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Process improvement with the use of Lean Management methods

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ABSTRACT:
Today's business market is constantly changing, and industries are finding ways how to gain competence and adapt to market demands. The competitiveness puts prerequisite for survival and therefore the need for constant improvement of the production processes and overall management, is becoming vital. The Master thesis aims to identify wastes in a production process and propose recommendation for improvements. The purpose is also to evaluate the usefulness of various Lean Management tools. For the thesis a single case study was chosen as a research methodology. Using Value Stream Mapping method, the current state of the process has been created. After the mapping, analysis of waste and improvement recommendations were made. The results of this thesis showed that material handling and transportation affected the case company's process. As the theory approved and the study resulted, that the Lean Management methods are very useful for improving productivity.

KEYWORDS: Value stream mapping, Lean, Kanban, 5S

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Abbreviations

BOM – Bill of Materials

TPS – Toyota Production System

1 Introduction

1.1 Background

In today's fast-growing industrial sector, it is very important for companies to stay competitive. Thus, to be as competitive as possible, companies must become more and more committed in the optimization of their resources and processes. In order to meet the customer requirements, companies focus more on the finding of new opportunities and world trends that help the optimization to be most beneficial with less resources. Their focus has to be set on the finding different ways they can keep up with the increasing competitive pressure that the globalization and innovation brings. For companies to stay competitive in the business world it is important to for them to reach or exceed the expectations of customers at the lowest possible prices.

Those companies who can execute with the speed and precision during production, possess strong competitive advantage. The aim is to execute excellence to details of the work, while minimizing any kind of waste and operating precisely in order to fulfil the customers demand and deliver the product on time. As the speed is the key element in the value stream, thus making it a powerful tool. As the time is being a limited resource, by delivering faster creates a big advantage compared to competitors. (Morgan, Liker, 2019, p. 78)

The Lean Management is one of the most commonly used methods for reducing costs and wastage. It helps to improve the productivity, which in turn, helps companies to survive in the increasing competitive business market and thus helping to develop themselves. In order to understand the main principles of Lean management it is important to know its origin and main characteristics. Implementation of Lean means knowing how and what kind of methods are rational to use, by taking into account the characteristics of a specific company and how it would be most convenient and easier to implement them.

1.2 Purpose

The aim of this thesis is to find out with the help of basic Lean Management methods, the types of wastes in the selected production process, analyse the reasons for their occurrence and to make proposals for their avoidance. In order to achieve the set goal, the following research questions were set:

- What are the biggest non-value-added activities in that specific production process?
- What kind of continuous improvement methods can be used in order to increase the productivity?

The master thesis consists of five major chapters: the introduction part, the theoretical part, the empirical part, the overview of the current situation and the results analysis part. The first chapter gives overview of the background and purpose of the thesis. The second chapter gives an overview of the history of Lean, the basic Lean Management tools and previously conducted studies. The third chapter, empirical part describes the choice of methodology, how this thesis was carried out, what methods were used, what data were used and how the data were analysed. The fourth chapter analyses the key indicators of the selected process and the problems encountered during the mapping. The fifth chapter outlines the improvement activities and the results achieved through them.

In the research both qualitive (case study) and quantitative research methods were used. The results of the thesis are presented in the last chapter, which also includes the suggestions of the author of the thesis for the further improvements.

The author of this thesis would like to thank the case companies' workers for the interviews and support in the work. In addition, the author would like to thank the supervisor Ville Tuomi for the support and advice.

2 Theory

2.1 The history of Lean

In order to understand where Lean Management methods has originated it is important to go back to the beginning of the mass production. Namely, in 1913, Henry Ford launched the very first conveyor-type production line at his factory in America. He named it “flow production”. It was a huge progress in the entire industrial world. To get there, Henry Ford had to do many things in advance. For that, it was necessary to standardize all the products and assemblies of those that were going to be produced on the conveyor. Also, it was important to ensure that the product assembling will be smooth and possible without any additional assembling at the line. It was necessary to standardize all the tools and measuring instruments. Determining the exact sequence of production operations and the time it took to make them, according to the standardized speed. Lastly, the training of workers was important so that they would be able to perform accurate and standardized work operations. The launch of the conveyor-line, created by Ford, is considered as the beginning of the mass production history. (Ruubel, 2018)

Before Ford begun with mass production, mainly craft-manufacturing principles were in use. Products were manufactured using multi skill workers, who made a product form beginning to end. The tools that were used were not standardized, as well the products did not have any standards. Every product that was produced, was unique and the products manufacturing time was uncertain. (Ruubel, 2018)

In 1950, the head of Toyota Motor Company, Eiji Toyota, visited Ford’s production plant in America. The aim was to see how the resources were used in their production and how thousands of similar cars were manufactured. At the sight, he immediately realized that, in Japan it is not possible to produce cars as resource-like, as in America. (Ruubel, 2018)

Japan, who had just devastated by two nuclear bombs, had an economy that was in a poor situation. The country was lack of capital and foreign currency. The industries had troubles with availability of the material, had shortage on money and human resources. In addition, the Japanese internal market was several times smaller than it was in America. American factories released thousands of the same products in a day, concluding that Japan should put its focus on manufacturing a lot smaller patches. Despite that, Toyota still decided to take the conveyor-line type production into use but making some changes to it before. Some of Ford's principles were changed and several new approaches were added (Kanban system, 5S etc.). (Ruubel, 2018)

In order to stay in the competitive business market, Toyota had to make significant changes. Due to the fact that Toyota lased on capital and resources, they needed to focus on doing the right thing and producing only what the customer wanted. It included choosing the right technology and investing in the right materials. It became important to produce products that are based on order. Production started when a customer gave an order and not before. In order to achieve that type of production methods, Toyota set the customers need into three aspects (Modig, Åhlström, 2016, p. 81-86):

1. What (What kind of product) does the customer want?
2. When does the customer want the product?
3. What quantity does the customer want?

To achieve it, Toyota developed a "pull system", where the production started only when an order came for a customer. The entire production process was treated as one flow, which consisted of several stages of the production. In order to ensure the optimal and efficient use and flow of resources, it was defined within the process when and how much is needed. Toyota named this new production philosophy as "Toyota Production System". (Modig, Åhlström, 2016, p. 81-86)

Today, this approach is known as Lean Management or just Lean. (Womack, Jones, 2010) Taiichi Ohno has defined the Lean Production as:

"All we are doing is looking at the timeline from the movement the customer gives us an order to the point when we collect the cash. And we are reducing that timeline by removing all the non-value-added wastes." (Ohno, 1988)

The development of Lean Management has also been greatly influenced by a rather old production method, which is craft-production. The following table (**Tabel 1.**) compares the three major production methods (Modig, Ahlstrom, 2016):

Table 1. Comparison of three major production methods (Womack et al., 2010, composed by author).

	Craft Production	Mass Production	Lean Production
Beginning		1913	1950
Originator		Ford Motor Company – Henry Ford	Toyota Motor Company – Taiichi Ohno
Production staff	Highly qualified staff	Narrowly specialized, often unskilled	Skilled at all levels of the organization, highly qualified
Production methods	Each product is made specifically for the customer, what the customer demands and one product at a time	Make high volumes of standardized products	Flow-based; produces what the customer has ordered
Production equipment	Simple and flexible, non-standardized or automated	Expensive and are focused on serving one purpose	Highly flexible and automated machines
Range of products	Diverse and according to the customer's wishes (unique copies)	The range is limited; standardized products	Diverse; product variety is very large
Production costs	High and do not decrease with the increasing quantities	Lower than in craft production and will decrease with increasing quantities	Lower than in mass production; the cost of each resource is lower
Organization/Management	Usually only one person; decentralized	Management is responsible; rigid and hierarchical	United team; division of responsibilities
Goal	Satisfy customer demand	To be good enough to save costs thereby allowing for defects and a small selection of products	Be perfect in everything

Lean as a term was firstly used in the 1988's when John Krafcik used it in his article "Triumph of the Lean Production System". The term got more popular and widely used after Womack, Jones and Roos in the 1990's published a book "Machine that changed the world". The book presented how Toyota usefully achieved productivity and quality, which the competitors were unable to do. (Modig, Åhlström, 2016, p. 91-93)

The table above (**Table 1.**) shows that Lean Management methods uses the advantages of both, craft, and mass production methods. From craft production, a production method was taken into use, where the aim is to produce a variety of products and unique items that are ordered by the customer. The customer must be able to choose, and to produce only what the customer wants and when the customer wants it. (Modig, Åhlström, 2016, p. 92)

This kind of production method has a disadvantage in the cost part, which are higher and thus result in the product price, that will be too high to sell to a wider market. For comparison, mass production has lower costs, but the product range is much narrower. Many products are produced into the stock because there are no specific orders from the customer. The advantage of Lean is that different products are produced according to customer order, thus the products do not remain in the warehouse and therefore the price of the product is also much lower. (Modig, Åhlström, 2016)

Equipment that is used in the craft production were much simpler, more flexible, and non-automated; compared to mass production where the equipment was expensive, quite complex and designed to serve only one purpose. In mass production, when an error occurs, the entire production needs to be put on hold, in order to resolve the issue (Modig, Åhlström, 2016)

That means that a problem at one point, stops the work at all points. (Hindle, 2003, p. 150) Lean production uses the advantages of both of the above-mentioned production

methods, where the equipment and machined are flexible and automated. (Modig, Åhlström, 2016)

When looking at the goals that those production methods have, in craft production it is at satisfying the customer requirements; mass production the aim is to be good enough and in Lean the goal is to be perfect. Comparing the goals of the methods, it can be seen how it has developed towards to being perfect. (Modig, Åhlström, 2016)

In terms of the staff, the craft producers are expected to be highly qualified. As most of the products were made by one employee that require versatile skills. However, looking at mass production, where most of the work is done by automated machined, the qualifications of the employees do not play a very important role, only the managers must have high qualifications. In Lean production, it is important that the employees have diverse skills, employees must be qualified to perform various work operations, as they are all equal. (Modig, Åhlström, 2016)

The difference that emerged when comparing these production methods, is the division of responsibilities within the organization. In craft production, all the work, from start to finish, is done by one person, thus the responsibility is directed towards him. In mass production, it is the opposite. All the responsibility is directed towards the management, because the workers do not play a big role in the decision-making process. However, in Lean production the aim is in the equality, where each employee is responsible for their own activities, there are fewer managers and thus by that it is possible to save cost. (Modig, Åhlström, 2016)

The difference that emerged when comparing these production methods is also the division of responsibilities within the organization. If in artisanal production all the work is done by one employee from start to finish, then the responsibility is also directed at him. In the case of mass production, the opposite is the case, where all responsibility is directed to the management. However, Lean Management is aimed at equality, where

each employee is responsible for their own activities, where there are fewer managers and thus it is possible to save costs. (Modig, Åhlström, 2016)

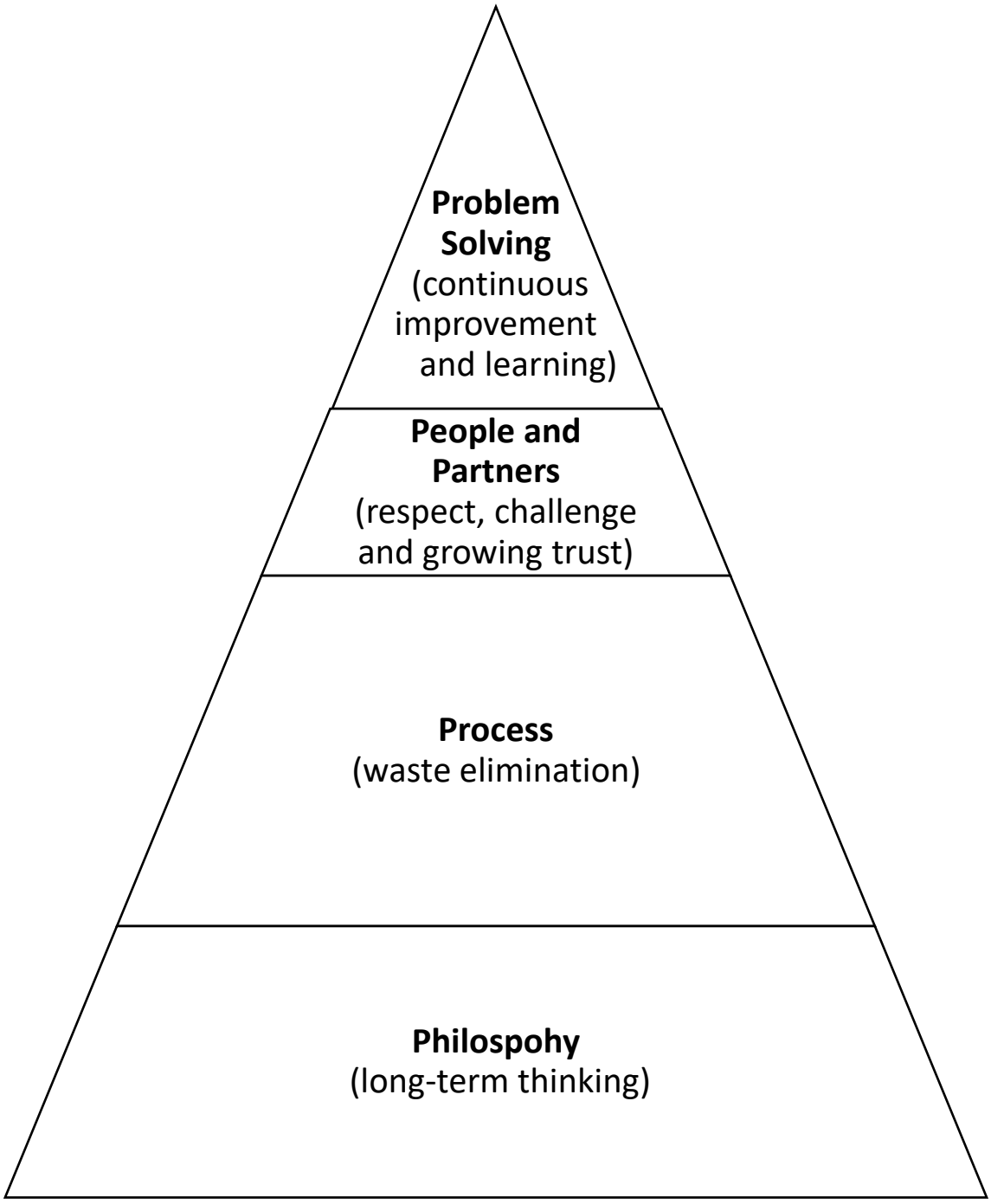

Figure 1. Lean Management 4P model (Liker, 2004).

In order to have a better understanding of the Lean Management, Jeffery K. Liker created a 4P model (**Figure 1.**), which name comes from the four words that begun with the letter P. These four words are called the pillars of Lean Management, which in turn are divided into 14 principles. The 4P model is presented as a pyramid to emphasize the importance of all the four pillars and their order. (Liker, 2004, p. 4)

For Lean Management to be succesful, it is important to start with the first pillar, which is a prerequsite dor all subsequent steps. (Liker, 2004)

A long-term philospohy is important for Lean Managemnt, which is also the first step of the pyramid. Acording to Liker(2004), philospohy is like a mission, where the company must be focused on the importance of increasing customer satisfaction.

The second stage of the pyramid is the process where the right processes lead to the desired results. At this stage, it is important to remove the various wastes. Liker (2004) has pointed out that very often the focus is on this stage and others are not considered important enough. The reality is that all steps are equally important and necessary, in order to achieve the desired results. (Liker, 2004)

The third level is the people and partners who are the real implementers of improvement. In order to ensure that the people and partners have the same goal, it is important to respect, challenge and help all the parties. Growing leaders who understand the work and are willing to live the company’s philospohy and by that teach others. (Liker, 2004)

The last or fourth stage is problem solving, which includes principles for solving initial problems and continuous learning of the company. As Liker (2004) has pointed out, that the Lean Management is never fully finalized in a company, rather it is a lifelong. In order to implement management fully and successfully, it is important to always follow all of those four principles. (Liker, 2004)

Lean as term has various definitions in different languages. Although those various definitions that are in use, the TPS (Toyota Production System) is often known as a Lean Production. (Liker, 2004, p. 15)

Jones and Womack (2003, p. 16-26) have defined Lean Production as a five-step process:

1. Defining customer value,
2. Defining the whole value stream,
3. Making it “flow”,
4. “pulling” from the customer back,
5. And striving for excellence.

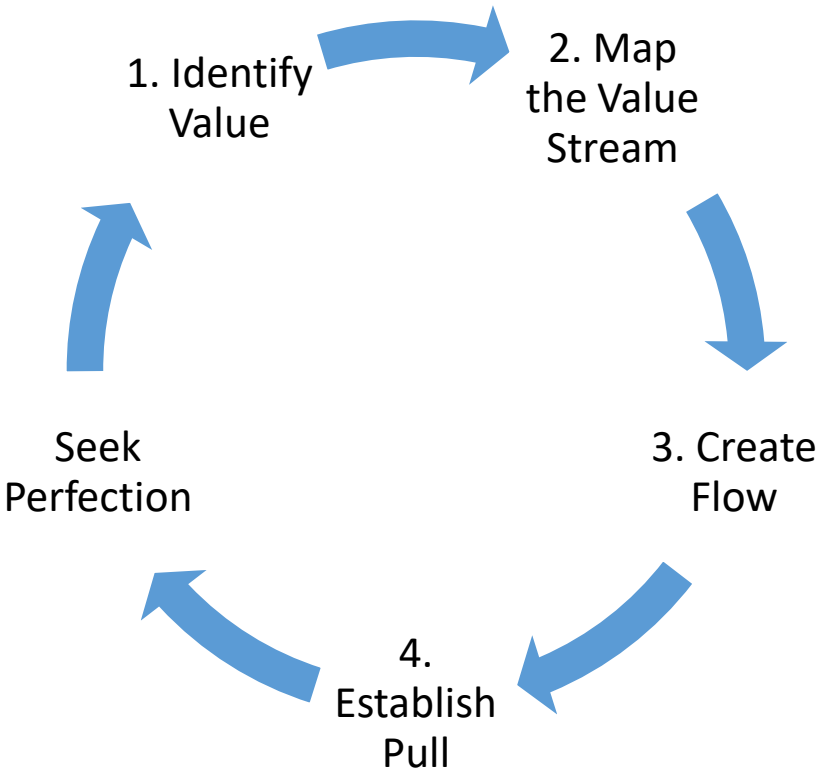

Figure 2. The Principles of Lean Manufacturing (Lean Enterprise Institute, n.d.).

The first step is defining the value that the company offers with its products, from the perspective of the end client. A good way to describe the principle is by an example of an airline. A customer buys a ticket with the aim of reaching desired destination from A

to B, thus the airplane makes the most value to the customer. Although a passenger needs to waste time for standing at the baggage registration or the checking for a passport. Therefore, airlines need to do their utmost to change the share spent on flying bigger, in other words, spend as little time as possible on other things. (Jones, Womack, 2003)

Secondly, it is necessary to map all the activities that are needed to provide that value. As it is important to identify the stages of process from the beginning of the production to the end, when it arrives to the customer. As the value is added on a particular stage of the product's development. Those activities are shown through value stream mapping. (Jones, Womack, 2003)

Thirdly, it is important to put the processes flowing smoothly through the entire value stream, in order that the product reaches the customer as quickly as possible with the lowest cost. The time the customer has to wait from the value stream should be eliminated, as it should be as short as possible. (Jones, Womack, 2003)

Fourth step is to create a pull system, i.e., the product is linked to the end customer by who's demand is the trigger for production. In other words, company should start to produce the product at the customer's request. Although this step is hard to adapt, but in many automotive industries, it is performing willingly. (Jones, Womack, 2003)

Lastly, the whole process needs continuous improvement and refinement in terms of the value stream. (Jones, Womack, 2003)

All of those above mentioned five principles are well connected to the Lean Management, as it has become a vital part of it. The identifying, evaluating, continuously improving and ensuring the value must be on an important part in every company.

2.2 Lean Management tools

There are many different and very useful tools that are used to implement Lean Management methods. Which method to use for the implementation largely depends on what is the situation that needs analysing. Thus, it is important to know how a particular process works all together. Many of the Lean techniques can be implemented separately, but many of them are more efficient when combining them and thus they reinforce each other. In order to choose the right method for improvement, it is important to determine what is the goal and what is needed to be achieved. Firstly, if there is a part of an organisation that needs improvement the very first thing is to find out what is the reason. The following section discusses the tools that were used to write this thesis.

2.2.1 Value Stream Mapping

In order to start to implement Lean Management into a production, the first step is to map the value stream, as it is the first block of Lean. The aim of mapping is to see and concentrate on the big picture. As it consists of all the actions that are required in order to deliver a product, thus include both value-adding and non-value adding activities. For the improvements to be made it is important to start to map the entire value stream of a chosen product. By mapping the current state of a production, it is possible to see and review how the value flows within a process. (Cudney, 2009, p. 45)

Term "*value stream"* refers to all the activities that a company must do to design, order, produce and deliver the products or services to a customer. (Liker, 2004, p. 275) Therefore, there is always a value stream when there is a product being made. (Jones, Womack, 2003, p. 81)

Value Stream Mapping as a method was firstly adapted in 1999 by Mike Rother and John Shook. It had evolved from Toyota's tool "material and information flow diagram" that was used in order to see the big picture of their current situation and thus identify any

kind of waste in the system. By that they were able to capture the whole process, how the material and information flow between them to the customer and to supplier. (Liker, 2004, p. 275) Those activities include both value-added and non-value-added actions.

The value stream has two main flows (Rother, Shook, 1999, p. 1):

- The production flow, from the raw material to the customer.
- The design flow, from the concept to launch.

Production flow includes two flows, the information and material flow that are equally important. The two flows are connected to each other and in order to make improvements it is important to map both of them. As to the production flow is the movement of material through the factory and the information flow tells each process what to do next. (Rother, Shook, 1999, p. 1)

The importance from the perspective of value stream it is important to work on the big picture, not just individual process, therefore improving the entire stream and not just optimizing the parts. (Rother, Shook, 1999, p. 1)

Value stream is referred as a pencil and paper tool that helps to see and understand the material and information flow as the product is moving through the value stream. Rother and Shook (1999, p. 2) point out the easiness of the value stream mapping, as by just following the path of the product from customer to supplier and visualising all of the process along the way, a value stream map will be conducted.

Value Stream Mapping provides a basis for implementing different Lean Manufacturing tools and helps organizations to create a plan for those implementations to be made. (Cudney, 2009, p. 45)

The Mapping serves multiple beneficial parts to a process. The first benefit of this method is that it allows people to see the entire process at the same time, not only single parts of it. As the flow of that process is being revealed. It helps to identify sources of wastes that occur at that process. (Cudney, 2009, p. 47)

The second beneficial part of the method is that it creates a common understanding of that process, with the ties together with Lean Management methods. The Value Stream Mapping is the only tool that provides the link between the information and material flow. It can be used everywhere that has a process that needs to meet a desired objective. (Cudney, 2009, p. 47)

The very step of this method is to map the current state of Value Stream. By evaluating the current process state, several improvements can be identified.
After the current mapping is done, the next step is to map the improvement of that process that represents the desired future state. Main purpose of the current state mapping is to clearly understand the current situation of that process and it is done by drawing the material and information flows. By delivering a product at the right time, with the defined specifications and at the right price, are the values that are defined by the customer that are required to fulfil. Purpose being in the identifying sources of waste and eliminating those wastes by the creation of future state map. (Cudney, 2009, p. 48)

Every process improvement starts from the selection of a production family, the description of a process and the analysis of it. After a specific product has been chosen the next step would be to map every step that are involved in the physical production and to the order-taking for it. (Womack, Jones, 2003, p. 20)

Womack and Jones (2003) identified three types of actions that are occurring in the value stream and that the analysis of will bring out. Those three types of actions are (Womack, Jones, 2003, p. 20):

- Activities that will definitely create value to the customer,
- Activities that are founded to create no value, although can be avoided with the use of various technologies and production resources,
- Activities that do not add any kind of value and can immediately be avoided.

When applying this method, it is important to look beyond the company and look at the big picture, as it involved various parties. As it consists of a set of activities that are needed in order to create and produce a specific product. Activities that make the whole picture of the value stream consist of (Womack, Jones, 2003, p. 20-21):

- creating a concept that goes through the design to actual place,
- opening a sale that goes through the entry and production phase,
- the overall production and delivering of the product,
- placing those raw materials into product and into the hand of the customer.

2.2.2 Layout

Layout is referred as a way, how material and equipment in the production are being arranged. Hales (1984) defined the layout as an arrangement of operations, machines, spaces, and the correlation that occurs between them.
In order to obtain good and efficient Lean manufacturing plant, the importance of materials and equipment placement is vital. Everything that is stored correctly, nor the placements are not well thought out, will eventually hinder the production.

Modifying or improving the lay-out it is important to think through the placements and movements of materials and workers. One thing to do is lesser the time spent on the

movements or storages of the semi-finished products that occur between machines. Thus, they should be placed logically or when there is a possibility to connect them to each other. The principle is that the input of a machine should be near the material warehouse and the outputs should be near the finished products warehouse. There should also be as few transportation path crossings and movements that do occur backwards. Every transportation route takes valuable resources, as the space of plant is expensive, and the time spent on movement is non-value added. The ideal would be that there should be as few transportation paths and crossing as possible. (Tuul, n.d.)

The main goal that the layout has in the Lean production, is to increase the overall efficiency. By designing the layout as it facilitates the material and production flow, with the help of arranging the equipment as in the sequence of specific production steps. (Mann, 2005, p. 195)

Literature has very many layout related issues that have been addressed. A study that was conducted in 1970 showed that 20-50% of all production costs are related to the material handling. In the study it was indicated that that kind of work processing related costs can be reduced through the efficient layout planning by 10-30% per year. Also, it advantages in the decreasing of semi-finished products and the throughput times, as well as the control of information and material flow will increase. (Carlo et al., 2013.)

2.2.3 5S

5S method is the easiest and most commonly used tool in order to implement Lean Management. Ana Rotaru (2008, p. 121) has defined the 5S, as being a system that organized the workplace and therefore supports the culture of continuous improvement.

The mantra of 5S method is “A place for everything and everything in its place”. The method used for reducing wastes and optimizing productivity – how to create clean, efficient, and effective workplace. (Purohit, Shantha, 2015, p. 225)

The method itself comes from Japan and refers to 5 Japanese words that each begin with the letter S and refer to the steps to visual management. Although there are very many versions of those 5S's, the core is to provide a methodology for getting and staying organized. (Locher, 2011, p. 76-77)

Those five steps involve the overviewing the items in a workplace, removing all not needed, organizing them, cleaning, performing maintenance and making sure that those previous things become habits. By the use of 5S the workplace gets more organized and by that it will be easier to see problems and the material movement will be more efficient. (5S Training and Research, n.d.)

The modern 5S system originated in the 1980's in Japan from the Toyota Motor Company who firstly implemented it. It was developed with the aim to increase the products or services value to the customer. (5S Training and Research, n.d.)

The terms translated to English are (5S Training and Research):

- Seiri (Sort),
- Seiton (Set in order),
- Seiso (Shine),
- Seiketsu (Standardize),
- Shitsuke (Sustain).

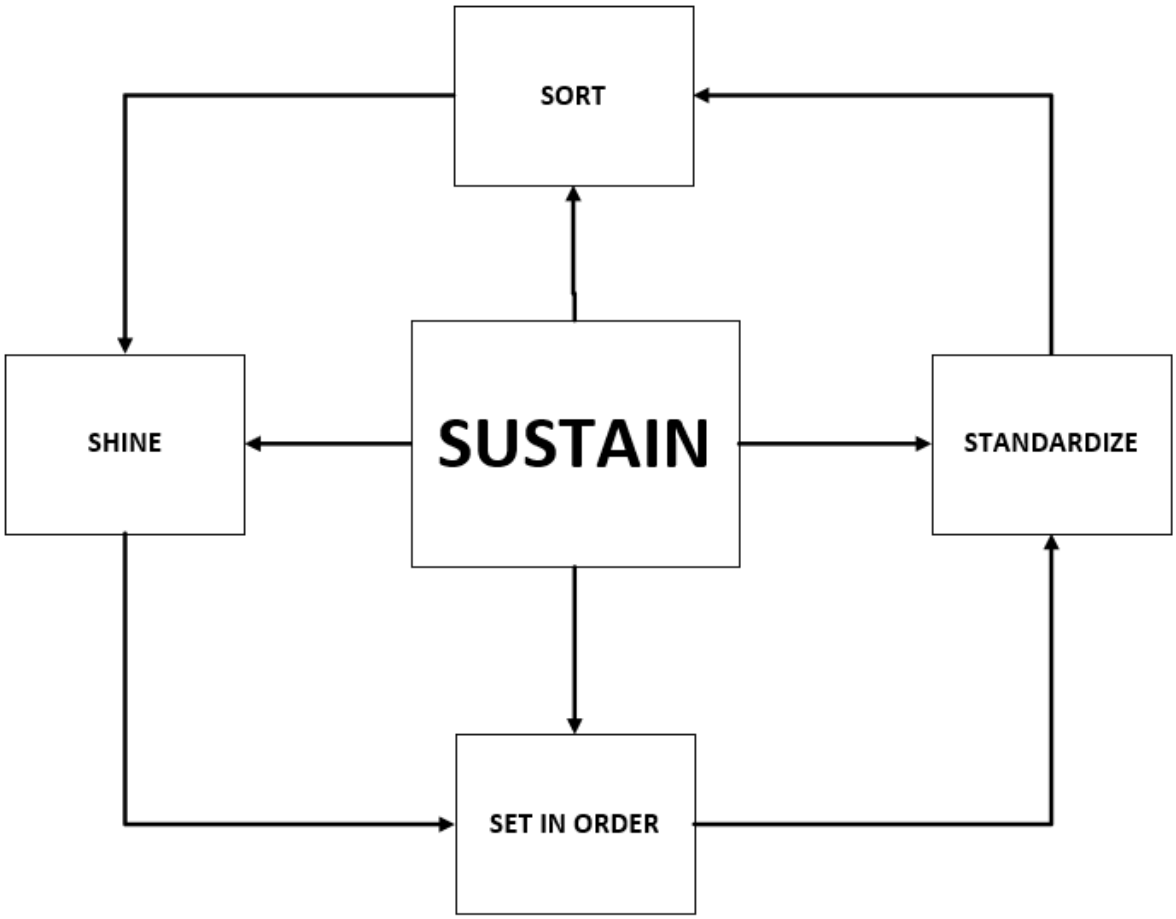

Figure 3. The 5S's (Composed by author).

The 5S method has 5 steps where every of them have an associated goal in order to help guide efforts. **Figure 4.** illustrates all of those 5S's, as they together create a continuous process for improving the work environment.

The very first step of the process is Sort, where the goal is to remove all the unnecessary items from the room or workplace and thus the spaces will be organized. Also, it indicates clear slate on which to build and carry out the following four steps. In the beginning of the Sort process, everything that are not needed will be removed from the target area. Even if it is just taking items from one place and putting them to another into a big pile of unnecessary things. By doing that it helps to make decisions about those items that

really are needed in the specific place and what are no longer needed or used. (5S Training and Research, n.d.)

When using this step there might be used four types of bins (5S Training and Research, n.d.):

- Keep – there will be those kind of items that are frequently used and are essential to the workplace. Those kind of items should be put back to the area after the sorting process is completed.
- Remove – there will be those kind of items that are not needed at that workplace and are just taking up space. Those kind of items might be like broken tools, outdated materials, or components or so one.
- Probation – in there the items are being evaluated for use. Those kind of items are evaluated after a set timeline and looked if they have been used or not. After the set date is past the items are either discarded or putted back to the workplace.
- To Move – there will be those kind of items that are needed in somewhere else in the company but not at that specific workplace. They are essential to some other places, as they make more efficiency somewhere else.

The second step of the 5S process is “Set in Order” that focuses on placing those items that were set essential in the Sort part back to the workplaces, but in a specific and well-organized way. In this step the goal is to find the most efficient and sensible places for those items in that area. There are multiple ways and techniques for implementing this step in a workspace. (5S Training and Research, n.d.)

One way how to set them in order in an efficient way and thus keeping it that way is to create shadow boards. Shadow boards mark the outlines of tools behind or beneath the places they hang or sit while they are stored. By this it is more easier for a worker to see what is missing and also helping to put it back. In this step it is also possible to set the placement of items personally, as every worker is individual, and everything does not

suit for everyone. To fulfil everyone's desires it is important to put those items in an easily adjustable way. (5S Training and Research, n.d.)

The third step is “Shine” that is meant to sweep or sanitize. In this step the overall cleaning of the entire workplace is being done. Workers clean, dust, polish, sweep and vacuum the entire space. Having a clean workplace means having a safe workspace. If the floors are clean then the risk of tripping, slipping, and falling will be reduced. Also, when workplaces are clean and tided the there will be less potential in getting different infections or other health hazards. Those kinds of cleanings should be done on a regular basis, on a schedule. (5S Training and Research, n.d.)

Fourth step of the 5S is “Standardize” where the direct connections the tips encountered form the previous step. In this step there will be built an idea of auditing and checking in on the 5S efforts on a regular basis. It is like a bridge between the “Shine” and the fifth step of 5S. Therefore, by the standardization of the approach to 5S, it helps to ensure that the efforts that are made organizationally, will be sustained in the long run. Being bad in the standardization phrase can lead to the work being sloppy over time and thus losing the efficiency. In order to standardize 5S methods it is important to make it more than an oral agreement. It must be clear, understandable method that all the parties are certain about what each individual are expected to do. One way to do this is to implement 5S audits, where there is a list that needs to be covered and checked on a regular basis. The checklist should consist of specific questions about the chosen work are, that help to ensure that the process is carried out as intended. In this step the making of rules is important, as everyone should have clear understandings about how and when a certain task will be performed. (5S Training and Research, n.d.)

And the last step of the 5S, and the hardest to adapt, is “Sustain” that focuses on the transformation of all the previous steps into ongoing habits in order to ensure their continuous improvements. (5S Training and Research, n.d.)

In order to get the most benefits out of this step it is important to follow four steps (5S Training and Research, n.d.):

- Demonstration – everything that is required from the workers should be demonstrated correctly by a person who has the right skills, training and knowledge. Thus, workers will gain the understanding of what is actually needed from them to do.
- Supervised undertakings – for worker to know what is expected they need to work with closely. Monitoring workers through the very first steps in order to ensure that the daily used 5S methods are being formed into expected and desired habits.
- Periodic check-ins – regularly checking if those techniques that were obtained in the standardizing step are running smoothly.
- Make changes as necessary – having a continuous undesired behaviours and undesired result that might have various consequences thus lead to faulty systems.

In order for the last S to be efficient it is important to sustain all of the new practices that were obtain in the previous steps and conduct audits for the obtaining discipline. The best way to do it is to continue doing those previous four steps over-time. By developing self-discipline in employees that will participate in the 5S, achievements can be made. (5S Training and Research, n.d.)

Overall 5S is a method that is a part of Lean Management in order to achieve higher quality levels through the minimization of wastage. It is most commonly used because it is does not require big investments from companies and thus the productivity will increase. Beneficial side of the method is also that the workers enthusiasm and punctuality will rise throughout the process, leading to safer work environment. (Purohit, Shantha, 2015, p. 230)

In 2014, Arunagiri and Gnanavelbabu (2014, p. 2074) conducted a survey with 91 production companies, in order to find out what kind of Lean Management tools were the most effective. 84 of those companies agreed that the application of 5S method gave very big positive results in the efficiency of production. Thus, using 5S method is the most effective tool in order to maintain flexible production system.

In order for this method to be completely successful it is important that the management of the organization fully supports it. As they must provide guidance, support, coordination and proper communication. Organizational management must provide a well-suited environment for the employees for them to utilize their skills the best possible way. A way to do it is the management supports and encourages the people to focus on the value-added activities in order to expose any kind of problems and therefore respond accordingly to them. (Cudney, 2009, p. 82)

2.2.4 Kanban

In addition to the previously mentioned 5S tool, there is another visual tool for Lean Management, which is Kanban. Kanban is a Japanese word that means “sign” or put in general it means “visual sign”. (Locher, 2011). In the west it is generally known as a “card”, that let’s to know that something is needed to deliver or produce. Kanban as a system has two aims, one being visible and the other one invisible. (Rother, 2014)

The visible aim of Kanban is to create a way to regulate the production between processes, resulting that only to produce what is needed and when it is needed. (Rother, 2014)

The invisible aim of the system is to support the process improvement, provide the desired state by defining the desired systemic relationships between processes, thus revealing improvements that are needed. Although Kanban has two different aims, one cannot work without the another. (Rother, 2014)

The roots of this method come from the Toyota Production system, where Taiichi Ohno developed them in order to control the production between processes at their plants. As a result, he minimized the work in progress and thus the costs that took holding inventories. (Gross, McInnis, 2003, p. 1-2)

Kanban helps to control the inventory levels, the stocks of products and components. In some cases, it can also be used in the management of raw material stocks as efficiently as possible. By the use of Kanban system, it helps to manage stock levels and products in a way that they are always present in the production unit. In addition, it checks that not too many of those products or materials are there. (Macinnes, 2002, p. 93)

As to the process controlled by Kanban then products are being produced based on the real usage not by forecasts. When Kanban has been successfully implemented, it can be used as a visual production schedule control for the for the supervisors. (Gross, Mclnnis, 2003, p. 2)

Having a real Kanban scheduling method applied, it must produce products only in order to replace the product that has been consumed by its customer and producing products only based on the signals that are sent by its customer. (Gross, Mclnnis, 2003, p. 3)

The advantage of this type of scheduling is that it takes away the daily scheduling activities needed for operating the production processes. Also, the method takes away the ned for continuous monitoring schedule statuses and change over times. (Gross, Mclnnis, 2003, p. 3)

There are quite many benefits that the Kanban scheduling brings in order to implement continuous process improvement. Those benefits are (Gross, Mclnnis, 2003, p. 5-8):

- Reduces inventory – the inventory levels will be decreased, as the Kanban quantities being calculated, identifying the material usage in real time. As the inventory reduces it also leads to the reduction of the physical space that was in use. Gross, Mclnnis, 2003 have pointed out that in their experience the inventory levels will be reduced by 25 percent to 75 percent.
- Improves Flow – by the control of inventory and design of material flow the overall operation flow will be improved. It gives the operators the guidance about what and when to produce.
- Prevents Overproduction – lacking the control of production processes and quantities lead to overproduction that is one of the seven wastes of Toyota Production System (TPS), that will be discussed in the next chapter. Using Kanban, it helps to prevent overproduction by specificizing container sizes as well with the maximum number of containers needed to produce. It uses visual signals for the operators to know when to start and when to stop the production process.
- Places Control at the Operations Level (with the Operator) - The design of Kanban tells the operators what, how much, what sequence to run the production lines. Thus, it tells when there is something wrong in the process and someone can go and make corrections. As it also reduces one of the seven wastes, where the proper usage of human resources is being utilized.
- Creates Visual Scheduling and Management of the Process – the use of visual Kanban it eliminates the usage of paper scheduling. Visual signs tell the operators what to produce and what sequence to produce them. Using visual Kanban, it allows to focus more on the production problems, planning the future and other kind of continuous improvement activities rather than daily controlling of the production schedule.

- Improves Responsiveness to Changes in Demand – Kanban sets up the maximum and minimum inventory levels, that provide the signal to what and when not to produce. Signals will stop the production as the demand increases.
- Minimizes Risk of Inventory Obsolesce – Kanban stops overproduction, as well preventing the risk of building inventories that can overall become obsolete. As the production is staring based on demand and not on the forecast.

The Kanban system uses cards as a visual signal for triggering or controlling the flow of material or parts during the production process. Thus, synchronizing the work processes through the organisation as well as those that involve the outside suppliers. (Macinnes, 2002, p. 93)

Card that is used as a Kanban controls the movement of materials and parts between production processes. It moves with the same material all the way down the production line. When there is a need for more materials or parts then it sends the corresponding Kanban to the supplier, as the card acts as a work order. (Macinnes, 2002, p. 93)

Typically, a Kanban card contains the following information about the production of items (Macinnes, 2002, p. 93):

- What to produce,
- How to produce it,
- When to produce it,
- How much to produce,
- How to transport it,
- Where to store it.

There are two types of Kanban cards in use: production and withdrawal Kanban. A production Kanban is used to describe how many of what item is required to produce. The production of a specific item starts when the Kanban card is in hand. The second type is

used in order to pull items form prior operations or storages. (Macinnes, 2002, p. 97) It is important that the Kanban card is attached to the actual item as it moves along with them. As Kanban helps to eliminate waste, those relevant value-added and non-value-added activities will be explained in the following chapter.

2.2.5 Value adding and non-value adding activities

In order to understand what kind of activities add value and which of them do not, it important to make the difference between them.
Toyota (Liker, 2004, p. 10) defined waste as to all the activities that takes time but does not add any value to the customer. The value is being defined as seeing the process form a customers' perspective and by answering the following question (Liker, 2004, p. 27): "What does the customer want from this process?".
To identify what is value added and what are not, Toyota has conducted three categories (Liker, 2004, p. 280):

- Value added - those activities or tasks require resources and time, thus turning a raw material into a final product. The course of those activities that are carried out lead to a products final shape. Those kinds of activities may also include the transformation of information, like engineering or accounting.
- Non-Value added - in here there are all the activities that do not add any kind of value, that are pure waste. That kind of task that by performing them a transformation of parts or material will not contribute to finish product.
- Non-Value added but are Required – this is a group of activities that do not add value to the customer but are required in order to produce a product. Those kinds of activities cannot be entirely taken out of the process, as they are necessary part of the process, but they can be reduced.

The non-value adding activities are occurring in almost every organization. Toyota has classified those activities into seven major types of waste that affect the organization's

performance. Later another type was later added to the group, talent. (Liker, 2004, p. 29) The unrealized talent of employees is also considered a waste - it is employees who know best how to make activities more efficient (Miina, n.d.). Thus, the involvement of employees in day-to-day processes is important.

Below the types of waste are being described (Liker, 2004, p. 29):

- Overproduction is waste when producing items before they are required. The waste will result on the overstaffing, storage space and the costs of the transportation that the excess inventory levels bring.
- Waiting - the time that is caused because a workflow had to stop. Waiting for the material or details, that are required for the next process step. For example, if a product is made from multiple parts and one part is missing then the time for waiting for them will be lost cost for the company
- Transportation - unnecessary movement of materials, information, people, or tools.
- Overprocessing is when unnecessary activities will be done in order to produce an item. Also, doing more than is required or producing higher-quality items than necessary.
- Inventory - having excess raw materials, semi-finished products or even finished products that cause higher lead times, excess transportation, and storage.
- Movement - unnecessary walking and searching for items that are not within the reach area or easily accessible. If the needed items are not within the usage areas, the waste will be in the searching, reaching, and stacking parts of them.
- Defects - doing work that needs to be redone because of errors. It can be defective items or correction of the work that has been done. Repairing and over inspecting leads to waste in handling, time and even effort made.
- Talent - not using the full potential of workers by not engaging or listening the ideas, skills, and improvements of the staff.

Ohno (Liker, 2004, p. 30) pointed out that the biggest waste of those eight is overproduction, thus it is the root cause of the other wastes.
When producing more than a customer is demanding by the use of any operation in production it leads to various types of waste. Somewhere along the way there will be unused material, that is waiting for a next step to begin. (Liker, 2004, p. 30)

In reality there is not reasonable to eliminate all of those non-value-added activities. Many of those kinds of activities do not add value from the customers perspective, thus they are required to be done in a company in order to maintain in the business world. (Pande, Neuman, Cavanagh, 2002, p. 312-313)

Lean Management focuses on the value stream in order to eliminate those non-value adding activities, as they are the biggest part of the total process time. Eliminating those unnecessary activities helps companies to focus to do the real work that the customer is willing to pay for, thus being maximally efficient. **Figure 5.** shows, that all the eight wastes mentioned above, are connected to each other.

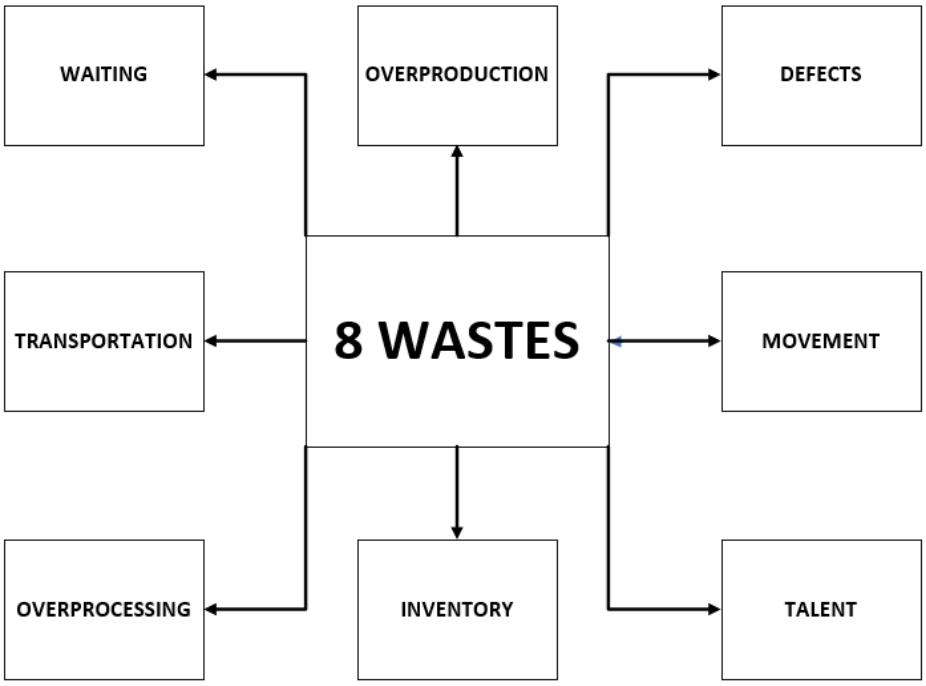

Figure 4. 8 wastes (Composed by author).

2.3 Former studies

There was a research conducted, where a company's activities were analysed in order to improve the competitiveness by effective management of the entire value chain. With the concept of Lean Management methods, the aim was to make proposals for eliminating those non-value-adding activities. By mapping the activities of various processes, it revealed that 66-84% of the time spent on waiting, thus being non-value added. (Vitsur, 2014)

In the book The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer there was presented an example from a case that also adopted Kanban system in order to improve their production processes. By making improvements the plant achieved incredible performance improvements, as to the semi-finished products was

reduced by 40% and overall lead time for making a product was reduced also by 40%. Those results that were obtained, are classical Lean transformations.

Mahmood and Shevtshenko (2015) in their research used different Lean Management tools in order to reduce cost and maximizing customer value while minimizing waste. By implementing Kanban system and other Lean Management tools they achieved noticeable results. As the semi-finished products reduced by 22% and overall inventory levels decreased about 13%.

A case study conducted by Subodh Patil et. al indicated that the use of Lean Management methods for the increase of production and productivity can have significant results. In the case study a systematic plant layout planning was used and by that several results were achieved. Placing material near the place they were consumption, the handling times, labour costs and transportation costs were minimized. Overlay the plant space was saved about 7%, production rate uncreased 15% and the efficiency of the line increased from 35.20% to 40.517%. (Patil, et. al, 2019)

The book “The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer” provides an example of the implementation of Lean Management methods for the process improvement. A company in Mississippi also used Lean methods for improving their processes and the results that they obtained were similar to the findings of this thesis. As the company made various improvements, the lead time decreased by 54%.

3 Methods

In the empirical part of this thesis the author gives an overview of the methodologies used in the work, explains the nature of the chosen process, and points out the current situation.

The empirical part is divided into three major chapters. The first chapter provides an overview of the methodologies used in the work, how this thesis was carried out, what methods were used, what data were used and how the data were analysed. The second chapter analyses the key indicators of the selected process and the problems encountered during the mapping. The third chapter outlines the improvement activities and the results achieved through them.

Both qualitative and quantitative research methods have been used in the analysis of the thesis. For the qualitative methods, an analysis of the current situation is used, during a case study. A case study is a method of researching a specific process. This thesis is a study of a specific process, with the aim of finding ways to improve the process and eliminate waste. Quantitative research is more about finding out about the effectiveness of resources to find ways to improve them. (Õunapuu, 2014, p. 51-54)

Using a qualitative method, it is possible to obtain data from the “natural” environment, the research results are rather subjective and based only on the opinion of a specific person, non-numerical data are used, and the result is a comparison with a theoretical approach to the existing situation. The main core of the quantitative method is numerical data and statistical value, which conclusions are drawn. (Õunapuu, 2014, p. 51-54)

Lean's thematic scientific work’s mainly uses qualitative data research methods that support the research and analysis in selecting a specific process. The opinions of the people carrying out a particular process and their vision of how the process can be improved are important. By performing their tasks, each employee can provide feedback on how

the process can be smoother, what are the bottlenecks that effect the performance of tasks and work together to find solutions to optimize the process.

The research object of the thesis is a specific production process in a case company. The aim of the work is to identify the biggest non-value-adding activities of the process using Lean Management methods and to point out the possibilities to reduce them. The work mainly uses case studies, where data is collected through observations, unstructured interviews, and document analysis.

Value chain mapping is used as an observation method, which is one of the most common Lean Management tools. It is a simple and resource-intensive method of analysis that can be used to assess process bottlenecks and identify the biggest wastes. (Rother, 2014)

In order to collect more data, there was one unstructured interview with related parties, that lasted about an hour. The purpose of the interview was to find out what problems occur in the job environment and when doing the job. Problems and bottlenecks were identified and taken into account in the mapping analysis of the current situation.

In order to get a comprehensive overview of the chosen process, the author of the thesis mapped the current situation using Lean Management methods. The mapping process consisted of three major groups of activities.

The first activity was to map the current situation of the process, which was carried out by the author, using paper and pencil. First, the current situation was manually recorded on paper, after which the results were transferred to an excel file. After the current situation was mapped, the cycle times of the process were measured. The author used a stopwatch for the measurement and each work operation was measured 4 times, in order to get accurate results.

The movement paths of workers and materials were also measured and counted how many times they pass through during the production of one product. Once the measurements were conducted, unstructured interview was conducted with related parties to discuss problems and bottlenecks in the production unit.

4 Analysis and improvement of the production process

The author of the thesis carried out a mapping of the current situation in the value chain (**Figure 6.**), with the aim of identifying those activities in the process that do not add value and that could be either reduced or removed.

Based both on the interview and the results of the mapping, it is possible to point out the bottlenecks that occur in the production process. The next chapter analyses the current situation of the selected process and then presents suggestions for improvement.

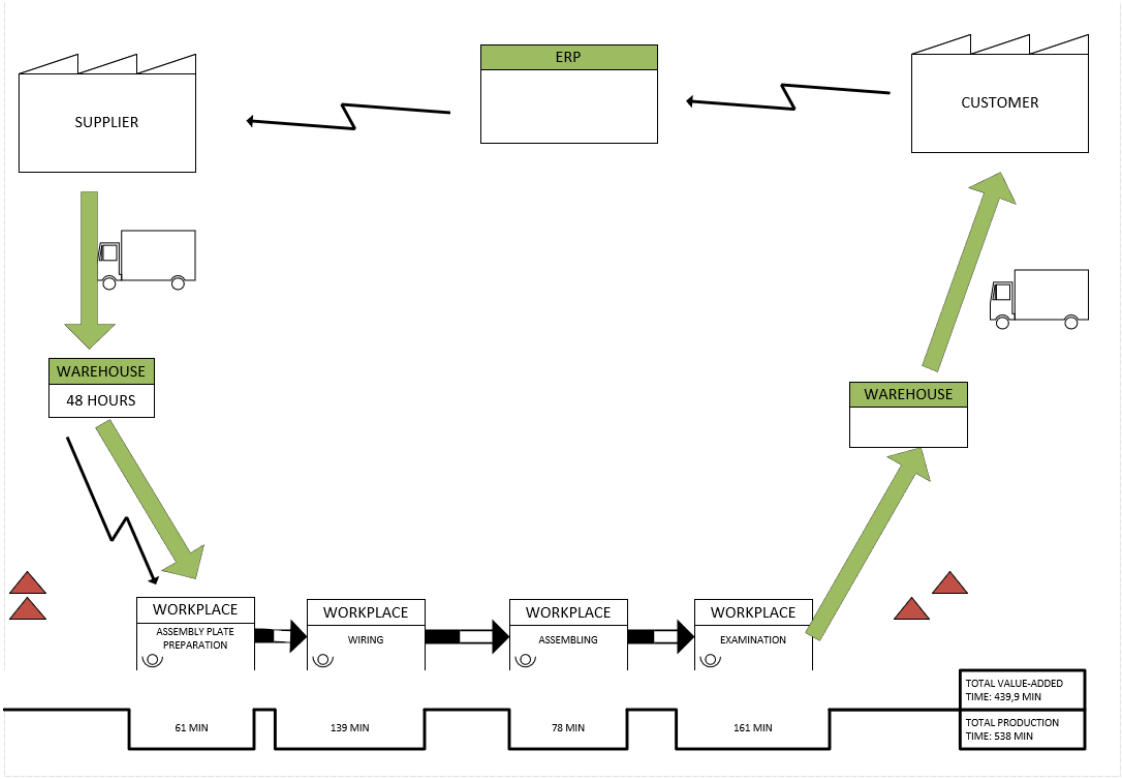

Figure 5. Current State Value Stream Map (Composed by author).

4.1 Analysis of the current state

The first and biggest bottleneck in the current state was the handling and transport of materials. The materials required for the work are ordered by the head of the given production unit, using the company's enterprise resource planning (ERP) system. Once the order had been delivered through the system, the warehouse has 48 hours to assemble the necessary materials and deliver them to the production unit.

As the delivery time of the warehouse is so long, a quantity of materials is ordered in 3 days. All ordered components and materials come to the production unit at the same time and on the same basis. Once the material had arrived, the head of the production unit starts to sort and unpack them. The parts are unpacked and then placed in either shelves or boxes, respectively.

There is one large shelf in the entire production unit, where all the materials needed for the work are located. From this shelf, the production workers themselves take the materials to their workplaces. As there were no places for the necessary materials in the workplaces, the production workers visited this shelf several times during the production of one product.

In connection with this, the distance travelled by the employee during the production of one product was also measured. To produce one product, the worker had to walk 504.3 meters. Such inefficient walking also caused excessive time. Transporting materials and components is certainly a necessary activity that cannot be eliminated but can be reduced.

By mapping the current situation, the production area used in the given production unit was also measured. **Figure 7.** shows the layout of this production unit and a total of 292 m^2 was used as production space. A very large part of the production area was occupied for the storage of various semi-finished products, materials, and other things not

necessary for work. In the **Figure 7.** the semi-finished products are shown as blue boxes and the red boxes indicate other things that are not necessary for the work.

Production layout is also one of the production tools in Lean Management, that promotes the good visibility of the entire production system and thus simplifies the management part. (Salleh, Zain 2011, p. 3947)

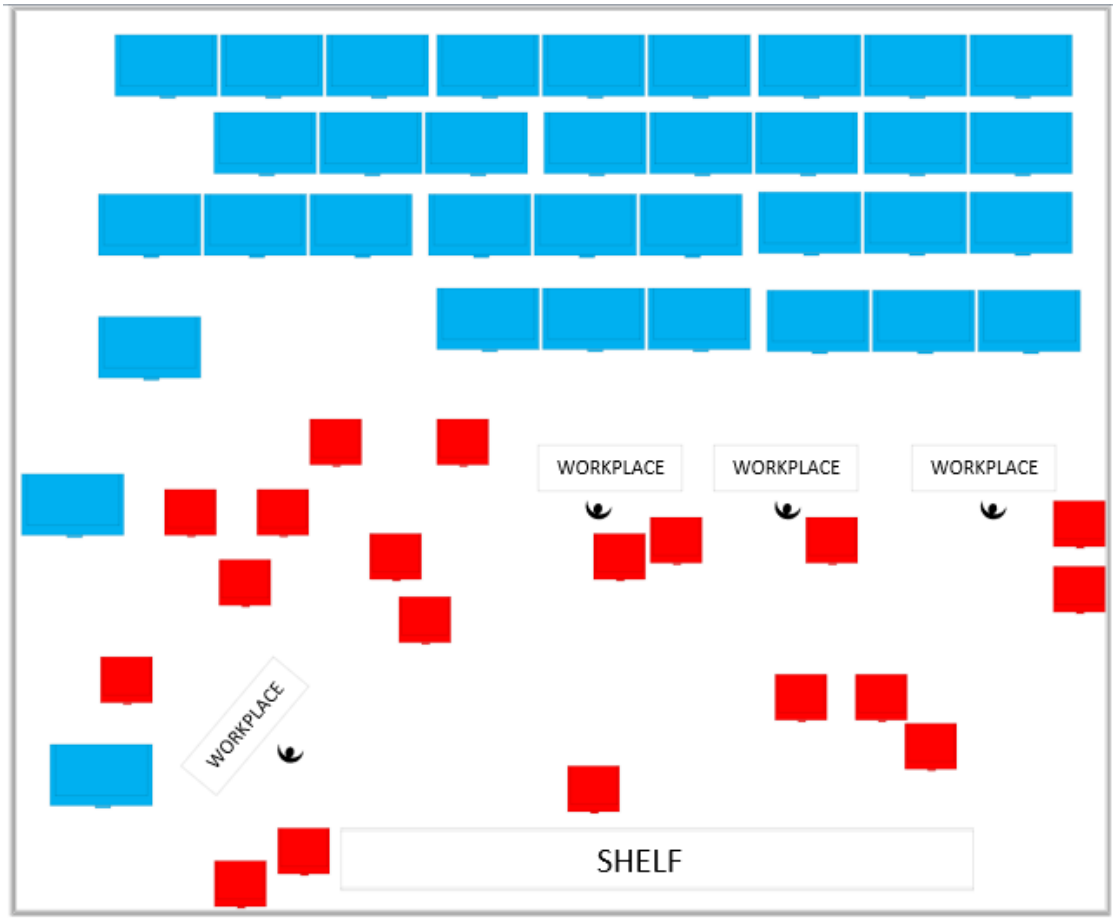

Figure 6. Current State production unit's layout (Composed by author).

Semi-finished products in production at the time of the survey were also recorded, which revealed that there was a total of 68 semi-finished products in production at the time of mapping. This number of semi-finished products was mainly since the availability of materials was not always guaranteed and therefore the production process of many products was incomplete.

However, such a large number of semi-finished products caused uncertain delivery to the customer and thus it was not possible to guarantee delivery accuracy. At the time of the situation, the time to go through production was 17 days.

During the mapping, the production cycle times of this product were recorded. To do this, the author used a stopwatch, and each work operation was measured 4 times so that they could be analysed. **Table 2.** shows the production steps for a given product with measured cycle times and the percentage of total value-added time.

Table 2. Production steps of the product (Composed by author).

Operations	**Time duration, min**	**%, all the value-added time**
Assembly Plate preparation	61	14%
Wiring	139	31%
Assembling	78	18%
Examination	161	37%
Total value-added time, min	**439,9**	**100%**

The total time measured at this production unit was 538 minutes, of which 439.9 minutes was value-added. **Figure 8.** shows the percentage of value-adding and non-value-adding times. It can be seen that 72% of the time was value-added and 18% was non-value added. The non-value-added time was primarily due to the loss of time caused by searching for and bringing materials. Actual work took 72% of the total time measured, excluding rest breaks and lunches.

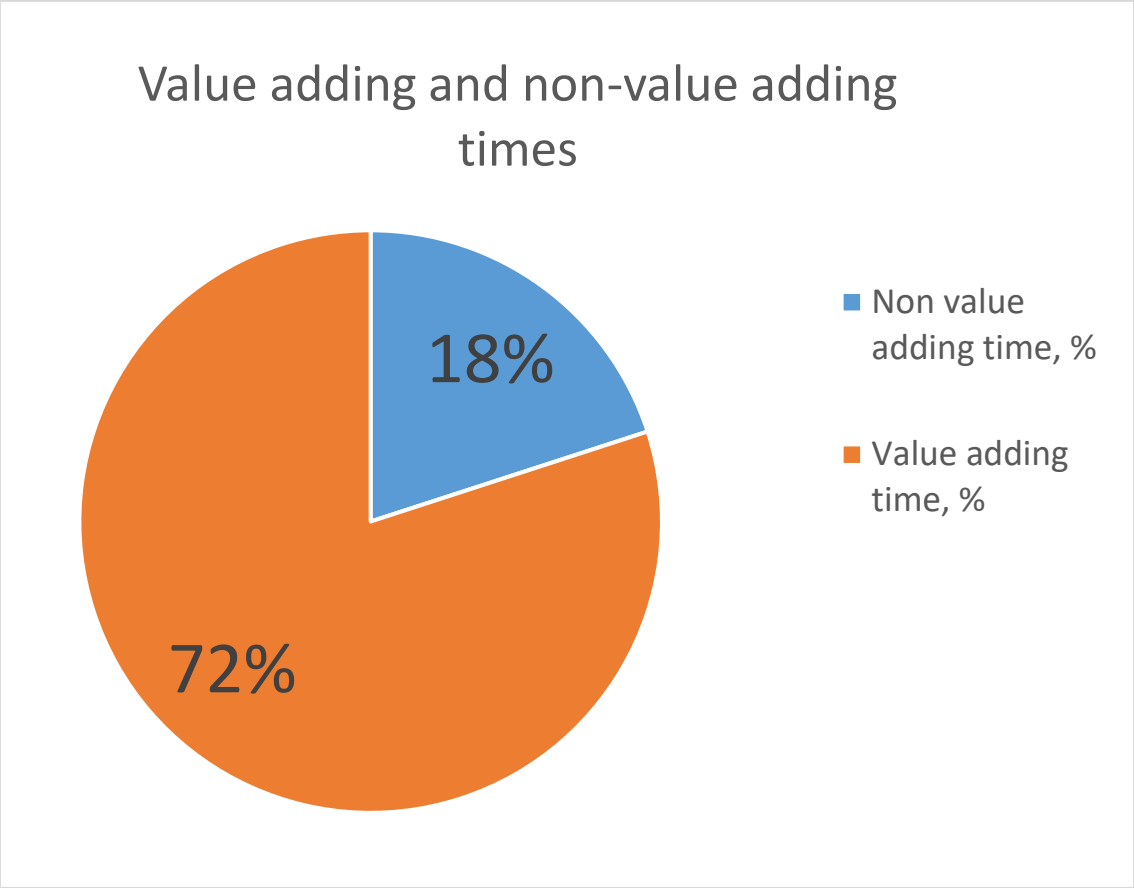

Figure 7. Value adding and non-value adding times (Composed by author).

5 Results

In order to reduce or eliminate the problems and bottlenecks identified above, the Kanban system was introduced. The production area was also reorganized using the 5S method. By applying these two methods together, it is possible to speed up production, reduce the number of semi-finished products and the space used in the facilities.

The Lean Management methods used to reduce non-value-adding activities in this thesis have been successfully introduced and applied. As a result (**Table 2.**) the following results have been achieved:

- 65% reduction in lead time. Prior to the implementation of the improvement activities, the selected product had a lead time of 17 days, which was largely due to the fact that there were a large number of semi-finished products at different stages. Now, after the successful implementation of the improvement activities, the lead time is 6 days.
- The use of space in the facilities decreased by 37%. The use of production space also decreased due to the placement of materials in the workplace, the delivery via the Kanban system and the removal of unnecessary items from the production area. By mapping the current situation, 292 m2 was used as production area in this production group, after the improvement activities, the production area of this production unit is 184.3 m^2.

  Figure 9. shows the production layout after the implementation of the improvement activities, where everything unnecessary has been removed and all materials have their own specific places.

Figure 8. Layout of the production unit after improvements (Composed by author).

- Decrease in the number of semi - finished products. When mapping the current situation, there were a total of 68 semi-finished products at different stages, which were largely due to the lack of materials.

  As materials now move through the Kanban system and the two-box system operates, the number of semi-finished products decreased by 43%. Now due to the lack of a few details, the number of semi-finished products in production was 39.
- Now that the material is moving to the production unit using the Kanban system and the workplaces and floor surfaces are marked. As it is arranged using the 5S method, thus most of the non-value-adding activities have been eliminated.

Table 3. Process improvements (Composed by author).

Metric	Unit of Measure	Baseline	Improvement	Improvement, %
Semi-finished products	Pieces	68	39	40%
Lead Time	Days	17	6	65%
Use of space	m^2	292	184.3	37%

All the above results (**Table 3.**) have been achieved primarily by introducing a Kanban system and organizing production according to 5S methods. Employees now spend less time bringing in, searching for materials, and can focus more on doing the real work the customer is willing to pay for.

5.1 Kanban

In order to implement the Kanban system, the quantities of materials were calculated according to the time requirements of the materials. A two-box system was introduced, where one box contains one day's worth of material, and the workplaces contain a total of two days' worth of material. If one box becomes empty or the material runs out, the worker shall place the empty box in the place provided by the warehouse worker. The advantage of the two-box system is that the work does not stop when a certain material has run out but can take more material from another box.

The production of this product in the factory takes place according to the customer's orders. Upon receipt of the order, the engineer prepares a Bill of Materials (BOM) for the ordered products, on the basis of which the purchasing department orders the materials necessary for production. The materials are ordered according to the purchase needs that have arisen. The Kanban system has already been successfully implemented in two other production units in the case company.

In production, Kanban materials are divided into two:

1. Overhead materials: is a material whose need does not arise from the BOM;
2. Project-based materials: are materials whose need is generated according to the BOM.

To order materials, the production worker places an empty box in the space provided and then starts using the material from another box. To ensure the supply of production-free materials, there is two boxes for each material at the point of use.

When planning the supply of production materials, the principle is that when supplying materials, the work zones of the warehouse and production worker do not overlap. The warehouse worker goes to collect empty boxes at an agreed interval. According to the information on the Kanban card, the boxes will be filled and returned to the place of use.

Picture 1. Kanban boxes used in case company (Author's photo).

The **Picture 2.** shows the Kanban card used in the company. The following information is marked on the Kanban card:

- product name;
- commodity code;
- location on the route;
- location in the warehouse;
- the amount of material in the box;
- type of packaging.

Picture 2. Kanban card used in the case company (Author's photo).

Kanban cards are managed by Excel files, which are separate for each production unit. The Excel file contains the same information as the Kanban cards shown above. Kanban labels are also printed via an Excel file.

5.2 5S

5S and waste reduction are interlinked to each other. The correct application of the 5S method creates a basis for reducing waste.

The 5S method had not been introduced in this production group before and the production staff had no knowledge about it, they had heard about this method, but nothing was known about its principles. As a result of the observation, the author noticed that there were no markings and fixed locations on the shelves, floors, and boxes near the workplaces.

A large number of materials were located at random locations and there was no complete overview of existing and missing materials. However, searching for and bringing in the necessary materials caused a lot of non-valuable time and waste, for which the customer is not willing to pay.

Such activities resulted in excessive loss of time resources for various search activities and identification of materials. It also turned out that there were a lot of semi-finished products and parts in random places, which were stored there due to ignorance. Due to the lack of markings and visual overview, there were very often situations where the material was placed in arbitrary places.

As a result of the observation, the author found that the very large deficit in this production group is visual. Various markings and labels that would give a better overview of which material is located and where it should be placed. Markings and labels would help to reduce the time it takes for production workers to bring materials as well as for warehouse workers to know where to place any kind of material. It would also make it possible to understand whether the required material is available, or something is missing. The mantra of 5S is "*A place for everything and everything in its place*", therefore the visual part is the key element of this methodology. (Purohit, Shantha 2015, p. 225)

Purohit and Shantha have outlined in their article “Implementation of 5S Methodology in a Manufacturing Industry” why all the 5S are equally important. In order to successfully achieve the benefits of the 5S, it is important to implement all five of those pillars. (Purohit, Shantha, 2015, p. 225)

Discussions with the employees of this production group revealed that they also lacked knowledge of the 5S method and the Kanban system. The word “5S” had been heard before, but there was no knowledge of their principles, usefulness, and operation. In order for employees to gain a better understanding of the use of the 5S method and general knowledge, training was provided.

The aim of the training was to support the introduction of 5S in stages. In the workshops, instructions were given in the workplace, with the aim of how to make practical use of the 5S system so that the results would be reflected in the company's key indicators.

The training itself consisted of five workshops. The first part was the theory part, where 5S possibilities were introduced in many ways with practical examples. The second part instructed the implementation of 5S in the workplace. After completing each section, participants were given a task to test the 5S methodology techniques discussed in this workshop. In the last workshop, feedback was given on homework and questions were raised. The workshops took place at 2–3-week intervals. The topics that were discussed in the 5S workshops are listed in the **Appendix 1.**

6 Conclusion and discussion

The aim of this master's thesis was to find out with the help of basic Lean Management techniques, the types of waste in the selected production process, analyse the reasons for their occurrence and make proposals to avoid them. This is important, because it is difficult to survive in the competition without continuously improving production processes as well as productivity. The research questions of the study were the following:

1) What are the biggest non-value-added activities in that specific production process?
2) What kind of continuous improvement methods can be used in order to increase the productivity?

To find the answer to the research questions, the author of the master's thesis used both qualitative and quantitative research methods. Unstructured interview and observations are classified as qualitatively.

The observation consisted of monitoring the selected production process, recording the process steps, the time taken for them, and then analysing the problems encountered there. The value stream mapping method was used as the observation method.

Theoretical part of the thesis consisted of the former literature and framework of Lean Management. The principles and methods were introduced in more detail in the literature review. In the empirical part of the work, these methods were used to find the development issues in the production processes.

Much attention has been paid to researches concerning production processes in recent decades, and research has shown that Lean Management principles support an organization's performance and give each organization a strong competitive advantage. An integral part of Lean Management is Toyota's production system, which, using the right

techniques, eliminates wastage opportunities, helping the organization to achieve efficiency.

The principle of Lean Management is to make each process as efficient and cost-effective as possible by controlling activities that do not increase profitability. Lean's main goal is to maximize customer value creation while minimizing waste. To put is simply, the aim is to create more value for customers with as few resources as possible. An organization that supports Lean principles, understands what creates value for customers and focuses on key processes.

The main waste that came out in this thesis was the handling and transport of materials. Tools and materials were not located close to the points of consumption, and this caused excessive time loss. Employees spent 18% of their time searching for and retrieving materials. To solve this problem, a Kanban system was introduced, and the production area was reorganized using the 5S method. This was the answer for the first research question.

There are several studies made concerning to Lean Management and the improvement of processes. The results of this research are in line with the theory and former studies presented earlier in this research.

As the results of a successful implementation of Lean Management methods are the growth of productivity, through that the value added and profits are also increasing, making the company more sustainable and efficient.

Comparing the results from previous studies to the findings of this research a conclusion can be made. As to the results achieved in this study, it can be said that Lean Management principles and methods bring significant results to the production process improvement and the increase of efficiency. Thus, it can be concluded, that based on those previous studies it can be noticed that the results achieved in this study are reliable and can be considered.

Practical implications of the study can be presented according to the results of the study. The author of the dissertation recommends that the company continues to apply Lean Management principles and methods in this production unit and, if possible, apply them in other production units of the company. As the study showed, lean principles and tools are very useful. However, if the principles and methods are applied in other production units, it would be good to take into account the special characteristics of a unit and problems.

In order for the implementation to be successful and effective, suggestions for improvement should be made in the framework of this project. It is important to look at what the most common obstacles for fluent processes were and how they could be avoided or reduced in advance.

The author considers it important that it is possible to successfully apply Lean Management methods in a given company, because there is potential both in the employees themselves and in the whole company. By adopting these methods, it is possible for a company to increase its competitiveness and thus be even more sustainable in business.

As an answer to the second research question, the most suitable continuous improvement methods to increase the productivity according to the research were 5S methods and Kanban system. The introduction of the 5S system helped to study the organization and rationality of workplaces. Analysing the organization of tools, materials, and the workplace, as well as keeping the work area clean, the idea emerged of improving the situation. To eliminate the problems, the workplaces were tidied up, the shelves and floor surfaces were clearly marked. All non-essential materials, tools and other non-essential items were removed from the workplaces. The materials and tools needed to perform this work were placed in the workplaces. These improvements can be seen as practical implications of this thesis work.

This study inducted mainly practical implications: This is because researcher could give practical recommendation to the case company. The results are useful at least in improving productivity. The results of the study can be only partially generalized because this research was a single case study.

There are several opportunities for further studies concerning Lean Management. In the future, research could be done to find out, what are the impacts of lean on production processes in the long distance.

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Appendices

Appendix 1. 5S training topics

The topics of the first workshop were:

- 5S as a way of thinking and culture;
- 5S as a methodology;
- how to implement 5S to help reduce waste.

The workshop ended with practical work and homework, which was the improvement of 1S.

- The topics of the second workshop were:
- inspection of homework;
- efficient use of time, quality and security;
- 5S relationships with other management routines.

The workshop ended with practical work and homework, which was the improvement of 2S.

- The topics of the third workshop were:
- inspection of homework;
- machine efficiency and 5S.

The workshop ended with practical work and homework, which was the improvement of 3S.

- The topics of the fourth workshop were:
- inspection of homework;
- 5S as a means of communication.

The workshop ended with practical work and homework, which was the improvement of 4S.

- The topics of the fifth workshop were:
- inspection of homework;
- 5S integrated into day-to-day management.

The workshop ended with practical work and homework, which was the improvement of 5S.