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Material management
optimization for small
agricultural metal
manufactures

*A thesis by Ruud
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applied sciences in
Dronten*

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Material management optimization for small agricultural metal manufactures

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Pre-face

Dear reader,

As a 4th year student at the aeres University of Applied Science in Dronten I wrote this thesis to graduate for the study 'Bedrijfskunde en agrifood business'. In my last school year, I did the minors food-supply chain management and export management what made me to do an internship at Sneeboer B.V in Bovenkarspel. This unique company helped me to write my thesis about a subject in which I am interested. My Canadian teacher Pat Burgess of the minor food-supply chain management wanted to be my coach. The collaboration with him was very good where I want to thank him for that. Next to him I will thank Pieter Vlaar as my second assessor for this thesis. Both are experts in my subject what helps me to create a good thesis.

Also I want to thank my colleagues and the owners of Sneeboer B.V for helping me to get the information I needed and in special Wilma Peelen, company owner, who let me do my internship and gave me all the space to do my research.

Enjoy reading this thesis about a unique case company and how to optimise it!

Ruud Slagter

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Summary

For 40 years, companies and academia see logistics as a main 'process' within companies. Supply chain become an individual department similar as purchasing, sales, finance and R&D. focussing on supply chain can lead to success but still are a lot of companies not aware of the possibilities of this discipline. For this thesis the subject is operational excellence in material management. The target audience are described as: Small sized metal manufactures within the agricultural sector. Looking to the theory, lean management tools are helping organisation to become more efficient. The focus of lean is to reduce waste, to save costs, and produce more. In the theoretical framework are the followed tools discussed: Lean: focussing on reducing waste and work in flow, six sigma: focusing on reducing the change on failures in the chain, lean six sigma: the combination of the two, theory of constraints: focussing on finding bottlenecks and solve them, quick respond manufacturing: small groups are making the whole product and inventory management: fixed quantity or time to reorder. These models are all focussing on making an organisation more efficient but on different ways. These models can be used separate from each other but in practise companies use combinations of different models. So now is it clear which tools there are, but it is not known if these tools are fitting the target audience, and when it is, which tools are the best for them? This is the knowledge gap of this thesis.

The main question of this thesis is: **How can lean concepts be used to improve materials management efficiency within small metal manufacturers in the agricultural sector?**

To answer this question, three sub-questions are made:

1. **What bottle necks/non-value adding activities are present within the process of the target audience?**
2. **Is the lean concept suitable to reduce bottle necks and non-value adding activities internally?**
3. **Which points of attention are present in implementing lean in small metal manufactures in the agricultural sector?**

For question 1, a value stream map is made to find the bottle necks and non-value adding activities. This map is made from a 'case company', therefore an empirical study is used based on the researcher's internship company. The reasoning being that the case company fits well to the target audience and the processes are known by the researcher. This information is combined with the theoretical framework to look which tools are helping to solve these problems. Sub-question two and three are answered with the help of an interview from a lean manager at a food company. The information from the manager in combination with the theoretical framework helps to answer the questions. The results of each sub-question are compared to each other which leads to an answer the main question. There are two bottlenecks: Inventory c (appendix II) and the mounting process. The data input for transport is the non-value adding activity. This can be solved with the help of the lean tools: inventory management tool, theory of constraints and six sigma. So, the Lean concept is suitable to reduce the bottlenecks and non-value adding activities for the target audience. The points of attention for introducing lean at the target audience are: create support from employees, know that lean is a continuously process, try it and dare to fail and stimulate initiative in the company. This information together lead to the final answer on the main question. The efficiency within small metal manufactures in the agricultural sector can be improved by using some specifical lean concepts. A value stream map helps finding the bottlenecks and non-value adding activities and the lean concepts can help to improve them. An important factor is that the employees, the ones which must work with the new lean concept, support it, otherwise the proposed improvement will not have a result. For the target audience is it important to understand that this research results cannot be adapted in a one-fits—all approach because no company material management is 100% the same. The results of this thesis are a hand-out for the target audience to help to improve the material management efficiency of the companies.

1.0 Introduction

This chapter will be the introduction for the preliminary research. The reason why this report is written will be explained, subject will be chosen and the knowledge gap will be described. In the end the main-question and sub question described.

Context, trends, developments

Since there is industry, there are topics like transport, inventory and warehousing. But for many years, these topics were being seen as a sub-process that did not receive a lot of focus from top level management. Throughout the last 40 years, both industry and academia are seeing logistics as a main-process within companies. Since then, the supply chain function became an individual department within a company similar to departments such as purchasing, production, sales, finance and R&D. Companies came to the conclusion that supply chain thinking can lead to success. This results in a scientific approach within companies (Alan Rushton, 2014). Most large scale industrial companies are working with supply chain managers, but still nowadays, a lot of small companies are not aware of the possibilities of supply chain management. Transport is seen as 'logistics' but these companies are not realising that the logistics within the company is important as well. It all begins with understanding your own company (Stanton, 2017). Next to 'big' and 'small' companies are there also extraordinary companies with extraordinary supply chains.

The subject of this thesis is: "**Operational excellence in materials management**". During the final internship at the exclusive garden tool company Sneeboer B.V the company owner, Wilma Peelen developed a question to analyse the supply chain of Sneeboer B.V. Normally a student at the agricultural university of applied science will not do the internship at a company like this. But after finishing the minor Food Supply Chain management it became more logical. Efficient supply chain can be the key to success in all kinds of companies: Food companies and non-food companies (Barney, 2012). In the field of operations management, Efficiency is mentioned as the actual output as percentage of the capacity. So working more efficient is producing more with the same amount of employees, machinery or buildings (Ferral, 1957).

Sneeboer B.v is a traditional family owned company which is located in the north-west of the Netherlands. The company started in 1913 and is now in the 4th generation. It is a traditional hand-crafted garden tool smith that produces high quality garden tools for the upper-class around the world. This is unusual because it is a relatively small company with around ten employees. But this product is so exclusive and unique that buyers all over the world buy garden tools at this company. The reason for that is the life-time quality of the garden tools and the traditional story of producing it. People are buying an 'experience' and a 'story' when buying a tool from this company. The core production of the tools is going in the same high insensitive way as the company did it 100 years ago. Of course, there is some new machinery that makes some processes easier/faster but the core process of forging a tool is going in the same way as 100 years ago. This creates a high-quality product and a positive story for the company. This makes the tools exclusive and the company is the only company in the world who is offering this kind of products. This results in no competition at the market and makes Sneeboer B.V able to create their own selling prices.

With no current and direct competition the company can create high margins. Around 30% margin if it is business to business and 55% margin if the company sells from web shop. The customer can customize the products in the way they want it. It is possible to package, labelling in different ways, to carve/burn a name in the handle and more things. The company is doing this because the customer is willing to pay for it. But all these customize options are highly labour-intensive.

The company is growing every year and is exploring new markets all over the world. As result the production must grow as well. Last year company experienced 12% growth. To handle the production growth in the future and to create more margin the company owner asked to look to ways to increase production or to make the supply chain more efficient.

The concrete question of Sneeboer B.V is: **“How can our material management become more efficient with without losing it traditional character?”** To use this question as a topic for a thesis it must be more fundamental, so applicable to similar companies in the sector. This makes it complicated because Sneeboer B.V is the only company known in the metal industry who is producing their products on this exclusive way. But supply chain optimisation is something what is normally applicable to all kinds of sectors all over the world. Because this research will go about a small hand-crafted industrial company with a high customization rate will this be the target audience.

The target audience = **Small sized metal manufactures within the agricultural sector**

- **Small companies:** companies with a turnover between €50.000 and €3.000.000 and between 1 till 10 FTE.
- **Family owned/small metal manufactures:** labour insensitive and traditional production
- **High customization rate:** customer can choose how they want their products
- **Relation with the agricultural sector:** it must be related to the agricultural sector

The target group does not know how, or which methods should be used to increase operational capacity. But increasing efficiency while maintaining the selling price will lead to more profit. The reason to talk about a ‘problem’ is the growth of demand what will lead to a necessary growth of production. The challenge for the company is to increase production with the current production team, because labour is expensive and will be more expensive year by year. Thinking about material management optimisation, lean is a popular trend what more and more companies are using these days. Working/producing lean can be done in many different ways and by using different models. Looking to the trends of 2018 within the metal sector, Rabobank concludes that there is more attention for efficiency (www.rabobankcijfersentrends.nl, 2018). So, the topic of this thesis is very relevant for the target audience. This thesis will helping to find out which model or models are fitting the target audience, and how the target audience must apply it.

In the theoretical framework there will be a wide overview of information that will be narrowed down to the actual information which will help to define the knowledge gap. This knowledge gap in combination with the issue of the client is the basis for the main- and sub questions. These questions will be focussing on Lean methods and the way to apply it to the target audience.

Supply chain models and the knowledge gap

To understand what is already known about **Efficiency in metal industry (garden tools)** will first be looked to a wider scale: Efficiency in the metal industry. Starting wide and narrow it down to more concrete information which is fitting the target audience more. So first will the metal industry be described followed by a description of the models LEAN, Six sigma, LEAN Six sigma, the theory of constraints, quick response manufacturing and inventory management. In the end it will be more specific to the subject and the knowledge gap will be described.

The Dutch metal sector

Looking to the Dutch metal industry there are in 2017 10.600 companies. 9.000 companies are 'small' companies with less than ten employees and 120 companies are big factories with over 100 employees. It is important to note, that from these 9.000 small companies more than 40% are one-man companies (www.rabobankcijfersentrends.nl, 2018). So, entrepreneurs with a small workplace for themselves or entrepreneurs who are contracted out to other metal companies. Although the target audience is not a typical metal industrial company, is it still important to understand trends within the industry, these are described by the Rabobank marks and trends there are some interesting things. The trends are as follows;

- Shrink batch sizes and decrease lead time
- Attention for efficient production (lean management)
- End customers ask for development capacity of suppliers
- Increase in demand of high quality assembled products
- Online communication (smart factory) is more important
- Development and (experimental) use of innovative production techniques like 3D-Printing (www.rabobankcijfersentrends.nl, 2018)

The purple-coloured trend is a trend what can be a big threat because the reason that the products of the target audience are exclusive is that the company forge the tools on the way they did it 100 years ago. If the company is going to change the production plan with new innovative machines and 3D printers, the story behind the tools (their unique selling point) is gone. The green-coloured trends are interesting trends for the industry. The first two are focussing on efficiency in production, what is similar to the subject of this thesis. The increase in demand in high quality products is a big opportunity for the target audience because this audience is already focussing in this niche market for years. From this source can be conclude that other companies in the sector are also concerned about efficiency and are focussing on shrink batch sizes, decreasing lead time and use lean management.

LEAN manufacturing

Lean is a management method to create an efficient supply chain by eliminating waste, create flow and stimulate pull (Productivity Press , 2014). To understand lean, it is important to know where it comes from:

The first industrial company which started to produce in a 'flow' is the Ford car factory in the USA in the beginning of the 20th century. Henry Ford developed the first factory with a conveyor belt which made it possible for the company to make raw iron into a car in less than 33 hours.

All processes are following each other up in one 'flow' so there was no place for inventory (waste). Henry Ford believed in the fact that production machines had to stand as close as possible to each other so there was no place anymore for stock. This was a fundamental of the start in Lean thinking (Productivity Press , 2014).

It is important to know that the real idea of lean started in Japan in the Toyota factory. Around 1950 started the manager of Toyota, Taiichi Ohno, with the thinking, in which processes are we "Toyota" adding value to the product (Toyota car). Since then Toyota started with using the pull strategy, so only produce when there is demand. The thought behind the pull strategy is that stock in finishing goods are also considered waste. At the same time transformed the assembly lines for mass production of Ford to an assembly line for making quick different types on the same line what makes mass customization possible. Toyota became much more flexible and customers were able to customize products more what created a competitive advantage. This is called quick consumer response (insitute of industrial engineers , 2012). Next to that, Toyota started with the idea to use the capability of employees. The company made employees 'thinkers' by taking them into the process of continue improving the production process. The company used the management to coach the employees to think in improvement instead of dictating the employees had to do (insitute of industrial engineers , 2012). This is still a radical change of the management set-up in a company.

The actual introduction of lean manufacturing as a management method started in 1988 by John F. Krafcik in the time John was a MBA student in the international Motor Vehicle program IMVP at the Massachusetts Institute of Technology (MIT). During the oil crisis in the USA Krafcik studied about the fact why the Japanese cars where cheaper and more economical compared to cars coming out of the USA and Europe. John concluded that car manufactures with almost no stock (finished stock as well as semi manufactured products) achieve more as the mass production manufactures in the USA and Europe. He was the first one who did study about it and published it (Ede, 2018).

After that, a lot of study is done about lean and improvement of the production processes. Now there are a lot of studies available which help to teach managers how to implement lean into a company (Productivity Press , 2014). In addition, lean also applied in the service sector like hospitals or accountancy offices (Ede, 2018).

The interesting thing about lean is that it is applied to companies in different ways. So lean is a way of 'Thinking' what can be reached but the application of it differs a lot between companies. This result in a situation that all companies globally using lean will have different version of lean (Productivity Press , 2014). To conclude: lean manufacturing thing is going about these subjects:

- Create flow
- Create pull: what does the customer want?
- Produce only at order, Just In Time (JIT)
- Eliminate waste (time, stock, failure products)
- Define value adding processes and eliminate the processes which have no adding value
- Make 'thinkers' out of your employees
- Create a circular system of continuous improvement of the processes
(Ede, 2018) (Productivity Press , 2014)

Six sigma

Six sigma is a management method that is focussing on quality and creating a production process what is nearly perfect. It is based on data and tools that are helping to create perfection (Pyzdek, 2003). Just like lean, six sigma is also focussing on reducing waste. At first is it important to understand where this method is coming from.

Where Lean was a method which was already used for many years at Toyota, Six sigma came some years later (Pyzdek, 2003). The method is developed by engineer Bill Smith in the mid 1980's at the Motorola Company. In that time Six sigma resulted in an increase in quality at the production area of Motorola what led to a competitive advantage. But the first company who made Six sigma a global success is General electrics. In the beginning, six sigma was mostly used in the processing and high-tech industry because of the quality specifications of the products. Nowadays it is used in other sectors as well, for instance banks and insurance companies. The name Six sigma refers to a production error of only 0.00034%, actually it means: 'perfect production' (Snee, 2010).

Working with six sigma is working by a philosophy: work smarter, not harder. Data is the key to success by using Six sigma. Data (key performance indicators or KPI's) will help to manage the production process and make it more perfect. The goal of this method will be increasing quality by standardising it, perfect production plan and meeting the consumer expectations. The outcome of six sigma projects are financial measurable (Pyzdek, 2003).

In practice there are two tools that help when using the Six sigma method. These tools are shown in figure 1.1 and 1.2. Figure 1.1 illustrates DMAIC, which stands for define, measure, analyse, improve and control. Figure 1.2 illustrates DMADV, which stands for define, measure, analyse, design and verify. The difference between these tools is that DMAIC is a fast responding tool for mostly short-term solutions. With DMADV is there time added for designing a new setup what will lead to a more long-term solution.

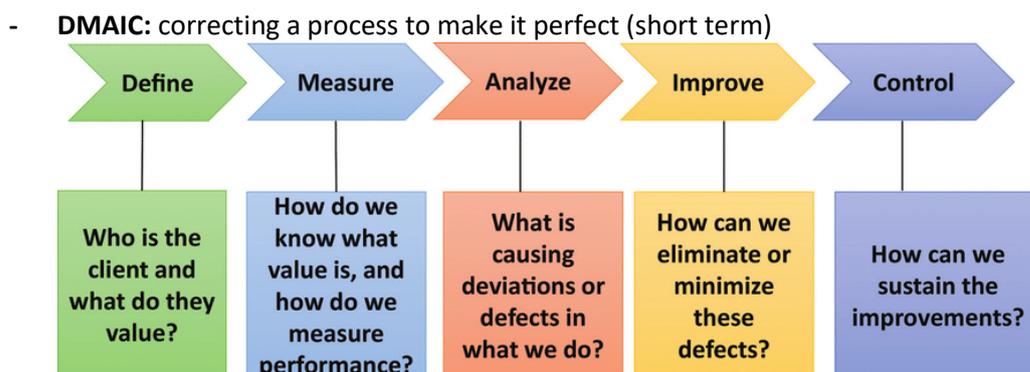


Figure 1.1 DMAIC tool (www.researchgate.net, sd)

- **DMADV**: prevention of making mistakes in a process (long term)

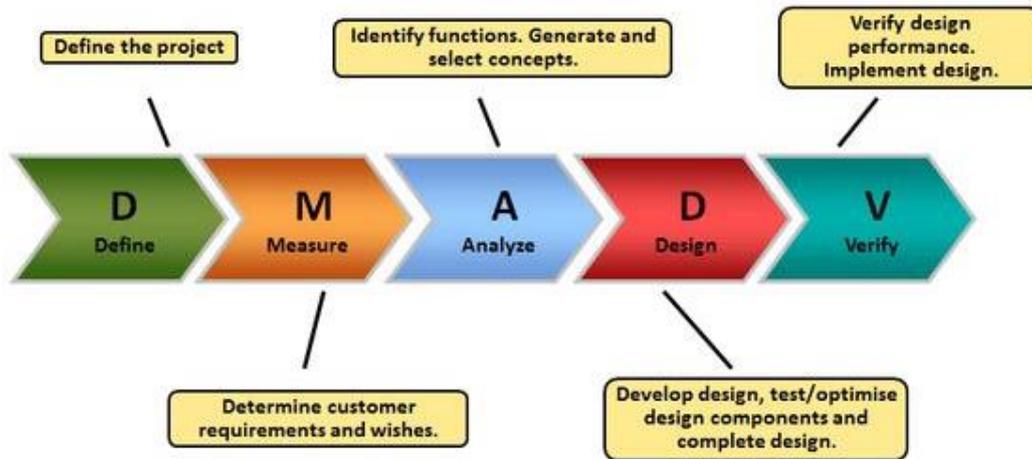


Figure 1.2 DMADV (cerasis.com, 2013)

Lean Six sigma

In practice a combination of Lean and Six sigma is often used within companies. These two methods are making each other stronger and helping an organisation come to the common goal: making an organisation/company more efficient. More efficient in a way of capacity but also production error and quality (Snee, 2010).

A study done by Ronald D. Snee gives a nice figure what will explain Lean Six sigma in one clear overview:

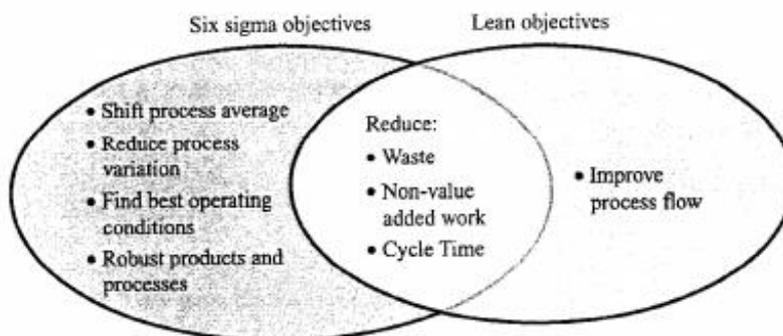


Figure 1.3 Six sigma and LEAN (Snee, 2010)

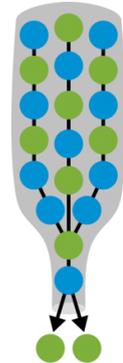
Figure 1.3 shows that the difference between Lean and Six sigma is that lean is mainly focussing on improving flow where Six sigma is focussing on data of the processes. The common goal is to reduce waste, non-value added work and Cycle Time (Snee, 2010).

There are a lot of education programs and seminars available about Lean Six sigma. These programs will teach managers how to implement this method and way of thinking into their company. There are lots of success stories what confirm the result of this method (Pyzdek, 2003).

Theory of constraints

The theory of constraints (TOC) is a method which is focusing on lead time. It is used as a part of LEAN-thinking but is an individual method. The goal of Lean is Similar as TOC-but the difference is in approach of the supply chain. Where Lean is focussing on creating a flow, the TOC is also focussing on flow but the key to success is: Bottlenecks (university of instanbul , 2014).

In the 1970's the physics philosopher Dr Eliyahu Goldratt was using mathematics to think about process optimization. Goldratt was focussing on the production chain as one. After Goldratt published his book 'the goal' in 1984 the TOC method becomes popular. It is saying: a supply chain is as fast as the slowest 'chain'. So a chain of processes links is as fast as the slowest process link. By improving the weak link the whole process will be faster. Figure 1.4 is showing a process 'chain', because one process is way slower than the other processes in the chain (the bottleneck) it create stock and will have a negative impact on the lead time (university of instanbul , 2014).



The interesting aspect about the theory of constraints method is that it is a never ending process of continuous improving the processes. If a company is able to solve a bottleneck in the supply chain, there will be a new process within the supply chain what will delay the lead time (www.procesverbeteren.nl, 2018). Figure 1.5 shows the circular process of TOC.

With this method it is important to start with a 'roadmap', a map of all the processes in the supply chain. By making this roadmap, it is important to give times by each process, waiting time between processes and inventory levels. This will help define the cycle time and lead time. In the end is the main goal to reduce the cycle- and lead times of the supply chain (Martin, 2013).

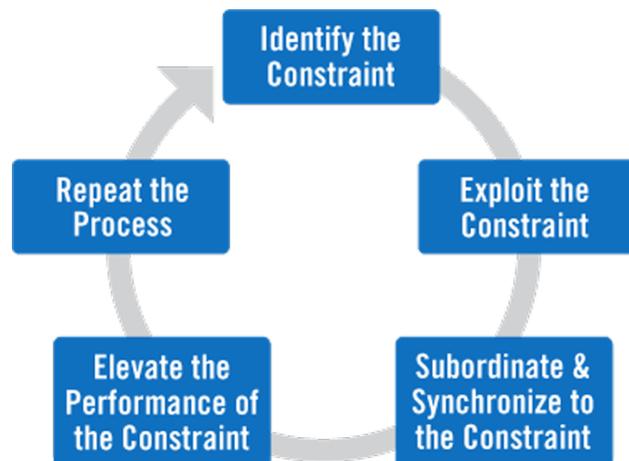


Figure 1.5 Circular process of TOC
(www.leanproduction.com, sd)

Despite having differences between the lean method and TOC, these two models are used simultaneously in companies. Just like Lean and Six sigma is also here a combination method possible (Sproull, 2009). Figure 1.6 shows the combination of Lean (dark blue) and TOC (inner circle).



Figure 1.6 Combination of Lean and TOC (www.leanproduction.com, sd)

These models can be used together but also separate from each other. TOC will improve flow by reducing bottle necks in the supply chain, this is also a part what falls under lean. The nice thing about these models is that a company/organisation is free in choosing a way how one of these models, or a combination of the models, fits as best to one individual company.

Quick respond manufacturing

Quick respond manufacturing (QRM) is similar compared with Lean and TOC. This method is also a logistics improvement method. QRM comes out of Lean and is a special method for industries with many different products and/or fluctuating demand. In other words, low volume high variety. The main focus of this method to increase speed, by decreasing the manufacturing critical path time (MCT). This is the time it takes to make and deliver one product (www.procesverbeteren.nl, sd). This is a different focus than lean and TOC because the former methods focus on cycle time and manufactures that have forecastable demand. In the case of QRM demand is fluctuating and are there many different products, for this reason it is important to have the shortest time to market for each product. It will lead to lower stocks and delivery times, and at the same time lower production costs. This method has been used in the United States from the early 2000's, mostly by customer order companies like Harley Davidson and Joy Global. From 2007 this method is also used in the Netherlands by companies like BOZ group and BOSCH schanieren (www.procesverbeteren.nl, sd). In the USA this method results in an average saving in costs of 25%. These companies are also using a system of customer order producing. The method is developed by professor Rajan Suri at the University of Wisconsin-Madison (Suri, 2010).

By using this method, a radical change of the supply chain is needed (Suri, 2010). It changes the way of thinking from thinking in one supply chain to cellular thinking. It is actually splitting the company in different production cells, Quick Response Cells (QRC). Every cell works in teams from 3 till 10 employees who are focussing on the processing of one specific market segment. Every team is multidisciplinary and working only on small batch sizes. The first step, which is similar to the other methods, is starting to make a value stream map to find 'waste' in the supply chain. Difference with lean is that with QRM queue time is not one of the 7 wastes (Lean) but it is the only thing where QRM is focussing on. Decreasing the Manufacturing Critical Path time (MCT) will lead to less queue time within the processes and in it will in the end also reduce the other 6 wastes of Lean (Suri, 2010).

MCT= time from setting the order to delivering, starting by raw materials (supply) to finishing goods

Planning with ERP (Enterprise resource planning) systems is only in headlines necessary. All individual self-managing cells can make their own planning to create more efficiency. The POLCA system (of lean) can help the cells by doing the overlapping planning between the cells.

Important by implementation of this system is to start with a pilot, because it will be a radical change of the work floor within a company. Also the accountancy must change. Nowadays accountancy is focussing on the costs per department within a company. Professor Rajan Suri is saying that this will conclude that QRM will lead to more costs in one department. In contrast, Professor Suri states the accountancy must focus on the whole costs of all departments (which are necessary for one market segment) together. The current system of cost counting is focussing on only the time it takes to make a product, but it is not counting the queue time. When a company is doing did, they will see that QRM in customer order producing companies will lead to profit. This confirms the complexity of this model, all departments within the supply chain must change (Suri, 2010).

Inventory management

There are four efficiency improvement concepts discussed. In all these methods is mentioned that the inventory of raw materials, semi-finished products and finished products as small as possible need to be, and in an idealistic situation zero stock. But there are also situations where inventory is necessary and with a good management of inventory can it lead to increase in capacity. Within the capacity philosophy are there two sides of thinkers: LEAN thinkers (Lean, six sigma, TOC and QRM) and inventory thinkers. Model will go about the 'inventory thinkers' (Goor, 2015).

In relation to inventory management there are two main types of inventory: raw materials inventory on one side and semi-finished and finished products on the other side. In this philosophy there is a formula which is called the formula of Camp. This formula had been developed in the beginning of the 20th century and is calculating what the most ideal inventory within a company is. In the formula are there two options: 1 Using order costs to determine the ideal inventory of raw materials. 2 using changeover costs to determine the ideal inventory of semi-finished goods and finished goods (Heizer, 2017). The Formula is as followed:

Formula Camp: $Q = \sqrt{\frac{2DF}{hP}}$

Q= Quantity

2=Multiplication factor

D= Demand (month or year)

F= Order costs (situation 1) or changing costs (situation 2)

hP= inventory costs of one piece/product

(Goor, 2015)

By using this method, the company has to define a point in which the company is going to order or to produce a new batch to complement the inventory again (inventory is increasing because of selling products). To define this moment are there also two different models: **Fixed reorder quantity system** and **Fixed reorder period system**.

Fixed reorder quantity system

With this system will a company order raw materials or start production when the inventory is going below a defined point. This point is calculated as followed (Krzyżaniak, 2017):

Reorder point= Lead time demand+ safety stock

Lead time demand= Lead time x average daily use

Lead time (in days) = Delivery time of raw materials/lead time production

Average daily use= how many productions does the company use a day

Safety stock = (*Maximum daily usage * Maximum lead time (days)*) –

(*Avarage daily usage * avarage lead time (days)*)

(Krzyżaniak, 2017)

Fixed reorder period system

By using this system, a company will not look to quantity to reorder but in periods. So, ordering once a week or once a month or producing a type of product once a day, once a week depending on type products and the market. When a company is using this, it will order/produce the amount of product what will make the inventory to its maximum. For example:

A company is producing product every Monday (once a week). On week 1 the inventory is 28, week 2: 12 and week 3: 34. The maximum inventory is 60 (calculated with the formula of camp). The production in week 1 will be 32 (60-28), week 2: 48 (60-12) and week 3: 26 (60-34) (Heizer, 2017).

The best system for a company depends on the type of the organisation and products.

Customer order decoupling point

The last important part of material management is the customer order decoupling point (CODP). This is a well-known part within the supply chain. The CODP is a place within the supply chain where the customer order penetrates the supply chain. All the processes and value adding activities before this point are not personalized. So, for the processes there are no difference if the product is produced for customer A or customer B. After this point in the chain, the production will be customized for each customer. This means that the product and process can alter after the CODP for customer A and customer B (Pollard, 2008). For example, the product can be the same product but have different colours, same frame of a car but different engine or, looking to the target audience, same metal but different handle/logo/packageing. In the theory are there 5 different levels of CODP:

The higher the level, the earlier the CODP is, which leads to possibilities for higher customization rates. In addition, products with a higher CODP rate are more exclusive because it cannot be produced in mass production. On the contrary the lower the CODP the easier it is to have inventory because sales and inventory is easier to plan. To understand a supply chain of a company, it is important to know where the CODP is. This will help to make decisions about the chain and how to improve it. This is illustrated in figure 1.7.

Generic Customer Order Decoupling Points

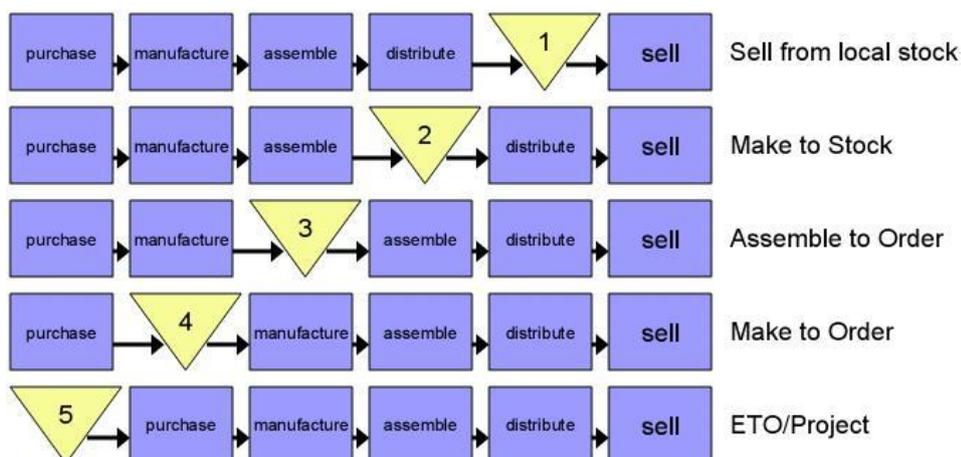


Figure 1.7 the customer order decoupling point (dazzdays.wordpress.com, 2018)

Knowledge gap

The raising demand of exclusive garden tools with a high quality and the increase in labour costs makes it necessary to work more efficiently (Sneeboer, 2018). The reason for that is that the product is not known in all countries. Each year are there new customers from new countries at the internship company. Because demand is rising, it is important to research what the target audience must do, increasing capacity and reducing supply chain and operational costs help a company stay competitive. The reason that there is not an easy answer on this topic is that companies differ from each other. Every company has a different supply chain, different mission/vision and his own uniqueness. So, for every company will there be a different solution to increase capacity. The models, which are described in the theoretical framework are general models. With only a standard model a company cannot increase capacity. It must be more personalized for one particular target audience/sector.

In total there are five different methods described about capacity and how to increase it. But as already mentioned, it is not clear which models are fitting the target audience and how to use it in practice. These methods are interesting and extended but are described for companies in general instead of a description for one particular individual company/sector. As is already described in the introduction of each model, these methods are all a guideline for companies, but it is not a blueprint for an individual company. This will mean that all different companies will have a different application of one of these methods or maybe a combination of some methods. All these methods are providing as set of tools or formulas what will help to create an ideal method for an individual company.

So, the most important knowledge gap is: which lean management concepts are fitting at the target audience? And how can these methods be applied to the target audience/client? Next to that is there one topic what is coming back in all the methods: a value stream map of the company. What is the value stream map of the target audience/client? This is the first step needed if a company wants to increase capacity. By understanding your own activities with all the information (lead time, production in a day, costs) added, it is easier to manage the materials management and to improve it. So, in the theoretical framework are there a lot of known improvement methods, but it is not known if these methods can have success on the target audience and how the industry can use it in practice.

Conclusion: the followed subjects are the Knowledge gap:

- Which methods will fit at the target audience?
- How to apply the methods to the target audience/client

Demarcation

The demarcation of the target audience of this research is done in the information topic where the target audience is already described. Additionally, research focus on the most popular methods of capacity optimisation which are described in the theoretical framework.

Main- and sub questions

The combination of the subject of this thesis and the knowledge gap can the main- and sub questions be defined.

Questions

The main question of this thesis can be defined as followed:

How can lean concepts be used to improve materials management efficiency within small metal manufacturers in the agricultural sector?

To answer this main question are there some sub questions necessary. These sub questions will be defined as followed:

- 4. What bottle necks/non-value adding activities are present within the process of the target audience?**
- 5. Is the lean concept suitable to reduce bottle necks and non-value adding activities within?**
- 6. Which points of attention are present in implementing lean in small metal manufactures in the agricultural sector?**

The combination of these questions will lead to a conclusion what will help the target audience to produce more efficient, save costs and making more profit.

Goals

The answer of this thesis must be clear and applicable to the target audience. So, the companies really can do something with this thesis. In the end it will help companies with increasing the supply chain to raise production and working more efficient. The target audience will use this thesis as a guideline for their company. The companies within the target-audience will have the same issues in the supply chain so this guideline must become very detailed and easy to apply.

Hypothesis:

Below are three hypotheses according to the main question:

H1- A mix of different methods within lean will fit to the target audience. This will be a combination of theory of constraints, inventory management and some other small parts within lean. The value stream map will be a tool which will help the management do make decisions and to control the chain.

H2 - A one fit model approach will not be applicable along the industry, and models will need to be adopted within different companies.

H3- Another being lean improvement may not increase capacity within the target audience and other methods be applicable

2.0 Material and Methods

In this chapter the methodology for each sub question is described. The empirical study in the form of the company analysis is a fundamental aspect of this research. The research is qualitative by nature, the empirical study of the case company, along with the in-depth interview will provide specific results related to the main research question. Therefore, the information gathered from these companies will be the basis of the thesis. Additionally, the theoretical framework and researches from past literature will be used to support the sub-question, main question and to provide recommendations for the target group. The empirical study/company analysis at the internship company is done by value stream mapping (VSM). This information will be analysed through calculations and by creating a visual overview of the processes. The combination of these two things makes it possible to answer the first sub question. In addition, an interview with an expert in lean within a food company has been conducted via a semi-structured interview. This information will be compared with the existing literature to answer the second and third sub question. The qualitative information will be analysed by the thematic content analysis method. By using this method the visualization and connection of common patterns can be grouped, which simplifies the analysis. Each group consists of one theme, so all the information from different sources can be compared by using these themes. The research method collection method along with the analysis method will prove and answer to the main question. These methods are described in further detail below.

Sub Question One: What bottle necks/non-value adding activities are present within the process of the target audience?

For this sub-question the tool value stream mapping or VSM is used. This method was introduced by Toyota, during the introduction of lean (Snee, 2010). The theoretical framework section illustrates models to increase capacity in relation to materials management. Prior to selecting the most suitable model for a company, it is crucial to understand the logistical process, and materials management flow within a company. A reliable tool for this is value stream mapping or VSM. This map is making an overview of all the processes within the internal supply chain of the company. When conducting a value stream map, it is important to consider a number variables. These variables are provided below.

- What processes are there in the material management phase
- Lead time (time it takes to produce one product, whole process)
- Cycle time (time it takes to do one process)
- Setup time (time it takes to start with a new product, changeover)
- Inventory between the processes
- Customer order decoupling point

To create the value stream map, an empirical study in the form of observation is needed. The researcher, maps out the value stream of the company, and records specific details in relation to processes. These details are related to the variables listed above. The case study used for the value stream map used for this specific research has been conducted at the researcher's internship company. The specific case company relates to the target group for the research and is therefore seen as a reliable source. The reason for this is that the internship company is well known so the value stream map can become more detailed.

The VSM method is a qualitative, empirical research method in the form of a case study. To create the VSM is an intensive analyse of the internship company necessary. It is a combination of observations and time calculations.

Sub-Question Two: Is the lean concept suitable to reduce bottle necks and non-value adding activities internally?

In the theoretical framework the most important lean capacity models for this research are describe, however it is not clear which model is suitable for the target audience. For this, the results from the value stream map, along with the results from an in-depth interview, can provide better insight into which models are most suitable for the target audience. To answer this sub-question (two), it is important to combine information and select the most suitable model. In order to secure reliable results a qualitative research method in the form of an in-depth interview was used. The interview has been conducted with a lean expert within a food company who has experience in implementing lean management models. The company being De Kroes, a fresh meal company in Almere. The interviewee, Jelle Beeren, the project manager of De Kroes. Jelle Beeren has his Black-belt what means that Jelle Beeren is specialized in Lean management. Appendix I illustrates the semi structured interview used for the company. The company is a different type compare to the target audience but both companies are operating in the agricultural sector and having a large assortment of different products what makes production planning complex. The specific expertise of the interviewed company, and large assortment of product will serve to provide reliable and relatable results. As the questions are open, qualitative questions, a descriptive analysis of the responses has been used, which will be used to support this sub question and overall main research question.

It is a qualitative interview (semi-structured), just as the theoretical information and the value stream map. The variables in this question are the different models.

Sub Question Three: Which points of attention are present in implementing lean in small metal manufactures in the agricultural sector?

Practical experience is necessary to answer this question. For this reason, the in-depth interview with the company “De Kroes” is used. The project manager of ‘De Kroes’, a fresh meal manufacture is interviewed to look how the company implemented lean efficiency methods in their supply chain. This is not the ‘target audience’, but about this subject a company can learn allot from other sectors. Appendix I is the interview which will help to answer sub-question 2 and 3. It is a qualitative research because it is a depth interview and a practical study. The variable is:

- Points of attention

The interviews will be combined with the practical research at the internship company to create a good answer on this third sub-question.

3.0 Results

This chapter will include the results of the research. This research exists out of three phases: theoretical research, a case study and two interviews by experts. The information collected from these three phases act as the basis of this thesis. The results of the theoretical research are already shown in chapter 1. Therefore, this chapter will illustrate the results of the case study and the interview. The results are presented in the same structure as the sub questions

3.1 Sub-question one: What bottle necks/non-value adding activities are present within the process of the target audience?

For this sub-question an empirical method in the form of a case study used. For this case study Sneeboer B.V represents the “case company”, as this company is a good representation of the target audience. The case company has a total of 10 FTE working at an operation level (on the production floor) and 2 FTE in management positions. It is a typical family company that was founded in 1913. The company produces exclusive products that can be customized for individual consumer orders. Customers can choose different types of wood or lengths in shafts, different ways of packaging and some other extras. Because of the high customization rate, this company is offering around 240 different product options. These options consist of 80 different iron tools with different handle/shaft options for each tool. The case company is selling B2B and B2C which is done via the company’s web-shop. The products are exported globally. The company is selling 50.000 tools a year. The peak period is from April until July, in these months is production 30-70 % higher compared to other months

To make this case clearer the floorplan of the case company added in appendix II. This floorplan shows the material management stream through the company and the amount of FTE’s at each area. In the case company are five different inventory categories (A-E) at different places in the company. It is important to mention that inventory category E (up-stairs) is inventory where all the extraordinary shafts are and bulk inventory of the most-used shafts. This is in relation to the lack of storage capacity for this inventory on the ground level. Inventory D (down-stairs) is an inventory where over 250 of each most used shafts are so there is no daily transport between inventory D and E. The green line illustrates the product flow through the company and is explained later. In this case, the company has a water cutting machine which can work 24 hours a day without manual-labour, it only has to be filled with new iron plates. In practice, the machine is working until 20.00 Monday-Friday. In the same production area are two forging platforms that provide place for two black-smiths. Next to that are there four welding stations and six grinding/polishing stations. Because the products in this specific case are hand-made, the only full automatic machine is the water cutter, the rest is made by hand. This will be described in further detail through the value stream map.

On the next page the process map is shown in figure 3.1. This is an overview of all the primary processes within the company. The colours green, yellow and orange are matching with the different areas of the floor plan shown in appendix II. There are two types of incoming orders, which are B2B and the web shop (B2C). The B2B orders >10 tools, a production planning is made once a week, B2C and small B2B orders will be processed as fast as possible from inventory C (appendix II). The production area can produce 1000 iron tools in a week, when the sales are less than 1000 tools, the production area will produce for inventory and when sales is greater than 1000 tools the production area will get tools out of the inventory B (appendix II). After mounting the shafts on the tools, the B2B orders are packed in big boxes, fast and save. The B2C orders have to be packed very nice because the packaging is going to the consumer. The Bottlenecks and non-value added activities are already shown in this figure but will be discussed in chapter 4. The customer order decoupling point is at the green arrow. In this phase, the customer order specifications will be added to the product. In this case, customers have the option to select which handle/shaft the customer want and do the customers have some extra’s to choose from.

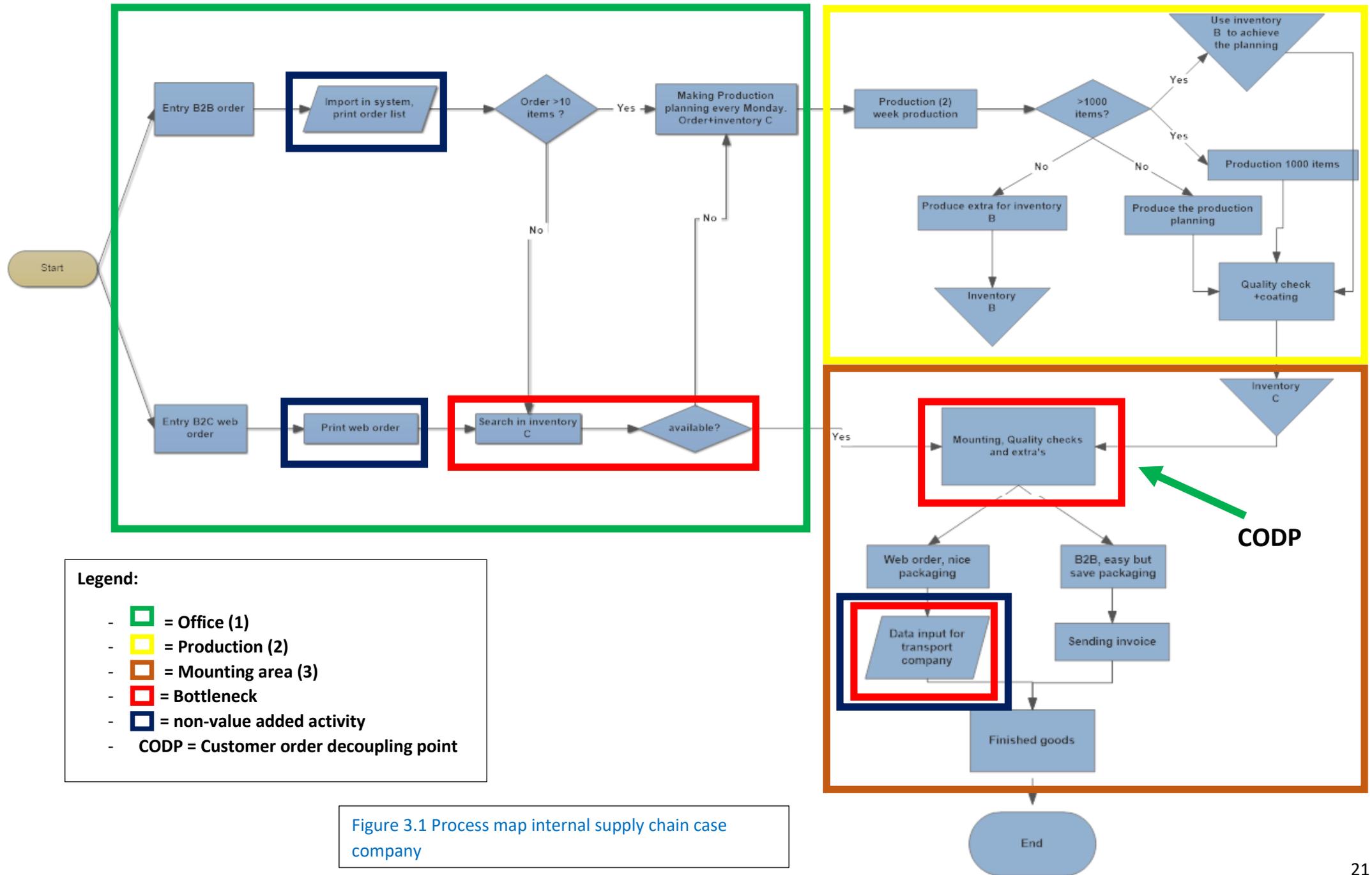


Figure 3.1 is an overview of the whole internal supply chain/logistics/materials management process of the case company. These are the process steps of an customer order through the company. In this figure are three colours used: green, yellow and orange. The reason for that is that there are three important sections in the case company: office, production floor and mounting area. Each area is making an individual planning dividing work tasks. To give a better overview of which production processes are necessary to produce the products/tools in this case, a Value Stream Map (VSM) is used. This map is shown on the next page in figure 3.3. This map shows all the processes to produce a batch of spades with steps, the production times, change over times, inventory levels and waiting times. In total, there are produced approximately be 500 spades with steps a year (with number 3051). There are also 4 other kinds of spades which have the same processes to produce but have different sizes.

The Spade, which has been produced in case, is shown in figure 3.2. The garden tool consists of four different parts: blade, steps, the 'house' and the shaft. The house of the spade is the iron part where the wooden shaft will be mounted in. Looking to the VSM

On the next page, there is a simultaneous process in the beginning. The reason for this is that the two production lines are independent of each other. The upper process line is related to making the blade, the lower process line is related to making the 'houses'. The houses are always made in bulk because the houses are used for many different tools. The houses exist of an upper house and a under house. The processes are the same for both, only the times are doubled because the process must be done for the upper as well as the under house. This is for all the processes within the green lines shown in figure 3.3. The production batch for the houses is the number of houses which can be made from one iron plate. 240 parts, for the under house and 450 parts for the upper house. The production and inventory time of the parts within the green lines are not included in the lead- and process time calculations because this is a bulk process, so the houses are most of the time already in stock when the production of an order spades start.

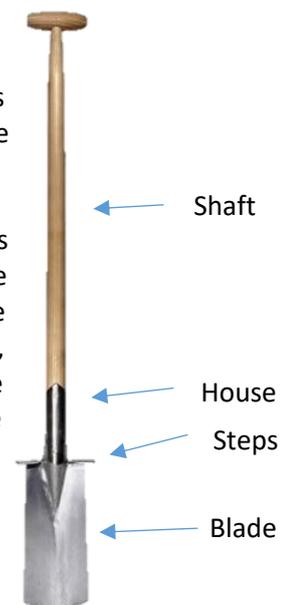


Figure 3.2 Spade with steps (www.sneeboer.com, 2018)

The cutting of the blade and houses is done by a water cutting machine that is working automatically. Another special process is the vinegar bath, in this process the iron parts are submerged in a bath of vinegar for 24 hours. This process makes it easier to make the blades look attractive after forging. Because this process is only submerging the blades in a bath and the blades will lay in the bath for one day, the time is removed out of the processing time calculation. It is better seen as obligated stock instead of a process. When the processing time is counted with the total processing time, it will give a distorted outcome because the total time will be 62 times higher. After the vinegar bath, the iron part will be welded together. To make to spade look attractive after welding, it will be grinded and polished. The next step is to weld the steps on the blade and polish it again. The blade will be sharpened and there is there a quality check. After the quality check, the iron receives a coating before the shaft is mounted. In the end, when mounting the shafts is done, the products will be transported to the customer.

The iron plates, in this case, are purchased two times a year and the wooden shafts four times a year. The reason to keep a lot of inventory for these products is that there is a high risk of running out of stock. There are only a few companies in the world who are producing the right type of iron and the right shafts. Lead times are normally one month and if there are problems, the case company cannot produce anymore. To avoid these risks extra inventory is held. Because the inventory is iron the products are not losing their value when it is inventory for this reason is it not a big problem to have some extra inventory.

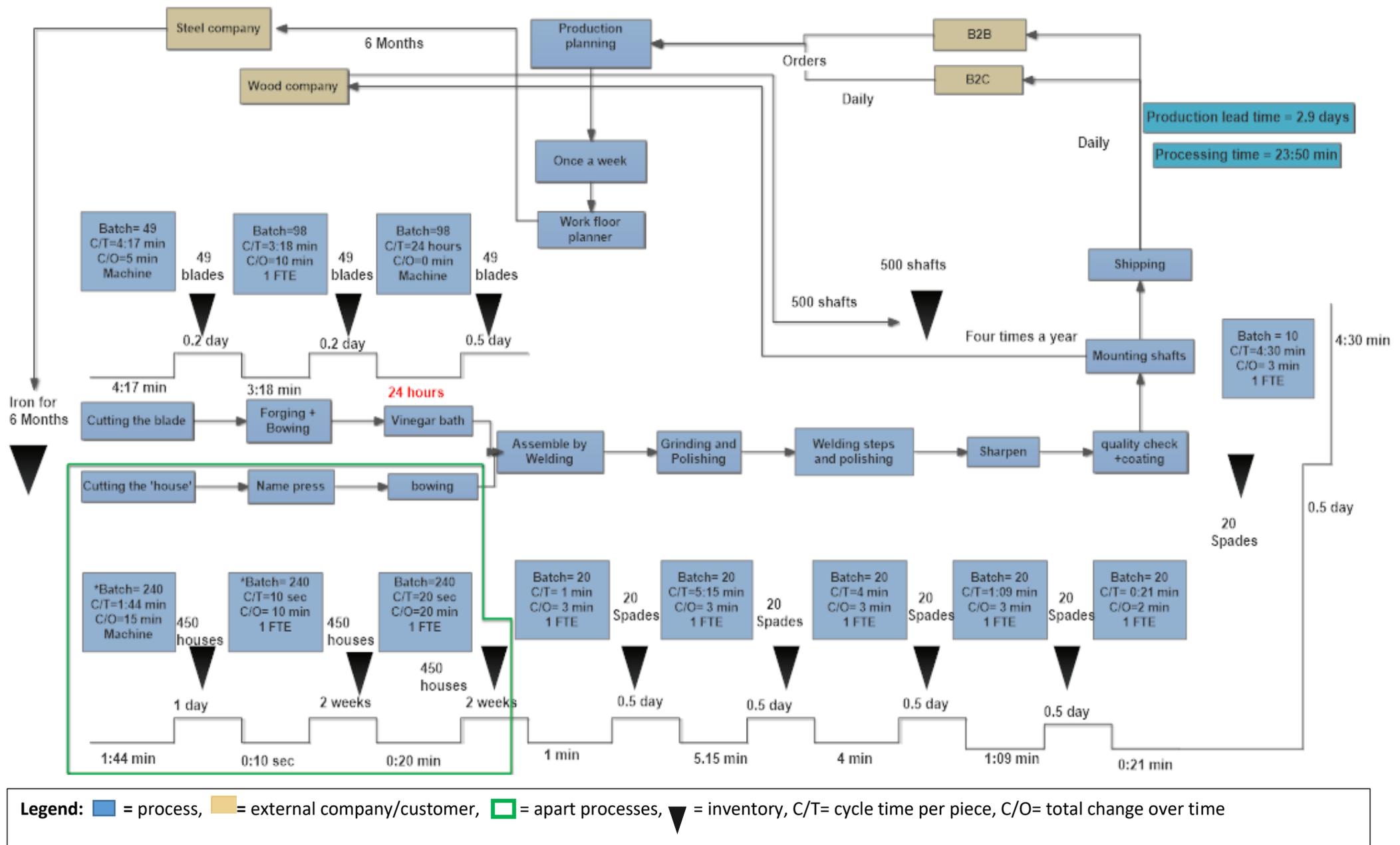


Figure 3.3: Value Stream Map Spade

Figure 3.3 gives information about the cycle time and the change over time of each process. Together with the batch size, the capacity of each cell can be calculated. The capacity will say what the time per piece production in each cell is. So, the capacity = cycle time + (change over time/ batch bigness). The cell with the highest capacity time can be defined as the 'bottleneck'. This means that these two processes are taking the most time within the material management chain. The other processes can produce more in the same time as these two processes so the two bottlenecks determine the speed of the production flow. Table 3.1 is showing the capacity calculations of each process/cell. The calculation of the vinegar bath is not done because of the 24 hours obligated waiting.

Table 3.1 capacity calculations per cell

Cutting the blades	Forging + bowing	Vinegar bath						Mounting shafts
C/T=4:17 min + (5min/49) =4:23 min	C/T=3:18 min + (10min/49) =3:24 min	..						C/T=4:30 min + (3min/10) =4:48 min
Cutting houses	Name press	Bowing	Assemble by Welding	Grinding and polishing	Welding steps and polishing	Sharpen	Quality check + coating	
C/T=1:44 min + (15min/240) =1:48 min	C/T=0:10 min + (10min/240) =0:13 min	C/T=0:20 min + (10min/240) =0:25 min	C/T=1:00 min + (3min/20) =1:09 min	C/T=5:15 min + (3min/20) =5:24 min	C/T=4:00 min + (3min/20) =4:09 min	C/T=1:09 min + (3min/20) =1:18 min	C/T=:21 min + (2min/20) =0:27min	

The green coloured cells in table 3.1 are the ones of the houses, so are independently of the rest as is already mentioned. The two red processes can be defined as 'bottlenecks' which will be discussed in chapter 4.

3.2 Summary depth interview at 'De Kroes'

To answer the last two sub questions, an interview with a professional lean manager is done. This information in combination with the information out of the theoretical research will help to answer both questions. So first is a summary of the depth interview added: (each number is corresponding to a question of the interview in appendix I)

De Kroes is a food company that is making microwave meals and meat products for the supermarkets and the catering industry. The company is growing, last year 20% increase in annual turnover. Also, the assortment is growing each year, the level of different products within the assortment is around 310. Because of this, efficiency in the company is a challenge. There are many changes during a day in making different products so there is a lot of change over times. This is the reason **the company decided to focus on process management tools (1). In the company the following models are used (2):** Theory of constraints, plan do act check, Value stream mapping, visual management, Critical presentation indicators and inventory management by using Kanban. All these tools are parts of Lean

thinking. Six sigma is, according to the project manager, is a model which is applicable for predictable mass production companies with a small assortment. For that reason, the company is not using Six Sigma. However, the fundamentals of six sigma, reduce every change on waste, is always good to keep in mind while managing a production company.

To apply the models (3), the project manager first tries to create support by the team managers. This is hard because the problems are not mention by upper and middle managers, so the team /line managers do not always recognize change. For this reason team managers have to implement the models to the different teams. The project manager will only check the teams on to see if the model is being used correctly. **The bottlenecks and value adding activities (4)** in the company are constantly moving through the process. The biggest challenges for the company are: inefficient use of production lines, production planning, inventory levels and the large assortment.

During the implementation of new models/way of work, employees always react (5) rebellious because the employees see this as a threat. The workers are afraid of losing the job of see it as criticism. **The project manager has followed the black belt course to get information about Lean (6)** and process optimisation for production manufactures.

The company is using the lean tools for almost a year now, so there is not a lot financial **proof (out of the annual report) that the models having results (7)**. But time measurement, production speed and inventory levels are showing that the improvements are having a positive effect. During last year, the project manager concluded that theory and practice can be completely different. The main reason for that is that in practice, the project manager must work with people and not only machines. People are unpredictable and cannot operate at 100% compliance rate. For this reason, it is important to keep company goals realistic. **If the manager could do last year over (8)**, the project manager would be more focussing on the employees and how to create support at an employee level. If employees understand the benefits, then the implementation of new models and ways of working would have a higher success rate. Based on the experience of the project manager, the **followed tips are made (9)**:

- Create support in the company (high degree of importance): employees and management should see the benefits of Lean solutions otherwise it will not work.
- It is a continuous process: when a company is using lean, the company has to focus on it all the time because it is never 'perfect' (Kaizen).
- Just try it: do not be afraid to try tools.
- Dare to fail: if an improvement fails, do not stop with lean, sometimes a company goes one step back to do two steps forward.
- Stimulate initiative in the company, maybe even reward the employees for good initiatives: some ideas can be a real eye opener for the company.

The subheadings below highlight the results related to the second and third sub question. Paragraph 3.3 and 3.4, will discuss these results in further detail.

3.3 sub-question two: Is the lean concept suitable to reduce bottle necks and non-value adding activities internally?

The in-depth interview of paragraph 3.2 exists of nine questions. All questions except of the last two are results to answer this question. Also the theoretical framework of chapter one is showing that according the theory, lean helps to reduce bottlenecks and non-value adding activities. The interview with a professional is mentioning that lean is adaptable on a company with many different products in the assortment, what is also a trait of the target audience. Improvements in inventory levels and production are proving that is can have positive results as well. It is important to understand that theory and practice can be different

3.4 sub-question three: Which points of attention are present when implementing lean in small metal manufactures in the agricultural sector?

Question 3, 8 and 9 of the in-depth interview are helping to answering this sub-question. These interview questions are showing the importance of support from employees by introducing lean concepts into a company. When employees do not see the benefits of the change for them in it, the elaboration of the new model will fail, or not give the expected result. Also, the expectations of a new introduced model should not be too high. The reason for that is that the theoretical result will almost always be higher as the practice (real) result. By implementing lean these two things are the key to make the project to a success.

The results from each sub-question are shown in this chapter. The discussion on the results is in the next chapter. There is a connection made between the results and the theory.

4.0 Discussion

In this chapter, the discussion of the research approach results, limitations, and applicability is provided. Firstly, the discussion will highlight research approach and most important findings from each sub question separately. When doing this, the results in combination with literature in the theoretical framework will be used to highlight the most important findings. Following this, a critical evaluation of combined results/variables will be discussed in relation to the main topic and question of the thesis. Furthermore limitations will be highlighted in relation to the thesis and overall research process.

In relation to **sub question one** *“What bottle necks/non-value adding activities are present within the process of the target audience?”* the purpose was to find out the materials management process within the company, to identify bottle necks and non-value adding activities within the process. Discovering the problems within the process was necessary to support the answer for the main question.

The research processes and limitations sub question one

The research method used to answer the first sub question was an empirical study based on a case specific company, it is important to understand the relation to the case and the target group. The company is well known by the researcher and there was sufficient time to analyse (5 months) and understand the processes of the company. It is important to mention that as the empirical study is case specific, a one fits all model is not applicable, and the model is not universal. For that reason, it is important that other companies within the target can use the basis of this research to alter the model towards each company and product or choose a different model that is more suitable.

The results sub question one

The results of sub question one are displayed into two different figures within chapter 3. Figure 3.1 is showing all primary processes which are needed to produce one order and figure 3.3 and table 3.1 are showing the VSM of the production of a batch of spades including each step. Both figures are already showing where the bottlenecks are. In figure 3.1 are the bottlenecks at three points. These bottle necks are described below.

The first bottle neck is shown in point Inventory c (appendix II): This is the inventory where the finished iron parts are in (short) stock before the shaft is mounted. Normally, when the company is only producing for B2B there is no problem in this inventory. But for the web-shop there needs to be extra inventory to be able to respond to web order faster. There is no policy on the amount of (extra) inventory. In practice there are some products in stock that only sell a few times a year and at the same times are fast-moving items out of stock. This part corresponds with the ‘inventory management’ part of the theoretical frame work. The theory is saying that a fixed order quantity system can help to make the inventory more efficient (Goor, 2015). This can be a solution to avoid unused inventory or getting out of stock. Thus reducing waste, and allowing for a higher level of dependability.

The second category of bottle necks are mounting, quality checks and extras: This is an evident ‘bottleneck’ within the company. In peak periods, the metal manufacturing production line can produce more parts than the mounting department can handle. The biggest reason for that that the ‘mounter’ cannot use his capacity full 100% (it is around 70% now). This is due to the fact that the employee in the mounting department needs to fix mistakes in relation to labelling and orders. By decreasing the amount of mistakes at this phase, overall production will increase as mounting phase in materials management will improve. This corresponds with the ‘Six Sigma’ theory of chapter 1 (Pyzdek, 2003) the theory says that minimize the change on failures will increase the production/efficiency. Also fits the theory of constraints at this point, finding the bottleneck and try to solve it. This model can always be used in the company because a bottleneck is a moving thing through the company. If one bottleneck is solved, the next one will rise in another place of the chain (university of instanbul , 2014).

The third bottle neck is the data input for transporter. This process results in time waste as the employee must fill information that is already in the company's system, into the program of the transporter. This makes the process a bottleneck and a non-value adding activity. Reducing time waste is a principle of Lean (Ede, 2018).

The other two non-value adding activities in the company are: import in system, print order list and print web order. These two steps are necessary for the company to give all the departments the right information. However, these steps give no extra value to an order. Table 3.1 is showing the capacity calculations from the processes of figure 3.3. This calculation is already proving that the 'mounting' process is the real bottleneck of the company. This process has a capacity time of 4.48 minutes. Only the grinding and polishing process takes more time: 5.24 minutes. At the grinding and polishing station are around 2 FTE compared to 1.3 FTE at the mounting area. However, the capacity time of the grinding and polishing process is a problem within the company. This process is labour insensitive therefore, difficult to increase capacity. To handle this problem the company will not produce small batches (<10), to avoid time waste in this step. It will be a big improvement in capacity if there can be made a machine for this process.

In relation to the **second sub question** "*Is the lean concept suitable to reduce bottle necks and non-value adding activities internally?*" The purpose is to confirm that lean is the right method to reduce bottle necks and non-value added activities (which are found in the previous sub-question).

The research processes and limitations sub question two

The research is done by a depth interview by a six sigma-black belt in lean project manager (highest education in lean six sigma). This professional has a lot of theoretical and practical knowledge. A point of attention in this research is that the interviewed company is not a company out of the 'target audience'. There are a number reasons for this, one is the uniqueness of the target audience, the second being the limited time in scheduling interviews within the research process. The target audience is limited to group of small agricultural metal manufactures, within the Netherlands. The interviewed company has, just like the target audience, a big assortment of products what makes the type of production planning the same. A big difference between the two sectors is that de Kroes works with fresh products, so inventory is a killing point. The target audience of this thesis have metal inventory where inventory time is not a problem for the product quality. This being stated, the experience of the interviewee, and the large product assortment provide reliable source of information in relation to lean.

An extra point of discussion of this research method is that there is only one company interview done. The reason for this is, that answering sub-question 1 is very time insensitive and the information what is coming out of this interview is quite the same for similar companies because the interviewee/project manager has done projects in different companies and during the studies the project manager has received a high level of knowledge and experience

The results sub question two

The results are processed into an interview summary. This makes it clear for the reader, and simpler to extract the important information out of the interview. According to the theoretical framework from chapter one it is conclude that, according the theory, lean will be suitable to reduce bottle necks and non-value adding activities (Heizer, 2017). The interview is confirming Heizer's, 2017, statement, but in addition mentions that the type of organisation/company is a critical factor when choosing the right model. For example, six sigma is fitting a company with a fixed production of a few product lines. On the other side is lean fitting a company with a more complicated production and more product lines.

This aspect, of understanding that different models apply to different organizations is an important result which arises within this sub question.

In relation to the **third sub question** “Which points of attention are present in implementing lean in small metal manufactures in the agricultural sector?” The purpose is to provide a guideline for the reader and to help companies understand how to use and apply the research. The process of this sub question is similar to the process in sub question two.

The research processes and limitations sub question three

The discussion on this sub-question is similar to the previous sub question because the method is the same (interview). Because the interviewee has a six sigma black-belt education, the manager has seen a lot of lean tools in practice, so the points of attentions are not coming from just one company experience. However interviewing more lean experts could lead to more detailed attention points.

The results

The results of this question are mentioned in the interview at question 3, 8 and 9. By doing the literature review within the theoretical framework and after having seen lean in practice it can be concluded that the points of attention from question 9 are important for the target audience. The most important point of attention is the first one, without support from the employees, it will be impossible to introduce lean into a company. Lean is not something a company just buy one time (like a machine) or a new work instruction, it is a way of thinking. When a company is using lean, it focus on it and change things all the time (Ede, 2018).

Critical discussion of main topic/research question: *How can lean concepts be used to improve materials management efficiency within small metal manufacturers in the agricultural sector?*

To critically evaluate the most important points highlighted in the research the results which relate to main topic/question need to be discussed. The main question of this thesis can be answered with the help of the three sub-questions. Answering this question helps the target audience improving the efficiency in the company by using lean concepts. Because the three separate researched questions together are answering this question, there is not an individual research to discuss. In this section is an overview of the three question discussed.

Research

The combination of three different research methods strengthen the research. The theoretical framework serves as a basis to support the research methods of the case study and the interview. Throughout the entire process, some key limitations can be highlighted. Firstly, lean concepts are not universally applicable across all companies and industries. Secondly, the empirical research method used is case specific. For other companies to use the research method, and to draw applicable conclusions it is important that the company designs the model and variables specific to each case. That being said, the model in this research can serve as a base, example, and set of practices, which other companies can use and alter when conducting research within different situations. An additional limitation to the research, was the limited time, and inability to have more in-depth interviews. That being stated, the results drawn from this interview can provide recommendation when implementing lean concepts and models across the industry. The combined research method of the empirical study, and the in-depth interview have the ability to draw strong conclusions and provide recommendations for the target audience which is seen in the following chapter.

Results Main Question/Topic

The final answer on the main question is given in chapter 5. The three sub-questions together are the 'results' of the main question. The bottlenecks of sub-question one showing different kind of problems a company from the target audience can have. Each bottle-neck can be approached with a different model out of the theoretical framework. Sub-question two and three are showing that with support from employees and good training/instructions lean can help to solve bottlenecks. Also these sub-questions are showing that the models which are fitting a company are depending the type of company and products. These results are covering the whole question and make it able to give an answer. The results from the case study and the interview are corresponding with the theoretical framework what makes the results stronger. The case study is showing the theory in practice at the target audience.

5.0 Conclusion and recommendations

This thesis will help small agricultural metal manufactures improve the material management phase throughout a company. Because of the large assortment of products, a company out of the target audience has a challenge in making an efficient work flow in the material management's phase of the company. Before the main question of this thesis can be answered the answer to each separate sub questions is provided

In relation to the first sub-question, "What bottle necks/non-value adding activities are present within the process of the target audience?", it can be concluded that the 'case company' which is fitting the target audience has three bottlenecks/non-value adding activities: inventory of finished iron parts, the process of mounting, quality checks and extra's and the (double) data input. The first two are critical bottle necks, the last one is a non-value added activity. There is also a bottle neck at the grinding and polishing process. In this bottle neck, there is less space for improvement, so the most obvious improvement point is to hire an additional FTE within this part of the company.

In relation to sub-question two, "Is the lean concept suitable to reduce bottle necks and non-value adding activities internally?" the answer can be extracted from the interview in combination with the theoretical framework. The theory was already confirming that lean concepts can help reduce bottle necks and non-value adding activities. The interview further supports the theory with practical proof that lean concepts can be applied to improve efficiency. Due to the fact that there are different models which are falling under lean, companies need to apply the model/concept most applicable to the situation (company and product).

In relation to the last sub-question, "Which points of attention are present in implementing lean in small metal manufactures in the agricultural sector?", give a list of four important points of attention. These are: (1) create support from employees: Without support, the project will not give the right results, (2) It is an continuously process: when a company is using lean, it has to focus on it all the time because it is never 'perfect', (3) Theory and practice are different: Do not make to high expectations of a project if a company is dependent on people. People are not machines so makes some times mistakes or works on different speed and (4) Stimulate initiative: Stimulate employees to come with ideas to improve the process and reward them for it. If an employee comes with an idea to improve the process, and the company works it out, there will be directly support because it is an idea of themselves. Support means positive effect what will help to make the improvements a bigger success. This will help a company apply lean successfully.

The main question, "How can lean concepts be used to improve materials management efficiency within small metal manufacturers in the agricultural sector?", can be answered with the help of the information above. Lean can improve the material management phase of the target audience as followed: The target audience has to deal with three kinds of bottle necks: inventory problems, inefficiency at the mounting section and double data input. It is already shown that lean works for production/manufacturing companies, but as each company is different, it is unknown which lean model/concept is most applicable for each separate case. The following models are most applicable to help to improve the material management efficiency within the target audience, which can lead to higher production rates. **Inventory management:** use fixed order quantity for the inventory of finished iron parts to be able to send web orders fast. Make a difference in slow moving, normal moving and fast-moving items to define what order quantity the company should take for a product group: **The fundamentals of Six sigma:** although six sigma is hard to implement at the target audience, the thinking of reducing every change on making mistakes will reduce waste and helps to use time more efficient (especially at the mounting section). **Theory of constraints:** it is important to find bottle necks, understand them and solve them. When one bottle neck is solved, a new one will raise somewhere else in the company. For this reason, the process of eliminating/reducing bottle is infinite throughout

time. Training employees to think in relation to 'bottle necks' so the employees will know what bottle-necks are, why it is a problem and how to solve them, is important to improve the process. If the target audience is able to achieve this, the company will increase in efficiency. Making Value stream maps will help to find the bottle necks and helps to control the production process. The VSM supports the theoretical aspects of research. **'Lean fundamental'**: reduce time waste of non-value adding activities by automation of ICT. If the ICT systems are working better together, a lot of unnecessary input can be reduced/eliminated. By implementing these models is the key to success: support from employees. If the employees understand that these models will make work more efficient and it will prevent mistakes the effect of the model will be better. As a project manager/company owner it is important to dare to fail. This will say that the manager should try things and it is not a problem if something does not work out well. Persistency, and the ability to establish urgency within the organization is a key success factor in relation to implementing new models and creating change. It can be concluded that hypothesis one is most relatable to answering the main question. Hypothesis one states that a mix of different management methods within lean will fit to the target audience. This will be a combination of theory of constraints, inventory management and some other small parts within lean. The value stream map will be a tool which will help the management do make decisions and to control the chain. As highlighted throughout the discussion, these methods will dependent on the company and products within the company.

Recommendations

As the research has shown, lean management methods can be implemented in the target audience to increase efficiency. To increase the success rate when implementing these models, various practical recommendation/implications are suggested. The first recommendation is to make someone in the company (within the target audience) a 'project manager' which will be focussing on the improvement of efficiency. This can be the company owner (small companies) but it is better to make an employee or line manager the project manager within the company. This is in relation to the fact that the employee is on the /similar level as the others, so it will be easier to get support. A further, yet related recommendation is to have the 'project manager' follow some courses/trainings in lean management to create better results. A third recommendation for a company which want to improve the efficiency, it is good to develop a VSM, in relation to a company and product to identify critical points within the process. This VSM will help to find the bottlenecks and can help the company to understand the material management phase of the company in greater detail. After the VSM is made, the theory of constraints can be used for solving the bottlenecks. Within lean, are there different other tools what van help an organisation. As each case is different, another recommendation is a company must find a method/model that fits to the company and helps to make the material management more efficient. For the target audience, which have a similar value stream map as the case company, inventory management can lead to success. So a final recommendation is that a company should find out which products are fast-moving and which are slow-moving and calculate what inventory level should be enough for a particular product. This will save inventory costs thus supporting lean management and avoid an out-of-stock situation within a company.

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Appendix I

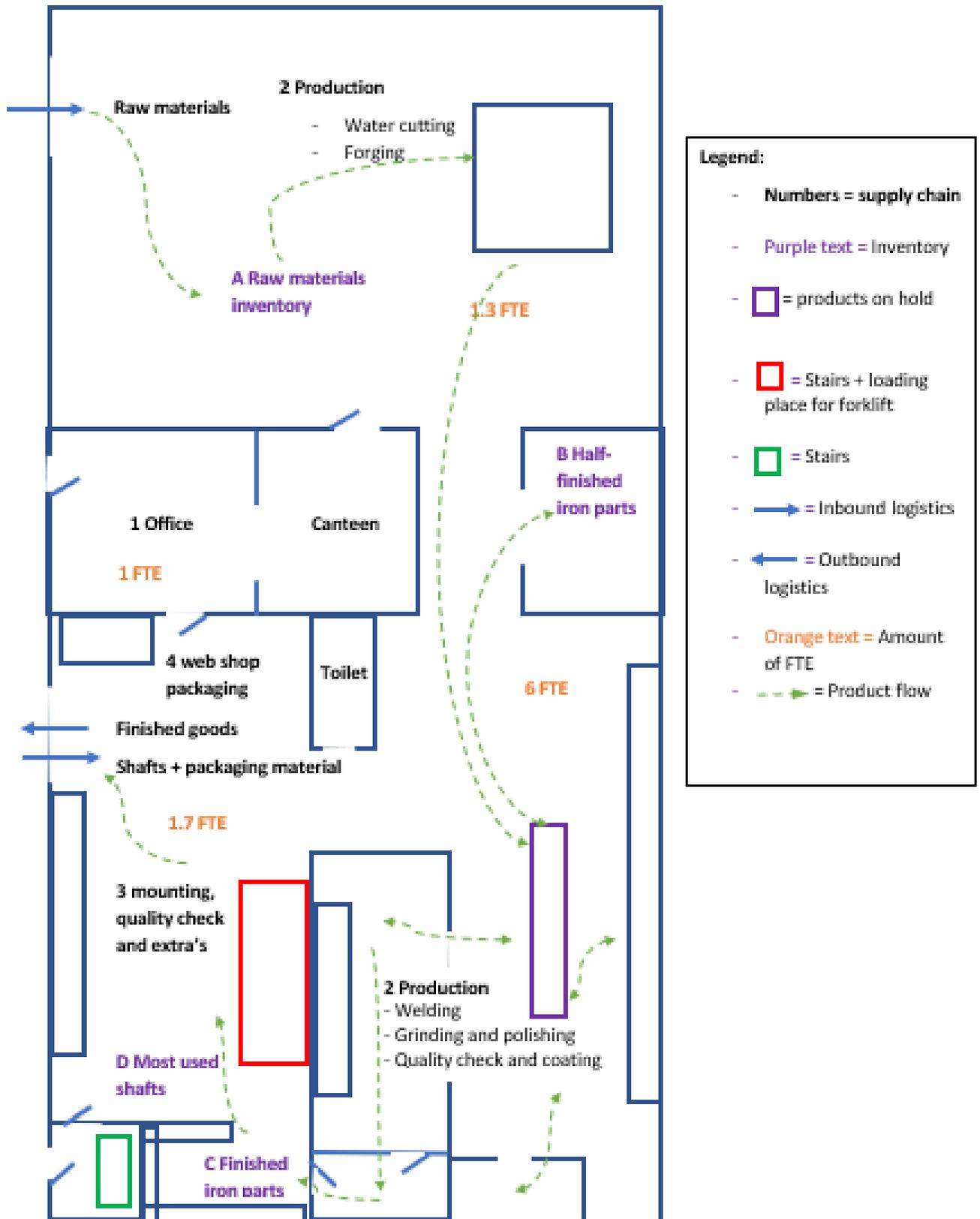
Semi-structured interview about process management models

The questions below are an **indication** of the question which can be asked at the company, there is a possibility to go deeper in some subjects because it is semi-structured.

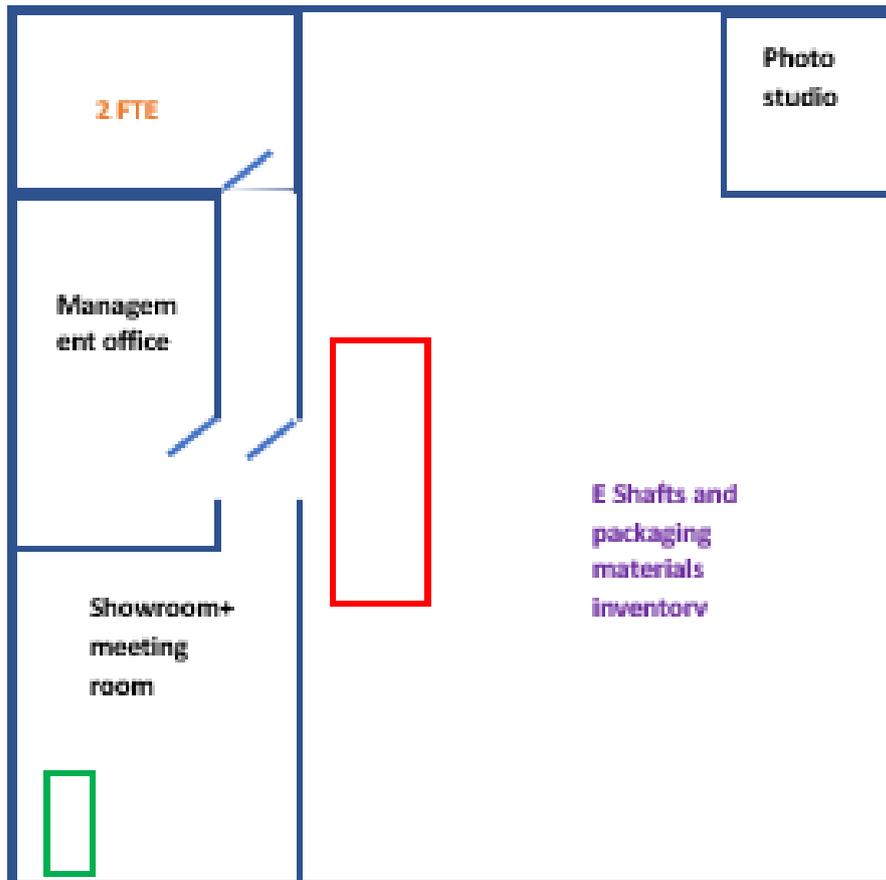
1. Did your company ever implement process management models?
2. Which models do you use/did you try and why?
3. How did you apply this model into the company?
4. What kind of bottle necks/non-value adding activities do/did you want to change by using the models.
5. Did the employees understand it?
6. How did you/your company know how to work with these models?
7. Do you have proof (facts) that shows the models are having results?
8. If you can do the whole process of implementing a model over, what would you do different?
9. Do you have tips for companies who wanted to use process management models?

Appendix II

Ground floor



First floor



Legend:

- Numbers = supply chain
- Purple text = Inventory
-  = Stairs + loading place for forklift
-  = Stairs
-  = Inbound logistics
-  = Outbound logistics
- Orange text = Amount of FTE