. For the loader driver, the questions will focus on identifying process weaknesses as well as the identification of practical application possibilities of the 5S “set in order” principle. This separation is necessary primarily because, due to different responsibilities, each employee can see process optimization differently; however, finding a joint solution to the problem and considering both points of view will most productively affect process improvement. A complete list of interview questions, along with their order, is shown in Appendix A and Appendix B.

Table 5 shows the interview questions for both the production manager and the loader driver employees, the questions of the first part of the interview. In addition, the table also reflects the question number and the essence of each question, and its impact on the process under the study.

Table 5

Production manager and the loader drive interview questions

The question number	The question	The essence of the question
1	How well do you think the loader operation process works?	This question is necessary in order to find out the need for the changes themselves in production, which are to be applied, as well as to understand the application of the lean production concept
2	Would you rate the loader operation process as productive for today's production system?	This question, similarly to the previous one, is essential for assessing the applicability of lean production, but it is also related to productivity as a measure of the specific process performance related to the loader operation process.
3	Are there loader actions now that could be removed to improve performance?	Since the lean production tool is related to the waste elimination, identifying and eliminating the waste related to the unnecessary transportation is a part of the 5S lean production tool application
4	How would you react to changes in the work process that contribute to the company’s productivity but at the same time require some time and effort for implementation?	This question is necessary to assess the readiness of the company to apply the 5S lean production tool
5	Regarding how the loader operation process, is there anything that could be changed?	The question is related to the identification of the spots where the 5S lean production can be applied

Source: Compiled by author

Table 6 reflects the questions of the second part of the interview for the production manager. In addition to the questions themselves, the table reflects the essence of this issue and its significance for the study. It is important to note that these questions presented in the table are directly related to the topic: “The lean production concept and the 5S lean production application”.

Table 6

Production manager interview questions (second part of the interview)

The question number	The question	The essence of the question
P6	Was the operation process of the loader analyzed before it was arranged?	This question is necessary in order to determine whether any instruction for the loader driver was intended during the work planning process
P7	How was the decision made about the location of materials outside the workshop? Is it, in your opinion, fit for the general operation process of the loader in terms of time?	The essence of this question is to find out whether the current location of materials outside the workshop corresponded to a particular order
P8	Do you think there is a need for a clear division of the actions of the loader into parts for the subsequent deriving of a sequence of actions?	This question is needed in order to find out if there is a need for analysis and division of the action in the loader operation process
P9	Does the driver have a specific work algorithm that he adheres to during the day or does the delivery of materials and cleaning of finished products occur as needed?	This question is necessary in order to find out the current order of the loader work if it takes place
P10	What steps do you think should be taken to reduce the loader's operating time?	After the current application of the “set in order” principle has been discussed, it is also necessary to discuss more clearly with the production manager for the most optimal application of the 5S lean production tool

Source: Compiled by author

Similar to the previous table, Table 7 reflects the questions of the second part of the interview for the loader driver. In addition, the table also has an explanation to reflect the essence of these questions. It is important to note that these questions presented in the table are directly related to the topic: “The “set in order” principle application”.

Table 7

Loader driver interview questions (second part of the interview)

The question number	The question	The essence of the question
L6	Are there any cleaning processes that are carried out regularly at this point of the company's development?	This question is necessary in order to understand the current order of the company's processes
L7	How often is the workshop cleaned in general? How long does it take?	This question is necessary to evaluate the current actions of the loader that make up a certain sequence or order
L8	Would you rate the delivery of materials and cleaning of finished products as optimal?	Regarding this question, it also helps to understand how well the loader operation process works now
L9	Do you adhere to the algorithm for the supply of materials if it exists and is well-established?	This question allows to assess the possibility of applying a special course of action if it is not yet fixed or is often violated
L10	Would it be right in your opinion to reduce the amount of time the loader works by the application of the specific sequence of actions?	This question is vital for assessing the possibility of applying specific order of actions for the optimization

Source: Compiled by author

In accordance with the questions presented above, a semi-structured interview with the production manager and the loader driver was conducted. Based on the data, the coding Table 8 is presented below, where the main answers to interview questions are reflected in the form of codes. A comparative analysis of the first part of the interviews was carried out according to two main categories highlighted in the coding table: the necessity of changes, and readiness for changes. It is important to note that both categories are crucial in terms of the lean production and the 5S lean production tool application. The other two categories derived for the analysis of the second part of the interview are the assessment of the current order of the loader operation process and the overall possibility of introducing order in a given production situation. These categories were chosen not only on the basis of logical themes but also on the basis of the responses of employees. In addition, these categories make it possible to assess the possibility of applying lean production, the 5S lean production tool, and precisely the “set in order” principle, the purpose of which this analysis is necessary to apply.

Table 8

The interviews answers coding table

Theme	Categories	Codes
Theme I: The lean production concept and the 5S lean production application	The necessity of changes	Well organized process Productive at some point Loader can't handle fast work The process is established Time-consuming actions Changing actions without changing the essence No major overhaul required Necessity to calculate effects before implementation
	The readiness of changes	Some changes can be made All actions are crucial Upgrade can be implemented Rebuilding will take time, and this is a disadvantage Minor changes are possible Actions are necessary Possibility of rebuilding the process
Theme II: The “set in order” principle application	The current order of actions assessment	Operation analysis was not carried out During the organization, the convenience of loading trucks was taken into account Cleaning takes place every day as the shop gets dirty Delivery of materials is not optimal at the moment There is no defined algorithm
	The possibility of the specific order implementation	The process needs to be improved The driver does not have an algorithm or a specific order For optimization, it is necessary to introduce an algorithm It is possible to reduce the time if you calculate all the actions

Source: Compiled by author based on the interview answers

For the analysis of the first part of the interview of the production manager and the loader driver, according to the selected categories, it can be said that both employees agreed on the need for changes in terms of the production process and the company's readiness for changes at this moment in the company's development. From the point of view of the need for changes, both employees believe that the process is organized satisfactorily, but could be improved due to the fact that often during intensive work the loader does not do its best and there are delays in the delivery of material. In this regard, minimal changes in the operation process are still necessary to solve this problem and optimize work and reduce time, and, as a result, reduce costs.

From the point of view of assessing the company's readiness for possible changes, the opinions of employees also did not differ. The position of the interviewed colleagues is that since the process works, although not optimally, there is no need for a global restructuring of it. Besides, some loader actions need to be reviewed and even take into account that it will take time to apply the changes. According to employees, all actions of the loader are now important, and there is no need to refuse any of them. However, changing the actions themselves could solve the problem. In this regard, according to the production manager, minimal changes in the actions of the loader will benefit the production process. In this regard, the loader driver's position was that some changes could be made, but the process at this stage can be described as organized.

For analyzing the results of the interviews on the current order of actions assessment, it is possible to make a conclusion that the company does not yet apply the order of actions as such. The cleaning process and the process of transporting materials were not analyzed before its implementation; however, some aspects of the placement of the material on the territory of the enterprise were taken into account. This makes it possible to apply the "set in order principle" in the company while analyzing the actions appropriately since no analysis has been carried out so far. It is also important to note that the production manager speaks of the process as suboptimal and also notes the lack of a well-coordinated work algorithm.

From the point of view of the possibility of applying a certain order of actions, both employees speak positively. From the point of view of the production manager, the process needs to be improved just by introducing specific instructions. The loader driver also does not oppose this introduction, allowing the “set in order” principle to be applied within the company. According to the employees, a certain algorithm will help to increase efficiency during intensive work.

2.4 Optimisation possibilities results based on the quantitative and qualitative analysis

In this part of the study, it is necessary to conduct a brief analysis of the results obtained in previous parts of the study and based on the information, prepare a list of recommendations regarding the optimization process and the 5S lean production tool application. For the results of the qualitative analysis the development of instructions for each individual type of product, taking into account the products produced on a particular day is a necessary part of the optimization. So, for example, in the production of roofing battens of a specific length and width, according to the instructions, the loader driver will bring a certain material at a certain time to a certain machine. It is necessary to develop a detailed instruction that takes into account the current production order, which on the one hand, will allow to sort out unnecessary actions of the loader, and on the other hand, will also reduce its downtime and increase productivity. The explicit instruction for the loader driver may exclude the unnecessary actions of the loader by implementing the “set in order” 5S lean production tool principle and therefore reduce the operation time of the loader, increase the productivity and optimize the loader operation process in general.

The cleaning process of the loader should also be included in the instructions since the speed and efficiency of its work inside the workshop depend on the cleanliness of the floor and the timely cleaning and maintenance of the loader. Products left by workers in the wrong place can significantly affect the speed of the loader and thus affect the company's costs. In addition, it is important to note that since the placement of materials within the workshop does not need to be changed according to the principle that they should be located as close as possible to the machines and places where they are needed. Since the materials are located correctly in terms of the mentioned principle, it is possible to speed up the loader's working time only with the help of cleaning processes, and in this regard, the actions associated with this were also considered in the analysis of the interviews and taken into account.

From the point of view of the analysis of the location of materials carried out in this study, it can be concluded that the location of materials inside the workshop is optimal in terms of the current location of the machines and the proximity of the material located at the machines. However, the location of raw materials located outside the shop should be changed. According to the quantitative analysis, it is important to note that it is necessary to move the location of the materials outside the workshop closer to the transportation line that delivers materials to the workshop and finished products from the shop to move to the warehouse. Strategically, this made it possible to significantly reduce the loader’s operating time since, during quantitative analysis, it was revealed that the loader spends the most time moving raw materials to the transport line, and significant time is spent moving finished products from the workshop to the finished product warehouse.

In addition to the list of recommendations, it is also necessary to take into account the order of application in the company. First of all, it is necessary to reorganize the location of materials outside the workshop. The next step in optimization is to implement the cleaning process in the workshop with a particular frequency, which will also reduce the operating time. Already later, it is necessary to introduce a specific instruction, taking into account the new location of materials outside the workshop and the cleaning processes included in it. The detailed instruction, which provides for specific actions of the loader based on the available materials, also helps establish order and thus reduces the time of the loader.

Table 9 is the list of recommendations regarding the company's production process. In addition, the table reflects the principle of the 5S lean production tool that corresponds to the optimization measure, as well as an explanation of the specific optimisation action.

Table 9

The list of recommendations for the company's production process optimisation

The ordinal number of the action	The 5S principle corresponding to the suggested action	The specific optimisation action	An explanation of the action
1	Sort	Displacement of raw materials and finished products closer to the workshop	The movement of materials is necessary in order to reduce the operating time of the loader, as well as to reduce the total amount of distance it is driven outside the workshop
2	Set in order	The regularly workshop cleaning process implementation	A regular cleaning process will remove wastes from the workshop that are often on the floor, and it will also reduce the time the loader moves inside the shop
3	Sort, set in order	The application of the instruction for the loader driver, considering the specific production order	Writing an instruction that includes a specific production order is necessary to exclude unnecessary actions from the operation process of the loader driver. In the case that the loader driver has an action algorithm (which also includes the cleanup process), this will also reduce the loader's operation time

Source: Compiled by author

It is also essential for the analysis to clarify the previous uses of the 5S lean production tool. For example, Roriz et al. (2017) also introduced a regular cleaning and moving process for optimization, and in addition to this, separation was also introduced in the 5S process; however, the article is talking about physical tools, not a process. In addition, some authors have also used time measurements to evaluate the process and make the necessary adjustments, as well as to eliminate the waste of time (Gupta & Chandna, 2020). Some authors also fixed the specific algorithm of actions for the optimization process (Al-Aomar, 2011). Thus, it can be concluded that these recommendations have been applied in other studies and, therefore, possibly from application in this situation, however, taking into account the existing specifics of the production and process.

Conclusion

In conclusion, it should be noted that the lean production concept of the time was applied is essential. It is a fact that at the very beginning of its invention and implementation, the 5S lean production tool and the accompanying lean production concept had a significant impact on the production process. Lots of different authors stated that in the twentieth century the mentioned above ideas influenced the production operations a lot (Kleszcz et al., 2019). Another example related to the production industry shows the significant impact of lean production and the 5S lean production tool nowadays (Costa et al., 2018). In summary, growers around the world have been solving very different problems with these tools. In this Thesis, a situation was considered in which it was necessary to solve the production optimization problem in the most effective and, at the same time, least expensive way to propose solutions for a company in a crisis.

The conditions in which companies producing wood products exist put them in a position in the economy where the issue of optimizing production comes to the fore. Thus, the 5S lean production tool, and the lean production concept, proposed and reviewed, were chosen to develop one of the integral production processes. Discussing this decision to choose lean production tools, one cannot but mention the versatility of the 5S lean production tool. According to previous studies, the effectiveness of this lean production tool should be noted as one of the highest, as well as its versatility compared to other lean production tools (S. Nallusamy et al., 2018).

Thus, taking into account all the theories described in the Thesis and the usefulness of the lean production concept, the most appropriate research methods were chosen that most accurately reflect the current situation. Such research methods in this Thesis were the calculation of the loader operating time as well as semi-structured interviews with the employees directly related to the issue of optimization. Based on the results of the study, considering the theory presented in the first part of the Thesis, a list of actions aimed at the implementation of the 5S lean production tool within the company was proposed, and the first two steps of the implementation of the 5S were completed, namely “sort” and “set in order” principles. In order to implement the whole 5S lean production tool, it is necessary to take specific actions related to the subsequent principles (“shine,” “standardize,” “sustain”) of the 5S. The first two principles, the application of which has been considered within this thesis, require preparatory work related to the analysis that has been done. According to the theory mentioned in the first part of the study, the list of actions has to contribute to the process of company optimization and subsequent application of the 5S lean production tool.

References

1. Al-Aomar, R. A. (2011). *Applying 5S Lean Technology: An Infrastructure for Continuous Process Improvement*. 6.

2. Borris, S. (2006). *Total productive maintenance*. McGraw-Hill.

3. Costa, C., Pinto Ferreira, L., C. Sa, J., & Silva, F. J. G. (2018). Implementation of 5S Methodology in a Metalworking Company. In B. Katalinic (Ed.), *DAAAM International Scientific Book* (1st ed., Vol. 17, pp. 001–012). DAAAM International Vienna. https://doi.org/10.2507/daaam.scibook.2018.01

4. Crawford, R. J. (1998, January). *Reinterpreting the Japanese Economic Miracle*. Harvard Business Review. Retrieved November 14, 2021, from https://hbr.org/1998/01/reinterpreting-the-japanese-economic-miracle.

5. Estolumber (2021). *About Us*. ESTOLUMBER. Retrieved December 31, 2021, from https://estolumber.ee/about-us/

6. Gapp, R., Fisher, R., & Kobayashi, K. (2008). Implementing 5S within a Japanese context: An integrated management system. *Management Decision*, *46*(4), 565–579. https://doi.org/10.1108/00251740810865067

7. Gupta, S., & Chandna, P. (2020). A case study concerning the 5S lean technique in a scientific equipment manufacturing company. *Grey Systems: Theory and Application*, *10*(3), 339–357. https://doi.org/10.1108/GS-01-2020-0004

8. Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management*, *24*(10), 994–1011. https://doi.org/10.1108/01443570410558049

9. Hopp, W., & Spearman, M. (2008). *Factory Physics.* Waveland Press, Inc.

10. Irani, S. A. (2020). *Job shop lean: An industrial engineering approach to implementing lean in high-mix low-volume production systems*. Routledge.

11. Kleszcz, D., Zasadzień, M., & Ulewicz, R. (2019). Lean Manufacturing in the ceramic industry. *Multidisciplinary Aspects of Production Engineering*, *2*(1), 457–466. https://doi.org/10.2478/mape-2019-0046

12. Liker, J. K., & Meier, D. (2006). *The Toyota way fieldbook: A practical guide for implementing Toyota's 4Ps*. McGraw-Hill.

13. McIntosh, M. (2015). *Situating and constructing diversity in semi-structured ... - sage journals*. Retrieved May 3, 2022, from https://journals.sagepub.com/doi/10.1177/2333393615597674

14. Mohan Sharma, K., & Lata, S. (2018). Effectuation of Lean Tool “5S” on Materials and Work Space Efficiency in a Copper Wire Drawing Micro-Scale Industry in India. *Materials Today: Proceedings*, *5*(2), 4678–4683. https://doi.org/10.1016/j.matpr.2017.12.039

15. Patel, V. C., & Thakkar, D. H. (2014). *Review on Implementation of 5S in Various Organization*. *4*(3), 6.

16. Popken, B. (2021, June 29). *How the lumber industry misread Covid and ended up with a global shortage and sky-high prices*. NBCNews.com. Retrieved November 14, 2021, from https://www.nbcnews.com/business/economy/how-lumber-industry-misread-covid-ended-global-shortage-sky-high-n1272542.

17. Roriz, C., Nunes, E., & Sousa, S. (2017). Application of Lean Production Principles and Tools for Quality Improvement of Production Processes in a Carton Company. *Procedia Manufacturing*, *11*, 1069–1076. https://doi.org/10.1016/j.promfg.2017.07.218

18. S. Nallusamy et al., S. N. … TJPRC. (2018). Study on Lean Tools Implementation in Various Indian Small and Medium Scale Manufacturing Industries. *International Journal of Mechanical and Production Engineering Research and Development*, *8*(1), 969–976. https://doi.org/10.24247/ijmperdfeb2018117

19. Spear, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*, 13.

20. Suárez-Barraza, M. F., & Ramis-Pujol, J. (2012). An exploratory study of 5S: A multiple case study of multinational organizations in Mexico. *Asian Journal on Quality*, *13*(1), 77–99. https://doi.org/10.1108/15982681211237842

21. Turnock, C. (2001). *Validity in action research: A discussion on ... - Wiley Online Library*. Retrieved May 3, 2022, from https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2648.2001.01995.x

22. Womack, J. (1990). *The machine that changed the world*. Coiiier Macrnillan Canada. Inc.

Appendix A

The questions of the production manager interview.

The theme I: The lean production concept and the 5S lean production application

1. How well do you think the loader operation process works?
2. Would you rate the loader operation process as productive for today's production system?
3. Are there loader actions now that could be removed to improve performance?
4. How would you react to changes in the work process that contribute to the company’s productivity but at the same time require some time and effort for implementation?
5. Regarding how the loader operation process, is there anything that could be changed?

Theme II: The “set in order” principle application

6. Was the operation process of the loader analyzed before it was arranged?
7. How was the decision made about the location of materials outside the workshop? Is it, in your opinion, fit for the general operation process of the loader in terms of time?
8. Do you think there is a need for a clear division of the actions of the loader into parts for the subsequent deriving of a sequence of actions?
9. Does the driver have a specific work algorithm that he adheres to during the day or does the delivery of materials and cleaning of finished products occur as needed?
10. What steps do you think should be taken to reduce the loader's operating time?

Appendix B

The questions of the loader driver interview.

The theme I: The lean production concept and the 5S lean production application

1. How well do you think the loader operation process works?
2. Would you rate the loader operation process as productive for today's production system?
3. Are there loader actions now that could be removed to improve performance?
4. How would you react to changes in the work process that contribute to the company’s productivity but at the same time require some time and effort for implementation?
5. Regarding how the loader operation process, is there anything that could be changed?

Theme II: The “set in order” principle application

6. Are there any cleaning processes that are carried out regularly at this point of the company's development?
7. How often is the workshop cleaned in general? How long does it take?
8. Would you rate the delivery of materials and cleaning of finished products as optimal?
9. Do you adhere to the algorithm for the supply of materials if it exists and is well-established?
10. Would it be right in your opinion to reduce the amount of time the loader works by the application of the specific sequence of actions?

Foreign-language resume

TOOTMISPROTSESSI OPTIMEERIMINE 5S LEAN TOOTMISVAHEND ALUSEL ETTEVÕTTE ESTOLUMBER NÄIDIS

Kaasaegses maailmas, globaalsest pandeemiast tingitud globaalse kriisi tagajärgedega võideldes, kerkivad esiplaanile ettevõtte optimeerimine, protsesside ümberstruktureerimine ja üldine kulude vähendamine. Lisaks seisavad täna saematerjali tootvad ettevõtted silmitsi tooraine ja logistikateenuste olulise kallinemisega. Ütlematagi selge, et selline olukord nõuab konkurentsivõime säilitamiseks rohkem kui kunagi varem olulist kulude vähendamist ja protsesside ümberstruktureerimist.

Üks võimalus kulusid vähendada ja protsesse positiivselt muuta on Lean tootmise teooria, mis töötati välja 20. sajandil Jaapanis. Selle teooria kohaselt on ettevõtte tootmisprotsessi optimeerimiseks vaja loobuda erinevatest kadudest, mis on seotud aja, raha, materjalide ja muu kaotusega. Nende kadude vähendamiseks või kõrvaldamiseks on Lean tootmise teooria kohaselt vajalik selle teooria moodustavate erinevate tehnikate laiaulatuslik rakendamine. Käesolevas lõputöös keskendume eelkõige 5S tehnoloogia kasutamisele, kuna uuritud teooria kohaselt sobib see konkreetse probleemi, üleettevõttelise saematerjali transpordi lahendamiseks.

Seega on käesoleva töö eesmärgiks välja töötada soovitused saematerjali tootmisega tegelevale ettevõttele Estolumber tootmisprotsessi optimeerimiseks. Selle ettevõtte tooteid kasutatakse erinevates tegevusvaldkondades, nagu ehitus, mööblitootmine, aga ka remont ja paljud teised.

Soovitused saematerjali transportimise protsessi optimeerimiseks töökojas ja väljaspool seda töötati välja Lean tootmise juhtimisteooria ehk 5S tehnika kasutamisel, mis koosneb mitmest teostusetapist ehk teisisõnu mitmest põhimõttest. Neid põhimõtteid järk-järgult rakendades saab saavutada protsesside optimeerimise ja vähendada ettevõtte kulusid. Käesolevas töös käsitleti ja analüüsiti laaduri tööprotsessi, mis on otseselt seotud tooraine ja valmistoodete transpordi probleemiga.

Tootmise hetkeolukorra analüüs viidi läbi laaduri tööaja arvestuse alusel, tuginedes intervjuudele tootmisjuhi ja laadurijuhiga. Laaduri tööaja arvestus oli vajalik selleks, et hinnata saematerjali hetke asukohta kaupluses ja väljaspool, samuti laaduri tegevuste “sorteerimiseks” ja seeläbi 5S esimese “sorteerimise” põhimõtte rakendamiseks, mis seisneb eristamises ja teha ainult vajalikke ja kasulikke toiminguid. Intervjuud tootmisjuhi ja tõstukijuhiga olid vajalikud 5S tehnoloogia teise “korda seadmise” põhimõtte rakendamiseks. Järgmise 5S põhimõtte rakendamise eesmärk oli kehtestada laaduri kõigi toimingute jaoks

kindel järjekord ja vähendada selle tööaega. Teooria ja analüüsi põhjal välja töötatud praktilised soovitused on seotud 5S esimeste põhimõtete rakendamisega. Järgneva 5S kolme põhimõtte otsene rakendamine ja transpordiprotsessi otsene muutmine vastavalt uuritud teooriale ja läbiviidud analüüsile mõjutab positiivselt tootmisprotsessi ning laaduri tööaeg väheneb oluliselt, mis toob kaasa ettevõtte tegevuskulude vähenemise.

Esiteks tuleb see töö Estolumberile kasuks kõigi 5S tehnoloogia põhimõtete juurutamise ning hilisema saematerjali tootmise ja transpordi optimeerimise osas. Lisaks on oluline märkida, et see töö on kasulik tootmisettevõtetele, millel on sarnane "töökoja" tootmine, eelkõige seetõttu, et 5S-tehnika rakendamisel on seda tüüpi tootmise jaoks ühiseid jooni. Lisaks on see töö kasulik ka teistele rahvusvahelise kaubandusega seotud saematerjali tootvatele ettevõtetele, kuna praegune olukord saematerjaliturul hõlmab nii tootmise optimeerimist kui ka tööprotsesside ümberstruktureerimist.

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