Application of Lean Focus on Manufacturing Process

A Case Study of an American Furniture Company

Master Thesis within International Logistics and Supply Chain Management

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Abstract

Introduction: To improve the target company’s manufacturing process by applying lean principles, including using and analyzing the internal value stream mapping. As more and more companies have paid attention to implement lean thinking in their manufacturing process, the value stream mapping played an important role for many companies to make a transition from their traditional production systems to lean systems. The content and resources of this master thesis come from an American furniture company named KAMA which mainly produces office furniture with different components. Although there are various types of products, the authors merely focus on the office chair products. This research is an attempt to understand and analyze the problems in the production flow on the example of KAMA’s office chair products that includes PH product family as the target research part.

Purpose: The purpose of this research study is to investigate, analyze and find out solutions for waste-related problems in the office chair manufacturing flow of KAMA.

Method: A single case study will be applied in this study paper. Data should be collected from telephone interviews with company’s managements, the studying of KAMA’s internal documentation and the secondary data from lean project report collected by Consultant EIMI. In order to improve the production process, the value stream mapping method will be applied to build the current value state map of Company KAMA and identify the potential wastes during the manufacturing process, and then analyze and give the solutions for future improvement. Additional, other methods including the order penetration point analysis, make-to-stock theory, and the CONWIP analysis have been subsequently applied in designing a draft of the future state map.

Conclusion: From the constructed current value stream mapping of KAMA office chair manufacturing process, it can be found that the most essential wastes are overproduction, waiting, unnecessary inventory and unnecessary movement. In addition, the improper workstation arrangement and unnecessary waiting time have been identified as the critical wasting reasons. Thus, any solutions to reduce or eliminate the identified wastes have been considered and would be given in the future state. In order to improve the efficiency and reduce the unnecessary movements, adopting the appropriate cellular layout in the mechanical workshop is quite beneficial. The mentioned methods to reduce wastes have been summarized in the draft of the future state map of the company. The main benefits of the proposed future state value stream mapping are faster and accurate order fulfillment process, reduction of unnecessary movements in workshop, low inventory, high productivity and reduced costs in the flow of KAMA’s manufacturing process.
List of abbreviations

ATO: Assemble-To-Order
C/O: Change Over
CONWIP: Constant Work-In-Process
CRM: Current State Map
C/T: Cycle Time
EOQ: Economic Order Quantity
ETO: Engineer-To-Order
FIFO: First In First Out
FSM: Future State Map
LD: Lead Time
MRP: Materials Requirements Planning
MRP II: Manufacturing Resources Planning
MTS: Make-To-Stock
MTO: Make-To-Order
NVA: Non-Value-Added activities
NNVA: Necessary but Non Value Added activities
OPP: Order Penetration Point
TPS: Toyota Production System
VA: Value Added activities
VSM: Value Stream Mapping
WIP: Work In Process
5S: Sort, Set in Order, Shine, Standardize, Sustain
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1 Introduction

This chapter presents the background and the problem formulation of the thesis. After the problem formulation the purpose of this thesis is stated, followed by research questions, delimitation and outline of the thesis.

1.1 Background

In 1960s, a Japanese car company, Toyota began to export its cars to Europe and US. Their cars are of cheap and high quality which quickly seized the European market and completely ended the times that ford motor had a monopoly of Europe and North American markets. Before that, no one had heard of Toyota and its innovative production system. Nowadays, as the competition among business intensifies on a global scale, a new era of commercial has came, which we called, the post-Fordism. (Amin, 1994) This era is with the characters of high information technology, more flexible, decentralized form of labor process and organization and a great emphasis on choice and product differentiation. (Hall, 1988, quoted in Amin, 1994.p.4) In this time, the Toyota’s flexible and small-batched production system and the lean manufacturing system which generated from the TPS (Toyota production system) provide a different, flexible choice of strategy to many manufacturers who are pursuing reduction of waste and its associated costs and better position in the marketplace.

In the traditional, Ford production model, manufacturers produce goods basing on a sales forecast, and then try to push the products out, which obviously does not apply for the buyers’ markets now. Plus, this production system is not environmental and generates a lot of wastes. Waste is viewed as any use or loss of resources that does not lead directly to creating the product or service a customer wants when they want it. In many industrial processes, such non-value added activity can comprise more than 90 percent of a factory’s total activity. (EPA, OSWER and OPEI Report, 2003) If manufacturing companies want to achieve goals like producing goods faster, better and cheaper, it is impossible to hold on to old principles and traditions. To be able to provide cheap products at a high quality manufacturing companies need to find new ways to reduce wastes and at the same time provide as high customer value as possible. (Cutler, 2005)

Compared to mass production, Lean manufacturing adopts a more flexible, small-batched production way and communicates with its customers very often, it also focuses on the elimination of wastes in business at all levels. The essence of lean manufacturing is that manufacturers produce goods only by the client order, thus to eliminate the excess inventory. In this concept, the customer orders created a pull effect on the manufacturing process, which is very different from the traditional mode of manufacturing. (Fargher, 2002)

Concretely what happens in the United States, the U.S. manufacturing industry is facing great global pressures, especially from the Chinese manufactures. Many U.S. manufacturers are moving toward to the restructure in the direction of lean and automation. The speed of the popularization of the practice of lean production theory is very fast, lean production has been considered as the primary strategy to ensure global success by the many manufacturers. Through leaning and streamlining their supply chain, these companies are trying to achieve the goal of establishing and consolidating their global competitive advantage.
By the end of 1999, lean thinking and practices have been incorporated into all levels of the manufacturing business operation by a few of most lean corporate manufacturing pioneers like Omark Industries, General Electric and Kawasaki (Lincoln, Nebraska). They were achieving great success and implementing visual controls (kanban), simplifying the reorder systems, and reducing the error-prone double data entry. (Cutler, 2005)

1.2 Specification of Problem

However, the penetration of lean is very low in the manufacturing industry. In terms of the United States, The Bureau of Labor Statistics gave a report which showed that in April 2005, the employment in manufacturing was keeping fluctuating slightly at 14.3 million, with small and offsetting movements among several of its components. For the furniture and its related industries, the long-term employment continued to decrease substantially. The status quo means that around 600,000 U.S. manufacturers support those 14 million-plus employees. But less than 1 percent has publicly announced that they adopted lean manufacturing and in those less than 1% fewer than 6,000 U.S. manufacturers have exposure their commitment to a lean manufacturing program through a press release, news announcement, or any other public statement. It is likely that another 12,000 U.S. manufacturers are implementing aspect of lean based on attendance at lean seminars conducted by EIMI and other lean consultancy organizations. At a conservative estimate, more than 550,000 U.S. manufacturers have yet to implement a lean process, that is, for the large scale of national and even worldwide manufacturing enterprise, lean manufacturing is more like a fad. With the 91 percent of U.S. manufacturers employing fewer than 100 people, the vast market potential of kaizen, kanban, and continued process improvement is staggering. (Cutler, 2005)

Even for the companies which already implement lean manufacturing into their production system, there are numerous of problems that hinder them from walking in this road forward. Self-interest, striving to personal schedule, lack of understanding of the overall, clinging to traditional methods and past practices all can lead to the failure during the process of implementing lean manufacturing into business. (Cutler, 2005)

Due to the problems above, this master thesis aims at how to build a lean manufacturing system inside of a company to reduce or eliminate wastes during production process; we adopt a case of an American company named KAMA, which operates mainly on the American and European markets in the furniture manufacturing industry and method of manufacturing its products. With the help of the consultant EIMI, they try to implement lean into their manufacturing process and operational system in order to improve the efficiency and productivity.

1.3 Purpose

The purpose of this case study is to study, analyze and give solutions for waste-related problems in the office chair product manufacturing flow.

1.4 Research Questions

Based on what have discussed in the paragraphs above the following problem formulation has been developed for this master thesis.

RQ1: How does the project help the company to redesign their production line by adopting lean as a tool?
RQ2: *What are the benefits by implementing lean manufacturing?*

### 1.5 Delimitations

Due to the restricted timeframe limit set for this thesis and the potential wide scope of the above presented research subject, there is a need of delimitation.

The empirical findings are confined to a single case study of a single company. The authors will give the analysis only basis on the case of leaning the manufacturing process to narrow down the scale of this thesis and this pattern of lean manufacturing enterprise is the exclusive model which cannot be copied simply by others. So the solutions and proposals for the implementation of lean manufacturing can not be applied in other manufacturers and cases.

Further, a rigorous research may consist of many different perspectives and the concept of lean manufacturing is broad but in this thesis the authors only approached it mainly from a limited number of aspects which are mentioned in the empirical case, e.g. the approaches with the virtues of being practical for developing lean manufacturing and optimizing the production line, in a word, to eliminate wastes and remain quality by using lean thinking as a guide.

Finally, the data collection referring to background information may be not abundant enough, so the analysis and discussion based on them may not be deep enough. It is also because of the limited personal knowledge that the study cannot exploit and expand into all the issues and challenges of lean manufacturing.

### 1.6 Outline of the Thesis

The thesis is divided into seven chapters according to the following structure:

**Chapter 1 – Introduction:** The first chapter introduces the reader to the subject by stating the background of the thesis. Further, the problem formulation of the thesis is presented, followed by the purpose. The chapter ends with research questions, delimitation and outline of the thesis.

**Chapter 2 - Frame of Reference:** This chapter includes the theories related to the research subject. The frame of reference focuses on the theories that are seen as important to better understand lean manufacturing and its relations which also includes the development of such concepts. Figures and tables are included in order to help the reader to better understand the theory used in the frame of reference.

**Chapter 3 – Methodology:** In this chapter the research method is presented. Among other things the research approach and strategy, the collection of data and sampling are discussed in this chapter. The chapter ends with discussion of the reliability and the validity of the thesis.

**Chapter 4 - Empirical Study:** The chapter presents the collected empirical material from the conducted interviews and data collection at one target Company. For that company the empirical findings are presented under the sub headers; general company information, company operations, development of value-added activities.

**Chapter 5 – Analysis:** In this chapter the intention is to give the readers our interpretation of the findings derived from the empirical study in association with the theory presented in the frame of reference.
Chapter 6 – Conclusions: In this final chapter relative knowledge will be looked back and the main problem discussed in this thesis will be highlighted again. The author will also give the suggestions and proposals for the future research, and the future in leaning manufacturing process will be explored.
In this chapter necessary theories regarding lean manufacturing process are presented. This is done by making sure that the reader could acquaint with the subject and also to lay down the cornerstone for the analysis.

The theoretical framework showed by Figure 2-1 presents all the concepts and theories needed in order to answer the research question of this master thesis. The figure also aims at helping the readers to understand the framework in an easy way. Our study is about application of lean focus on KAMA chair production, we structure it as constructing a building. The theoretical part is the foundation to sustain this building, to make the whole pilot reasonable and base on a scientific approach.


To implement lean manufacturing, pull system and single piece flow are the basic method of this thesis. Dettmer (2001) gave his definition about pull, and then Liker and Meier (2005) helped to differentiate pull system from push, which is quite clear to understand. Single piece flow, one of the key success factors of lean manufacturing defined by Dettmer (2001) provided the theory support of FIFO (first in-first out) approach.

The study about KAMA program follows the three supporting principles, specifying value, identifying value stream and making value flow, which are generated from Womack & Jones (2003) in their famous book ‘Lean Thinking’. To specify value, we have to understand what is value to the customer, which was given by Monden (1993) and Womack & Jones (1996). The definitions and classification of three types activities in any business present help us to specify value in the production process. We analyze KAMA manufacturing process by using the tool of Value Stream Mapping (VSM). Value Stream Mapping was disseminated by Rother and Shook (1999). Rother and Shook also present the goal of VSM.

To realize continuous improvement, we present the theories of Shingeo (1989) and Taiichi (1988) about seven wastes in manufacturing industry in this thesis and talk about why the identification of waste is useful. We refer to Kanban system, CONWIP and Cellular layout as the practical tool to implement lean production. They are supported by Hobbs (2003), Tufekci (2009), Sugimori et.al. (1977), Hopp & Spearman, (2001) and Tapping & Shuker (2003).

We also analyze the Order Penetration Point (OPP) which was based on the previous works of Olhager (2003), Berry & Hill (1992) and Hoffman (1991). The OPP position helps to rearrange the company’s strategy and production model, and it also matters the pull/push scheduling that company adopts.

2.1 Lean Manufacturing

According to Cutler (2005), Lean manufacturing is a process to improve manufacturing and service operations, reduce waste, improve quality, and drive down costs. Activities that consume resources but generate no redeeming value in the eyes of customers are wastes that must be eliminated in the lean paradigm. (Womack and Jones, 1996) The lean manufacturing methodology is also described as a series of techniques that allow product producing one unit at a time, at a formulated rate, and eliminating non-value-adding time, queue time or other delays. (Hobbs, 2003, P.76) Carroll (2010) argues that lean manufacturing is a systematic approach to identify and eliminate wastes—non-value added activities through continuous improvement at the pull of the customer in pursuit of perfection. (Boone, 2010)

It should be noted that lean manufacturing is not the same as the Toyota Production System (TPS); TPS is ‘a collection of advanced manufacturing methods pioneered by the Toyota Motor Company in the 1950s which aimed to minimize the resources it takes for a single product to flow through the entire production process.’ (EPA, OSWER and OPEI Report, 2003) The TPS is a major predecessor and successful example of lean manufacturing. Based on that method, Toyota also ‘created an organizational culture focused on the systematic identification and elimination of all waste from the production process.’ (EPA, OSWER and OPEI Report, 2003)

Toyota’s successful story leads ‘hundreds of other companies across numerous industry sectors to tailor these advanced production methods to address their operations.’ (EPA, OSWER and OPEI Report, 2003) When the efficiency and quality gains became compelling evidence to the outside world, American executives traveled to Japan to study it. Norman Bodek made a contribution to translate the works of Shingo and Ohno into English to the western world. Womack, Jones and Roos (1991) creatively used ‘lean production’ in their book ‘The Machine that Changed the World’ to introduce the manufacturing methods established by the Toyota Production System in 1990s. (Sorensen, 1956; Kanigal, 1997; Lacey, 1986)

As EPA, OSWER and OPEI Report (2003) wrote, lean production ‘is a shift of production schema from conventional batch and queue functionally aligned mass production to one-
piece flow, product-aligned pull production for lean manufacturing. During this process, the process-control in a well maintained, ordered, and clean operational setting which incorporates principles of just-in-time, employee-involved and continual improvement are highly required'. (EPA, OSWER and OPEI Report, 2003)

<table>
<thead>
<tr>
<th>Mass Production</th>
<th>Lean Production</th>
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<tbody>
<tr>
<td>Product</td>
<td>Customer</td>
</tr>
<tr>
<td>Batch and queue</td>
<td>Synchronized flow and pull</td>
</tr>
<tr>
<td>Reduce cost and increase efficiency</td>
<td>Eliminate waste and add value</td>
</tr>
<tr>
<td>Inspection (a second stage, after production)</td>
<td>Prevention (built in by design and methods)</td>
</tr>
<tr>
<td>Economies of scale and automation</td>
<td>Flexibility and adaptability</td>
</tr>
<tr>
<td>Expert-driven periodic improvement</td>
<td>Workforce-driven continuous improvement</td>
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Table 2-1: Comparison between Mass Production and Lean Production.

To make a summary, the essence of lean manufacturing is eliminating wastes and continually improving the operational process. As the figure below, team work’s importance can be showed along the manufacturing system and the supply chain pipe due to the practical need and TPS principles. (Björnfot, 2006)

Figure 2-2: The essentials of Lean Manufacturing


2.2 Benefits of Lean Manufacturing

Here we quote the sentences from the U.S. Environmental Protection Agency (2003) report, showing that companies can receive benefits by implementing lean manufacturing into their production process as following:

- ‘Reduced inventory levels (raw material, work-in-progress, finished product) along with associated carrying costs and loss due to damage, spoilage, off-specification, etc;’ (EPA, OSWER and OPEI Report, 2003)
• ‘Decreased material usage (product inputs, including energy, water, metals, chemicals, etc.) by reducing material requirements and creating less material waste during manufacturing;’ (EPA, OSWER and OPEI Report, 2003)

• ‘Optimized equipment (capital equipment utilized for direct production and support purposes) using lower capital and resource-intensive machines to drive down costs;’ (EPA, OSWER and OPEI Report, 2003)

• ‘Reduced need for factory facilities (physical infrastructure primarily in the form of buildings and associated material demands) by driving down the space required for product production;’ (EPA, OSWER and OPEI Report, 2003)

• ‘Increased production velocity (the time required to process a product from initial raw material to delivery to a consumer) by eliminating process steps, movement, wait times, and downtime;’ (EPA, OSWER and OPEI Report, 2003)

• ‘Enhanced overall production flexibility (the ability to alter or reconfigure products and processes rapidly to adjust to customer needs and changing market circumstances) enabling the implementation of a pull production, just-in-time oriented system which lowers inventory and capital requirements;’ (EPA, OSWER and OPEI Report, 2003) and

• ‘Reduce complexity (complicated products and processes that increase opportunities for variation and error) by reducing the number of parts and material types in products, and by eliminating unnecessary process steps and equipment with unneeded features.’ (EPA, OSWER and OPEI Report, 2003)

2.3 Value

Womack & Jones (1996) submitted 5 principles, which are specifying value, identifying the value stream, making value flow, pull scheduling and seeking perfection, to define and describe the lean concept. Specifying value is the critical first step in these 5 key principles. Value can only be defined by the ultimate customer, and it’s only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer’s needs at a specific price at a specific time. (Womack & Jones, 2003. p.40-48)

The activities during the manufacturing process were classified into three categories according to if there is value generated by such activity by Yasuhiro Monden (1993), which are:

**Value-Added activities (VA)**

As Francis (1998) raised, VA activity ‘directly results in the accrual of value in the eyes of the end customer so that this kind of activity is considered essential with regard to the perceived quality of final offering and regulatory compliance. It is that activity which is unthinkable not to conduct in any future state model or scenario’ (Francis, 1998).

**Non-Value-Added activities (NVA)**

NVA is ‘any activity which adds cost but creates no value so that can be removed immediately’ (Francis, 1998). NVA is a kind of pure waste which needs to be eliminated immediately. It is notable that this kind of activities need to be reduced or eliminated with ‘minimum or no capital investment and with no detrimental impact on end value’ in a short run
(Francis, 1998). Womack & Jones (1996:20) classified this activity as Type Two muda. (Francis, 1998)

**Necessary but Non Value Added activities (NNVA)**

NNVA is the activity which creates no value but still necessary because of the current limitation of technology, capital assets and ‘operating procedures of the system under examination’ (Francis, 1998), which is also called Type One muda (waste) classified by Womack & Jones (1996:20). The documents movements between company departments are the typical example of NNVA. According to Francis (1998), ‘this kind of activity will ideally be eliminated in the long-run but it is envisaged that this will require capital investment and/or re-engineering activity’.

<table>
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<tbody>
<tr>
<td>Value-Added activities (VA)</td>
<td>Value-Added activities</td>
</tr>
<tr>
<td>Non-Value-Added activities (NVA)</td>
<td>Type Two muda</td>
</tr>
<tr>
<td>Necessary but Non Value Added activities</td>
<td>Type One muda</td>
</tr>
<tr>
<td>(NNVA)</td>
<td></td>
</tr>
</tbody>
</table>

**2.4 The Seven Wastes**

One of the essences of lean manufacturing is to eliminate wastes. Taiichi Ohno (1988) gave 7 categories which cover almost all the means by which manufacturing organizations waste or lose resources and money; these have become known as The 7 Wastes, which specially means any human activity which absorbs resources but creates no value. Then Hines & Rich (1997) explained 7 wastes in English in their academic article ‘The seven value stream mapping tools’.

**Overproduction**

Overproduction is regarded as the worst waste because it has a negative effect on the smooth flow of products and services. Such kind of waste also leads to excessive lead time and large storages so that to inhibit productivity and quality of goods. As a result the workers can not detect the defects early; superfluous goods may get rotted and workers may suffer the heavy work pressures. In addition, overproduction may lead to massive WIP stocks which result in the physical operations disorders and poor communication between the staff. (Hines & Rich, 1997)

**Motion**

Reducing unnecessary motion could benefit the employee and improve the ergonomics. The possibility of work-related muscular skeletal disorders in the arms, back and shoulders could be effectively reduced by reducing excessive motion, which means, the employee’s benefits often relate to the motion wastes, and such kind of waste easily results in productivity and quality problems. (Hines & Rich, 1997; Hunter et. al., 2004)
**Waiting**

Waiting happens when time is being used ineffectively. In a factory condition, this kind of waste occurs whenever products are not moving around or being worked on. The waiting time should be reduced and eliminated for a faster flow of elements. Workers need to be trained properly and the 5s system needs to be implemented into the operating system to maintain and optimize the continuous flow. Moreover, reducing waiting time also results in overproduction elimination. (Hines & Rich, 1997)

**Unnecessary transportation**

The transport activity consists of all kinds of goods being moved about. It can be said that any movement in the factory should be regarded as waste so that people seek to minimize the transportation. What’s more, damages are likely to be occurred by ‘double handling and excessive movements’ and inaccurate communication happens when there is long distance between the operators. (Hines & Rich, 1997)

**Over-Processing**

The advanced high technology sometimes brings an overly complex solution while the simple methods are actually enough to do the work; over-processing occurs in such a situation. According to Hines & Rich (1997), example of over-processing is ‘to use a large inflexible machine instead of several small flexible ones’. The over processing may ‘discourages ownership and encourages the employees to overproduce to recover the large investment in the complex machines’ (Hines & Rich, 1997) The poor layout are also encouraged by over-processing which leads to excessive transport activities and inaccurate communication. The easiest possible machine settings to produce the required quality which locates near the upstream and downstream operations are the ideal way against over-processing. (Hines & Rich, 1997) The machines used under the poor safeguard conditions also cause over-processing, ‘such as poke-yoke or jidoka devices, so that poor quality goods are able to be made’. (Hines & Rich, 1997)

**Inventory**

Hines & Rich (1997) considered that ‘unnecessary inventory tends to increase lead time, prevent rapid identification of problems and increase space, thereby discouraging communication’. Excessive inventory has problems hidden behind which are hardly to be found. Thus, reducing inventory is unavoidable to be able to solve the problems. Besides, unnecessary inventories also increase costs for storage, hence, the competitiveness of the organization are lowered. (Hines & Rich, 1997)

**Defects**

According to the Toyota philosophy, defects are viewed as opportunities to improve goods quality. ‘Thus defects are seized on for immediate kaizen activity.’ (Hines & Rich, 1997)

Another waste was defined by Womack and Jones (2003) as eighth waste; it was interpreted as manufacturing goods or services that do not meet customer demand or specifications.

In all, waste is over using of resources what is actually needed to produce products as required by customers. If the customer does not need it or would not pay for it then it is regarded as waste, which includes materials, equipments and labors. (MAS-SW, 2010) The 7 wastes is not a tool to solve the problems, but they do play a valuable role in reducing inefficiency and associated cost. The idea of clarifying 7 wastes gives companies a way to sum-
marize problems and then focus their attention in the appropriate areas once the wastes have been identified. However, the identification of wastes is not a simple task since some waste is behind the manufacturing process which is not easy to be found and eliminated. To be specific in our case, most of the waste from office chair manufacturing process is discarded to the landfill, the cost of which is enormous. All these waste is generated from expensive raw materials. Reducing waste will be significantly cut down the cost and increase company’s profits.

The clarification of waste is also a key to establish distinctions between value-added activity and non-value-added work (Ohno, 1988), which already be described in the above part.

2.5 The Value Stream Mapping (VSM)

Once value is clearly defined, then value streams can be clearly identified. Value stream mapping (VSM) is a lean manufacturing technical methodology applied to interpret the flow of materials and information currently needed to transit goods or services to the end consumer. Both the spare parts and sub-working procedures in the working process from raw material to the finishing good completed products are involved. (Rother and Shook, 1999) Womack and Jones (2003, p.1) described the VSM as a simple process of directly observing the flows of information and materials as they now occur, summarizing them visually, and then envisioning a future state with much better performance. (Cited in Gustavsson & Marzec, 2007) They also extended the VSM to the Value Stream Macro Mapping (VSMM) to describe the entire supply chain. (Womack & Jones, 2003)

The goal of VSM is to identify all types of waste in the value stream; decrease and eliminate these wastes. (Rother and Shook, 1999). This mapping method identifies the total value stream chain for each product including three critical management tasks of any kind business, which includes: (Rother and Shook, 1999)

- Production flow - from raw material input to completed products delivery;
- Design flow - from idea to launch; And
- Material & information flow and the integration of design & production flow.

2.5.1 Define a product family

As Abdulmalek and Rajgopal (2006) described in their paper as Gustavsson and Marzec (2007) quoted that the first step of implementing VSM is to define a particular product or product family as the target for improvement. Characteristically a product family will incorporate a group of product variants that pass along comparable processing procedures and use ordinary appliances in the workshop (Jones & Womack, 2003, p.1, cited in Gustavsson & Marzec, 2007). Nevertheless, it is suggested to keep away from the products or product families which are made in large bunch or are the parts of many other product families (Rother & Shook, 1999).

2.5.2 Current state map (CSM)

The first step is to draw a current state map that is mainly a portrait catching how works are now being done. (Seth & Gupta, 2005) CSM aims at helping to depict a future state value stream flow. Portraying this procedure will provide the operators a clear impression of the wastes that impede the kaizen flow, in order to reduce and eliminate the wastes found. (Tapping & Shuker, 2003)
As Jones & Womack posed, to draw a CSM, one needs to make a list that includes all necessary activities to create a product. (See Table 2-3) The total elapsed time (total product cycle time) is recorded on this list to sum the time required to conduct all of the approaches for a product. This time is then compared with the actual value creating time, which is the sum of only the value creating steps. To judge whether a step adds value, one has to think like a customer and ask if he would like to pay money for the product or be less satisfied with the product if a given step and its corresponding time were not done. (Cited in Gustavsson & Marzec, 2007)

Table 2-3: Physical Actions Required Creating A Product.

<table>
<thead>
<tr>
<th>Total steps</th>
<th>Value Creating Steps</th>
<th>Total Time</th>
<th>Value Creating Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials Supplier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory X, Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport Link 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second-Tier Supplier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory Y, Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport Link 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company Assembly Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory Z, Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport Link 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Then, as Jones & Womack showed, all facilities serving the customer can be started to draw. The entire icons signification can be seen in Appendix 4. (Cited in Gustavsson & Marzec, 2007)

Besides this basic map a data box placed under each facility will be added. This data box consists of data on inventories (Raw Materials, Finished Goods, Work-In-Process), the amount of productive time (the number of shifts per day and the number of working days per week), the frequency of the production cycle (displaying how often every parts is made), and the change over time. (Jones & Womack, 2003.p.22f; cited in Gustavsson & Marzec, 2007)

The next step is to draw the transport links between each facility, which may be ship, train or airplane. One need to add the frequency of transports inside the icon, and information
about the distance in kilometers or the shipping batch size also will be written by words too. (Jones & Womack, 2003, p.25; cited in Gustavsson & Marzec, 2007)

Finally there is a time-and-steps line needed to be placed along the bottom of the map. The data line shows the total time for each workshop, each distance traveled and the value added time for each stage in manufacturing. A summary box will be added at the end of the line displaying the total lead time, and value added time. (Jones & Womack, 2003, p.26; cited in Gustavsson & Marzec, 2007)

After the physical flow of the product is mapped, the information flow can be drawn. The information flow comprises the frequency of orders and the way it is transmitted between each facilities, e.g. by phone, electronically or fax. (Jones & Womack, 2003, p.30f; cited in Gustavsson & Marzec, 2007)

To sum up, the Current State Map (CSM) includes 5M – Man, Machine, Material, Method, and Message (or Information) followed by VA as well as NVA operations. (Wee & Wu, 2009) Through the analysis of CSM, the 7 wastes and the obstruction for further lean technique are identified and the improvement actions can be presented. After data collection and analysis, the CSM will become a visual improvement tool for work group to set up challenging target with measurable indicators. (Wee & Wu, 2009)

**2.5.3 Future State Map (FSM)**

The next step is to draw a future state map (FSM) which makes the lean improvement based on the result of the current state map analysis. (Gustavsson & Marzec, 2007) The FSM gives the best way that the process could operate starting from the current state analysis, (Pasqualini & Zawislak, 2005, p.119) in other words; to depict how the system should look like after all the inefficiencies have been eliminated. Through gap analysis between CSM and FSM, the work group could discover all the problems and countermeasures and make improvements. (Wee & Wu, 2009) And after each improvement session, the FSM changes back to CSM. This is similar to Deming’s P-D-C-A cycle (Juran and Gryna, 1993) of continuous improvement. See Figure 2-3.
Accordingly, VSM has the following benefits: (Wee & Wu, 2009)

- VSM provides a complete visualization of process that constructs the value stream of definite product families.
- Materials and information flows are combined visually, so it is possible to understand its relationships and motives of flow disturbances.
- VSM helps to highlight and expose the hidden 7 wastes.
- VSM provides the possibility of describing each facility process both qualitatively and quantitatively, enables the practice of comparisons between current state map and future state map. (Wee & Wu, 2009)

**2.5.4 Summary**

VSM method visually maps the flow of materials and information from the time the products come in the back door as raw materials through all manufacturing process steps and off the loading dock as finished products. The lean VSM links all processes from raw material to final consumer smoothly. This results in a shorter lead time, higher quality and lower cost (Rother and Shook, 1999).

VSM can help to understand and streamline the manufacturing process and thus is mainly used as a communicational and strategic planning strategy to help manages, production engineers, dispatchers, suppliers, and customers find out waste and identify its reasons. (Value Based Management.net, 2010)

**2.6 VSM Measurable**

*Cycle time (C/T):* *Cycle time (C/T):* C/T is the total time taken from the start of the production of a product or service to its completion. In this paper it only means the proc-
essing time, doesn’t include the move time, wait time, and inspection time which doesn’t create value.’ (BNET Business Dictionary, 2010)

**Lead time (LD):** ‘LD is the amount of time between the placing of an order and the receipt of the goods ordered.’ (BNET Business Dictionary, 2010)

**Change Over Time (C/O):** ‘C/O is period required to prepare a device, machine, process, or system for it to change from producing the last good piece of the last batch to producing the first good piece of the new batch.’ (BNET Business Dictionary, 2010)

### 2.7 The Single Piece Flow

Liker and Meier (2005) mentioned the single piece flow, which is also called one-piece flow, is that products move continuously through the processing steps with minimal waiting time in the shortest distance; single piece flow represents the highest efficiency in producing industry (Liker and Meier, 2005). It also means that products pass one piece at a time from one operation to the next within priority of FIFO (first in-first out) (Dettmer, 2001).

According to Miltenburg (2001), due to the shorter and shorter product life cycles and the increased demands of customization for some goods nowadays, it is difficult to move production from batch flow to a line flow. However, the batch flow is just a temporary production system which is a transitory stage from job shop to line flow. Thus the customers may be discontent with the levels at the cost and quality of the product currently. In order to improve the levels of the outputs, the line flow principles are incorporated into the batch flow production system which is the so called single piece flow. The new production system produces the products in medium volumes. The physical flow is regular and paced by a cycle time of the equipments installed in the work cells. The single piece flow provides high levels of flexibility, innovativeness and qualitative outputs but with the high levels of the costs. (Miltenburg, 2001)

Liker (2004) gave the summary that single piece flow creates the real flexibility to respond in short lead time and manufacturing what the customer really wants. Shingo (1989) states the benefits of one piece flow as reducing production cycle time within lower batch sizes and reducing work-in-process. According to Rother and Shook (1996), single piece flow also aids in the continuous flow of products.

### 2.8 The Pull System

Dettmer (2001) mentioned the pull system as ‘a manufacturing philosophy based on synchronizing production objectives and rates with actual customer demand, rather than on forecast and arbitrary finished inventory levels’. Each workshop can be viewed as an isolated cell having its own supplier (the upstream work cell) and its own customer (the downstream work cell). When a customer order is presented, the agent process will fulfill the demand from the finishing product inventory. Just as the finishing products are taken from the finishing goods inventory, a signal is created to trigger the production of the upstream workshop so as to replenish the finishing product inventory. (Ghrayeb, Phojanamongkolkij, & Tan, 2009)

With the precondition of the general environmental issues, Spearman and Zazanis (1992) submitted the following benefits of pull system:

- There is less congestion in pull system.
Pull system are inherently easier to control than push system.

The benefits of pull environment owe more to the fact that WIP is bounded than to the practice of the pulling everywhere. (Spearman and Zazanis, 1992)

Material Requirements Planning (MRP) and Kanban are the representative systems of the traditional push and pull strategy. A hybrid system such as constant work-in-process (CONWIP) strategy has a more general applicability in a range of businesses and industries than the traditional pull system Kanban.

Liker and Meier (2005) reported that the terms pull or pull system are often used interchangeably. To differentiate pull from push, there are three elements of pull as following (Liker and Meier, 2005).

- ‘Defined: A defined agreement with specified limits pertains to volume of product, model mix, and the sequence of model mix between two parties (supplier and customer).’
- ‘Dedicated: Items that are shared between the two parties must be dedicated to them. This includes resources, locations, storage, containers, and so forth, and a common references time (takt time).’
- ‘Controlled: Simple control methods, which are usually apparent and physically constringing, maintain the defined agreement.’ (Liker and Meier, 2005).

2.9 5S System

Many organization workshops often have the disorder problems because of the larger numbers of people working together and countless hours of time engaged in very costly non value adding activities. Such problems exacerbate the business administrative work environment and these day-to-day workplace organization issues manifest into bigger problems such as: (Chapman, 2005)

- Long lead times.
- Low productivity.
- High operating costs.
- Late deliveries.
- Unreasonable ergonomic.
- Space constraints.
- Frequent equipment breakdowns.
- Hidden safety hazards. (Chapman, 2005)

5S is the name of a workplace organization methodology and a popular tool used in lean manufacturing environments to clean up; organizes the business environment for the sake of solving the problems above. The 5S system includes five steps. See Figure 2-4:
• Sort: To tidy the organization. It refers to go through all tools, materials and equipment etc., in the plant and work area, remaining only necessary items. Other things are piled or thrown off, which leads to less adverse impacts to the production work... (Masaaki ,1997 & Parrie, 2007)

• Set in order: To make the organization orderliness. Each item should be clearly labeled and systematically arranged for the easiest and most efficient access in order to promote efficient work flow. The requirements for arranging in order should include: storage should be simply organized with visual confirmation.; most frequently using tools and equipment are located closely to the employee; the tools, toolboxes and drawers need to be arranged visibly to open and close with less motion; work instructions is updated regularly and presented at the workstation; ergonomic guidelines should be used in work and tool design; key indicators should be showed by information boards to give guidelines for workers, product lines as well as production goals and status such as inventory, training, and calibration. (Masaaki ,1997 & Parrie, 2007)

• Shine: ‘Shine’ brings a workspace back to proper order by the end of each working day. It requires periodic systematic cleaning. There are responsible operators establishing the cleanup methods (such as tools, checklists, etc.). They inspect the results periodically to keep the workplace clean and neat. At the end of each shift, the work area should be cleaned and everything is restored to its place. This makes it easy to know what goes where, ensures that everything is where it belongs and is ready to use at any time. What’s more, it is important to make the daily work become a habit. (Masaaki ,1997 & Parrie, 2007)
Standardize: Standardize is used to maintain the first three S's and makes those duties into regular work routines. These methods should be standardized and followed by all the staff around company-wide. Once the first three S's are ready, the works and details are formulated into regulation maintained and continued every day. This regulation should consist of procedures and simple daily checklists, and should be posted in every work station. (Parrie, 2007)

Sustain: Once the previous 4 S's have been established, they become the new way and parts of the company culture. So the fifth ‘S’, sustain, makes the organization to sustain the previous 4 S's and does not allow the companies falling back into the old ways. (Masaaki ,1997; Parrie, 2007)

2.10 Layout
Facility layout is the configuration of facilities, work stations and equipments with specially emphasis on the motion of customers, materials and information through the system. Facility layout involves process layouts, product layouts, fixed-position layouts, hybrid layouts (combination) as well as cellular layouts. (M&DC, 2010)

Process layout is also called Functional Layouts or Flexible-Flow Layouts. It is a layout configuration organizing the materials, employees and equipments by function rather than by service or product. Process layout is often set in work shops or companies which produce customized, low-volume products that demand different handling requirements and steps of operation. It is facility group with similar nature of activities together in departments of job cells. (Reference for business, 2010; M&DC, 2010) See Figure 2-5.

![Batch and Queue Production](https://via.placeholder.com/150)

However, this traditional process layout is incommensurate to the changed conditions of pull system and single piece flow. (M&DC, 2010) It has disadvantages as following:

- The slow processing rates and long lead time.
- Physical storage in a process layout must be large to accommodate the large amount of WIP.
- Costly physical processing and variable path tactics.
- Production planning is more difficult. (M&DC, 2010).

Cellular layout is a configuration that equipments are grouped in a sequence to support a smooth flow of materials and components through the production process. The machines are grouped based on the similar item characteristic and require similar processing. The groups are called cells. Cellular layout combines the flexibility of process layout with the efficiency of product layout, allows products moving through the manufacturing process one-piece at a time. On an extreme condition, it takes a single product to flow through the entire manufacturing process. (M&DC, 2010; Reference for business, 2010) See Figure 2-6:

![Cellular Layout Diagram](image)

Figure 2-6: Cellular Layout.

A study by Assad, Kramer and Kaku (2003) compared the process layout and cellular layout, showing that cellular layout system can reduce flow time as opposed to job shop configuration.

To be simple, cellular layout has such advantages to enhance the single piece flow:
- ‘Reduced material handling and transit time’
- ‘Reduced setup time’
- ‘Reduced work-in-process inventory’
- ‘Better use of human resources’ (M&DC, 2010)

### 2.11 Requirement Triggered Kanban System

Kanban was originally invented by Toyota Motor related to its Just-in-Time (JIT) Production system. Products are produced according to the rate of demand under the Kanban
control system. Demands are fulfilled to meet the customer through the chain of material and information. In 1953, Toyota used this methodology in their main plant shop. (Ohno, 1988)

Hobbs (2003) stated Kanban as ‘a material presentation method by providing simplification of material handling and inventory management’. Materials are replenished by the kanban signal rather than production schedule.

There are two kanban types, which are production kanban and withdrawal kanban. According to Tufekci (2009), Withdrawal Kanban is used to carry a predefined kind and quantity of components from an upstream process to the downstream process. Parts cannot leave the container without signal. The withdrawal kanban is removed from the container only when the materials are demanded by the downstream manufacturing process. This is shown in figure 2-7.

Withdrawal kanban is suggested when the two connective inventory buffers need be installed between two production processes. Withdrawal kanbans are not required when the two production processes are close enough. (Tufekci, 2009)

![Withdrawal Kanban Diagram](Source: Suleyma. KANBAN CARD CALCULATIONS)

Production kanban specifies the quantity and type of the production to the preceding process for the downstream manufacturing process. The production is originated and passes from the first workshop to the final stock. (Tufekci, 2009). See Figure 2-8.

Tufekci (2009) also pointed that if the manufacturing process represents a single machine in a extreme condition then it is a classical one machine production kanban environment. If process involves many machine stations, a CONWIP structure is formed. We will talk about CONWIP in the following part.
These two kinds of Kanban are always attached to the containers holding parts. The Withdrawal Kanban shows the kind and quantity of product which a production process need to withdraw from the preceding process. The Withdrawal Kanban is removed from container and carried to the buffer of the upstream process by a worker to withdraw the parts. The Kanban card is attached to the container holding part. The withdrawal kanban passes authorization and fills the information gap between the upstream stage and downstream stage. (Sugimori, Kusunoki & Uchikawa, 1977)

Then, the Production Kanban attached to the container holding part is removed and delivers information for the internal process. Parts are produced to replenish the inventory buffer consumed as quickly as possible. (Sugimori et. al, 1977)

Thus, as Sugimori et al. (1977) pointed, ‘the production activities of the assembly line are connected in a manner like a chain to the preceding processes or to the subcontractors and materialize the just-in-time production of the entire processes’. See Figure 2-9:
2.12 CONWIP

CONWIP is the abbreviation of *Constant Work-In-Process*, indicates a control system that confines the total number of parts into the production line simultaneously. (Spearman et al, 1990) CONWIP is a generalized form of Kanban. Like Kanban, it relies on signals. In a CONWIP system, the cards travel a circuit along the entire production system. There is one card attached to a standard container of parts at the beginning of the line. When the end container is consumed, the card is removed and sent to the beginning to ultimately be attached to another container of parts. (Hopp and Spearman, 2001).

**Figure 2-9: Flow of parts and Kanban.**

**Figure 2-10: CONWIP control system.**
Source: Analyzing Kanban and CONWIP controlled assembly systems. Ghamari, 2006
2.13 Order Penetration Point

The order penetration point (OPP) represents the different stage in the manufacturing value chain, where different product relates to different, specific customer order. Sometimes the OPP is also called the customer order decoupling point (CODP) to emphasize the involvement of a customer order. (Olhager, 2003) Berry and Hill (1992) believed that the OPP strategy choice is a choosing of production planning approach, making decision between make-to-stock (MTS), assemble-to-order (ATO), and make-to-order (MTO). This approach is further developed by Vollmann et al. (1997) and Hill (2000).

Different manufacturing environments relate to different positions of the OPP which shows the ability of the manufacturing operations to adapt the wide product range. (Olhager, 2003) See Figure 2-11. Thereby, ‘the OPP divides the manufacturing stages that are forecast-driven (upstream of the OPP) from those that are customer-order-driven (the OPP and downstream)’. (Olhager, 2003)

<table>
<thead>
<tr>
<th>Product delivery strategy</th>
<th>Design</th>
<th>Fabrication &amp; procurement</th>
<th>Final assembly</th>
<th>Shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make-to-stock</td>
<td></td>
<td></td>
<td>OPP</td>
<td></td>
</tr>
<tr>
<td>Assemble-to-order</td>
<td></td>
<td>OPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make-to-order</td>
<td>OPP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineer-to-order</td>
<td>OPP</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2-11: Different order penetration points. The dotted lines depict the production activities that are forecast-driven, whereas the straight lines depict customer-order-driven activities.

Source: Olhager, 2003. Strategic positioning of the order penetration point

**Engineer-to-Order (ETO)**

This logic is applied by the company produces customized production; the large construction program often adopts this manufacturing approach. (Fogarty, Blackstone & Hoffman, 1991, 1991.p.2-3)

**Make-to-Order (MTO)**

MTO is also called as the pull strategy and many companies take this approach. The company produces goods based on actual customer demand instead of sales forecast. The products are standard design, while parts production and assembly of the final product is based on the need put forward by the final customer; inventories are decreased and eliminated, however customers now need to wait for delivery. (Fogarty et al., 1991.p.2-3)

**Assemble-to-Order (ATO)**

Key components are made and stocked in the expectation of the customer’s requirement; the product or service is built on the sales order. This supposes a large number of modular products can be built from common components and parts; Dell's approach of planning production in customizing is a representative example. (Fogarty et al., 1991.p.2-3; LO-ASM SAP AG, 2001)
Make-to-Stock (MTS)

This approach is commonly used as the push strategy. Products are produced according to a sales forecast. Goods are sold to customers from the inventory held at the end of the supply chain; this logic is usually applied by grocery and retail merchandises. (Fogarty et al., 1991.p.2-3)

Olhager and Ostlund (1990) discussed the use of push and pull systems related to the position of the OPP, arguing that pull-type systems are applicable upstream of the OPP and push-type systems are necessary for downstream operations.
3 Methodology

In this chapter, the choice of methodology will be presented by authors, including the choice of method, research approach, case design and data collection, etc. And then, the reasons and analysis of choosing methods will be introduced. Reliability and validity can be presented in the final part.

3.1 Choice of Method

The research methodology can help the researchers to put in force and achieve their goal of a research or a study (Holme & Solvang, 1997). In order to make the result of our research more accurately and easily understanding, the methodology we used must integrate with the fact and truth (Denzin, N. K, 1978). Generally speaking, there are two possible methodological approaches can be chosen, including the quantitative method and the qualitative method. According to Holme & Solvang (1997), “the choice of methodological approach is strongly based on the information investigation, the problem identification, the purpose and finally the current research questions of the research”. Moreover, a qualitative study enables the researchers to gain rich and deep understanding of the studying content and concepts by gathering relevant information in a flexible way (Holme & Solvang, 1997). Since the authors would do this paper depends on studying relevant information and will collect the data themselves, the choice of method for this thesis was a qualitative method.

As McDaniel’s and Gates (2005) mentioned in their book, a quantitative method always based on studying statistical information and is often used to find out the relationships between different variables. A quantitative method is formalized with highly structured level of control, while a qualitative method is on the other hand formalized with more flexibility (Holmes & Solvang, 1997). Holmes and Solvang (1997) further stated that a qualitative method always can provide a deeper understanding about a research subject. “A qualitative method is therefore also sufficient doing investigation of standpoints and values among respondents” (McDaniel’s & Gates, 2005). Consequently, in our opinion, a qualitative approach was the best suitable choice for this paper. To fulfill the purpose of this thesis, a deeper understanding of how to apply lean thinking as a guide in a manufacturing process was needed. The authors of this thesis believed that these experiences and relevant information could best be found easily by using a qualitative method as a research approach.

3.2 Research Approach

Generally speaking, there are two main research approaches, which are named as deductive approach and inductive approach (Wigblad, 1997). The selection of an appropriate approach has to be according to the research object, research purpose, problem definition and the scientific theories, etc (Lundahl & Skårvad, 1999).

Figure 3-1 below shows the relation between reality and theory when using a deductive or inductive specific approach.
An inductive approach often can be used for a number of single case studies and assumes that a connection in all these cases is also generally valid (Mats Alvesson and Kaj Skoldberg, 2009). In this research paper, the authors used a case study method together with studying collected information and existing reports and documentation. In addition, an inductive approach is usually combined with a qualitative research method (Wigblad, 1997; Bryman & Burgess, 1999), especially for a case study method. Based upon the discussion of Lundahl & Skärvad (1999), “an inductive approach starts with the empirical data and thereafter creates theories based upon these facts. On the other side, a deductive approach bases on establishing theories, drawing logical conclusions and then testing these conclusions through empirical studies” (Lundahl & Skärvad, 1999).

The scientific approach in this thesis is inductive, since the authors use this method together with an explorative case study. For example when the authors explored peoples’ opinions about their views on their work situation, one can generally conclude on the peoples’ work motivation.

### 3.3 Case Study

To be able to answer the research questions and fulfill the purpose, a case study strategy would be applied in our thesis. The advantage of a case study method is to provide the researchers with further insight and understanding of a complicated fact, together with widen experiences or add strength to what is already known from previous research (Yin, 1994, p. 56). A case study method focuses on a limited number of events or conditions, and gives out the detailed analysis of the facts and identification of the relationship (Robert K. Yin, 2007, p.76). Researchers have applied the case study research method for many years across different areas and disciplines. According to Robert K. Yin’s (2007) definition, the case study research method can be described as an empirical inquiry that investigates a contemporary phenomenon within its real-life context under the situations that when the boundaries between phenomenon and conditions are not obvious; and when the multiple sources of evidence are applied during research process (Yin, 1994, p. 23).

The reason why the authors choose doing a case study was because of the complexity of studying a manufacturing process. The purpose of this paper was to analyze the wastes occurred in production process and give out the solutions by implementing lean as a tool, and
finally make out the results and benefits after optimization. To be able to achieve this purpose, the authors of this thesis need to gain a deep insight and understanding on lean thinking and interrelated experiences of how to operate manufacturing process by using lean concept. Otherwise, investigating a manufacturing process was a complex procedure, so it was further hard if our research areas would be even widen. What a case study can do but other methods cannot complete is to examine everything in detail. In the case studies, the relationships between issues and the research processes played essential roles which can lead to the consequents. The advantages of using a case study approach is that it generate the opportunity to not only find out what the outcomes are, but also provide the answer that why the final outcomes might happen (Martyn Denscombe, 2003). Consequently, a case study was an appropriate method for our research. Furthermore, a case study is also designed to bring out the details from the viewpoint of the participants by using multiple sources of data (Stake, 1995), which is another important reason for choosing this method.

### 3.3.1 Single-case Study

Yin (2003a) state that there are as a minimum six types of different case studies. First, case study can be based on single- (focus on one event) or multiple- (focus on two or more events) case studies. Single case study may be used to confirm or challenge an existing theory, or to represent a special or extreme case (Yin, 1994). Single-case studies are also quite appropriate for revelatory study where the researchers may find a new phenomenon that was not dealt with in previous researches (Yin, 1994). Multiple-case studies can be included in replication logic; it often covers a number of cases which are under similar situations (Levy, 1988). The authors of this thesis chose single case study method, since we believed that only focus on one detailed case would bring on deeper understanding and insights of our topic in matter. Although the outcome of this research is quite applied for this company, the authors hope it can be used for other enterprises that have the same tough situation after the research. According to the reasons we mentioned above, a single case method was applied in our thesis.

### 3.3.2 Exploratory Single Case Study

According to Yin (1993), no matter the method of case study is single or multiple, the case study can further be defined as exploratory, descriptive or explanatory. An exploratory case study targets to define the questions of a later research or at determining the feasibility of the desired research procedures. On the other hand, a descriptive case study aims to present a complete description of a phenomenon within its context. An explanatory case study instead presents data bearing cause-effect relationships - explaining how events happened (Yin, 2003a).

As mentioned above, the purpose of this thesis was to design a more optimize manufacturing system and analyze the results and benefits after implementing lean for an American furniture named KAMA. Our aim was to examine which factors will influence the manufacturing process and how the companies can improve and facilitate this process by using lean thinking as a guide. To achieve this, profound knowledge of how a successful lean manufacturing process operated was needed. The authors of this thesis believed that by studying and designing a manufacturing process for one single company can receive a greater insight and understanding of the problem together with the lean manufacturing process.

To come up with a guideline or possible suggestions on how this company can optimize and improve their manufacturing process, the authors of this thesis consider that we must
first examine and learn the existing manufacturing process of another companies which have applied lean successfully. Next, we need to identify the problems our target company faces and analyze the situation. Finally, the possible solutions will be suggested. The authors believe that defining the questions of a later research or at determining the possibility of the desired research required fulfilling the purpose of this thesis. That is the reason why the exploratory single case study was the most appropriate method for this research. In order to achieve this “Exploratory single case study”, a company which could provide the researchers with some valuable information was needed. The selection of such an appropriate empirical base of information will further be described in the following chapter.

3.4 Case Design

We prefer a single-case study method as our case study strategy. First of all, we built a contact with the company. One of the authors has communicated with the managements when she was in America, so it is not hard for the authors to continue the touch with the target company. Having contacted with the company, the authors began an investigation of the manufacturing process and current value stream of Company KAMA’s products under the real context by implementing some sources, including interviews with the management of Company KAMA, study of internal documents and researches from EIMI’s project reports. In addition, we merely focus the manufacturing process and identify the wastes happened under this process, other phenomenon cannot be controlled.

In the following, there are our two research questions:

RQ1: How does the project help the company to redesign their production line by adopting lean as a tool?

RQ2: What are the results and benefits by implementing lean manufacturing for the company?

In order to answer our research questions, the following methodology is presented in the following Figure 3-2.
The interviews with the KAMA’s managements, internal documents of the company and project reports of EIMI together with lean thinking, can be implemented as a guide for identifying value and wastes and analyzing value stream map. Having using the gathered information from all above data collection methods, the authors made a draft of the current state map (CSM) of the company in order to identify the wastes happened in the KAMA flow. As the result of the analysis, the solutions of reducing the various wastes were presented and drawn in a draft of the future value state map of KAMA products flow.

### 3.5 Research Limitation

During the research process, the authors encountered some problems that might limit the paper result. Firstly of all, the authors had a language barrier when they made a communication with the company managements. Although the authors tried to eliminate or minimize the difficulties to a certain extent, there are misunderstandings while conducting an interview. And then, the distance between authors and KAMA Company limited the approach of communication, the only way that could make a conversation with the company managements was using telephone. In addition, another problem that the authors met during interview was time arrangement. Since the interviewees were always busy with their
own daily work, they did not have long time to answer our questions.

Furthermore, the company produced various series of products; the authors cannot consider all of the products in this paper. We have chosen the office chair components manufacturing flow as our target products series, and especially focus on products R-18 and R-20.

Apart from the limitations the authors mentioned above, the most serious problem we met was 6 hours time difference between Sweden and America. The authors have to consider and plan the reasonable interview time which was possible for both Sweden and America.

### 3.6 Data Collection

Data Collection is an important factor for any type of research study. The accurate data collection can finally bring on valid results. Any information and different kinds of data could be divided into two types, including primary data and secondary data which according to who collected them (Patel & Davidsson, 1994: 56). If the data is collected by researchers themselves, the data is considered as primary data, while other data collected by other persons are referred to as secondary data (Anderson, 1998: 150). Since the aim of this thesis is to study the lean manufacturing process in order to come up with some suggestions on how this Company KAMA could improve and optimize their manufacturing process by using lean thinking, a profound interrelated knowledge was needed about the lean production process. In addition, the authors need to learn and understand the current situation and problems the company faced. Consequently, both primary and secondary data have been used in this thesis. Primary data was collected through telephone interviews with company management, while secondary data was instead obtained by studying some previous reports, researches as well as company’s internal documents.

Table 3-1 presents an overview of different kinds of data collection techniques.

<table>
<thead>
<tr>
<th>PRIMARY DATA</th>
<th>SECONDARY DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stimuli</strong></td>
<td><strong>Non-stimuli</strong></td>
</tr>
<tr>
<td>Qualitative data</td>
<td>Observation techniques</td>
</tr>
<tr>
<td>Unstructured and semi-structured interviews</td>
<td>Indirect techniques</td>
</tr>
<tr>
<td>Projective techniques</td>
<td></td>
</tr>
<tr>
<td>Psychological tests</td>
<td></td>
</tr>
<tr>
<td>Quantitative data</td>
<td>Observation techniques</td>
</tr>
<tr>
<td>Standardised/structured interviews</td>
<td>Indirect techniques</td>
</tr>
<tr>
<td>Questionnaires</td>
<td></td>
</tr>
<tr>
<td>Psychological tests</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-1: Overview of different kinds of data collection techniques.

Source: Anderson, 1998: 151

### 3.6.1 Collection of Primary Data

Primary data collection methods involve individuals collecting data for themselves by using means such as interviews or questionnaires. The main characteristic of primary data collection is that the information collected by researchers is unique to the individual and their research. Furthermore, the primary data is not seen by anyone else until after it has been published. A number of different methods of collecting primary data are used including ques-
tionnaires, interviews, focus group interviews, observations, case-studies, diaries, critical incidents as well as portfolios (Tellis, W. 1997b).

Since the company the authors studied was an American furniture company, the distance was a big problem. The author cannot use face-to-face interview or meeting to collect primary data. Consequently, telephone interview was a better method.

### 3.6.2 Telephone Interview

The purpose of interview is to collect useful information about our research and gain a deep understanding of a manufacturing process of the target company.

The primary data is collected by the authors by doing open unstructured personal telephone interview with Drew Schramm working at Company KAMA, in America. The Figure 3-3 below presented the internal organizational structure of Company KAMA so that the readers could learn the positions of our interviewees in this paper.

![Organizational Structure](image)

**Figure 3-3: Organizational Structure.**  
*Source: Internal Company Documents*

The reason why the authors using unstructured interviews was to let the respondents formulate their own answers and to have a high flexibility. During the telephone interview process, since the authors have language and communication equipment barriers, the interview would be recorded and played up on a speaker phone in order to ensure that the risks of losing and misunderstanding of information would be as low as possible. The interviews were also according to template of possible physical actions in the manufacturing process, assembling and delivery of components. The telephone interviews conducted by the authors are shown in Table 3-2 as following.

**Table 3-2: Overview of Interview**
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drew Schramm</td>
<td>Senior V.P. of Supply Chain Management</td>
<td>2010-04-06</td>
<td>11:00am</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>USA Time</td>
</tr>
<tr>
<td>Don Goeman</td>
<td>Executive V.P. of Research, Design and Development</td>
<td>2010-04-11</td>
<td>2:00pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>USA Time</td>
</tr>
<tr>
<td>Judy Leese</td>
<td>Workshop Knowledge Consultant</td>
<td>2010-04-16</td>
<td>10:00am</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>USA Time</td>
</tr>
<tr>
<td>Drew Schramm</td>
<td>Senior V.P. of Supply Chain Management</td>
<td>2010-04-21</td>
<td>10:00am</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>USA Time</td>
</tr>
</tbody>
</table>

### 3.6.3 Collection of Secondary Data

Secondary data is a historical data that was collected by former or other researchers and can be found in the internal documents of the company, in library, or might be on the Internet, etc. The authors used secondary data to understand the feature and nature of product, for instance, the product R-20.

Moreover, secondary data helped the authors to gain a deeper understanding of the supply chain of KAMA and learn more about their internal structure of the company.

### 3.7 Data Analysis

Data cannot be translated by itself, thus it has to be interpreted by the researchers (Repstad, 1999). The analysis of the data is the process where one is trying to gather and present the data in such way so it has a good structure and becomes easy to understand (Repstad, 1999). During the analysis the information is being consolidated, reduced and in some cases interpreted (Merriam, 1994). The goal of the analysis can be able to come up with trustworthy conclusions which are based on the empirical data.

When carrying out the analysis it could be a good idea to go back and look at the initial problem discussion and purpose to ensure the connection to the purpose (Merriam, 1994). Robert Niles (1997) mentioned on his website that the data analysis usually depends on interviews or questionnaires that are written down by the researchers. The data needs to be interpreted and it is then vital that the researcher performs this with the aim that the respondents and readers can understand the information in the analysis process (Robert Niles, 1997).

The data analysis process is quite significant for our research, so the data must be handled seriously (Seale, C. 1999). Firstly, we will record and write down the contents of each interview after conducting them. And then, we need to listen to the record and read the written information again to make sure both of us have understood them clearly. Next, these messages need to be analyzed and interpreted by the authors. If there were lots of information exists in one telephone interview, it might be necessary to make it shorter through selecting
the most distinct and important comments (Stenbacka, C. 2001). Having made completed comments; we will analyze the data and make a comparison between the interviews. In addition, we will compare the empirical study and the theoretical study through analyzing the data which has been collected in relation to existing theories. The combination of the data gathered from the empirical study and our own data interpretation can educe the key factors which make the manufacturing process further successfully. These critical success factors need to be evident in order to perform a successful implementation of lean as a solution and to reach the desired effects of such solution. It is easier to depict the effects caused by applying lean, but more difficult to make clear interpretation and analysis of the outcomes and how these changes make effects on KAMA’s manufacturing process.

3.8 Validity

Validity means the researchers have to make a depth access to the knowledge and meanings of the subject which has being studied (Easterby-Smith et al., 1991). Empirical variables and the theoretical concepts are the two general and the most essential parts of validity (Easterby-Smith et al., 1991). According to Saunders (2003), “the validity of documentary data is difficult to assess, therefore the data collection method needs to be examined to ascertain the precision needed by the original primary user”.

Before we started our research, we have designed a brief interview guide in order to avoid any leading question during the interview process. The interview questions have been chosen seriously. Any question is highly relevant to the concept and theory regarding the areas of our research and can bring us an insight understanding of our focus. This contributes to the validity of the study. Something that could affect the validity negatively is if the mixes of questions in the interviews are not ultimate (Creswell, J. W. & Miller, D. L, 2000). Since our study is an explorative case study, the reality cannot be found out in advance, but will come out during explorative process. Furthermore, because of the time and distance limitation, we might miss some relevant questions; it would affect the validity negatively. The authors conducted and analyzed the interviews together in order not to miss relevant information, and hence, to raise the validity. The interview respondents are top managements of the company of focus for our research. The top managements should have the most accurate knowledge and perception regarding the company’s strategies and current status. This is therefore raising the study’s validity (Wainer, H., & Braun, H. I. 1988).

In our opinion, the internal documents of the company are quite important and accurate for our research, since these documents are collected by former researchers and will be used by the current managers. In addition, we have used the company’s website when collecting background information about the company which can enhance the validity of our study.

In our opinion, a case study, especially a single case study, can strengthen the relevant of our research. The detailed information and data we collected help us make a deeper insight of studying lean thinking and how to implement lean into manufacturing process. Thereby, a clear connection can be seen between the empirical findings, the theoretical framework and the purpose of our thesis.

3.9 Reliability

When discussing the reliability of a qualitative study, there are two general problems. Firstly, there is a communication problem between the interviewers and the respondents during data collection process. The data cannot be alike each time according to many conditions,
such as questions, the respondents’ emotion, misunderstanding of interviewers, etc (Strauss, A. & Corbin, J, 1990). Therefore, it is difficult for different researchers to gain the same results in the later study. The second problem is that the consequent and result of a research mainly depends on the researchers’ analysis and understanding. Thus, because of the dissimilar investigation condition, it is difficult to attain a high-leveled reliability when another researcher conducts the same study (Clont, J. G, 1992).

In order to increase the reliability, we discussed our course of action before we designed the interviews, conducted the interviews and also analyzed the interviews. We asked all the managers questions in the same way, so that not to affect them in different directions. Since our interviews were all telephone interviews, there is the disadvantage that if the respondent does not understand the question, we could not explain it more clearly. Therefore, we sent the respondents the interview guide in advance so that they could read the questions before the interview and make better preparation.

We tried to explain the reasons why we made the choices as detailed as possible and the methods we used in order to enable the readers understand our research further fairly and raise the reliability of the paper. Both of us have attended all the interviews and discussions so that the decisions and impressions would be made together. This will also enhance the reliability of the results of our study. Further, we will use a recorder during the interviews in order to reduce or eliminate the misunderstanding of respondents’ words.

We also considered that if someone else makes interviews with the same respondents, the outcomes would be different. We believe that the information and data we collected about the manufacturing process are correspondingly accurate, since all the participants have many years of experience and knowledge of the company’s manufacturing process. In the cases when it has been necessary to follow up initial responses to clarify uncertainties we have conducted the follow-up questions by e-mail or telephone.

3.10 Summary

To get an overview of the methodology choices, a summary is presented below in Figure 3-4.
4 Empirical Studies

This chapter is to present an introduction of Company KAMA, including its historical development, current situation, products, etc. There is also an introduction of EIMI Consultant and their lean project.

4.1 The Introduction of Company KAMA

Furniture Company KAMA is a professional furniture manufacturer in the USA, which is in design, development, production and oversea marketing. Figure 4-1 presents global ratio of KAMA’s market. The production department includes of office table workshop, cabinet conference table workshop and office chair workshop. The most important products of the company are office furniture (Company KAMA’s website).

The company has 17 years’ experience in office furniture manufacture and 12 years’ exporting history. It gains great reputation in oversea office furniture marketplace since 1999. In Additional to participating in CIFF annually, they also show their products circuit in different oversea exhibitions, such as Dubai Index in U.A.E, Orgiastic in Germany, MIFF in Malaysia and NeoCon in U.S.A, which lead them became a 100% export-orientated production enterprise (Company KAMA’s website).

By the rich experience both in production of exporting product and the knowledge of quality standard or special requests in different countries, the structure of products, selection of raw material and quality control are more suitable for the global importer and distributor’s demand, which strengthen their competitiveness in global office furniture market (Telephone Interview with Don Goeman, 2010-04-11).

After 12 years’ endeavor, the company accumulated rich exporting experiences and set up an excellent export sales group that enable their clients to obtain a direct and the most effective solution when they are communicating and handling problems with the customers, which completely avoided the high export charge, delay shipment, mistake production, unstable and inferior quality irrational structure owning to raw material cost increase and
USD currency devaluation, assembly cost increased, structure and quality misfit local marketing and other problems result from lacking experience. With the rich export experience, they can handle all export procedures smoothly (Internal Documents of Company KAMA).

Judy Leese promised that we could replace the defect product unconditionally except for man-made damage. Even though a few parts damaged during assembly, we can send the replacements free, hope we could get your recognition in our professional before service and after service (Telephone Interview with Judy Leese, 2010-04-16)

4.2 Present-day of Company KAMA

The company owns more than 20 representation offices all over the world and 150 manufacturing facilities. Manufacturing facilities make up of several departments such as stamping, cutting, sewing, assembly, wood team, painting, and warehousing (Telephone interview with Drew Schramm, 2010-04-06).

The management structure of the company is shown in Figure 4-2:

![Figure 4-2: The management structure of Company KAMA. Source: Internal documentation of Company KAMA](image)

Company KAMA has several suppliers and sub-suppliers. However, in this paper, we only mentioned one provider named Supplier X as example, which supply several types of chair raw material. ‘Our company purchases approximately 65 percent of needed raw materials from the Supplier X’. (Telephone interview with Drew Schramm, 2010-04-06) The measures of choosing this supplier were its flexibility, reliability, and the good quality of raw materials. (Telephone interview with Drew Schramm, 2010-04-21)

4.2.1 Production Flow of Company KAMA

Now the company’s products have full range of office furniture, including wood furniture line, melamine furniture line, office chair and office sofas line, almost 30 different kinds of models. You can see clearly and fully for how each product finished from first step to the last step.
Costs have been cut down 6% because of new technology implement and great production in the recent years. Production output in the year of 2006 has 30% of improvement compare production value date year 2005.

You can see clearly how wood furniture line, melamine furniture line and soft furniture line from beginning production till finish in all the procedure below:

Figure 4-3: Product Procedure of Wood Products (1).
Source: Internal documentation of Company KAMA.
Figure 4-4: Product Procedure of Wood Products (2).
Source: Internal documentation of Company KAMA
4.2.2 Products of Company KAMA

The product categories of Company KAMA are various including the standard offerings such as, conference table family, melamine family, sofa family and office chair family (Company KAMA USA homepage).

We selected to study and focus on the flow of the office chair product family, some examples of the series are listed as follows, see Figure 4-6. KAMA’s office chair family is the original product family of the company, thus the production and value flow is correspondingly mature.
4.2.3 The Value Supply Chain of Office Chair Family at Company KAMA

There are four main factors involved in the supply chain procedure of KAMA. See Figure 4-7.

**Supplier X**

We mentioned the top raw material supplier of Company KAMA as Supplier X due to confidential concerns. Supplier X provides the largest and the most comprehensive range of raw materials with the company yearly. It affords not only warehousing and shipment services but also offers manufacturing support, logistics and business solutions (Internal documentation of Company KAMA). In this paper, we mainly focus on studying manufacturing process, thus we do not mention much about Supplier X.

Company KAMA purchases fabric, leather and other special profiles from Supplier X. Supplier X sells about 65% of elements and other special profiles to Company KAMA per year (Interview with Company KAMA, 2010-04-06).

**Company KAMA’s Mechanical Workshop**

Company KAMA’s mechanical workshop involves various types of activities, including stamping, cutting, sawing, welding, drilling, painting, and etc. ‘There are about 80 persons work in the mechanical workshop out of 140 who work in the other production workstations such as wood team, packing and warehousing’ (Telephone interview with Company KAMA, 2010-04-21). The components made of different materials transferred through the different manufacturing processes. There are also some automatic machines instead of hand-make processes.

The production process of different office chair can be processed at the same time. In a word, the entire manufacturing process of an office chair consisted of three separated but parallel processes. The lead time is about two weeks.

Figure 4-8 presents detailed production process of soft furniture products.
Outbound Logistics Companies

The outbound logistics providers play an important role under the Company KAMA’s value chain. However, our focus is based upon the production process flow. Thus, we do not pay much attention on the outbound logistics providers in this paper.

In order to ship the products to the customers, Company KAMA mainly employs the logistics providers for this service, such as DHL. How to choose a provider is a serious process. KAMA chooses its proper logistics providers depends on their credit standing, speed, facilities, geographical capability, locations, histories, etc. Company KAMA had signed a long-term agreement with DHL. According to the agreement, if the orders were prepared to be shipped, KAMA had to reserve the shipment one day in advance. The logistics providers have to pick up the customer orders from Company KAMA several times per day. (Telephone interview with Drew Schramm of Company KAMA, 2010-04-06).

Customers

The customers of Company KAMA can be divided mainly into the five groups including 1) private use; 2) governmental organizations; 3) counties; 4) hotels; and 5) normal companies. The normal companies are the most important and largest customers of Company KAMA. They amount of selling products to normal companied holds approximately 66-72% of all customer groups. (Telephone communication with Drew Schramm Company KAMA, 2010-04-06).
We have to notice here that the all types of customers mentioned in the former part are not the final users. Except for those private users, the other groups of customers purchased the chairs for their end customers. Thus, the final users are all people who use the products.

Furthermore, we do not mention more about the customer flow, since we pay more attention on the flow under manufacturing process.

### 4.2.4 Order Fulfillment Process

Order fulfillment process of Company KAMA is very complicated. It includes various activities, such as order entry and order shipment, which are parallel important for delivering products to the customers. The order fulfillment process is shown in Figure 4-9 below.

![Figure 4-9: Order fulfillment process.](Source: Internal documentation of Company KAMA)

### 4.3 The Introduction of Project

Due to the increasing pressure of rapid competition in the current furniture marketplace, Company KAMA plans to improve the efficiency of manufacturing process and reduce wastes by using lean thinking. They begin a lean project with the help of a consultant which named Consultant EIMI aiming at design a more customer-oriented production line. Although the project has not been completed yet, there is a long-term prospect that the company will gain benefits and improvement for the whole supply chain process, especially for production process.

This new project described a lean pilot project conducted in 2008 with Company KAMA that implemented lean methods to improve the productivity during manufacturing process and reduce wastes under the whole supply chain, especially manufacturing procedure.

#### 4.3.1 Project Objectives

- Evaluate the benefits of lean practices.
- To gain insight understanding for implementing lean in production process
- Get experience for future project
Identify and analyze unnecessary wastes.

Find out solutions for the reductions of wastes

Improve productivity and efficiency

(Internal documentation of Company KAMA)

4.3.2 Project Activities and Results

This lean project was put in practice by three teams, the fabric & leather team, the wooden team and the elements team, which will be described below. The staff worked for Company KAMA and for Consultant EIMI would share their jobs and information together; it means that the staff will be cross-functioned. These three teams implemented value stream mapping together with lean to improve manufacturing activities, and attended KAIZEN activities to use lean thinking. During these lean activities, the teams identified and analyzed the costs and wastes in the whole production process, and then tried to find out proper solutions.

The collective efforts of Company KAMA’s lean project resulted in considerable benefits both for company’s operational function and financial function. The improvements of manufacturing process conducted reduction in costs, wastes, lead time, overproduction, unnecessary inventory, unnecessary motions of operators or workers, etc.

As a result of the project, Company plans to realize $0.79 million per year in cost savings. Company KAMA expects to save an additional $115,000 in raw material and waste reductions and 1,500 labor hours from the pending investment of three cross-cut saws. The saws are expected to increase the efficiency of wood ripping and reduce the equivalent of up to 18,000 wood sheets per year (Internal documentation of Company KAMA). Additional benefits would be generated by the lean project, such as improvement of product quality, customer service, staff safety and health, etc.
5 Analyses

This section begins with a simple introduction what Company KAMA’s customers’ value is. Next, the authors draw a draft of the company’s products’ current value map, including the time structure and order fulfillment procedure. In addition, analysis part targets at waste identification and would give solutions of wastes’ reduction. Finally, according to the completed analysis mentioned in the former part, we visualized and identified the future value stream map of the company.

5.1 Lean Manufacturing Principle-Specify Value

The first step in lean manufacturing is to understand what value is, which activities and resources are absolutely necessary to create that value and which are not. According to Womack and Jones (2003) value is defined by the end customer and created by the producer, which means, consumers translate product or service attributes into benefits (or consequences of use) and then into their own value orientation, in a hierarchical representation (Gengler & Reynolds, 1995). Thus, values are beliefs that guide actions and judgments through specific objectives and situations, beyond immediate objectives to deeper end-states of existence (Olver & Mooradian, 2003; Rokeach, 1968). Four steps are required for one to be able to specify the value and these are (Björnfot, 2006; cited in Gustavsson & Marzec, 2007):

- Define the customer
- Define what is of value to the customer
- Define what is of value to the delivery team
- Define how value is specified by products

5.1.1 Define the Customers

Value is the critical starting point for lean thinking, and can only be defined by the ultimate end customer. Due to the complexity of modern manufacturing technology and the numerous industrial processes, there are great numbers of interim participants contrasted with the ultimate end customer, or the user of the product. Specifically to the official chair manufacturing, there are developers, designers, sales agents, marketing agents, general contractors, sub-contractors, distributions, fittings suppliers, leather suppliers, and the heavy equipment suppliers and so on. In this case the end customers are the private people who buy and use the chairs. There may be many sales agents and furniture retailers in the supply chain pipe before the chairs are coming into the possession of the consumers, but only ones who take possession of the chairs and translate the value into benefits by consumption are the ultimate consumers.

5.1.2 Define What is of Value to the End Customers

Michael J. Lanning and Edward G. Michaels (1988) gave a clear, well-articulated view of value creation and delivery process in their staff paper ‘A business is a value delivery system’ which emphasized that the modern view of value creation and delivery process starts
from the customer wherein the companies have to create value first before they undertake operations to deliver the same. The process of value delivery is divided into three components namely choosing the value, providing the value and then communicating the value.

**Choosing the Value**

Choosing the value is a set of activities undertaken before the product (offering) is developed. To genuinely choose a value the business needs to have a clear specific statement of it, not just a feeling. It is oriented on the markets and starts from customer segmentation to develop value. The decision making of value adding confines to limited numbers of numerous options considered only from the consumers aspect and every function and department (not just manufacturing) understands it and uses it to closely guide their everyday operational decision-making. (Generated from Michael J. Lanning and Edward G. Michaels, 1988) In this case, Kama targets to deliver the utility, comfort and safety through their office chair to the customers.

**Providing the Value**

Once chosen, the value must actually happen in the life of the intended, target customer. The business must actually provide the chosen resulting experiences to the intended customer. That is, the component of providing the value undertakes product development on the basis of chosen value. This includes operations of manufacturing, sourcing and distribution of the value offering (the product). (Generated from Michael J. Lanning and Edward G. Michaels, 1988) In this case, KAMA needs to build value into their products and avoid non value adding activities as much as possible.

**Communicating the Value and Learn**

In addition to providing each resulting value, a business must communicate these experiences as well. During the consuming process, the business needs to stay communication with target customers to make sure they can improve their value building process by the knowledge deriving from the previous experiences. (Generated from Michael J. Lanning and Edward G. Michaels, 1988)

![Figure 5-1: The value creation and delivery process.](source)

Source: generated from Michael J. Lanning & Edward G. Michaels, 1988 by authors

**5.1.3 Define What is of Value to the Delivery Company**

To identify what is of value to the delivery team, one can based it on a range of office swivel chairs that KAMA produces. In order to better implement this process, KAMA
need to ignore the existing assets and technologies and to rethink the firm on a product-line basis with strong, dedicated product terms.

**Base**

The five-stars-shaped base, is made of new polished aluminum, to make sure the chair has a better powder distribution to the ground so that there won’t be any deformation happen during long-term used. People won’t fall down unless they deviate from the center line more than 30 degrees when on the chair. KAMA also offers the chairs with nylon and iron plating bases.

**Caster**

KAMA uses high-tensile zinc-aluminum alloy in most of the casters of chairs. This material is after testing with advantages of impact resistance, abrasion resistance and corrosion resistance.

**Gas spring**

With the gas spring people can adjust the chair up and down to achieve a comfortable state. Commonly used materials are aluminum alloy, high tensile steel and iron on the surface through electroplating, sandblasting, spraying and other processed techniques.

**Internal structure**

All of KAMA’s office swivel chairs have qualified gas springs after impact test and its impact tolerance is around 200-250 kg. The chair can up and down 300,000 times without damage and can be normally used for five to eight years. The gas cylinder is filled with high-pressure nitrogen gas which concentration is generally above 90%. To prevent in case accidents happen such as steel bar bursting out of the seat surface (because the dramatic changes of the internal gas pressure), KAMA also installed block plate with thickness of 2-4 mm under the seat.

**Regulator**

By using the regulator to act on the gas lift, customers can adjust the height lever. In addition to those values that all the products deliver, some of the high-end office swivel chairs also have the value-added features as follows:

**The seat and the back**

The seat and back are used of a variety of materials, such as leather or cloth bag with sponge inside, mesh back, plastic, etc., made according to customers’ requirements and needs. Varieties of colors can be chosen. The seat and back are made by advanced technology, and are fully consistent with the human body curves to make people sit more comfortably.

**Armrest**

The multi-functional and adjustable armrest make the user always follow his habits. The armrests are made of all kinds of materials that can be used, such as leather with aluminum, wood with aluminum, plastic and so on.

**Head**
The design of the head position is consistent with the curves of human neck. It can be adjusted up and down in order to achieve the most comfortable statue. Head cushion also use different materials, leather pillows, plastic, cloth and so on. See Figure 5-2.

Figure 5-2: KAMA delivers values from its products.
Source from Internal documentation of Company KAMA.

**Summary**

KAMA produces a series of office chairs which are divided into different grades, to fully meet various needs from companies and individuals. All the office swivel chairs meet the Standards presented by American National Standard for Office Furnishings - General Purpose Office Chairs. (ANSI/BIFMA X5.1-2002).

5.1.4 Define How Value is Specified by Products

The chair elements must be movable or transportable to allow the delivery company to create value in order to meet customer needs. This is reached by the good quality of raw materials used for making the chair and its lightness and portability. As said previously, KAMA has been working hard to improve its manufacturing processes in order to eliminate wastes and build more value into the products. Moreover the shipping department and the DHL make sure that the chairs are packed safely to avoid damaging risks during the long distance journey.
5.2 Lean Principle – Value Stream

Although the whole supply chain of KAMA is even complicated, we merely target on the procedure from the entering of the raw materials into KAMA’s workshop to the moment the final products get ready to be shipped to the customers. The order fulfillment process and the shipment process have been ignored in this paper.

And the result shows that substantial cost savings can be realized through information sharing. This motivates trading partners to share information in the supply chain and improve their performance (Zhao et al., 2001).

Figure 5-3: Schematic picture of the value stream for Company KAMA office swivel chair & components.
Source: Internal documentation of Company KAMA

KAMA concentrates itself in the main value adding process of chairs making, so that some other sub-manufacturing tasks such as wood processing, parts and elements, packaging materials and products delivery, are outsourced to other companies and manufacturers, which can be called sub-contractors. In other words, even though the whole value stream for the office swivel chair consists of several flows, KAMA is considered as the largest and the most important key factor in the value stream pipe.

As Figure 5-3 shows, according to the sourcing of raw materials, the suppliers of KAMA can be divided into four large types, which are, leather and fabric supplier, wood supplier, frame supplier and the internal filling material supplier. The good filling part is one of the necessary conditions of ensuring the chair quality in order to deliver comfort to consumers, however, compared to other three sources of material, no matter from the selection of material or from the technique used, this part is not as important as other two.

For the leather and fabric, there are also many procedures inside. Leather needs to be handled with corrosion protection, cutting, layering, and washing, dyeing, greasing, sizing, drying, vibrating, polishing, pressing and embossing. Fabric needs to be weaved, dyed, pressed and embossed. Here the supplier who provides the totally dyed and finished leather and fabric is KAMA’s direct supplier and is considered as having the largest stock of leather
and fabric in whole America. With the better and better market performance KAMA grows with increasing demands and puts a pressure on the supplier to provide raw materials in accordance with requests. The supplier is a flexible company which oriented on its customer need. KAMA has many different customers with dissimilar requirements on products, thus, KAMA has to cure the raw materials into various shape, size or colors. To fulfill the requirements of KAMA, the supplier may send the leather and fabric for dyeing and embossing to other companies. But due to the clear limitation of this thesis, other sub-contractors are out of our scope.

The other supplier supplies the components and frames of chairs to KAMA. KAMA cannot perform the activity by itself due to the complexity and incurred high costs. KAMA has no time and resources to make the components and frames itself since it has to cover office chair with style varied, to employ the high cost technologies and to have skilled employees, and thus, the activity is outsourced. The components and frames are assembled by the KAMA in its manufacturing department and then painted different colors.

Inside KAMA, there are several manufacturing departments. The stamping department primarily stamps the brand on the leather or clothes, perforates, creases and marks other natural defects in order to remove from the cutting area. The cutting department cuts the leather and fabric according to the mold and the drawing paper. The sewing department stitches the leather and fabric up together, and then sends them to the assembling department. At the same time, the wooden team is on process, too. The workers in that department cut the wood into pieces of armrests, backs and seats. The pieces are carefully polished to meet to standards and requests of customers. In the cushion assembling department, the components and frames are preliminary assembled into cushions and seats. Then the painting department paints and varnishes all the elements, parts and pieces by using natural and environmental paint.

KAMA produces office chairs in a variety of types and materials, however, to sum up and easily represent, here the pilot only chose two different types of chairs, R-18 and R-20 as to explain and optimize the order fulfillments process. The two types of chairs are finally assembled in different departments and the R-20 type has more elements and processes so it is a little more difficult to assemble than the R-18 type. Finally, the finished goods are sent to the test department and tested the safety and quality by manual operation.

Of course, there is Transportation Company acting as a third party to transport the chairs to the dealers, but, since it is not the key factor in our case, we don’t mention it too much in the paper.

To sum up, KAMA has four main supplier, leather and fabric supplier, wood supplier, frame supplier and the internal filling material supplier. According to the different sources of materials, there are three main manufacturing processed inside the company and we name them as the leather and fabric team, the wooded team and the element team. The three team work in their own workshops. Wood and elements are painted in the painting department and then all the pieces are assembled into finished chairs in the two assembling departments. Inspection is required as the final approach for the finished goods.

5.3 Value Flow (I): Analysis of the Current VSM State

In order to identify non-value-added activities we map the current state flow of KAMA’s chairs family components, see Figure 5-3. As we have illustrated in Figure 5-3, the flow of
KAMA consists of the four parallel flows, namely process I, process II, process III and process IV:

- Processes I – the flow of leather and fabric, see Figures 5-4, Figure 5-6 and Appendix 5. Leather and fabric are made into the covers of backs and seats, and then the cutting foam is filled inside of them.

- Process II – the flow of wooden materials, see Figures 5-4, Figure 5-6 and Appendix 5. This section consists of pieces of wood made into backs, armrests and seats. All these wooden parts are all varnished at painting workshop.

- Process III – the flow of frames and elements, see Figures 5-4, Figure 5-6 and Appendix 5. Frames and elements help to support and fix the chair.

- Process IV – the flow of foam. Foam is cut in order to make cushion with frames and elements.

The authors provide some distinct information associated with the actors of the CSM in Figure 5-6 and Appendix 5 which reveal the total steps and physical actions required to create and install a chair. Our thesis concerns one product family: office chair assembled in two types: R-18 and R-20. The R-20 type chair is of superior grade than the R-18 type. These two types of chairs are finally assembled in two different assembling cell, which named Assembling 1 and Assembling 2, and of course, the cycle time of complicated type R-20 is a little longer than type R-18, which is, 600 minutes to 400 minutes. For every month, KAMA produces about 212 chairs, 112 R-18 and 100 R-20. We derived the number from the forecasting per one week. The workers work 30 days per month and each work cell is operated on two shifts. There are 8 hours every shift, two 10 minute-breaks during each shift, and, with overtime if necessary. The raw materials come once a week.
These chairs are sent to the dealers nearby, and the shipment to the customer is once a week.

5.3.1 The production process

As mentioned in the former part, the figure shows the factors associated with the customer order fulfillment process. The suppliers and customers have to be mentioned in this part. The lead time and cycle time in the information box are based on the average of 100 items. For the inspecting and packaging process, there are three cycle time in the data box. The packaging process has two cycle times, including the first cycle time (100 min) stands for curing plastic materials of each chair part, and the second cycle time (150 min) stands for second step packing. During the second packing process, all the parts of which any same or different chair will be packed and cased into the big container. The inspection cycle time is about 300 min.

The production process KAMA is based on the one month forecast of its customers. The planning departments plan resources and give orders to each mechanical work cell. Planning department also orders raw material from each supplier. The leather, fabric, fames and foam are delivered to the mechanical department at KAMA by the suppliers. The inputs go through the production processes in each workshop, to become finished chairs and the logistics department orders the transportation to the dealers and customers.

In order to understand the production process more fairly, the total lead time and the total cycle time happened in the manufacturing process need to be accounted before our analysis. Here is a place need to be explained. In Figure 5-6, there are data boxes under each step of each process showing C/T and C/O. Some of C/Ts are found different from the ones in the flow-time line at the bottom. This is because as mentioned in above paragraphs, there are basically four processes in the chair production and these four manufacturing processes are parallel and happened simultaneously. To calculate the total lead time and total cycle time of a finished chair, L/T and C/T have to be observed and achieved from the real practice data with the four production lines running together. So that some steps may finish earlier but they have to wait until other elements come, in order to get into next step to be assembled together. The waiting time here is considered as wastes for the finished earlier elements but it is value-adding time to the elements which need longer time to be produced. For the whole chair, this period of time is also value-adding time since some elements are under processing.

The total L/T is 10.5 working days. Each day has 8*2=16 working hours. The total C/T is 3528 minutes. In other words, the value added time is 3528 minutes and the non-value added time is 10.5 days for the production processes. So it takes 3528 minutes to produce 100 items of chairs and the value-added activities in percentage of the processes are 3528/(3528+10.5*16*60)=26%
Figure 5-5: Value Added and Non-Value Added time in Value Stream Mapping of KAMA.

According to Figure 5-5, the value added activities account for around 26% and the non-value activities account for approximately 74%. From the figure, we find that more resources and much time have been used to the non-value added activities, while just a small part spent to the value added activities. On the other hand, the non-values added activities also include those non-value added but necessary activities.

The manufacturing process of KAMA shows that there are some wastes in it. We will identify some main wastes in the next section.
5.4 Identification and Analysis of Wastes in the Operating System

The current value map of Company KAMA’s manufacturing process revealed some wastes in the production flow of the company. At the bottom of the value stream mapping, we can find the time-and-step line where the value adding and non-value adding steps are shown. We identified the wastes depends on studying the current value stream mapping of the company together with the reports and internal documents made by the consulate EIMI. During the process of studying current value stream mapping, some empirical
methods will be applied as follows: telephone interviews with Company KAMA's managements, study of the company's internal reports and some useful documents of the workshop and warehouse, and study of the consulate's research and documentation provided by KAMA. As the result of application of the above mentioned methodology, we were able to identify several evident wastes in the following:

1) Long waiting time during the whole the flow of supply chain and manufacturing process.
2) Unnecessary inventories during the manufacturing process.
3) Unnecessary movements of operators and workers in the workshop.
4) Overproduction.

However, the managements of Company KAMA can only identify these wastes from 2 to 3, excluding 1 and 4. Consequently, the wastes of ‘Waiting’ can be identified from the current value stream map of the company, while the unnecessary movements are primarily revealed from the internal reports and documentation of Company KAMA.

5.4.1 Waiting

"Waste doesn't add value to a product or service under the whole supply chain. Any activity which doesn't contribute to this can be classified as waste." (Womack J and Jones D, 1996)

Waiting in the order procedure

According to timeline of the current mapping state, we can find that waiting occurs when the customer make an order. It always occurs when there are not enough raw materials in the stock. Consequently, the company needs to send the orders to the providers and ask for supplementing processed materials. It results in long time of waiting until the needed components are delivered (Telephone interview with Company KAMA, 2010-04-06). Actually, the planners do not wait and produce other components. Whereas, according to Figure 5-7, there is one week gap during order entry of the customers and beginning of production in the workshop. In a word, it results in about one week order postponement under this period, one week for production, one week for welding and assembling and 3-5 days are taken for shipment to the customers. Since the customers are located in the different places, the final delivery time is various which mainly depends on the location of the customers. Generally, the lead time in the workshop is about 10.5 days. The entire production process would be delayed 7 days owning to one-week delivering of raw material, since the manufacturing step was postponed about one week.

![Figure 5-7: Order frame time structure. Source: Internal documentation of KAMA](image)

As the figure shown above, the Company KAMA is willing to deliver the final products to its customers within three or four weeks.
Waiting happened in the workshop

Waiting happened in the workshop according to the lack of organizational structure of the mechanical workshop. According to the interview of the management of the Company KAMA (2010-04-21), we have learned that there are three workshop managers plan and design the production procedure in the plant. They arrange and direct the workers what should produce, when the products need to be finished and by who to produce. Also, they make and give orders. Only three operators supervise at least 100 workers, so they are always busy. It implies that the components need to wait until the operator is free, or the operator needs to wait until the components arrive. Otherwise, we identified waiting during the manufacturing and operating process through studying the historical documentation of Company KAMA together with the reports from the consulate EIMI (2008). The waiting occurs also because the different C/T between the upstream and the downstream operation line. The overproduction of upstream machines result in the WIP waiting until the downstream machines could accept them. The time lines show the relationship of the value-adding time and the total lead time.

A fundamental concept should be mentioned here, the value added time (C/T) and the total time (L/T). The two types of times required for different operations. The difference between C/T and L/T might add no value to product, thus the authors gave the suggestion that it could be eliminated. The reason why there is non-value added time happens is because the layout of the workshop is not proper.

As the Business Dictionary mentioned on its website, the process layout can congregate the workstations though operations, for instance, cutting area, welding area, drilling area, assembling area, etc. The improper workshop layout stops and slows down the continuous production flow in the workshop so that results in delay and time waste during manufacturing process. Consequently, the components have to been waiting in the workstations until all of them are finished.

Finally, the abilities of the workers are limited. The workers can only finish their own tasks and no one can do others’ jobs. It means that the workers have to wait until others finished their tasks, which causes waiting of product components. In addition, Company KAMA does not only produce one type of office chair, they have various of chairs (Internal documentation of Company KAMA). Since, different products were often required at the same time; the components would be produced at the same time either. This caused long waiting time during the production process.

Waiting in the inventory

Waiting happens in the warehouse in Company KAMA during the manufacturing process. The components need to wait about one week until they receive a new customer order. The Third Party Logistics Company use more than 2-3 days for shipment to the customers (Internal documentation of KAMA).

The waiting occurs in the warehouse W. Until the raw material will be needed for production in the workshop they have to wait in warehouse W. According to the requirement of the main supplier, the Company KAMA needs to purchase a fixed amount of raw materials from suppliers. Therefore, Company KAMA often has an excess stock of raw material in warehouse W. Having studying the documents and making interviews with the managements of the company (2010), we found an calculated that it is not necessary and efficient to cut a small amount of raw materials for many times, since different products have different required sizes and shapes, and the machines have to be adjusted according to these
various requirements. It reveals that there are always a small number of raw materials waiting to be produced in warehouse W.

5.4.2 Unnecessary Inventory

Unnecessary inventory, again as the name implies, is inventory that is not needed. (Chen Jianlong, 2008 p.132).

Now, how you can tell when inventory is not needed, you might ask. Well here's a thought: If inventory is sitting idle somewhere (anywhere) in your facility, with nobody working on it, is it needed? There are pretty much only two ways to accumulate inventory that is not needed: buy it or make it. (Bill Carreira, 2005)

There are many forms of inventory: finished goods sitting in a warehouse unsold, work in progress tied up in your process, and raw materials awaiting production. In manufacturing a major concern of unnecessary inventory is work-in-progress (WIP) which cannot be readily sold either to customers or to other companies. The inventory of Company KAMA occurs in three areas where include warehouse W, warehouse M and the mechanical workshop. We will identify these three different unnecessary inventories respectively, and specially focus on inventory of WIP. According to the report of the project research (2009), we consider that the unnecessary inventory as the non-value added activity and has to be reduced or eliminated by using lean thinking finally.

**Unnecessary inventory of raw materials awaiting production**

As we have mentioned in the former part, the raw materials provided from Supplier X are always stored in warehouse W.

The reason why the company has to store raw materials in warehouse W is because Supplier X makes the fixed amount to be purchased. Supplier X does not provide the raw materials unless the required amount is no less that set amount which can be treated as economic order quantity (EOQ). It causes the company has to purchase this amount although they do not need.

The company decides the requirement bases on the changeover cost of machinery. This cost is about 13$ per machine (Internal documentation). Company KAMA usually needs much less amount of the metal and woods. Otherwise, the company does not only order the raw materials from Supplier X, they also demand other types of raw materials from other different suppliers, including woods, plastics and leather (Personal communication with Company KAMA, 2010-04-06). Thereby, Company KAMA has to achieve the economy of scope and scale by ordering the total required quantity from the Supplier X and another few types of the raw material from the other suppliers. However, since not all of the raw materials will be processed immediately at the same time, it causes high-leveled inventory.

Additionally, another reason for causing high-leveled unnecessary inventory of raw material is according to the company’s internal information system. KAMA sets a buffer level for the warehouse, and when the inventory of raw materials reach that level, the IT system will inform the warehouse manager that they need replenishment. And then, the operator sets the orders to each supplier for replenishment. Since the IT system works automatically, the information about replenishment of raw material occurs even though there is no customer order happens.
Unnecessary inventory of finished goods sitting in a warehouse unsold

The Company KAMA puts the finished components in warehouse M which is located in company’s industrial area. According to the documents of the company (2009), we find that there always is an excess unnecessary inventory of finished components stored in warehouse M.

Few reasons for causing high-leveled components inventory in warehouse M will be presented in the next sector. Firstly, according to the communication with the management for Company KAMA (2010-04-11), the production plan depends on not only the annual production forecasting, but also the customer orders. The production strategy changed accordingly to the low and high months and seasons (Personal communication with management of Company KAMA, 2010-04-16). Thereby, we can identify that the manufacturing policy is ‘make-to-stock’ during the low months and during the high months is ‘make-to-order’ strategy. This revealed that the production primarily varies by different period. Thus, the production strategy always changed and it highly varies according to the orders from customers.

Moreover, the production capacity of the company is limited, especially during the high periods. It is one of the most important reasons why Company KAMA ‘makes-to-stock’ during the low periods.

Additionally, the products of Company KAMA are changing to be various because of drastic competition in the current marketplace. Thus, the company provides a high variety of products to different customers. It implies that the company has to adjust new production plans frequently.

Unnecessary inventory of WIP

We find there is the unnecessary inventory of semi-finished components’ flow under the manufacturing processes and between the different performed tasks, which was named as WIP unnecessary inventory.

The reasons why the unnecessary inventory happened during WIP are the different C/O between upstream operation line and downstream operation line. The quicker C/O of upstream results in the machines produce larger amounts of WIP waiting along the process until the downstream machines could accept them. The other reason is the shortage of cross-skilled operators, especially during high periods. For instance, there are 30 welders working in the welding area. Although all of them can do the welding, they have different levels according to their personal abilities. The company produced various types of chairs, thus the components are not same. Some welders can complete type one and type two, while the other can only do one type. “We have 30 welders, but only 9 welders out of 30 can perform the operation of Type R-20” (Telephone interview with Company KAMA’s managements, 2010-04-21). Additionally, the workstations of the mechanical workshop, such as tailoring area, cutting area, welding area, etc, are grouped by operations; the manufacturing procedure has to be processed step by step.

5.4.3 Unnecessary Movement

“As we have mentioned in our theoretic part, the unnecessary motions are such motions such as walking between different workstations or workshops. These unnecessary movements make workers and operators tiring for their jobs and are likely to result in low productivity and efficiency and, sometimes, in poor quality of the products” (Hines & Rich, 1997).

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**Unnecessary movements of transferring the raw materials**

We found that one of the most important unnecessary movement of workers often occurred under transferring the components from warehouse W to the mechanical workshop. As we have discussed in the empirical study, suppliers always delivered the raw materials not only to warehouse W but also to the mechanical workshop. This is according to the total purchased quantity that was demanded for the production plans. The raw material which is stored in warehouse W is needed to supplement the production constantly, thus the workers always bring the material to the workshop when they are requested to be used. Although warehouse W locates not so far away from the main company’s facilities, it still takes time and the workers have to transfer the raw material to the workshop. Company KAMA has calculated that this movement often takes 1 day per week which will cost extra money for Company KAMA (Internal documentation of Company KAMA). The company considers this movement as a waste of the activity which is called as non-value added but necessary activity (Telephone interview with the company, 2010-04-16). However, according to the authors, we identified this kind of movements as non-valued wastes, and could be reduced or eliminated by using proper workstation layout.

**Unnecessary movement under production procedure**

Secondly, we identified the unnecessary movement happened under the manufacturing process. During this process, components will be delivered from one workstation to another. When the semi-finished parts have been completed, they always are delivered by the work coordinators to the next workstation to the workers who have finished their former activities (Internal documentation).

Otherwise, there are a set of various types of tools in each workstation, including large or small ones (Internal documentation of the company). When the work is in progress, the workers need tools to accomplish the tasks. The workers often take the tools to their own working areas, and then forget returning them back the original place. Thus, it always happens that the tools are missing and the workers have to search them or get them from another working area. In addition, it sometimes happens that ‘a tool is hanging around the workstations and nobody knows to which workstation it belongs to’ (Telephone interview with Company KAMA, 2010-04-16). It results in the difficulties of finding the tools for workers so that causing much unnecessary movements between different working areas. This implies that this waste is non-value added activity and can be eliminated after optimizing. It seems that these movements can be considered as non-value added activities but necessary. However, we identified the unnecessary movements as only non-value added activities. The reason why these unnecessary movements happened is because of the unreasonable arrangement of process layout. If the current process layout can be optimized, the wastes can be eliminated.

**Unnecessary movement in order taking process**

As we mentioned in the previous parts, the manufacturing planning department creates the production plans which does not only depends on the forecasting, but also on the customers’ orders. Under the current status, if the company receives a new order, the workers from the mechanical workshop come and pick up the documents of production orders once a week. However, if urgent orders happened, the workers have to come to pick up order tasks a few times per week. And then, the production planning department in the mechanical workshop designs the manufacturing processes.
According to studying the documents of the Company KAMA (2009), there are three planning management in the workshop. The planners often have responsibility to check which production plan can be performed. If the answer is yes, they will mark a red stamp on the task documents, and then the task will be sent to the production operator. The responsibility of the production operator is to check the planners’ decision and deliver the tasks to the manufacturing departments (Internal documentation). It is identified as the non-value added activity, but necessary.

5.4.4 Overproduction

Overproduction (1 of the 7 wastes in Lean manufacturing) occurs when a part or product is manufactured before it’s needed: either before a customer has ordered it or before it can begin the next process in the production system (Scoville Hamlin, 1994).

Overproduction means making more than is required by the next process, making earlier than is required by the next process, or making faster than is required by the next process (Scoville Hamlin, 1994).

- There are some causes of overproduction:
  - Bottleneck processes
  - Unbalanced capacities
  - Quality problems
  - Long change-over times, necessitating large batch sizes
  - Poor logistics
  - Poor layout (no flow)
  - Poor machine reliability
  - Emphasis on keeping machines busy opposed to keeping material busy
  - Local optimization
  - Cost accounting practices
  - Things will go wrong’ mentality
  - Lack of stable schedules

Here, we only identified the reasons of overproduction during the manufacturing process of Company KAMA.

Overproduction bases on consumer psychology

Among the reasons for overproduction the least understood is that of changes in consumer psychology. This is more than a reason of alteration of taste, custom, or demand for particular products (Scoville Hamlin, 1994). It seemed to be realized that the changing of customer demand was not only for particular things, but also for general products, for example the furniture products. This also happened to Company KAMA, because of the unpredictable and frequent changeable customer demand for furniture products, such as style, color, or whether the product is healthy for human vertebra, the company has to design
and improve the existed products frequently according to their customers’ requirements. Due to the incomplete forecasting system, the company cannot dope out the exact market demand for the new requirement of products, it results in overproduction of old-styled ones.

**Improper layout**

Overproduction happened owning to poor layout. Since the company has various series of products, if they only produced a small amount of products frequently, the workers of operator have to move several times which resulted in waste of time. Thus, Company KAMA has to process as many goods as possible once, which causes serious overproduction. We identified this part of waste as unnecessary one that can be reduced or eliminated after using lean.

### 5.4.5 Summary of Wastes

In conclusion, the all identified wastes in the manufacturing flow of Company KAMA will be presented in the following part; we give out Figure 5-8 that the main reasons for wastes are shown.

![Figure 5-8: The reasons for wastes.](image-url)
5.5 Make Value Flow (II): Solutions to Reduce or Eliminate the Unnecessary Wastes

KAMA’s current manufacturing activities are mostly based on forecasting in peak season, and the flow of parts is of high-volume batch. Once the products are produced, subassemblies are pushed to the next level whether needed or not. Final-finished products are stocked in warehouse M for customer order. The company uses MRP as the planning tool to manage the production procedure and its organization structure is under the centralized control. The low production cost and the high speed of delivery become advantages of KAMA. The Order Penetration Point is positioned closer to the final goods inventory than that of the competitors, which means, downstream the supply chain. (Mason-Jones et al., 2000) See the red point in Figure 5-9:

![Figure 5-9: Order Penetration Point Position of KAMA Current](image)

Obviously KAMA adopts a Make-to-Stock (MTS) production strategy, authorize production and set requirements in advance of demand. This system will always have a push element in it, like MRP. However, using MTS strategy brings problems as below:

1. **Long Lead time**

According to the previous discussion about wastes, the first waste that Consultant EIMI found is the long waiting time of raw materials. KAMA use MRP as its production managing and scheduling tool, the planning horizon of a Master Production Schedule (MPS) in MRP is as equal to the cumulative production lead time from the lowest level to the final assembly in a production hierarchy. (Im & Schonberger, 1988) In this case, the initial level also requires an appropriate planning horizon to purchase necessary raw materials and elements from the outside suppliers, which is the 7 days. A long planning horizon results in more uncertainty of demand because of high forecast error involved.

2. **Large amounts of work-in-process inventory**
The traditional push manufacturing causes inventory purposely held in each operation. The products are made by upstream process and then pushed to downstream process, and because of the different cycle time, upstream produces parts at a higher rate than the downstream could accept, and the WIP inventory pile up.

Due to the disadvantages above and the shift of strategy from mass production and modular design to a higher degree of customization, EIMI gave a solution that KAMA should adopt Make-to-Order (MTO) and add some pull systems in its production process.

In the future, the Order-Penetration-Point position can be moved upstream in the KAMA’s supply chain, and the company’s manufacturing system will depend on the requirement of customer orders instead of the old push system. In other words, our production system would much rely on MTO principles, but not MTO. (Internal documentation of KAMA) Having applied the new system, it will bring some benefits for KAMA’s supply chain, which includes less overproduction, less unnecessary inventory, less amount of WIP, less waiting time of raw material but better knowledge of the contents of customer orders. The reduction of the upper mentioned wastes also has a valid effect on other wastes such as unnecessary motion. See Figure 5-10:

5.5.1 CONWIP

The pull system has been proved superior to the push system; however, all manufacturing environments are not well-suited to the use of Kanban. In particular, production lines which produce many different parts face serious practical problems. Here KAMA need a system that possesses the benefits of a pull system but easier to be implemented, and can be used in its manufacturing environments. The CONWIP (CONstant Work in Process) approach offers the promise of achieving this goal. CONWIP would be a better alternative pull system for using under a multistage assembly production line, to effectively reduce WIP inventory and shorten lead time. (SPEARMAN, 1990)

In this case, a simple CONWIP-controlled assembly system is implemented, which is called Distinct Card Buffer, (DCB), designed by Ghamari (2006). According to this policy, a job
is released in a fabrication line when there is an available card in the corresponding card buffer.

![Figure 5-11 Distinct card buffers (DCB) policy CONWIP controlled assembly system. Source: Ghamari, 2006](image)

When a customer demand arrives at the system, it requests the release of chairs from B2 to the customer. At this time there are two possibilities: Ghamari (2006).

- If products are available in B2, they are released immediately to the customer and the two CONWIP cards are detached from the container and transferred to queue C.

- Otherwise, the demand is backordered and waits in the queue until new products completes from the upstream stage arrives.

For other stations beside the last station, they will be operated in the same way as under the push system.

It has been found that this system significantly reducing WIP inventory, and factories using this system have less average WIP and the same throughput rate (or even higher) than the ones adopting other CONWTP policies. (Ghamari, 2006).

### 5.5.2 U shape Assembly

When EIMI saw the flow assembly line of wooden team and fabric & leather team, they had a inspiration that to combine the pressing, cutting and polishing departments of wooden team and the stamping, cutting and sewing departments of fabric & leather team since these departments have similar equipments and way of operations.

In the current state, both the wooden team and fabric & leather team use a straight-line layout, operators perform one or more tasks on a continuous portion of the line. For example, for the wooden team, there are three process of operation, which may conclude several steps to complete. See Figure 5-12.
In order to improve continuous flow, increase factory yield, and reduce use of raw material, KAMA need a U-shaped layout instead of the straight-line layout. (Internal documentation of KAMA) Operators are allowed to work across both legs of the flow line, and assembled units are followed the U-shaped configuration. For the wooden team, the pressing parts are placed at the start of line, the cutting parts are in the middle and the polishing part are at the end of the line, where Operator 3 could perform Task 7 on the front side of the line, and then travels to the back side to complete Task 4 on a different unit, and then returns to the front side of the line to begin the next cycle. See Figure 5-13.

By allowing operators handle not only adjacent tasks, but also work across both sides of the line, U-shaped layout requires fewer workstations than the comparable straight-line layout. Aase et al. (2002) also proved that U-shaped layouts can improve labor productivity modestly on average.
5.5.3 Double D Assembly

EIMI also suggested that KAMA’s facility should be reconfigured from a traditional flow line to a Double-D manufacturing configuration for the final assembling process.

According to the contents described in the case background, there are the two types of chairs (R-18 and R-20) assembled along the operation line of KAMA. The R-20 type has more elements and processes to do so it is a little more difficult for R-20 to be assembled than the R-18 type.

**Current: the hardware assembly flow line**

For the current hardware assemble configuration, it is a straight assembly flow line with one worker per workstation consisting of two sections. There is an upper portion which is a long table with several workstations for the initial assembly of the primary wooden pieces and hardware frames. Hardware frames are stored at the end of this section of the line until pass to the circular portion of the flow line. See Figure 5-14. (Internal documentation of KAMA)

![Figure 5-14: Assembly flow line (Current).](image)

At the circular portion of the flow line, the workers, each one with a workstation, add components to the initial assembled chair parts. The moveable assembly fixture table can roll from workstation to workstation around the flow line circle allowing interior workers mount the initial assembled chair parts and then pass them to the flow line again.

In addition to the straight section workers and the circular section workers, two employees are present beside the assembly flow line to assist with handling materials and keeping the area supplied with elements and tools.

**Future: Hardware Assembly with the Double-D Manufacturing Cell**

After reviewing the current assembly line, a lean manufacturing solution was developed. In the redesigned subassembly process, the initial fixture assembly table remains the same; however, the circular area will be completely reengineered. (Internal documentation of KAMA)
Rather than a circular shape, the manufacturing cell consists of two rectangular or D-shaped portions. See Figure 5-15 This Double-D shaped assembly cell is used rather than one large circular or rectangular cell to minimize worker walking distance and the area needed to allow enough workspaces to meet the maximum daily requirement for hardware units. In addition to conserving movement and space, the Double-D configuration creates a shape with straight-line sections resulting in considerably less expensive roller conveyors than those needed for a circular space. An additional benefit of the Double-D design is added flexibility within the cell. (Hunter et. al., 2004) One D could be used for the R-18 size chair assembly while the second D could accommodate R-20 size chair units.

The straight-configured upper flow line supplies both Ds with the basic hardware component upon which the subassembly is built. These hardware units will then be diverted into the lower units. The D units are positioned back to back and the left side has a counterclockwise material flow while the right side material flows in a clockwise direction. (Hunter et. al., 2004)

The texture of the floor is no longer an issue to hamper movement as the assembly fixtures no longer need to be mounted on roller tables and are instead moved around the assembly cell on 30-inch wide gravity roller conveyors. This method of transport provides almost effortless movement of the assembly fixtures to the cell workstations. (Hunter et. al., 2004)

![Figure 5-15: Double-D Assembly flow line (Future).](image)

Benefits: (Hunter et. al., 2004)

- The new Double-D assembly cell increase productivity with less labor than before.
- Double-D assembly allows assembly cell supervisor the capability of accurately adjusting the cell’s output by simply adjusting the number of workers in the cell. This flexible system can easily throttle output up or down
- Simply by adding or removing workers.
- Improving quality
- Improved ergonomics (Mital, 1995)
- Continuous process improvement
- Easy communication
- Increasing movement on the job floor. (Hunter et. al., 2004)

5.5.4 5S system

5S is short for ‘Seiri’ ‘Seiton’ ‘Seiso’ ‘Seikeetsu’ and ‘Shitsuke’ as the five words start from ‘S’ in Japan. By the management of the work field and articles, 5S can make a safety, comfortable and bright work environment, cultivate a good work habit and promote the quality of truth, beauty and goodness of the staffs. (Chen Jianlong, 2008, p108)

If the 5S management system is carried throughout the enterprise, it can help the company to optimize and standardize the workshop so that to reduce the some unnecessary wastes. First, the facility order should be reorganized and the unnecessary items needed to be removed and sorted. Major equipments are moved to improve flow. These could significantly reduce WIP and save floor space. The lead time could also be saved because of the re-arrangement so distance of the chair components travel from spraying to completion is shortened. (Generated from Srinivasan, 2004).

Then the remaining necessary items are rearranged for easy used and efficient access. Here, we also suggest several shadow boards for tools, which could reduce operator travel. See Appendix 7. (Generated from Srinivasan, 2004).

The third step, the work area should always keep clean, the maintenance of tools is also included. By doing this, one can discover small problems in machinery before big failure occurs. (Chen Jialong, 2008, p62)

The forth step named ‘cleanliness’, and it has a little different with the former step. The third step only means ‘clean up the feculence’, while the ‘cleanliness’ does not merely concern environmental cleanliness, but also personal cleanliness in order to keep a favorable status. To achieve this purpose, all these steps have to be retained and repeated again and again (Chen Jialong, 2008, p65).

The final step is to improve staff’s general capacity and disposition as a result of long and regular self-discipline, which can be named as ‘accomplishments’. This step is the most critical one in 5S principles and it can sustain the other four steps effectively. The top managements of Company KAMA should enhance the employee’s personal education and dissertation in order to advance the company’s organizational culture. (Chen Jialong, 2008, p66).

5.5.5 Closer collaboration with supplier

Currently, Kama receives raw materials from its suppliers once a week and holding a seven-days inventory of raw materials. EIMI believes that it is a little contact between KAMA and its suppliers and KAMA hold too much of raw material inventory. To reduce the time in order taking process, eliminate wastes, and to reduce the inventory level of raw materials, negotiating with the suppliers is a good way to solve the problem. The specific method is to receive raw materials from the suppliers more often.
EIMI suggested that KAMA should reduce the waiting time by taking the orders 2 times per week instead of one time per week, which means the inventory level of raw materials reduce to 3.5 days. So the total lead time could also be reduced because of the often contact. (Internal documentation of KAMA)

5.6 Draft of Future Value Stream Mapping of Company KAMA

Having identified and analyzed all the wastes involved in the production process by applying current state map method of KAMA, the consultant EIMI offered some essential suggestions and made some changes for KAMA’s manufacturing process, which were presented in the future state map. See Figure 5-16

KAMA will change its work from MTS to MTO production strategy as shown in Figure 5-16. In order to implement the new MTO strategy well, KAMA will continue to carry through its manufacturing flow which are involved in this project. Several supermarkets are put into the value creating process small inventories available so that the downstream customers could come to them to pick out what they need. The upstream work centers are responsible for replenishing stocks as customer required in case the continuous flow is impractical, and the upstream process has to operate in batch mode, a supermarket reduces overproduction and limits total inventory.

FIFO (First In First Out) lines are set between the operations to reduce WIP inventory. Since the FIFO chute can only hold a specified amount of items, when the chute is full, the supplying process will stop producing until the downstream process finishes working on the items in the chute, and there is room in the chute again, which solve the problem that the upper stream machines have much quicker C/T that the downstream ones quit well. By
implementing FIFO method into the production flow, the single unit component of the product can be transferred between the different workstations instead of moving the entire ones.

Another concept will be suggested to apply in KAMA’s manufacturing process which named CONWIP. It can provide useful information and control the whole products flow. As we have mentioned in the upper section, the planning department would sent the specific orders to the final packing department at the moment the company receives a customer order. And then, the dictate will be delivered to the nearest supermarket and the finished chairs can be taken from there. If there aren’t finished products in the supermarket or warehouse, CONWIP will send a signal to the first production department. The raw material will be sent to the manufacturing department from the warehouses. If the raw material needs to be replenished, the planning department would give the message to the suppliers.

The suppliers are required to replenish the raw materials twice a week. The information exchange between KAMA and its suppliers will still depend on customers’ orders and forecasting.

The supermarket system, CONWIP and FIFO all aid in achieving continuous flow in the workshops and MTO production strategy. In addition, the use of U-shape layout and Double D assembly layout make the continuous flow move more smoothly. We only show the blueprint how the order fulfillment process would work in the future state map draft because the whole program of KAMA is a pilot project and only be implementing among a very small area in an experimental way. (Internal documentation of KAMA)

5.7 The Benefits of New Value Stream Flow of KAMA

The benefits of the optimized KAMA’s value stream map will be sum up in the following part which compared to the current one:

- The unnecessary inventory will be reduced to the safety stock level.
- $0.79 million per year in cost savings on motion, labor, warehouse renting costs and unnecessary inventory.
- Increasing the efficiency of wood ripping and reduce the equivalent of up to 18,000 wood sheets per year.
- Reduced lead time in the product line.
- Reduced floor space needed for WIP the production line by 590 square feet.
- Improved general workplace organization, ergonomics by new cellular layout.
- The new CONWIP system will control the raw materials flow the warehouses. (Internal documentation of KAMA)
6 Conclusions

The answer to the problem formulation from three perspectives opens this chapter and at last reflections around the thesis together with suggestions for further research are discussed.

6.1 Answer to the Research Question

RQ1: How does the project help the company to redesign their production line by adopting lean as a tool?

This case study describes how the lean thinking can be used in manufacturing process.

First of all, the identification of wastes and attempt are essential steps for value mapping method. We mainly identified four types of wastes in the whole supply chain flow of the company, including waiting time, unnecessary movement, unnecessary inventory and over-production.

And then, before drawing the value stream map, value must be defined at the customer level, the delivery team level and the products level. This is done in order to identify which activities add value to the product and which do not. “It can be considered from the analysis that the value to the customer depended on customization, flexibility, design, time and cost efficient” (Jones D., and Womack, J., 2003), while the value delivery is proceeded in manufacturing the elements and then assembling them in the workshop. The value specified in the product focuses on its move ability.

Next step, the identification of the value stream, was based upon the value stream mapping methodology. We first identified the current value map of the company and made some analysis about how to and which part could be redesigned by implementing lean in the manufacturing process. And then, we analyzed a future value mapping with implementation of several lean and optimized tool and strategies.

EIMI suggested KAMA to redesign their production process in order to make change from ‘make-to-stock’ to ‘make-to-order’. It can help KAMA to reduce or eliminate several wastes in the manufacturing process and improve the efficiency and productivity.

Some proposed improvements suggested by EIMI will be presented in the next section:

- In order to change improper layout, we introduced Double-D layout, U shape layout, 5S principles and FIFO components flow as suitable tools for functional improvements.
- Production principle was proposed depends on ‘make-to-order’ strategy.
- The order fulfillment system was suggested using ‘pull-system’ instead of ‘push-system’ in the proposed future map.
- Production control and information exchanges were suggested by implementing CONWIP system.

RQ2: What are the benefits by implementing lean manufacturing for the company?
The supermarket system, CONWIP and FIFO all aid in achieving continuous flow in the workshops and MTO production strategy. In addition, the use of U-shape layout and Double D assembly layout make the continuous flow move more smoothly.

We summarize the benefits of the new KAMA value stream flow in the following part:

- Millions money will be savings on motion, labor, warehouse costs and unnecessary inventory and overproduction.
- Increasing the efficiency and productivity
- Reduced total lead time in the whole product line.
- Reduced floor space of the warehouse.
- Improved general workplace organization, ergonomics by new cellular layout.

6.2 Methodological Conclusion

In this paper, lean thinking was implemented as a tool together with the application of value stream mapping theory to identify, analyze and find out solution. To achieve the purpose of this thesis, a combination of theoretical application and empirical application were used in this paper.

In the theoretical section, the authors mainly presented a value stream mapping approach in order to find the unnecessary wastes and the lack of organizational structure. In addition, other methods are implemented as “gap filling” to consummate the value stream mapping method, for instance, order penetration analysis, Double-D and U-shape strategies, etc.

In the empirical part, three methods are presented in the former methodology part, including the telephone interview with KAMA’s top managers, investigation of company’s internal documentation and study of EIMI’s project reports. The interviews were designed based on lean thinking as a framework in order to gain a deeper understanding of the company’s status. A draft of current value stream mapping was then described and identified for the sake of finding reasons of wastes in the current state.

Having identified and analyzed the reasons of wastes, a proposed future value stream mapping is pictured and visualized. The authors made a modification for the KAMA’s office chair production flow. It is essential to notice that there is research limitation for practical application of the project results. The authors only analyzed a single product family, thus the consequence of analysis should not be generalized. In spite of the mentioned limitations in the methodological process, the results of this research would be implemented by the company for other product family or other products in office chair family. In addition, the research results can be implemented by other companies which have the same products profile or faced the analogous problems in their production process.

6.3 Theoretical conclusions

The theoretical section mentioned in the former research methodology consisted of the value stream mapping method, order penetration analysis, the application of proper layout and CONWIP method. All these methods are combined with lean thinking as a frame guide.

Generally speaking, the steps of using lean thinking include five factors:
1. Specify what the value is;
2. Visualized current value stream map;
3. Identify wastes and reasons of wastes;
4. Modification for current map;
5. Build proposed future value stream map.

In this paper, the authors concentrate on the third and forth steps, since the identification and solution of wastes are quite significant parts in this paper. The first step and second step build preparation for making the current value flow. Under step 4 process, several lean tools were used, which mainly depends on lean thinking as a tool. The final step 5 was not considered unduly, because the paper does not focus on how to implement these tools in a manufacturing process.

The value stream mapping method was implemented to up build a common value map. Other theoretical and empirical tools can be applied to make identification of wastes and an insight understanding of wastes.

6.4 Reflections

In the following section reflections of this study is presented:

This study was based on lead times, wastes and information collected from a number of different informants, such as telephone interviews, internal documentation, former report, website, etc. Because of a lack of research time and information resources the lead times based in this study were provided mainly from the interviews with managements of Company KAMA. If the lead times had been clocked and collected by ourselves the results would have been more detailed.

Additionally if we can get more detailed data on the information flow, inventory data and defects, this can enable us to analyze and perform a more complete VSM and to give the company more useful recommendations on how to reduce or eliminate unnecessary wastes during manufacturing process. On the other hand we cannot help but wonder if we would have been able to analyze all the data and provide this master thesis on time. As we are experiencing it now more data to analyze would make it impossible for us to finish the Master Thesis on time or we could suppose that we would have provided and performed a less deep analysis of the data.

6.5 Suggestions for Future Researchers

In the following section suggestions are presented for future research within this lean project:

*Follow up on error reports*

A later follow up on error reports should be done studying if there are any errors occurring in a later state that could have been avoided in the beginning. A study should also be done to see how the error reports sent between the organizations are actually followed up and if there are any improvements to be seen at the construction site.

*Learning curve*
Such a study should be done at a later stage in the construction process to see how performance has improved in the supply chain. The Company KAMA project will take place began in 2008 so many opportunities exist to conduct a comprehensive study that would provide information for conducting a learning curve analysis. A learning curve analysis would also show if the expected goal at the company’s construction site – to reduce the delivery schedule can be actually met.

**Consequences of waste**

In this study some sources of waste and causes have been highlighted. It has also been shown that waste can ultimately result in difficulties meeting construction project schedules. A future study should be done where economical consequences of waste and delays are identified. It would be interesting to see how contracts are arranged and which actor in the supply chain takes the responsibility for the delays.

**Identification of waste in other supply chains**

In this study the researchers have identified waste and unnecessary activities in the manufacturing process of office chair production. Similar studies should be done to other departments or products as well.

**More detailed value stream mapping (VSM)**

In the future a more comprehensive value stream mapping should be done that is not only taking lead times into consideration but also inventory data and more thoroughly detailed information flow.
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Appendix

Appendix 1-KAMA’s Manufacturing Facilities

Source: KAMA’s website
Appendix 2-Interview Guide

We make the following questions as our interview guidelines. However, these questions are only an outline for our later interviews, we will design more detailed questions for the interviews based on the guideline. The interview questions are different for each sectors or departments.

Production Process

• What the main problems do the company faced during manufacturing process?
• How does the workstation look like?
• How many people working in the workshop in your company?
• Is the production process automated or by hands?
• What is the lead time of the products?
• What is the cycle time of the products?
• Do you think the manufacturing process efficient?
• How long does a worker work in the workshop?
• Who has responsibility for the components stock?

Warehousing

• How does your company organize the warehouse?
• How many warehouses you own?
• What the places of your warehouses?
• Are the warehouses far away from each other?
• How the components are stored in the warehouse?
• What is the pack size?
• How do the packs be shipped?

Supply Chain Participants
Appendix

- How many suppliers do you have?
- Where are your suppliers’ location?
- Who is your main supplier?
- How big is the inventory stock? (in days)
- Who are your customers? Where is their location?
- How many types of customers do you have?
- How many packs do your warehouse contained?
- Who is your main customer?
- Do you have other partners in the supply chain?

Customers

- How do your customers choose your products?
- Do you help your customers to choose proper goods?
- Do your make some special orders for some customers?
- Do you provide your customers products information frequently?

Raw Materials

- Does your company always have proper materials for production?
- Do you often inbound proper quantity materials?
- If not, how many excess materials do you have? What is the reason?
Appendix

Appendix 3-Interview Questions

Interview Introduction

We are the students from Jönköping International Business School. Our major is International Logistics and Supply Chain Management. We are writing a master thesis about an American furniture company named Company KAMA currently. We will interview the managements of KAMA while our research began.

In the following sector, the detailed interview questions are presented. We designed different questions for each department. All these questions are based on lean thinking.

Purchasing Department

• How many suppliers do you have?
• What are their locations?
• How many suppliers do you consider as important?
• Do the suppliers only provide one type of raw materials?
• What are the measures of choosing your suppliers?
• How often do you inbound the materials? For instant, one week? Or two weeks?
• What is the minimum quantity you purchase once?

Planning Department

• How do you make planning?
• Who has responsibility for planning?
• How often does your customer require an order?
• How does your customer sent an order?
• What are your most important customers?
• How does the planning department sent the orders to the production department?
• How many products do your company produced?
Appendix

• What is the current lead time and cycle time?

**Production Department**

• What kind of production system does your company have?

• How do you design your production plan?

• What are the production activities take place for office chair family products?

• How many types of office chair products do your company produced?

• How many parallel production flows in the production process?

• How long does a component be delivered to the next department?

• How the workers work?

• What is the shape of the workstation currently?

• How long do your workers work per day?

• How many workers work in the workshop?

• How does the worker control the quality?

• Does the worker need to move during production process?

• How many production steps of producing an office chair?

**Warehousing Department**

• Who has the responsibility to organize warehouse?

• How big is/are your warehouse(s)?

• How to operate the warehouse?

• How many warehouses does your company own?

• What the locations of your warehouses?

• How does your company to arrange the products?

• What is the pack size?

• Why does your company choose the warehouses?
Appendix

• How often does your warehouse department sent an order?

**Customer Service Department**

• How many customers do your have per year?
• What are the types of customers?
• What is the largest of customer?
• How do you choose your customers?
• Do you make special orders for special customers?
• How customer’s orders reach your company? For instance, via email, telephone, or faxes?
Appendix

**Appendix 4-Icons**

- Supplier, Outsourced Operation or Customer
- Withdrawal Kanban
- Operator
- Process Box
- C/T =
  - Setup time =
  - Up time =
- Data Box
- Forklift
- Physical Pull
- Push
- Supermarket
- FIFO Lane
- Kanban Post
- Inventory
- Signal Kanban
Appendix 6-Future State Map
Appendix

Appendix 7-Shadow Board

Source from: Internal documentation