ADOPTION OF LEAN MANUFACTURING SYSTEM WITH AIM OF EFFICIENCY IMPROVEMENT WITHIN A LATE LEAN ADOPTER COMPANY (A CASE STUDY)

by

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THESIS PRESENTED TO ÉCOLE DE TECHNOLOGIE SUPÉRIEUREIN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR A MASTER'S DEGREE WITH THESIS IN ENGINEERING, CONCENTRATION IN INNOVATION MANAGEMENT
M.A.Sc

MONTREAL, SEPTEMBER 20TH, 2018

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE
UNIVERSITÉ DU QUÉBEC

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ACKNOWLEDGMENT

Foremost, I would like to express my deepest appreciation to my advisor Prof. Michel Rioux for his continuous support during entire of my master program. He gave me this opportunity to work on my favourite field. It was not possible for me to accomplish this research without his precious comments and ideas. I always benefited from his fortitude, motivation, enthusiasm and immense knowledge.

Beside my advisor, I would like to thank the rest of my thesis committee: Prof. Tony Wong and Prof. Mickaël Gardoni for taking time to read my thesis and offering insightful and valuable comments.

I would also like to thank the experts who answered my questions with patience and helped me hearty with gathering data to conduct this study.

Last but not the least, I must express my very profound gratitude to my family specially my dear parents Ali and Mahin, for their unconditional love and endless encouragement in all scenes of my life.

ADOPTION D'UNE APPROCHE DE FABRICATION LEAN EN VUE D'UNE AMÉLIORATION DE L'EFFICACITÉ AU SEIN D'UNE ENTREPRISE RETARDATAIRE DANS CE DOMAINE (ÉTUDE DE CAS)

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RÉSUMÉ

«Lean manufacturing» (LM) et «Lean production» sont les termes et les concepts qui ont été introduits dans le monde de l'industrie depuis les années 1990. Au cours de ces trois dernières décennies, de nombreuses entreprises de différents secteurs ont appliqué le Lean dans le but d'éliminer les gaspillages et de mettre en œuvre des améliorations continues dans leur organisation. Bien que les capacités et les avantages du Lean aient été prouvés au fil des années, certaines entreprises hésitent encore à utiliser cette approche. Selon la théorie de la «diffusion de l'innovation», fondée sur le facteur d'innovation, les adoptants d'une innovation sont divisés en cinq catégories : innovateurs, adoptants précoces, majorité précoce, majorité tardive et retardataires. L'innovation peut être considérée comme une nouvelle idée, procédure, pratique, produit, etc. Chacune de ces catégories a ses propres caractéristiques. L'objectif de cette recherche porte sur l'adoption de LM dans une entreprise retardataire.

Le cas de cette étude (entreprise X) est un fabricant de meubles au Québec avec principalement un système de production sur commandes en flux poussé. On constate actuellement de longs délais de livraison, un manque d'espace dans l'atelier et un taux de production insatisfaisant. Des entreprises similaires avec les mêmes problèmes que l'entrepriseont amélioré leur efficacité globale en appliquant le concept Lean, mais notre cas n'a pas été transformé en LM jusqu'à présent et les dirigeants ne sont pas très intéressés par la mise en œuvre d'une telle démarche. Le processus de décision d'innovation comporte cinq étapes : la connaissance, la persuasion, la décision, la mise en œuvre et la confirmation. Dans cette étude, il est prévu d'aider l'entreprise à atteindre la troisième étape pour prendre une décision sur la mise en œuvre du LM.

L'implantation du Lean est un long voyage et il sera plus long encore pour les retardataires. La raison pour laquelle ils sont réticents à l'adoption du Lean est leur ignorance des pertes existantes et de leurs impacts dans le système. Dans ces entreprises avec une structure organisationnelle traditionnelle, l'inconscience est le résultat d'un travail en vase clos et de communications faibles. Afin de convaincre les retardataires, il est essentiel de briser les silos, d'améliorer les interactions et de développer une synergie mutuelle. Les retardataires n'accepteront pas une innovation tant qu'ils n'auront pas complètement acquis la certitude qu'elle est sans danger pour eux. Dans cette recherche, nous proposons une feuille de route pour indiquer l'opportunité d'augmenter l'efficacité totale du cycle de 29,4% à 78,3%.

Mots-clés: Lean Manufacturing (LM), Diffusion d'Innovations, Retardataires, Processus d'Innovation-Décision, Système de gestion de silo, Fabricant de Meubles.

ADOPTION OF LEAN MANUFACTURING SYSTEM WITH AIM OF EFFICIENCY IMPROVEMENT WITHIN A LATE LEAN ADOPTER COMPANY (A CASE STUDY)

Sahand JALILI MARANDI

ABSTRACT

"Lean manufacturing" (LM) and "Lean production" are the terms and concepts which have been introduced to industry world since 1990s. In these almost three decades many companies in various sectors have applied lean with aim of eliminating wastes and implementing continuous improvements in their organization. Although the capabilities and advantages of lean have been proven over the years, some companies are still hesitate to use this method. According to the theory of the "Diffusion of Innovation" (DOI), based on innovativeness factor, adopters to an innovation are divided into five categories: innovators, early adopters, early majority, late majority and laggards. Innovation can be considered as a new idea, procedure, practice, product and etc. Each of these categories has its own characteristics. The focus of this research is about adoption of LM in a laggard company.

The case of this study (company X) is a furniture manufacturer in Quebec with mainly push production system. They are currently encountering with long delivery times, lack of space in the shop floor and unsatisfied production rate. Similar companies with the same problems as company X have improved their total efficiency with applying lean concept but our case has not been turned into LM until now and they are not very interested in implementing this procedure. Innovation-decision process has five stages: knowledge, persuasion, decision, implementation and confirmation. In this study, it is intended to help the company to reach to the third stage to make decision about lean implementation.

Lean is a long and time taking journey and it will be longer in case of late adopters. The reason that they are reluctant in lean adoption is their ignorance about existing wastes and their impacts in the system. In such companies with traditional organizational structure, unawareness is the result of working in silos and having weak communications. In order to convince laggards to make decision about lean implementation, it is essential to break down the silos, improve interactions and deploy mutual synergy among them. Laggards will not accept an innovation until they completely become certain it is safe for them. In this research, we propose a road map to indicate the opportunity to increase total cycle efficiency from 29.4% to 78.3%.

Keywords: Lean manufacturing (LM), Diffusion of Innovations (DOI), Laggards, Innovation-Decision process, Silo management system, Furniture Manufacturer.

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LIST OF ABREVIATIONS

BPR	Business Process Reengineering
CI	Continuous Improvements
DOI	Diffusion of Innovations
ERP	Enterprise Resource Planning
JIT	Just in Time
LM	Lean Manufacturing
MTO	Make to Order
NVA	Non-Value-Added
SMEs	Small and Mid size Enterprises
TPS	Toyota Production System
TQM	Total Quality Management
TSSC	Toyota Supplier Support Center
VA	Value-Added
VSM	Value Stream Map
WIP	Work in Progress

LIST OF SYMBOLS

hr	Hour
min	Minute
s	Second

INTRODUCTION

Late Lean Adopters

Plenty of literatures have focused on applying lean in different kinds of businesses but there is a lack of attention in the steps of implementing lean in laggard companies. In this thesis it is not intended to study the results of implementing LM in a specific industry or business. The goal of this study is to find solutions and procedures that lead to convince the managers of a company, who have the characteristics of laggards or late adopters, that lean concepts and tools will help them to improve efficiency and increase the profitability of the organization. To do this end, after introducing laggards and their specs in brief, we are going to present lean concept and its tools which are appropriate to the subject of this study, then investigate the current situation of the company and diagnose the wastes in the system. By indicating these wastes and their impact it will try to take the attention of the top management. Proposing solutions and recommendations for the future to improve the overall efficiency within context of the lean will be performed with the aim of persuading managers to think about potential opportunities for implementing continuous improvements (CI). The case of this dissertation is a furniture manufacturer which is one the important industries in the area (Quebec).

Capabilities and advantages of lean have been become obvious in various industries especially in manufacturing sector in recent decades. Many enterprises have followed lean thinking and applied its tools and benefit from advantages of this procedure by reducing wastes and implementing CI. After almost 30 years from advent of lean in production lines and see its dramatic effects on increasing total efficiency of the organizations, it is not an unfamiliar concept in mind of managers. However, nowadays some companies are sceptic or hesitate to turn from traditional production way into lean manufacturing (LM).

Generally, individuals may respond to an innovation in different ways. This innovation can be a new practice or drill, procedure, product, tools, equipment and so on. According to the

theory of the “Diffusion of Innovations” (DOI) which has been developed first by Everett M. Rogers in 1962, there are five adapter categories: innovators, early adopters, early majority, late majority and laggards. Late adopters or laggards are the last group who will be interested to apply an innovation. Rate of adoption, which is measured by needed time to accept an innovation, is relatively longer for laggards than the other groups.

Global Competition in Manufacturing

Nowadays with the impressive technological advancement in every aspect from designing steps to producing and deliver the final product, customers expect faster services and higher quality commodities from manufacturers. These expectations create a competitive atmosphere for all manufacturers especially small and mid size enterprises (SMEs) to produce articles and offer services which can properly respond their clients’ needs. Many manufacturers are forced to resize or shut down some of their branches and production lines because they did not succeed to gain customers’ satisfaction. This dissatisfaction usually has root in delivery time, quality and price.

However stay alive in global market is important, but it is not enough. Some companies produce high quality products but on the other hand their delivery time or final price do not meet customer’s expect. This unbalanced conditions in offered service, put these companies in danger of losing even their loyal clients. Undoubtedly managing all these factors (quality, time and price) is not possible without cost. Therefore, managers are looking for affordable tools and techniques which can effectively reduce costs and lead time and also improve the quality.

A helpful solution to lessen costs and time in a manufacturer is to completely study all the processes in production cycle and then identify non-value-added (NVA) activities in these processes. The next step is to eliminate these wastes and improve the general function of the firm. Actually this is exactly what lean manufacturing and its tools are talking about.

Background

History of lean manufacturing (LM) is reachable in various literatures and websites. Many believe that Henry Ford was the first person who practically used Just In Time (JIT) and lean manufacturing concepts. However his innovation and achievements are considered as a revolution in automobile industry in 1910s, his mass production procedures were not found applicable to implementation in Japan by Kiichiro Toyoda and Taiichi Ohno who traveled to America to study Ford's method. They found American's mass production method full of wastes or Muda (in Japanese). With making revisions on Ford's idea about production, then they proposed Toyota Production System (TPS).

"Lean Production" or "Lean Manufacturing" is the terms which first used by Womack and his colleagues in the book *The Machine that Changed the World* for TPS which is about their results in studying automobile production systems in the world. Table 1 describes the evolution of lean manufacturing during last decades (Halgeri, Pei, Iyer, Bishop, & Shehadeh, 2008).

Table 1.1 Evolution of lean manufacturing

Year	Event
1910	Ford is considered by many to be the first practitioner of Just In Time and Lean Manufacturing.
1950	Toyota Production System (TPS) or Just in Time
1980	Toyota had increasingly become known for the effectiveness with which it had implemented Just-In-Time (JIT) manufacturing systems.
1990	The term "Lean Manufacturing" or "Lean Production" first appeared in the book The Machine that Changed the World.

TPS and lean manufacturing has the same foundations: eliminating wastes and continuous improvements by all the employees. "Doing more with less" is a famous phrase in definition

of lean manufacturing which means using resources in efficient way in a firm. These resources could be money, time, work space, human, tools and etc.

It is important to know that lean implementation does not mean just using specific tools and techniques in order to improve the function of a factory or manufacturer. Many enterprises failed in applying lean because lack of top management commitment. To have a successful result the entire culture and mindset of the company should change (Liao, 2005).

About the Company

The case study of this research (company X) is a furniture manufacturer in Quebec. It has been founded for about 50 years and its products are mainly used in health care and hospitality industries. Company X consists of around 150 employees who are working one shift each day from 7:30 to 16:45. With having various production line and product families, they produce high quality furniture packages, both metal and wood chairs, which vary from living industry such as dining and resident rooms, lounges, theaters, chapels, beauty salons and etc. to resaurants, bars, cafeterias and so on. The company is also active in furnishing schools, universities, shopping malls, arenas, funeral homes and party salons. Corporate X produces and sells large variey of commercial furniture to customers from Canada and USA.

In order to control and orginize stocks in inventroy and also the processes of the production, management team believed in using Enterprise Resource Planning (ERP) software in their organization. Hence, they bought ERP software and were looking for proper conditions to implement it in the shop floor. But after visiting the shop floor and production processes, it was recognized with current facilities, the plant has this ability to increase the production capacity and raise the profitability of the company. Therefore, it was suggested to them first think about reengineer and simplifying the processes and try to use the maximum capacity of the production before applying ERP system. According to the results of Schniederjans et Kim (2003) use of Business Process Reengineering (BPR) and implementing a Total Quality

Management (TQM) culture have substantial effect on successfulness of a company in establishing ERP system.

Statement of the Problem

According to the subject of the thesis, the fundamental problem which is going to be addressed in this research is unwillingness of the management to apply lean in their corporation. Company X is a luxury furniture manufacturer and it is wellknown in supplying packages for special industries like hospitality and healthcare. Since these industries both are increasingly expanding, currently the company has faced with a significant increment in amount of received purchase orders. For some reasons they have not turn from traditional production into LM. Hence, in this situation company X has encountered to three problems. The first one is a common problem among all manufaturer in the same condition which is about delivering final products to customer on time. They have obligation to deliver the goods to the client within maximum six weeks, but in most of cases this period is not respected.

The second problem is organization of the space in the shop floor. They are not satisfied with the size of the workhouse and claim that the size of site in not suitable for the current rate of production.Eventhough the company has rented another place to stock their production and materials, they do not have enough space to manage the processes in their workshop. This lack of space somtimes forces them to decline new orders.

The third problem which is the last priority of the company, is volume of the production. Managers believe that with current workforce, equipment and conditions they are capable to double their production rate but on the other hand, most of times ther are unable to respect dedlines of current orders. In the opinion of the management, they are not working in their full capacity and this issue is intensively impact the profitablity of the company.

Research Objective

In the most studies focused on LM in various applications, mainly the objectives are to define the current situation, use lean techniques and principles and ultimately report the final results which indicate applied procedures lead to improvement in overall efficiency. Lean journey is relatively long and it will take months to see the remarkable effects of applying LM. Furthermore, it can be longer and lasts years if the case is a late adopter or laggard. Therefore, it was not possible for the researcher to indicate the results after implementation with real data in the time frame of this study. Besides this, as it was mentioned before, the objective of this research is not to assess the results of LM implementation in a furniture manufacturer.

The first objective of this research regarding to these conditions is to make sure that the case of the study is belonging to laggard category. The second objective is persuading the managers of such case to have positive attitude toward LM and helping them to make decision about implementing CI in their organization. Also the results of this research are intended to set recommendations to improve the delivery time and use the space of the workplace in more efficient way which lead to increase production and profit rates.

Scope of the Project

Company X is producing a wide range of the furniture. They are manufacturing three main categories of the furniture which are chairs, soft seats and banquettes. However, they have some other activities such as producing tables, wood works and new products development. Since the significant portion of their sales is rely on chairs' production, the scope of this project is limited to study of the chair's production line. Moreover, creating value stream maps (VSM), to describe current and future status of the production, have to be done based on repetitive sample and at the time of the study the most pressure of the production was in chair department and other products in soft seats and banquettes stratums were not produced in high volume and repetitive mode.

Research Questions

By considering mentioned problems, it is needed to answer the following questions to conduct this research and find solutions for the problems:

1) Why the case of the study has not turned to LM until now and in which stage of adoprion process they are blocked in?
2) What is the current situation of the company?
3) Which activities are value added and which ones are not?
4) What are the potential and applicable solutions within lean principals to improve total cycle efficiency for the production line?
5) What will be the result of recommendations and what does the improved future value stream map look like?

Organization of the Thesis

Following the introduction section, this thesis contains four chapters. Chapter 1 is literature review which is about related researchs to support this study. Chapter 2 is the methodology of the research which is about how the project was conducted and also the process of data gathering will be explained in this part. In the third chapter the current status of the company X from different points of view is explained with presenting gained data. In the last chapter, potential solutions and recommendations to existence issues which were found out by analysis of the current status will be discussed. This chapter comprises discussions about how the system can be improved after implementing LM. Finally the dissertation will be ended by presenting conclusion.

CHAPTER 1

LITERATURE REVIEW

In this chapter we are going to review literatures and papers related to this study. First, we will begin this section with introducing DOI and late adapters. The reset of literature review comprises similar researches about implementing lean manufacturing in various industries. Their procedures and methods that used to obtain successful results have been surveyed carefully and have an important role in conducting this research. In the following of the literature review we are focusing in lean manufacture's principles and tools and lean leadership.

1.1 Diffusion of innovations

In respond to an innovation, individuals may react in different ways. Everyone does not immediately accept an innovation even if it has obvious advantages which have been proven long time ago. This innovation can be an idea, procedure, product, drill and etc. which is considered as new by the practitioners (Rogers, 2010). There are various studies have been done before in field of diffusion of innovation but theory of the DOI was first developed by Rogers in 1960s. The basis of this theory is its compliment about diffusion in which define it as the process of deployment of an innovation within the members of a social system through certain channels. In this definition social system refers to a set of interrelated units which are engaged in joint problem-solving to fulfill a common goal (Rogers, 2010).

After developing the theory of the DOI, plenty of researches have been done based on this opinion in various domains. Raynard (2017) analyzed the results attitudes of student and faculty toward using electronic books as an innovation and aligned them with the DOI theory. Nickerson, Austreich, et Eng (2014) considered mobile technology and Smartphone apps as innovations and examined the diffusion of them in a specific domain. Based on framework of diffusion of innovations, Valle-Cruz et Sandoval-Almazan (2015) found out

that local governments have not been completely understood the use of social media. In their study social media was considered as innovation. Wang, Lin, Chang, et Hung (2011) used the tenets of DOI to investigate how radio frequency identification (RFID) technology was deployed and adopted in Taiwan's logistics industry. Awad, Engelhardt, Coleman, et Rogers (1984), Marsan et Pare (2013)and Romanelli (2016) have done studies about diffusion of innovations in health care organizations and services.

One of the most important discussions in the book of Rogers, *Diffusion of Innovations,* which is very helpful for this study, is about innovation adopters who are divided into five categories. This grouping is based on "innovativeness" factor which is defined as the degree an adopter is relatively earlier in accepting new ideas than the other members of the system. Therefore, adopter categories include: innovators, early adopters, early majority, late majority and laggards. Figure 1.1 comprises two curves which both of them are plotted over the time. The bell-shaped curve represents the adoption of innovation on a frequency basis. On the other hand, if the adoption data is plotted based on cumulative number of adopters, the result is an S-shaped curve (Rogers, 2010). The S-shaped indicates that by adopting an innovation to laggards (the last group) the market will be saturated and the process of the diffusion will be finished.

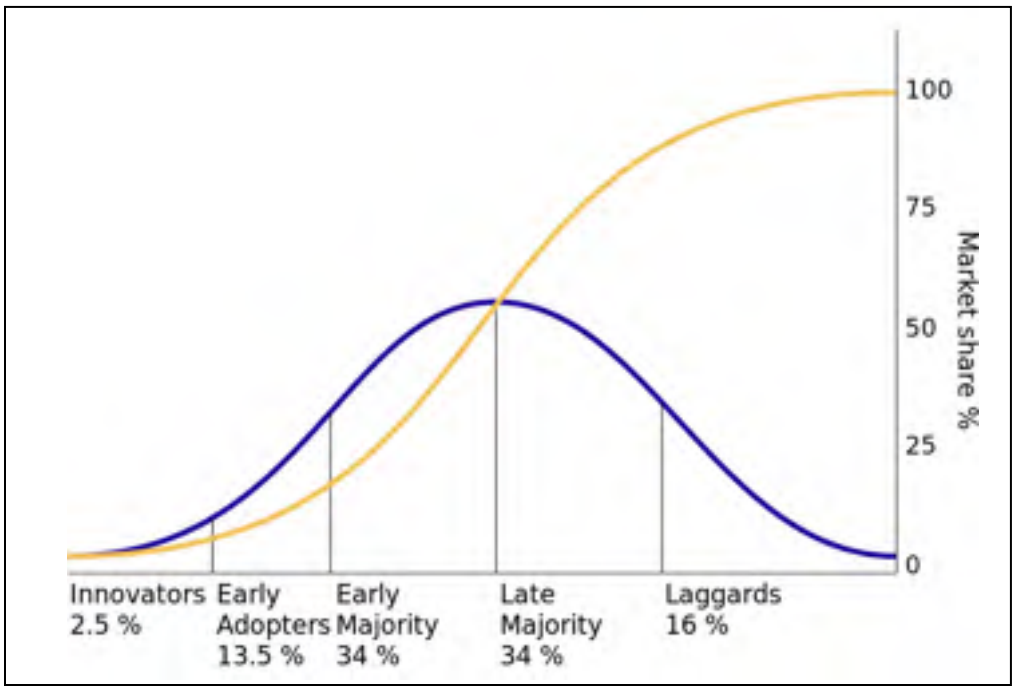


Figure 1.1 Diffusion of innovations curves[1]

However, the focus of this research is to convince decision makers with aspects of laggards toimplement LM in their organization; to better understand the relation between DOI and lean implementation we are going to explain each of five categories in brief. Rogers (2010) describes the characteristics of these groups as follow:

Innovators: The first group of adopters who are eager to try new ideas and accept an innovation. They are interested to take the risk of applying new ideas even if the fail. This interest leads to venturesome become an obsession for them and helps them to have cosmopolite social relationship. They have developed communication patterns and their access to substantial financial resources helps them to absorb the possible loss from risky innovations. They play the role of a goalkeeper in the flow of new ideas into a social system by launching the new idea in the social system with importing the innovation from outside of the system's borders.

[1]https://en.wikipedia.org/wiki/Diffusion_of_innovations

Early adopters: This group is more integrated than the first one. Despite innovators who are cosmopolites, early adopters are localities. They act as a role model among the other groups and are the references for advice and information about the innovation. Hence, they have a respectful place within the social members and because they want to retain this dignity so they must make judicious innovation decisions. Therefore, early adopters decrease uncertainty of a new idea by adopting it and providing an intellectual evaluation of the innovation to near-peers by means of interpersonal networks.

Early majority: The members of this category forming one-third of a system and usually adopt innovations just before the average number of a social system. Their critical position between the very earlier and the relatively late to adopt gives them an interface role in the system who provides interconnectedness. The followers of the early majority may deliberate some time before completely adopting innovations. Therefore, they have longer adoption process than the last two groups. They prefer to communicate others like themselves and rarely take leadership positions and wait to see what competition has to offer. They care about the price but interested to pay for good quality and service (Jahanmir, 2016).

Late majority: Contrary to early majority, late majority adopts innovation just after the average number of a social system. They also possess one-third of the members of the system. They movement toward innovation can be because of the economic necessity or pressure of the peers. They adopt new ideas with sceptical and cautious approach. Their insufficient financial recourses cause them not feel safe until almost all risks have been removed. Hence, they won't make adoption until others in their social have done so.

Laggards: Followers of the last group of the innovation adoption almost do not have any idea about leadership. They mainly have traditional attribute and put the past performance as the reference of future plan. They also have interaction with members that have traditional ideas like themselves. Laggards react in a suspicious way with innovations and change agents. Their traditional trend slows down the process of adoption as much as possible and innovation-decision process in relatively long for them. They believe in their hesitation in

acceptance of new ideas because of limited recourses they have. Laggards must be certain that an innovation won't be fail then they will afford to adopt and usually when they convince to do adoption, that innovation may have been substituted by another more recent idea which is already being used by the innovators. A good example for this case is the tendency of the companies to use new ERP software to manage the recourses years after applying reengineering and quality management tools such as LM.

1.1.1 Innovation-decision process

According to Rogers (2010) the innovation-decision process is the process in which decision maker person passes from first knowledge of an innovation, to creating an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. Rogers states that this process includes five successive steps over the time that individuals go through them to evaluate the new idea and decide whether they want to integrate innovations to current situation or not. He explains these five stages as follow:

1. *Knowledge:* Occurs when decision maker becomes aware about existing the innovation and gains some information about it;
2. *Persuasion:* Occurs when decision maker forms a favourable or unfavourable tendency in face of the new ideas;
3. *Decision:* Occurs when decision maker engages in activities that results his or her decision about accepting or rejecting the innovation;
4. *Implementation:* Occurs when decision maker apply the innovation and integrates it with current situation;
5. *Confirmation:* Occurs when decision maker is looking for more support to applied innovation. In this stage it is possible that he or she returns from the made choice because of receiving conflict message about the innovation.

Regarding to above definitions, Rogers (2010) proposes a model for the stages of innovation-decision which is shown in figure 1.2.

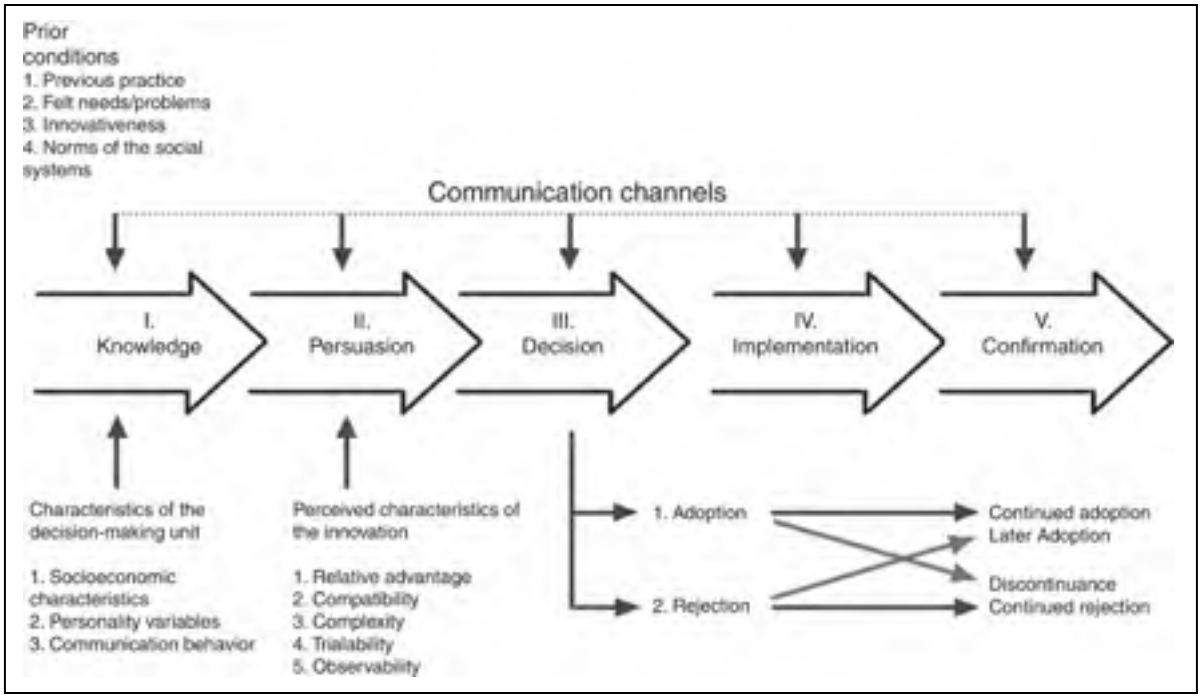


Figure 1.2 Model of five stages in innovation-decision process[2]

1.1.2 Silo management system

In companies with traditional structure, management relies on experts in given departments to develop systems and procedures to guide the organization. These experts merely care about their own sections (silos) and have specialists working for them who created culture and systems for the silo master (O'neil, 1994). In other words, people with silo mentality work in their best interest, to do the best performance and get high level of results, regardless of the effect that might have upon others (Hotăran, 2009). This phenomenon occurs when certain departments and sections in an organization do not share their information and knowledge with each other and flow of information is very slow in such company. The "silo effect" is a common term in the business and organizational communities to describe a lack of communication and common goals between departments in a company (Hotăran, 2009).

[2]https://www.sciencedirect.com/science/article/pii/S1809203916300067#bib0105

Silos do not really physically exist in organizations, but they are in the mind of employees who have a shared impression of its reality. In their mind, it is more safe and comfortable to keep others out and in this case silos are considered as barriers in organizations which creates "us and them" attitude (Cilliers & Greyvenstein, 2012). To better understand the point, imagine two silos right next to each other and if people were inside them they could not be able to communicate because silos are tall, narrow and without any hatch to the outside (Hotăran, 2009).

O'neil (1994) states that the silo master keeps the control of his or her area by giving to understand to other silo masters that how his or her department works and there will be no interference from other groups or departments. In this situation, managers of the departments do not fully understand the requirements for positive interaction within each other. He explains this matter by giving an example in which customer's order passes through several departments like marketing, design, manufacturing engineering, manufacturing and each of them just perform based on their own interpretation without having effective communication. Quality control department diagnoses the product undesirable and they have to do the job again with the same attitude. At the end, when the final product is delivered to the customer, it is rejected because it does not meet his requirements.

Silo management system leads to poor connection and this will reduce efficiency of the organization and undermine the spirit of cooperation and corporate culture. It imposes additional costs to the company and creates complicated situations. "We are getting better today at breaking down silos and allowing interaction through cross-functional team management. Management should evaluate themselves to determine if their management style is autocratic or team oriented" (O'neil, 1994).

1.2 Lean manufacturing

With publishing two well known books by Womack and his colleagues in the 1990's, *The Machine That Changed the World* and *Lean Thinking*, lean manufacturing (LM) was known in North America. The main concept of LM is based on Toyota Production System (TPS) that founded by Taiichi Ohno, a former chairman of Toyota, in 1978. The basis of the TPS is waste elimination. Just In Time (JIT) and Autonomation (or automation with a human touch) are the two pillars needed to support the system (Liao, 2005). "All we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes"(Ohno, 1988).

Just In Time: JIT, the most substantial segment of the TPS, refers to a concept in which, the exact material or parts have to deliver to assemble line at the time they are needed and only in the amount needed (Ohno, 1988). Actually, this way of thinking will help a company to approach zero-inventory. This concept comprises continuous flow, takt time and the pull system (Koole, 2006). Takt time is calculated with dividing available working time in one shift (usually in minutes) by units of needed jobs per shift. For example if available working time is 505 minutes and the customer requires 100 units job per day, then the takt time will be 5.05 minutes per job. To Comparing to traditional production system, JIT is more capable to response to customer's requirements. In this system, the manufacturing process changes to PULL system that means a product will be produced only when the customer ask for it. To simplify the process, we have to calculate the number of parts and the frequency of use in a specific time interval. However, the concept seems easy, but it is hard to implement. Enterprises which attempt to apply JIT in a short period probably will get fail. It can be implemented with no significant investment but all employees and managers must have commitment to it (Liao, 2005).

Regarding to origin of the LM and the given background, it is a concept about removing wastes in production system and making continuous improvements. “Lean production is “lean” because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products” (James P Womack, Jones, & Roos, 1990). Lean manufacturing aims to produce quality products in the most efficient and economical way by decreasing human effort and inventory and also having on time delivery. LM centralizes on increasing output, planes to produce products and services with the lowest cost and highest pace (Rahman, Sharif, & Esa, 2013).

According to foundation of lean manufacturing, which has the same root with TPS, distinguishing between value and waste and then eliminating waste are the primary goals of this concept. “VALUE” is defined by end user and it is considered as everything that the customer has desire to pay for it and anything else is recognized as “WASTE”. All activities and action that are done within a production line or shop floor divide in to three groups. The first group is activities that add value to the production. Second group is activities that add no value to the production but they are necessary or unavoidable for production such as inspection. The last group is activities that do not add value and they are not necessary. The mission of the lean is to improve the first group, reduce the second one as much as possible and eliminate the last group of activities.

In definition of the activities, the second and third categories are defined as waste. In the theory of the lean thinking, there are three types of wastes: muda (waste), mura (unevenness) and muri (overdoing). Muda comprises two types. The second and third groups of activities, which have been defined before, are muda type I and muda type II respectively (Austin, 2013). Muda happens in seven forms (TIMWOOD):

1. Transport: any unnecessary movement of material, production or information,

2. Inventory: any kinds of raw material, work in progress (WIP) or finished goods which are surplus of what is required,
3. Movement: movement of personnel between the processes that does not add value to the product directly such as movements for adjustment,
4. Waiting: any stop (idle) time between two processes is waiting and considered as waste,
5. Overproduction: making more than what customer needs. This also causes waste in other areas at the same time,
6. Over processing: expending extra resources to produce products that do not have value from customer's perspective
7. Defects: repeat production or processes because the product does not conform to customer's requirement which leads to rework.

1.3 Lean principles

The structure of the lean thinking contains of five principles. All decisions made by managers have to conform to these elements in order to have a successful lean implementation in an enterprise. J.P. Womack et Jones (2010) describe the summary of these principles as follow: "precisely specify *value* by specific product, identify the *value stream* for each product, make value *flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection.* By clearly understanding these principles, and then tying them all together, managers can make full use of lean techniques and maintain a steady course". In the remainder of this section, we explain each of these principles in more details.

1.3.1 Value

Value is the first and important point for lean thinking and it is always defined by customer. Value of a product or service is determined based on needs of customer at a specific price and specific time. Producers create the value and this is their reason for existence from the customer's point of view (J.P. Womack & Jones, 2010). It is critical to recognize value from

client's standpoint and not from producer's perspective. Some manufacturers set their processes without considering what their customers really want to pay for. This only leads to produce wastes in long term. Once the value is identified, managers can distinguish between value-added and non-value-added activities. Value-added activities are those which turning the raw material in a way that contribute to the end user. Activities else than this are all wastes or muda (Austin, 2013).

1.3.2 Value stream

To understand strengths and weaknesses of a production line or a given service, we need to have a clear outline of all ongoing activities within the firm. Value stream comprises all required activities and events to bring a specific product (a good, a service or both of them) through the following three important business tasks:

- Problem-solving task: running from concept through detailed design and engineering to launch of the production,
- Information management task: the process from placing an order to detailed time plan for delivery,
- Physical transformation task: the process from transforming raw material to a finished product in the hands of the customer.

The next step is to analyze the entire value stream for each product or product family. However, most firms neglect to do value stream analysis, it reveals remarkable amount of wastes within processes (J.P. Womack & Jones, 2010). With aid of value stream analysis three groups of activities, which has been discussed before, are identified and decisions for improving, re-engineering and eliminating of these activities are made. Value Stream Mapping (VSM) is a simple but very useful tool of lean which give a transparent vision to the managers about what is going on the shop floor. VSM will be explained in more detail in lean tools section.

1.3.3 Flow

When value stream has been well identified and non-value-added activities and wastes have been eliminated from the production process, now it is time for the next breathtaking step in lean thinking: Make the remaining, value-creating steps flow (J.P. Womack & Jones, 2010). In other words, the production process from the moment that client put order to the time that the product is received, should flow without any stoppage. If this process is interrupted by any reason such as machine downtime, waiting as inventory and rework because of defects, it is considered as waste and should be eliminated (Austin, 2013). Flow is defined as a value-creating step. Resource and information flow are the two areas that get more impact from flow process. It is a great challenge in field of lean management to make the process to flow smoothly and requires rearrangement of thinking way, great efforts and persistence (Ramalingam, 2008). “One piece flow” production versus “batch” or “mass” production has several essential superiors that the most important of them are process time reduction, lower idle time, preventing overproduction, faster detection of defects and ultimately higher efficiency.

1.3.4 Pull

Significantly reducing the time required going from concept to launch, sale to delivery and raw material to the customer is the first sensible effect of transforming from departments and batches to product teams and flow. This will lead to save a remarkable amount of time in production development, order processing and physical production (J.P. Womack & Jones, 2010). In the next move by following *pull* production system, producer makes what the customer wants at the right time and as much as needed. With this policy there is no need to sales or production foresight. In other words, in this case the customers pull the product from manufacturer or producer as needed rather than pushing onto client. By applying this procedure, beside than preventing from overproduction, the demands of customers become much more stable because they realize that it is possible for them to have what they want

right away and also producers do not conduct rebate events to sale unwanted goods (J.P. Womack & Jones, 2010).

1.3.5 Perfection

When in a company value is specified, value stream is identified, production processes flow smoothly and customer is able to pull product from the company, lean thinking is running in that firm by previous four principles. The last principle of lean thinking, perfection, is about to continuously maintaining all these improvements. As it is show in figure 1.1 all these principles interact with each other in a virtuous circle. It means that effort for reducing time, cost, space and mistakes while producing a product that conforms to customer's requirements, is an endless process. Getting value to flow faster makes wastes detectable in the value stream and the harder you pull, the more flow obstacles are identified so they can be eliminated (J.P. Womack & Jones, 2010).

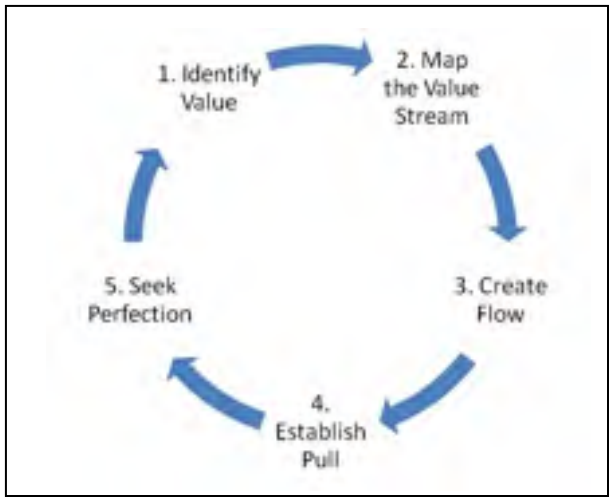


Figure 1.3 Principles of lean[3]

[3]https://www.lean.org/WhatsLean/Principles.cfm

1.4 Lean Tools

There are numerous tools within lean context to implement its principles and conduct projects through the lean thinking. The aim of these tools is based on lean's philosophy which is identifying and eliminating wastes and implementing continuous improvements. In this section we will explain some of these tools which are related to this thesis in more details.

1.4.1 Value Stream Mapping (VSM)

As it is mentioned before, once the value is defined by customer it is time to identify value stream that demonstrates which activities are VA and which are not. The classifications of these activities help us to detect mudas in production processes and get ready to remove them. Value stream mapping (VSM) which first developed by TPS, is a simple but very powerful and useful tool in lean's toolbox in order to realize and visualize value and flow in the processes. This pencil and paper tool presents essential data about material and information flow within manufacturing processes by depicting a holistic blueprint of all ongoing activities, either VA or NVA, which are needed to produce a final product from raw material and deliver it to the customer. This final product can be a good or service. The goal of value stream map is to reduce wastes in production line as much as possible. These wastes prevent the constant move of material and information (Behnam, Ayough, & Mirghaderi, 2018).

VSM as a process mapping tool, is capable of showing both process flow and communication within the process or value stream and also gathering, analysing and presenting information in a very condensed time period. Therefore, this method reached to acceptance in field of continuous improvement rapidly. Furthermore, VSM is a tool that every stakeholder from the management to the newest entry-level employee can understand it and visualize the process. Normally two kinds of VSM are developed in a company: *1) Current State Map:* that is about existing and ongoing process from which all improvements are measured, *2) Future*

State Map: shows the state of value stream after improvement implementation (Nash & Poling, 2011).

We can see in figure 1.2 that normally each VSM has three major parts. To create an effective value stream map, it is important to support these parts with enough details that make VSM clear and understandable for any audience (Nash & Poling, 2011).

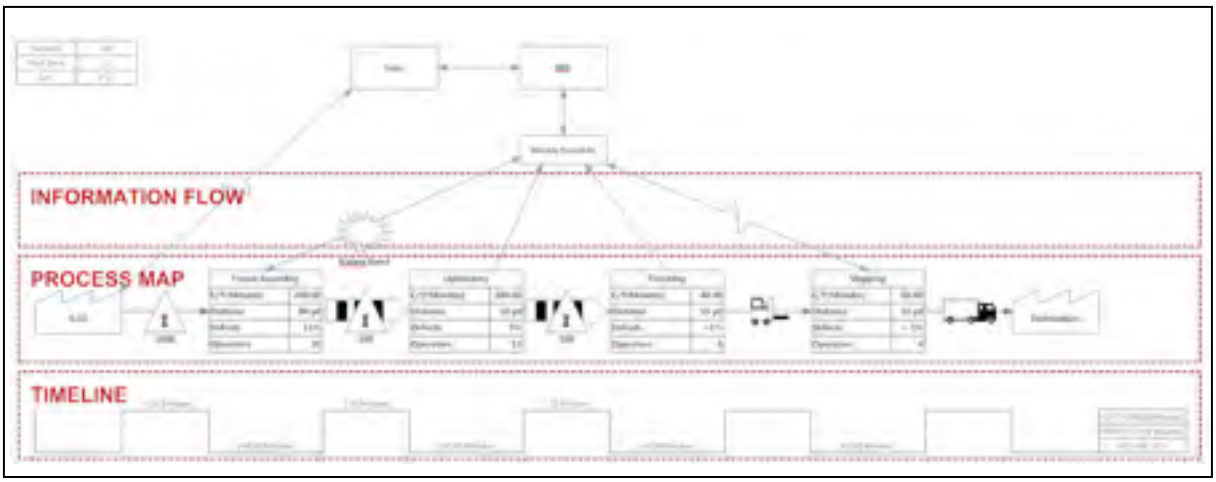


Figure 1.4 VSM components[4]

Process or production flow: this section is always drawn from left to right. To develop this part, the material flow of the product is traced from getting the raw to storing the final product which is ready to deliver it to the customer. Process flow also provides data about operation such as current schedule, number of operators and the amount of inventory in various queues (Irani & Zhou, 2011). By looking to the process as a whole, we can discuss about problems and opportunities exist in the current state map that enable us to find solutions, eliminating wastes and improve process (Nash & Poling, 2011).

Communication or information flow: this part of VSM is drawn from right to left or from the customer back to the supplier. The top portion of VSM makes it possible to see all of communication, formal and informal, that exist within a value stream. NVA communication

[4]https://www.smartdraw.com/value-stream-map/

can be detected through information flow (Nash & Poling, 2011). This section provides important information for determining the pacemaker process in the manufacturing system or production line for which the current state map is being developed (Irani & Zhou, 2011).

Timelines and travel distances: after process and information flow have been mapped, a timeline at the bottom of the map represents the processing time for each operation and the transfer delay between operations. It shows the VA and NVA steps in value stream (Irani & Zhou, 2011). Timeline has two parts. The top line measures the process lead time which demonstrates how long it will take on average to move all the existing material or work through to completion. Lead time typically is measured by number of days. The bottom line is showing total cycle time which observed at each process step and documented beneath each process box on the map is brought to the lower line (Nash & Poling, 2011). By an initial comparing between lead time and cycle time we can recognize waste and NVA activities. Some maps also have another line under the timeline that represents the travel distance of the people moving physically within the process (Nash & Poling, 2011).

To conduct a future VSM, with consideration of current state map we plan to eliminate waste and implement continuous improvements. We suppose ideal conditions and try to approach to that as much as possible. VSM helps us to identify areas which need reformation and provide essential information for other continuous improvement tools like Kanban, Kaizen and 5S.

1.4.2 Kanban

“Kanban” is a Japanese word composed of two parts. “KAN” which means visual and “BAN” means card. As its meaning implies, basically it is a signalling system for inventory management. Kanban was first developed by Toyota and it is based on pull system (Ramasahayam, 2016). In other words, in this system customer is pulling the part from the supplier of that part. The customer can be an actual consumer of a finished product (external) or the production personnel at the next station in the manufacturing facility (internal) which

in this case the supplier can be the personnel in at the preceding station (Rahman et al., 2013). This tool enables companies to benefit from JIT production properly in order to control the flow of work-in-process (WIP) and inventory which leads to preventing overhead production and cost reduction (Skaf, 2007). LM wants to reach high output or service demands with less inventory. In this way Kanban acts as a tool to control the levels of buffer inventories in the system to regulate production quantities. When a buffer reaches its preset maximum level, the upstream machine is signalling to stop producing that particular part type. Therefore, Kanban within manufacturing are signals used to replenish the inventory of items used repetitively within a facility (Rahman et al., 2013).

Normally, a traditionally Kanban system consists of cards with information required to move parts between preceding and succeeding processes. This system can be divided in to two types: withdrawal (pull) Kanban and production Kanban. Cards for the first one allow the movement of parts between operations and for the second one authorize the manufacturing of parts in the quantities indicated. The benefits of implementing Kanban system are (Lin, Chen, & Chen, 2013):

- Reduce inventory holding,
- Better material flow,
- Prevent overproduction,
- Ensure control at the material handling level,
- Develops visual scheduling and process management,
- Increase response to market,
- Minimize obsolete inventory,
- Improve supply chain management

Within Kanban discipline the assumption is that material will not be produced or moved unless a signal is received from the customer's side. It is a method to achieve effective production operation and there are few determinants in order to set it up. Four factors should be considered to ensure the successful Kanban implementation:

Inventory management: without this factor a company cannot attain a low-cost strategy. There are four types of inventory: raw material, WIP, finished goods and maintenance, repair, operating. Inventory involves with storage and holding costs and space in manufacturing plant. Hence, its management is important and complicated in an organization (Rahman et al., 2013).

Supplier participation: Within Kanban method, we need minimum level of inventories in production line where the inventories number and the production numbers should be the same. In order to have an efficient and smooth production line, supplier should have full commitment to provide raw materials. Five criteria for choosing supplier are quality, willingness to work together, technical competence, geography and price (Rahman et al., 2013).

Quality improvement and quality control: Besides decreasing cost with having fewer inventories, Kanban also helps company to control and maintain quality improvements of the output. JIT is one the elements constituted in Total Quality Management (TQM). All parts should have acceptable level of quality before going to the next step or delivering to the customer. For sure, improved processes lead to high quality, high quality creates credit for the producers, customer used to high quality product and ultimately high quality reduces costs such as prevention, appraisal and failure costs. Before, quality was considered as cost and traditional companies believe defects are caused by workers and the minimum level of quality that can satisfy the customer is enough. But, within Kanban concept quality leads to lower cost, that system caused most defects, and that quality can be improved with aid of Kaizen (Rahman et al., 2013).

Employee participation and top management commitment: To have a useful solidarity and meet the goals in a company, commitment and good agreement between employees and management are the essential factors. In today's work environment this has been become as a culture. All employees should be concerned, participative and have sense of responsibility to

successfully deployment of new system and prosperity of organization in the future (Rahman et al., 2013).

1.4.3 Kaizen

"Kaizen" and "Continuous Improvement" (CI) are the concepts which always come along together. CI refers to unending effort for improvement including all people in the organization and is an important factor to develop advance production procedure in today's competitive environment (Singh & Singh, 2009). Kaizen is another Japanese term and also philosophy with the meaning of betterment or improvement.VSM is a tool which shows you where you are and where you are going but without specifying *how*. The answer to this question that how we can improve the value stream, is Kaizen. Like any other items in lean's toolbox, the goal of Kaizen is to eliminate waste in the system (Sayer & Williams, 2012). Since every activity and product is able to be improved, the umbrella of Kaizen covers many of management techniques such as JIT, Kanban, total quality control and etc. The philosophy of Kaizen is that continuing effort results small improvements. It cultivates process-oriented thinking because in order to gain improved results, it is needed to improve processes. This may be opposite of the manner of the most Western managers which is result-oriented. Standardization is an important trait of Kaizen. Standards mean set of policies, rules, directives and procedures defined by management for all major operations as guidelines that enable all employees to perform their jobs successfully. If people are unable to follow established rules, it is the management responsibility to train employees or review and revise them. Once the standards were implemented, they have to be maintained and then try to improve them (Wittenberg, 1994).

Kaizen is people-oriented as well. "Of course results count, but kaizen assumes that improvements in people's attitudes and efforts are more likely to produce improved results in the long run than mere result-oriented thinking would do" (Wittenberg, 1994). Kaizen includes everyone in an organization from top management to workers and operators. It is a regular and daily activity that focuses on humanizing the workplace and eliminating hard

work. In this regards, people must be respected in the system. They are not only shouldn't be blamed or judged for the past mistakes, but also encouraged to share their suggestions for improvements. Kaizen requires everyone's cooperation and in management level roles are different. Defining directions of Kaizen for the company, setting goals and creating the culture in which kaizen can thrive have to be done by senior managers. In addition to provide required resources, they ensure that the direction of improvement continues to improve customer value and improves the business in the direction of ideal state. At the second level, middle managers ensure that the employees have requirements like skills, materials and tools to perform Kaizen. The execution of the Kaizen from guide and teach to its implantation is also their responsibility. At the last level, supervisors check if Kaizen is happening on both individual and workgroup step and make sure that everybody is following standards. It is important to be noted that managers show their leadership by practicing Kaizen themselves (Sayer & Williams, 2012).

Until now it can be concluded that Kaizen starts with people and attends to their efforts. Work of people on processes results their continuous improvement and gaining better results. The ultimate benefit of these endeavours is customer's satisfaction (Wittenberg, 1994). Wittenberg (1994) presents ten essential rules to practice Kaizen in the shop floor:

1. Quit from traditional production methods;
2. Instead of looking for the reason of why it cannot be done, think about how to do it;
3. Do not make excuses. Start by questioning current practice;
4. Do not look for getting complete success. Do it immediately even to get half of results;
5. Correct mistakes at once;
6. Do not spend money for Kaizen;
7. Difficulty leads to emerge of intellect;
8. Ask "Why' five times to reach to the root causes;
9. Wisdom of the group of people works better than knowledge of one;
10. Kaizen is an endless effort.

1.4.4 5S

In organizations, specially manufacturing sector, the places where the work is created must be in order, neat and clean. Having such environment will bring several benefits for the business. The first one is that it causes smoother flow in the shop floor. Flow is a vital segment of any production line. If it has obstacles or be interrupted it will impact other factors such as cycle time and lead time. Organized workplace will also improve the mentality of the operators and enhances their confidence and this will increase the quality of the products. Another advantage of working in a tidy place is its safety. In addition, it is hard to identify defects and mistakes in welter position. Therefore, in ordered place we can find and rectify issues easier and faster. When the significance of being regular in work stations was determined, it is time to apply applicable drills to move toward this target.

5S is one the most useful methods in lean manufacturing to organize work stations and implement continuous improvements (CI) in shop floor. The term and method is originated from Japan in the mid 1950s and it is the short form of five Japanese words which stands for Seiri (Sort), Seiton (Straighten), Seiso (Shine), Seiketsu (Systematize) and Shitsuke (Sustain). In some literatures another S has been added to this list which is for ‘Safety’. 5S is the first step to apply CI and ensure it in housekeeping and results in better environment and safety standards (Gupta & Jain, 2014). Like any others lean tools, the ultimate goal of 5S is also removing wastes from the system. Discarding junks and individual cleaning responsibility are some of typical 5S activities which everyone should does in order to have a total-quality work environment. Since these activities seem simple, people do not pay enough attention to them but with presence of 5S functionality in a facility, out of place or missing items or tools stand out and time spent for searching for them gets essentially eliminated (Chitre, 2010). Implementation of 5S has two phases. The first one is throwing out all junk and do not work around it and the second one is creating a system in which everything has its place. Fundamental to these two phases is ensuring the safety of the people through effective layout and design. An important matter before applying 5S is determining the bounds of area

it is going to be used. Addressing the entire facility at once may overwhelm people and creates this risk that items are not really removed, but just are shuffled around (Sayer & Williams, 2012).

Sort: The first step of the 5S is about discerning between what we need and what we do not in work place and then just keep those we need. To decide how essential the things in the work place are, any production team have to know about their product, customer and customer's requirements. In other words, they have to identify value-added activities and only keep those tools which are needed to accomplish these activities and remove the surplus ones. This is more than just a cleaning process. Actually, it is an opportunity for all departments to re-evaluate the tools at their disposal to ensure they are using the best available tools for their process (Chitre, 2010).

An effective procedure to sort items in work place is dividing them into three R categories (3R technique):

- Retain: Retain needed items to perform VA activities. These items are divided into two groups: regular use and occasional use;
- Return: Return any items which do not belong to you to their source place.
- Rid: Rid the area of all other items. Physically move them directly to the recycle bin or dumpster for disposal. If it cannot be decided to throw out an item or not, dedicate an area in the shop floor and dispose these items there.

In the Rid stage, before transferring items to dedicated area, attaching a red tag on each item with information about its disposition can be very useful. This tag includes information such as date it was moved to the area, the place it came from, the person who moved it, the desired disposition and the functions that need to sign off on the disposal. Items which remain in red tag area more than one week and in this period nobody uses them should be discarded forever. This technique also can be applied to digital information by deleting duplicate or obsolete email messages or data in folders (Sayer & Williams, 2012).

Straighten: Once the sorting operation, the first phase of 5S, was done successfully, the next S in 5S is the beginning of the second phase. It is needed to find a place for everything and put everything in its place. Items that are always needed have to be moved to places where they have to be (Sayer & Williams, 2012). The benefit of performing this stage is that tools which are needed to do a job will be accessible easily and this will reduce cycle time in each process. Creating current and future VSM is a helpful method to recognize material position and plan on how things can be re-arranged to make the movement more effective and efficient (Chitre, 2010). Activities which can be done to straighten items are (Chitre (2010), Sayer et Williams (2012), Gupta et Jain (2014)):

- Labelling: Put label on everything with definite color, name and number to easily find them;
- Painting floors: Draw borders to distinguish different work areas;
- Creating standards for the colors: For example indicate aisles in the facility by yellow, safety stations by green, dangerous areas by red and so on;
- Dedicating place for items: Use rack, shelf and shadow boards to store tools

Shine: In this step it is assumed that unwanted and waste items have been removed completely and everything is in its place. Now everybody has to do deep cleaning in his or her area. This means thoroughly scrub everywhere including checking and fixing equipment if they have leakage or need paint and eliminate the root cause of problems. It is important that this phase is done by team members who are focused on interpreting information that the cleaning process is generating not by an outside contractor because there is probability to lose those information. People have to do shining as a habit and daily activity and it should be audited by a specified team. Because less waste results in more revenue and this is one of the most difficult and critical accomplishment in an organization (Chitre, 2010). Employees have to do cleanliness automatically. This process can be more effective if it is done zone wise and workers follow specific standards to perform it (Gupta & Jain, 2014). Sayer et Williams (2012) present following as the reasons of the importance of this step:

- People working in a tidy place have better moral and are more productive;
- Cleanliness results in having clean mindset;
- Clean equipment helps to recognize defects with them easier;
- Clean and clear areas help to create safer work environment.

Systematize: By performing the first three S's the entire area got clean one time. With establishing schedule and systems the gains from previous steps will be become as a contract and team members work in the new way of working without expectation. It is important to prevent procedures from breaking down. Because this helps to reinforce drills that will be key in driving improvements in the future (Chitre, 2010). Employees' have remarkable role in developing standards. They know their responsibilities and do them in a regular routine. Best work practices are performed and various ways are find out to make sure that everyone is doing his or her activity in work station (Gupta & Jain, 2014). The points which can help to better systematize the process are as follow (Chitre, 2010):

- Document the gains from the first three steps and make them part of the daily routine;
- Apply visual aids and visual management such as shadow boards, labelled shelving, tagged bins and so on to reveal irregularities;
- Schedule 5S activities as often as possible;
- Set a 5S contract or agreement with mentioning roles and responsibilities before starting the implementation of the program.

Sustain: This is the toughest part of the 5S process to implement. Because we have to turn a one-time event and new practices into the way we conduct business (Sayer & Williams, 2012). Since it is hard to change long standing procedures and behaviours, there is a risk to go back to old fashion. The last S involves making 5S concept as the way of life in an organization and personal discipline to follow agreed upon new standards. Many companies fail to perform this final step even if they successfully completed the first four ones. The

reason is company's culture that commands how this phase turns out for them (Chitre, 2010). To intercept from failure, standards have to be maintained long time in an effective way, workers should be consulted regularly and also setting reward system can motivate employees.

1.5 Lean leadership

Until now it was discussed about lean philosophy and goals which are identifying waste in the system and attempting to eliminate them and finally gaining customer's satisfaction. Lean implementation results in fulfilling works with less effort and lower cost. To reach to these targets five core principles which are value, value stream, flow, pull and perfection have been introduced. Once the outline of the plan was created, various tools and methods will be applied to achieve lean (Alefari, Salonitis, & Xu, 2017). According to the situation and conditions of the case of this study, required tools such as VSM, 5S, Kanaban and Kaizen were discussed in previous sections. Most of lean practitioners think solely by using several methods they will attain desired results in short time. After a while, when improvement is not achieved in the state of production, the commitment to the principles will be lost. They usually ignore the importance of the role of people and at the top of that senior manager in successful LM implementation. Lean is a time taking journey and transition to this way is not one-night process and needs managers' fortitude and commitment.

1.5.1 Successful lean implementation

A comprehensive explanation about consequence of implementing lean just through applying its tools, has been brought by Liker (2003) in the book *The Toyota Way*. He states that some plants in U.S. decided to run TPS and lean in their organization with assistance of The Toyota Supplier Support Center (TSSC). Even though, lean production cell and pull system were there and cycle times have been reduced, but over time, the lean production line which was set up by TSSC fell down instead of getting improvement. The companies failed to implement lean and faced with less efficient production lines. Liker argues this as follows:

"The problem, I believe, is that U.S. companies have embraced lean tools but do not understand what makes them work together in a system. Typically management adopts a few of these technical tools and even struggles to go beyond the amateurish application of them to create a technical system. But they do not understand the power behind true TPS: the continuous improvement culture needed to sustain the principles of the Toyota Way" (Liker, 2003). He introduces four categories of 14 principles which are the foundation of the TPS which are: Philosophy, Process, People/Partners and Problem Solving. Figure 1.3 indicates a model of these principles with the name of "4 P" (Liker, 2003).

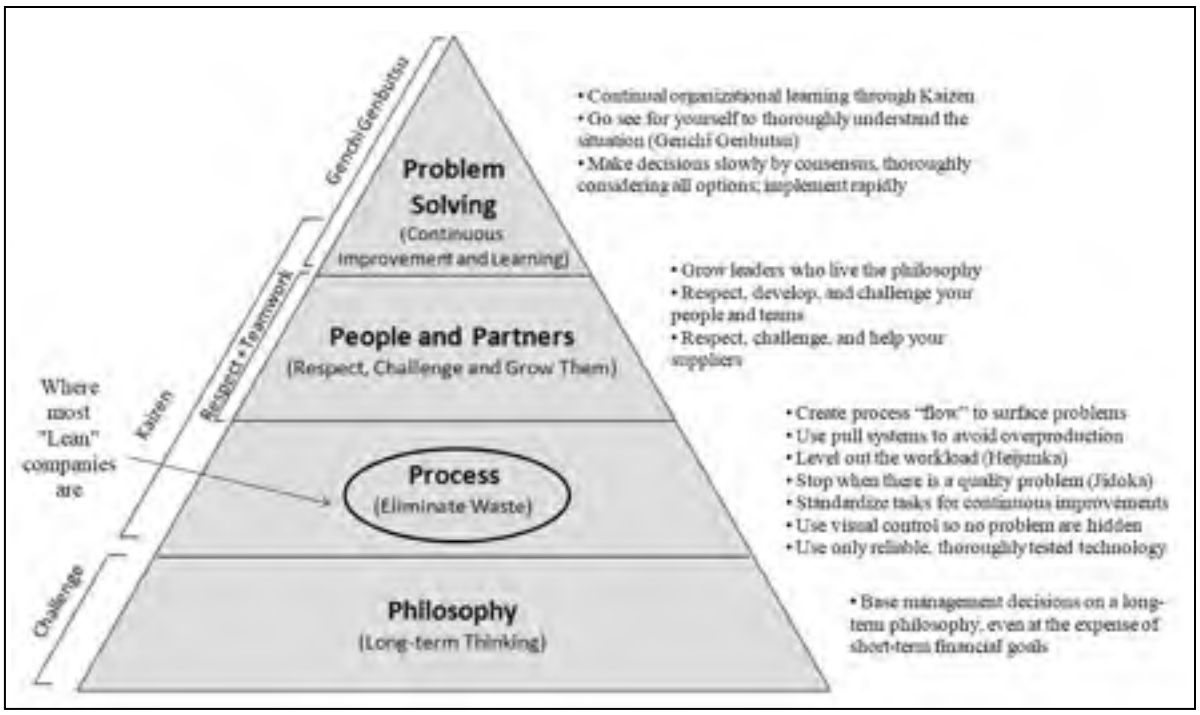


Figure 1.5 "4 P" model of the Toyota Way[5]

As it is indicated in the figure, most companies are in "Process" level. Without passing through other stages, their implemented improvements are superficial because there are not any heart and intelligence behind them to make those improvements sustainable throughout

[5]https://www.alfraconsulting.eu/lean-transformation-model/

the company. Desired results will not be gained and their performance will continue to lag behind those companies that adopt a true and complete CI culture (Liker, 2003).

1.5.2 Role of management

However, lean is a well known term in modern industrial world, there are still challenges in its successful implementation. Turning from old mass production system into the lean thinking depends on numerous factors. Some of these factors which have investigated in numerous studies are: organizational culture and ownership, developing organisational, management commitment and capability, providing adequate resources to support change, teamwork and joined-up whole systems thinking, training and education, employees, thinking development, communication and so on. Almost in all studies, managers' commitment is the common and obvious factor in lean transformation. A critical factor to introduce LM is employees' engagement and leadership is considered as a cornerstone to this matter (Alefari et al., 2017).

To sustain the lean changes in the system, we have to foster culture of CI within all employees. Creating and maintaining this culture is on the shoulders of the managers and they can motivate and courage people to follow new method by representing their obligation. Hence, senior management commitment is a vital factor and could be demonstrated as developing clear vision ensuring sufficient financial resources and providing strategic leadership. LM as a change is not one-off project but it is a continuous process with influence on processes and people. This change journey is often desirable to be driven from the shop floor. It is the responsibility of the management to lead this movement from the first stages (Change Management). It is inevitable that the role of leader is essential in every organization. Therefore, the more important matter is the people who will play this role. An interesting difference between western manufacturing companies and Toyota (as a symbol of LM) is that they rely on the common practice of employing managers with the substantial lean experience when they want to implement lean, whereas Toyota invests in developing

leaders (Alefari et al., 2017). Based on literature reviews, there are several expectations from management. Alefari et al. (2017) summarize them as follow:

- *Top management commitment:* Usually when desired results are not gained because of misunderstanding between results and objective, the commitment creeps. Managers in all levels, who have complementary roles in the lean implementation, should retain their commitment;
- *Leadership style:* The complementarily of the roles can be improved by distributed leadership even in informal way. The expected behaviours from leaders are being: firm and inspiring, relentless and resilient, demanding and forgiving, focused and flexible and ac as role models;
- *Engaging and developing employees:* engagement of employees is important which usually is done in form of hierarchy. It means that top management engage middle managers and then middle managers will engage employees. This process can be done through training, practicing, mentoring coaching and so on;
- *Setting a lean strategy:* The leader has to outline a clear plan for lean introduction and implementation. He or she needs to indicate long-term consistency based upon the lean philosophy and values. This strategy should be along with the company's direction.

Once the role of management and its importance in LM implementation were explained in details, in the next section a list of fundamental principles for lean leadership will be discussed.

1.5.3 Leadership principles

In the previous section it was mentioned to successfully implantation of the CI, it is needed to engage people with daily improvements. This is what leadership supposes to perform within lean context. Using tools represents at most 20 percent of the effort in lean transformations. The other 80 percent of the effort is included on changing mindset and

behaviour of the leaders. The responsibilities of the leader which were mentioned before are accomplished through regular, direct involvement. There is a missing link between lean tools and lean thinking and it is the set of leadership behaviours and structures (Mann, 2009).

As we know, it is the customer who decides an activity is VA or not and he or she is going to pay for the correct operation of the product but not for organizational activities at the producer's site. Therefore, leadership is not a VA activity and the leader has to be aware about this matter that it is the shop floor worker who created value in the stream. Leadership can only prepare standards for an ideal value creation. We cannot consider lean leadership as a substitution of the LM nor its extra feature. It is a essential factor to reach to CI (Dombrowski & Mielke, 2013). With considering these points, the following is a holistic definition of lean leadership which has been resented by Dombrowski et Mielke (2013):
"Lean leadership is a methodical system for the sustainable implementation and continuous improvement of LPS. It describes the cooperation of employees and leaders in their mutual striving for perfection. This includes the customer focus of all processes as well as the long-term development of employees and leaders" (Dombrowski & Mielke, 2013).

Based on a thorough literature review and survey, Dombrowski et Mielke (2013) also have been set a list of basic and essential principles for lean leadership. This list comprises five items and following is the summary of them:

Improvement culture: This principle is also known as "lean culture" and is about all trends which lead to a continuous striving to perfection. Here perfection does not only mean to reach to zero defects in the system, but is the long-term thinking. A part of improvement culture is considering failure as opportunity with finding root cause of it. This is also called no-blame culture which is in contrast with mass production that focuses on the person who did the mistake. In this culture employees' idea should be supported by the management because they are conscious about the weakness points in the processes. CI will not work properly without formal rules. It might be more decentralized but leadership still is the core part of that.

Self-development: The second principle of the lean leadership is about attributes that leaders have to be learned and developed. However, some skills depend on their personality the others can be attained with help of teacher or mentor.

Qualification: leaders have to develop the qualification of employees besides the self-development. This task can be done by holding classes and trainings or by solving actual challenges in the shop floor.

Gemba: As it defined before, gemba refers to the shop floor or the place which real work is generated. This principle is also known as “go-to-gemba” or “genchi genbutsu”. It is about involving managers directly with the processes in the in the shop floor in order to accurately understand the whole production process, failures and their root causes. A useful method to perform this principle is Ohno circle in which the lean leader is steps to an imaginary or real circle that is drawn on the floor and observes the processes. It is also recommended to locate the offices of senior managers close to work place. Gemba also indicates leader’s destiny regarding to operative work in the company. There are five rules to integrate these features with their routine:

1. Leaders should go to gemba first when there is a problem;
2. Check and analyze every things;
3. Take temporary countermeasures before detecting the root cause;
4. Find the root cause, get help from 5 whys;
5. Once the root cause is found, steady countermeasures can be taken.

Hoshinkanri: the last principle is also known as “target management” or “policy deployment”. It is about aligning CI activities of the teams in the same direction of the long-term goals. Each team has to be informed of its contribution on the big-picture goal.

CHAPTER 2

METHODOLOGY

To find the answers of the research's questions and create value stream maps for the case study, it was necessary to observe the manufacturing steps. Before defining proper road map to conduct this research, first it is needed to confirm the characteristics of the company X as a late adopter and then finding out in which step of adoption process they reject to implement LM in their organization. Data and information regarding to this study have been gathered by observing the processes of each department and daily activities of the employees. To do this end, the researcher went to the production plant and studied the flow of the process and material in the shop floor. This observation was done from late March 2018 to the end of May 2018 (approximately two months).

Observing the work flow, manufacturing steps and routine of the factory resulted in generating data which is precious to figure out the current state of the production and identifying major wastes. When all of these become clear, it is the time to recommend improvements and set future goals by applying lean tools. In this chapter the procedure of the data collection, results analysis and provide suggestions for improvement of the production will be discussed.

2.1 Characteristics of the company and finding rejection step in innovation-decision process

The characteristics of laggards were discussed in literature review. During the observation the processes, the researcher realized that the most of procedures are used to perform the job have been defined long time ago. For example, even though they possess modern technology to generate computerized templates to cut fabrics, they are not fully adopted to use that and in some cases they return to traditional way. There are work cells in each department but almost all times pieces are pushed to the next station. Changes, even small ones, have to pass

through multiple steps to become as roles in the shop floor. These changes have to be checked accurately from financial standpoint of view and saving money in any condition is one of the most important aims of the company if with cost of losing time. With current structure of the company, it can be concluded that the case of this study belongs to the last category of the innovation adopters. Regarding to characteristics of the laggards, in order to adopting lean concepts in this organization, it is needed to ensure managers that new procedures will be effectively increase production rate and profitability. This will be done by studying the current situation and then indicating major wastes in the system and proposing potential solutions.

According to five steps of innovation-decision process, the managers in company X have been exposed to the concept of LM and they were already aware about this method. Beside their own knowledge, the researcher conducted a holistic literature review about lean concepts and its tools to provide complementary information for them. Therefore, the first stage of the adoption process has been passed. Since the most parts of the shop floor is working with traditional procedures and their main goals are delivering high quality product to the customer and saving money in any possible situation, senior management is not fully informed about the wastes which is occurring within production line. They also do not aware and sure how lean can help them to improve the production rate. Therefore, it seems that they are currently having unfavourable attitude toward lean implementation and the problem is in persuasion stage.

Until now, it became obvious that the case of the study is kind of laggards and they have stopped in the second stage of the innovation-decision process and they have uncertainty about lean implementation. With these explanations, the first point to start lean adoption is proving that there are remarkable wastes in the system and in the next movement ensure top management that by investing and deploying CI in the organization they can benefit from potential improvements.

2.2 Identifying product families

Performing observation, creating value stream map and production analysis needed to choose a proper sample. Since the company X is producing large numbers of furniture models, the researcher had to know these models fall into how many categories. Hence, before going to production plant and observing manufacturing processes, researcher got basic information about scope of activities and the main groups of products in company X by visiting their web site and also reading the catalogue of the products. This gave an initial idea about what kinds of products are being produced in the factory. At the day that the researcher went to shop floor, production manager held a general visiting tour through the different parts of the factory in order to introduce the products and related departments.

Basically, customers order to the company what they want (chair, sofa, banquettes and etc.) and for which application and environment. For instance, chair is one of the product families and based on customer wants to use ordered chair in home, office, clinic or restaurant, the company can offer different models. In other words, the models within product families vary based on their application and the environment that they will be used.

Company X is the manufacturer of the wide range of furniture for specific industries like hospitality, health care, office and restaurant. They produce chairs, soft seats, banquettes, booths, tables and etc. If client wants a special model which does not exists in their product list, they also can design and develop new product based on customer’s order.

All of the company’s productions are divided into four categories: the firs category that has the highest production rate is chairs. With producing more that 110 models of chairs, a significant portion of the company's sales is dedicated to this group. The second product family is soft seats. Near to 160 different models of sofas, recliners, rockers, sleep seating, benches and ottomans belong to this category. Banquettes and booths are forming the third group. Company X is producing approximately 36 products related to this family. Tables are the fourth product family. Tables are divided into 8 sub-categories and in total there are near

to 60 different table designs for this family. The company also can provide parts of tables or desks separately like table tops, bases and legs in both wood and metal materials.

The production of the chairs, banquettes and booths are being done in the same place, but the others departments are independent and have their own area in the shop floor for their activities. However, depend on the situation and volume of the orders; it may be some interactions between different departments such as chairs and soft seats. Otherwise, each department has its own work order which is issued by production control every three weeks. Among these four product families, the researcher chose chair for the study. The reasons of this selection will be presented in the next section.

2.3 Sample selection

In order to do observation for the study, we couldn't just follow the production steps of several chairs or sofas and then record data without considering their model. Because production procedure and to the point of it, required time to complete the process of the manufacturing are varied for product families type by type. Hence, we had three challenges to choose a sample in order to conduct a holistic observation to map the manufacturing processes. First we had to choose which product family we want to study. Production managers prefer to focus on chairs because they are the most profitable products for the company and any improvement in their production system can influence directly the company's total income. Another reason to choose chairs is that, at the period of the study, there are less work orders for products of the other families. We needed a sample which repeated several times during the observation to allow us gather the data completely and consequently creating value stream maps.

After we selected the product family the second challenge was which model is proper for the study. It was important we choose a sample which is ordered frequently during the year and is a well-known model among the customers. Therefore, a product quantity analysis was conducted with help of production manager and ten of the most produced products in chairs

family in year 2017 were detected. The list of ten chairs was sorted from higher to lower frequency rate. Since an identical manufacturing method is not applied to all models and it may be different from chair to chair and this could prevent to investigate the process of the chair manufacturing completely, e.g. some chairs do not need preparation activities, the list was curtailed to models which go through all production steps.

In the last step we had to check the final list with ongoing work orders to find out which models are available for study and also have acceptable quantity. Then according to result of the analysis and also ongoing work orders, a specific model was chosen to study its manufacturing steps from preparation to packaging. This model, hereafter we call it P1, had the second rank in the list of most produced products in year 2017.

2.4 Initial observation

When it became clear which product will be used to focus on for data gathering and creating VSM, the researcher began to identify the current road map of P1 manufacturing. In other words, with this initial observation researcher wanted to know what steps should be a P1 taken to become a finished good from raw materials. To do this end, researcher got help from the production manager to understand the production processes of P1. Generally, our chosen sample has to pass through five stages after putting an order from customer up to time it is ready to delivery. From start to finish, assembly, painting, preparation, chair upholstering and packing are the all units which production control gives them customer's order with all needed details. According to management preference about passing up two first steps, assembly and painting, we considered preparation as the department which starts production process and data gathering was began from this point.

Once the researcher found out about involved sections, an up dated layout of the shop floor gave a good vision to him to better learn the location of units and also this helped out with following the flow of the processes and materials easier in the next steps of the study. Researcher talked with the supervisor of each department to know what sub-processes will be

done within their part if they receive a command for producing P1. They explained about the works and also order of these works that they should do in respect of the P1. With these gained information the researcher set up appropriate tables of data gathering specifically for each unit. In these tables the title of activities (sub-processes) and their duration were recorded for five observations.

2.5 Conducting current value stream map

In the next step, from the existing orders for chairs work groups, a command which included 20 P1 chairs was selected to observe and data recording. Since we supposed that the process of P1 manufacturing begins from preparation part, the researcher started from this point to measure the time that these 20 chairs spent in each unit to complete the related production cycle. In these measurements total cycle time and NVA time were documented.

Once the following of 20 P1 chairs across three steps was finished, results of observations were entered in a table to use it for creating current and future VSM. Table 2.1 is a part of mentioned table shows what kind of data was required to do this end. Break and off times were deducted from total spent times (see Annex I).

Table 2.1 Data collection for creating VSM

Sub-Process	Process	Start Date	Finish Date	Duration (Min)	Waiting Time (Min)	Total Cycle Time (Min)	NVA (Min)	Workers	WIP	Remarks
Webbing	Preparation	12-04-2018	12-04-2018	83.8	505	477	7.6	1	60	280 min waiting time to start foaming is included in total cycle time.
Covering	Preparation	12-04-2018	12-04-2018	26.2			6.4	1		
Foaming	Preparation	12-04-2018	12-04-2018	15			5.8	1		
Seat installation	Preparation	12-04-2018	12-04-2018	72			15.5			
Subtotal				197			35.3	3		

In this table, waiting time for each process is the amount of time that the samples waited until that process began. Regarding the columns of this table, if any sub-process was done by more than one employee, it was not possible to measure NVA of each worker separately because all of them were working same activity at the same time. We had this problem also in cases which a downstream activity started when the upstream activity was not finished yet. To solve this problem and have a reasonable estimation for NVA time in these cases, the researcher used the average NVA time from the table for five individual observations which will be explained in the next section.

Once all required data to creating VSM was gathered and entered into the table, the researcher started to draw current and future VSM by paper and pencil. He observed the production from back (customer) to front (supplier) and then mapped the steps of production process. In this step by putting gathered data, process boxes show name, total cycle time, NVA time and number of employees for each section of the production. By adding the quantity of inventory (WIP), waiting times, connecting start and end point of the process with push, pull and shipment arrows the flow of process and materials were indicated. To justify information flow, types of communications between customer, supplier and production control and the frequency of them were shown by using proper communication arrows. Finally, a timeline was drawn at the bottom of the VSM. On the bottom, VA time that is the result of subtraction NVA from total cycle time was written. On the top, total cycle time for each process was written. At the end, by sum up these values, process lead time and total VA time were calculated. Process cycle efficiency is percentage of VA time out of process lead time.

2.6 Process observation

During the following of 20 chairs and also other orders of P1 within the time of study through three sections, each sub-process was observed separately five times in total. The purpose of these measurements was to understand how long each activities of P1 production

take (cycle time) and how much of this time is waste (NVA). The recorded data was entered in tables like table 2.2 for sub-processes of each department (see Annex II).

Table 2.2 Data collection for sub-processes

Sub-Processes of Preparation		**Observations**					**Average**	**Remarks**
		1	**2**	**3**	**4**	**5**		
Webbing	Cycle Time (S)	240	230	240	225	200	227	
	NVA (S)	19	26	23	21	20	21.8	
Covering	Cycle Time (S)	65	75	80	60	70	70	
	NVA (S)	16	18	21	15	19	17.8	

The intent of researcher to design these tables was to study each activity individually in order to find areas that can be ameliorate by lean tools quickly. All measured times in each observations of the sub-processes are relating to one P1. In cases that one activity was performed on more than one P1 simultaneously, e.g. foaming in preparation or fabric cutting in chair upholstering, the measured times (cycle time and NVA) were divided by quantity of the P1 in that action to estimate spent time for one P1. These items have been marked with an explanation in “Remarks” part of the tables. If several workers were assigned to a same job, e.g. five employees were doing seat upholstering, all of them were included in observation and data recording .The data of these tables was used in creating time analysis graphs. These graphs show time consuming activities and in this way we can identify bottlenecks and improvement opportunities.

Data was recorded by stopwatch and all period of the observation, the researcher tried to not be bias in evaluation and study. His aim was to ensure that all employees are doing their routines with normal speed. The researcher collected data and documented it based on visual observation and did not interrupt ongoing activity by asking questions as much as possible.

In general, the goal of study was to observe and record the events as they are to gain real data.

2.7 Analyzing the results

After gathered data through visual observations was organized and complied, the results were presented in forms of time analysis graphs and current value stream map. The researcher began to analyze the current situation of the company. First, he evaluated VSM to identify bottlenecks of the production. Once these points (production processes) were detected, he studied them in details by aid of time analysis graphs. The aim of researcher was to know which sub-processes in each department affect the performance of that department.

Identifying problem, bottlenecks and different types of wastes and then finding their root causes, gave this opportunity to the researcher to create future value stream map by optimizing these issues. He drew this map, like the current VSM, first with paper and pencil with the goal of reducing mudas type I and eliminating mudas type II. Final version of both current and future VSM were done with Microsoft excel software.

2.8 Suggestions for improvements

The researcher's attempt was to depict a realistic look at what was happening in chairs' production line. He accompanied the presented graphs and maps with recommendations to improve the efficiency of the company X. the researcher considered to types of recommendations and purposed them to management: short term and long term.

Short term recommendations: This type of recommendations do not have any cost for the company and are about applying simple lean tools such as Kanban, Kaizen, 5S and JIT manufacturing system which can be performed quickly. However, the results of applying these tools may appear after several months. The most important advantage of implementation of these fast changes and amendments is that the management will see

progress in production ratio after a short period and this will give them encouragement to think more serious about applicability of the long term suggestions.

Long term recommendations: As it mentioned before, lean is not a methodology that changes everything over a night. Long term recommendation to the company X was about lean leadership and educating all staff with principle of lean production. Management is playing a critical role in promoting lean culture among the employees. Furthermore, the researcher suggested that investment in automation in the future after implementing lean basics can reduce total time and cost in production line.

CHAPTER 3

ANALYSIS OF THE CURRENT SITUATION

Company X is the manufacturer of a large variety of furniture such as chair, sofa, table, bench and etc. With consideration of all administrative and operative employees, in total approximately 150 personnel are working there five days a week. There is only one shift of working that its duration is 505 minutes without lunch and break times. The system of the company for production is “Make to Order (MTO)”. It means that they start production only when they receive customer’s order. The description of the current status of the company X in going to be presented in this chapter. For this purpose, current value stream map, graphs of time analysis for each main process, and plant layout will be provided. The data has been gathered through the direct observation of the whole production process of a specific product. The data and results of observations in this chapter were done with the goal of showing serious wastes in the production system to the management and create positive attitude in their mind toward LM and help them to pass through the second stage of innovation-decision process.

3.1 Involved departments

The sample that was chosen for this study, P1, is a specific model belongs to chair product family. As it is shown in figure 3.1, from the time that client wants to put order until the reception of completed good, seven departments are involved for the whole production process. Customer service and production control are considered as administrative sections and the rest are operative ones. Customer service receives orders from customer and issues them to the production control. Product families have been not separated in these work orders and it is the responsibility of the production control to give each department proper list. The arrows which are going from production control to assembly, painting, preparation, chair upholstering and packing departments mean that all of them receive order but the production starts from assembly part. However, a complete production process of P1 comprises all these

seven units, according to the reason which has been explained in previous chapter, in our study and observation we considered preparation as the department which begins the process and data gathering is from this point onwards. Further explanations will be provided on the functioning of each of these three units.

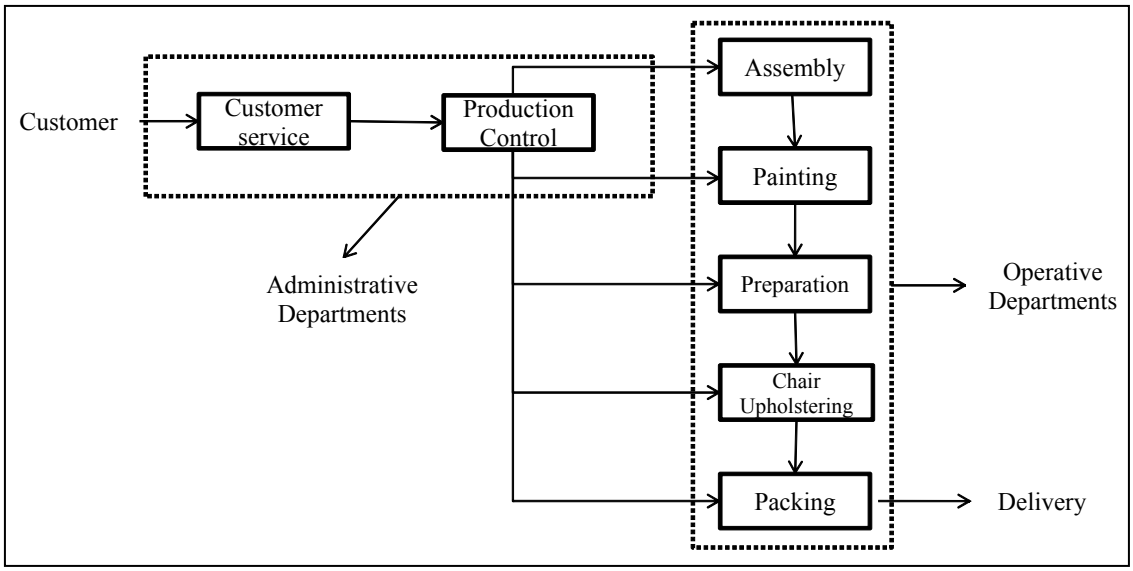


Figure 3.1 Seven workflow steps by department

3.1.1 Preparation

This department is responsible to do infrastructure operations for all furniture. All product families except tables, receive their feed from preparation unless models that do not require preparation at all. Doing infrastructure operation means attach suitable materials such as foam, spring, band and etc. to seat, back and arms of the furniture and make it ready to upholstering process. Depends on model and product family, preparation department receives frames from two places. If the order is for soft seats or banquettes and booths groups, they get frame from inventory, but if it belongs to chairs they will get assembled and painted frame from painting department. The important point is that the volume of the WIP in preparation may include all types of products. Based on models and also customer's preference preparation activities can be vary. For P1 preparation process include: webbing, covering, foaming and seat installation.

3.1.2 Chair upholstering

As it was mentioned before chairs, banquettes and booths are accomplished in the same place. In this section the prepared frames are got upholstered. This means they put and stitch fabric that has been cut before on the parts which were prepared in the last step. Actually this part the heart of the production process because making operation ends up at this stage and furniture are ready to packing after this point. Furthermore, the final look of the furniture is heavily relying on the outcome of this process. Hence, it should be done very precisely. They have specific upholstering instruction for each model. For P1 they do this operation for seat and back parts of the chair. The sub-processes which are done regarding to P1are: fabric cutting, sewing, upholstering (seat and back) and piping (seat and back).

3.1.3 Packing

This section is responsible to prepare any kind of furniture to delivery. Therefore, all product families can be present in their WIP list. They gather all finished furniture from other departments and bring them to packing place which is next to shipping port. However, in previous steps operators check the result of their work before passing commodity to the next unit, in packing department for the last time the final goods will be verified from every aspect with the customer's order prior putting them in delivery boxes. The procedure of packing the procedure of packing is varying regarding to different groups of products but it is almost the same for all types of chairs. Generally, the actions take place for P1 packing comprises: labelling, cutting legs, drilling, gliding, cleaning, wrapping and packing.

3.2 Job completion path

Almost all wooden chairs follow the same path to become a final good from raw materials. The two most important materials that have to be purchased and ready to start the production process are frame parts and fabric. For some chairs, P1 is also within them, Frame components are provided by another company monthly and there is a stock for them inside

company X. Assembly department takes parts from inventory based on order and erects them together. When raw frames are ready they are moved for sanding and painting. Fabric is the other important material which can be either provided by customer itself or by the company.

When frames are ready to use, preparation process begins. Preparation department has a buffer place with the size of 80 to 110 numbers of finished frames. This place is between the locations of the preparation and painting shop. Only frames which have been passed successfully through assembly, sanding and painting operations will be transferred to this place. This makes it easier and faster for preparation department to access to ready frames. The only part in P1 needs preparation is seat. This part is detachable and it is prepared separately and then will be installed on the frame. The first preparation action on the seat is called webbing in which six stripes of wide bands are attached on the seat by pneumatic stapler. Depends on customer's preference, instead of wide bands they can also use springs. In the next step those bands are covered by a special material called FLW by stapler again. Two persons are responsible to doing webbing and covering. At this point covered seats are moved to another station to paste foam on them. In the last move, frames are brought from buffer place to foaming station and there completely prepared seats are installed on the frames. At the end of this point preparation operation is finished and chairs are moved to chair upholstering section in their buffer place. Foaming, seat installation and moving chairs are done by the third operator.

WIP for chairs department included chairs, banquettes and booths but they have a special buffer place just for chairs with the capacity of 100 chairs. Upholstering process begins with fabric cutting. This activity is one of the most important parts of the production process for all kinds of furniture. Generally, each part of the furniture like seat, back, arms and body has specific template for itself. The responsibility of the cutter is to cut fabric in exact dimensions according to the dimensions of the parts and also to use it in the most efficient way. There are two methods to do this action:

Using handmade templates: in this method, the cutter first checks the fabric with order which contains information like name of fabric, way of cutting (horizontal or vertical) and usage estimation. Attention to this paper he cuts the first layer and starts drawing pieces on the fabric with using handmade templates which have been made from carton. His aim is to use the most area of the fabric. Therefore, the cutter spends a lot of time to play with templates to do this end. When he is done with drawing, depended on how many pieces can be fitted on one layer, he cuts layers as much as required. Then he puts the first layer which has drawing on the top of the tissues pile and starts cutting pieces with electrical cutter. This method is taking longer than the other one and in the majority of the situations in chairs department they use handmade templates.

Using software to generate pattern (Marker): In this way plus the order's paper, cutter has two other papers which are called Marker and mini-Marker. Marker is a large size paper in which all the needed shapes have been drawn on that and mini-Marker is also contains these shapes in smaller scale within letter size paper and some information about the fabric and procedure of cutting. Both of these papers are provided by specific software. In this method the cutter first check the marker with handmade templates to make sure that all dimensions are correct and after that he prepares the pile of tissues and then put the marker on top of that and at the end starts to cut. To apply this method the dimensions of the intended model have to exist in the computer which for P1 there are.

When the pieces for seats, backs and pipes got cut, pipes for seat and back are sewn by two workers. On the other stations upholsters start upholstering the seats and backs of the chair. The distribution of the workers to work on seat and back depends on the volume of the order. Usually because seat upholstering takes longer than back, the supervisor dedicates more people to work on seats. Is does not matter to start upholstering with seat or back, when both are done two other workers or sometimes upholsters themselves install sewn pipes all around seat and back. With installation of the pipes, actually the process of chair making is completed officially. They check the article from every aspect and if the quality is acceptable it will be transferred to buffer place of packing department.

As it mentioned before, the whole process of packing is almost the same for all types of chairs included P1. The buffer capacity just for chairs in this section is approximately 100 pieces. The first action is taking chair from the buffer place then attaching tape and label via stapler on the bottom of the chair by one person. It is passed to the next station in which the legs lengths are getting levelled by a cutting machine. Then four holes are creating on the bottom of the legs by a drill machine to put roller or glide inside them. All these three sub-processes, cutting legs, drilling and gliding are done by one operator. Next step is the last place that the quality of the chair is controlled and necessary works such as cleaning or minor color restoration with brush are done on the chair by another one worker. The operator in adjacent station is responsible for wrapping the chair with plastic and paper. At the last step, wrapped chairs are put inside boxes and moved to the shipping port and at this point the whole process of chair production is completed. The numbers of workers who do the packing depends on volume of the order but at least two persons are dedicated to this activity.

3.3 Current value stream map for P1

To find improvement opportunities in the production line, we must have a comprehensive look at the entire production process. In this regards, Current VSM is a useful tool to depict the running status of the manufacturing with all required information to identify critical points. Among the available work orders for chairs in the time of study, we chose an order for 20 P1 chairs and follow them from start of preparation actions. When frames were released from painting shop, they remained one working day (505 minutes) in buffer place. Since no action was taken place on frames in this period, it is considered as NVA. The numbers of WIP were 60 for preparation department at that time.

Next day, preparation started with webbing and covering. Because the operator of the foaming was doing something else, seats remained on the station of the foaming for 280 minutes. The operation of the foaming was being done for two or three seats each time. Seat installation was done one at the time. Prepared frames were moved to buffer place in chairs department two by two.

The numbers of WIP items for chair upholstering process were 80. Hence, it started after waiting 290 minutes with fabric cutting. For this sub-process only the action of cutting the fabrics is VA and all other movements such as fabric checking, drawing with chalk on the first layer and cutting preparation are NVA activities. The operation of fabric cutting was done on the pile of tissues two times with use of handmade templates. The first time 20 pieces for seats and the second time 20 pieces for backs. At the both times, all of these 20 pieces were cut together. Once fabrics were cut, sewers started making seats and backs pipes and on the other side five upholsters began seat upholstery. When these five upholsters finished their first pieces, two other upholsters started back upholstery and after completion the chairs were moved to do piping on them. Two persons, one for back and one for seat were responsible of the piping. There was a time period which seat upholstering, back upholstering, seat piping and back piping had overlaps together. The arrangement of workers may be changed due to situation and work load. Finished chairs were transferred to packing buffer place which is next to the piping station.

Packing department is responsible to prepare all kinds of furniture and put them in proper boxes to be ready for shipping. The numbers of WIP items for this step were 80. 20 P1 stayed here for 350 minutes until labelling got started. After finishing 15 chairs with labelling, other operator started to level the legs. Labelling and cutting legs had overlap together but since cutting legs, drilling and gliding were done by one operator, they did not have overlap with each other. When gliding was in the process, cleaning was started by another worker. Wrapper began his job when there were 5 chairs in the line. Actually, in a special time interval, gliding, cleaning and wrapping had overlap together. Two persons did packing for each five chairs in the same time. For example first they prepared five boxes, then put one chair in each boxes and then closed them. They wrote some information on the boxes with marker and moved boxes nine by nine to the shipping port. This is the end point of the P1 production and figure 3.2 illustrates all these processes with adequate details in a snapshot.
In the process of creating VSM, it should be mentioned that:

- all times which an action was done on the raw material and customer is paying for that, were considered as VA times and all other times such as bringing and moving material, set up time, reloading stapler and etc. were considered as NVA times.
- Processes in which their activities had overlap together, in order to measure total cycle time, all 20 P1 were considered as a unit job. Also in these cases to estimate NVA times, the researcher used average amounts from tables in Annex II with consideration of the overlap.
- Break and off times have been excluded from calculations.
- In all steps, frames or chairs were moved to the next section regardless of its immediate needs. Therefore, production has been depicted as push method in all parts.

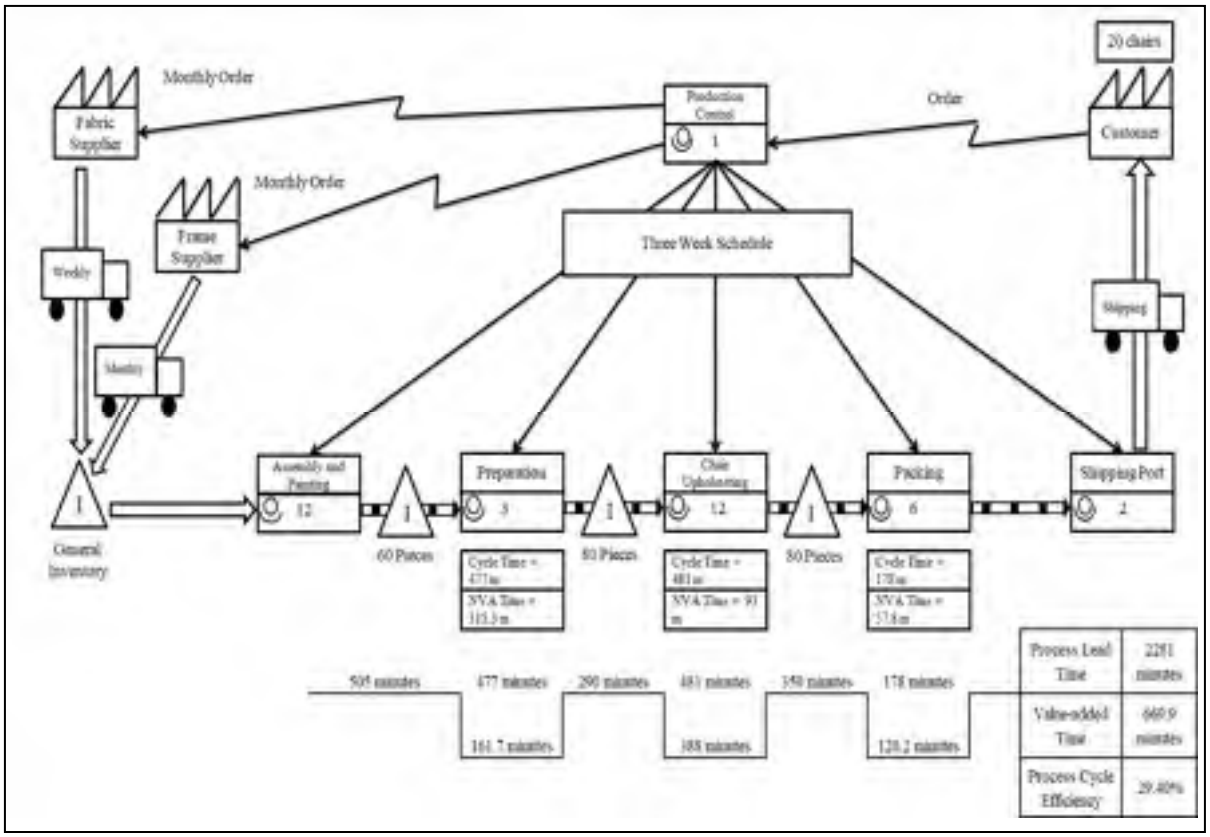


Figure 3.2 Current value stream map for P1

Waiting time between the main processes and within activities are the reasons to have 2281 minutes as process lead time. With 669.9 minutes value-added time, process cycle efficiency is 29.4%.

3.4 Waste identification within processes

Current VSM indicates that waiting times between processes is the main reason of occurring long lead time. Generally, in push production system when we move products to downstream unit without attention to its requirements, products have to wait until it gets free. Waiting or idle time is waste in production. Furthermore, this will cause creating WIP before starting each process which is another kind of waste based on lean concepts. Since WIP items occupy space in the shop floor, we must expect to have more movement in order to access materials and this is also type of waste in the system. Therefore, we can see how push production can be root of at least three sorts of waste in a system.

Another important part of VSM is amounts of total cycle times. The researcher believed that in each process some activities are too much time consuming. In order to have an appropriate and precise vision to detect these activities, he observed the cycle time of each sub-process five times. The average time to do each activity was calculated and the results were presented as time analysis graphs. Figures 3.3, 3.4 and 3.5 are related graphs to preparation, chair upholstering and packing processes respectively.

Figure 3.3 is the result of time analysis for preparation sub-processes. Based on observations, among three main processes the shortest one is preparation. The researcher concluded that each activity of this process is done as fast as possible and in this case waste times are muda type I which can be reduced by applying simple lean tools. Waiting time between sub-processes which is muda type II constitutes the significant portion of total cycle time in the preparation process.

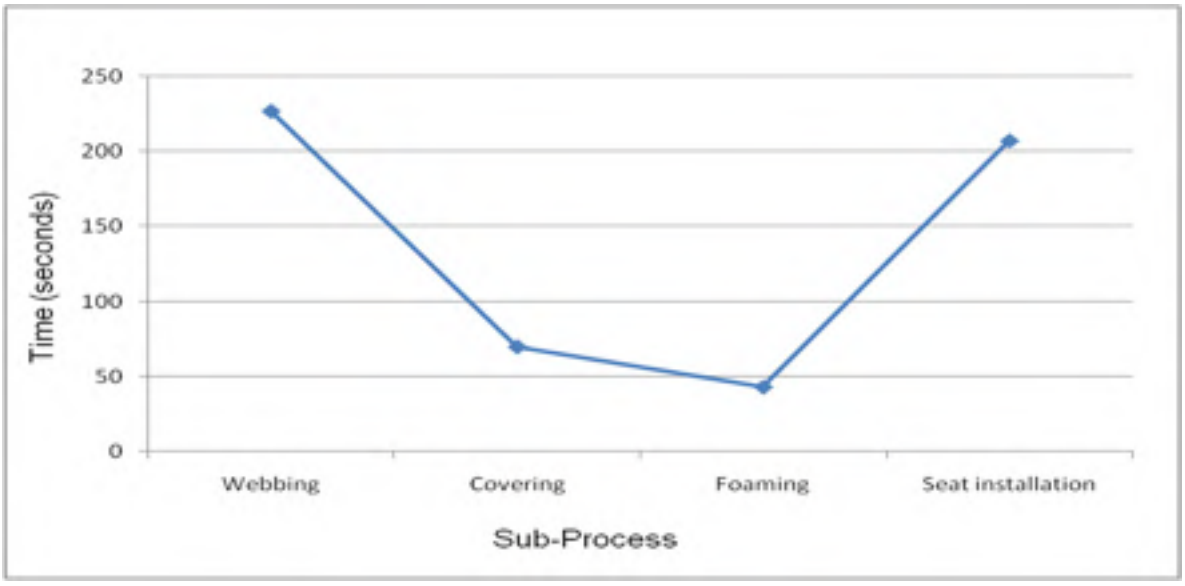


Figure 3.3 Time analysis of preparation process for P1

Current VSM shows that upholstering process is the most time consuming part of the production process. Usually in this department employees work on the same order together and there is not any notable waiting time between activities. The things that make this process longer than the others are sub-process themselves. Figure 3.4 indicates the result of time analysis for upholstering process. Except sewing part, the average of cycle time for other activities is long. Sub-processes such as seat and back upholstering and sometimes piping are done by several workers and since their speed is not equal, the cycle time of each those activities is not optimum. The accuracy of this claim can be clearly seen in recorded times for these activities at individual observations table of the chair upholstering process. As it was mentioned before, in preparation of these tables, if several persons were doing same action, it was tried to observe each worker at least one time. This helped researcher to have an idea about the maximum and minimum needed time to do such sub-processes. On the other hand, fabric cutting is also taken too long because at least 50% of its cycle time is occupied by NVA activities like drawing.

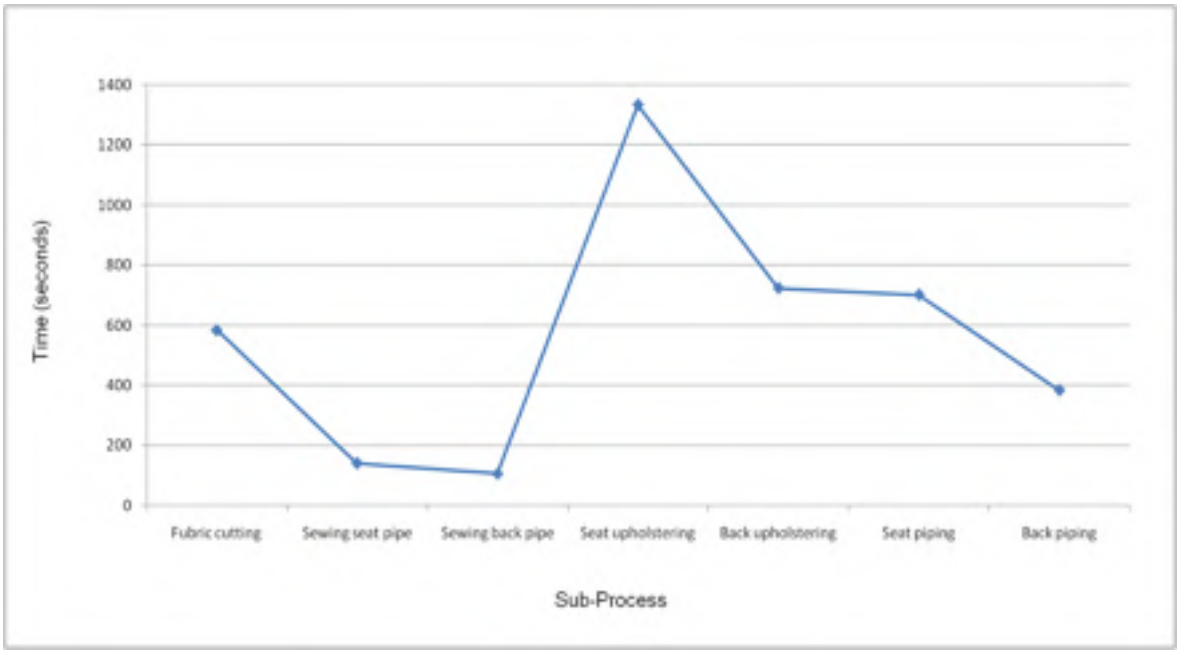


Figure 3.4 Time analysis of upholstering process for P1

According to the figure 3.2 the fastest process in production line is packing. Similar to chair upholstering department, most of times all the members of packing's team start and finish an order together. Therefore, they usually do not have waiting time within their sub-processes. Important matter here is lack of coordination between operations. Most of activities in packing process have overlap together which is useful to shorten total cycle time. However, within their manufacturing cell sub-processes are done with different paces and if they pass chair disregarding of speed of next station, this will cause creating disorder and accumulating chairs in some places. Other problem that the researcher found out during his observation which leaded to slow the process was ignoring one-piece flow principle. For example in packing part, first they make several boxes, and then put chairs in them, and then close all of them and at the end write on each box. This procedure cause more unnecessary movements and in result of that they waste time.

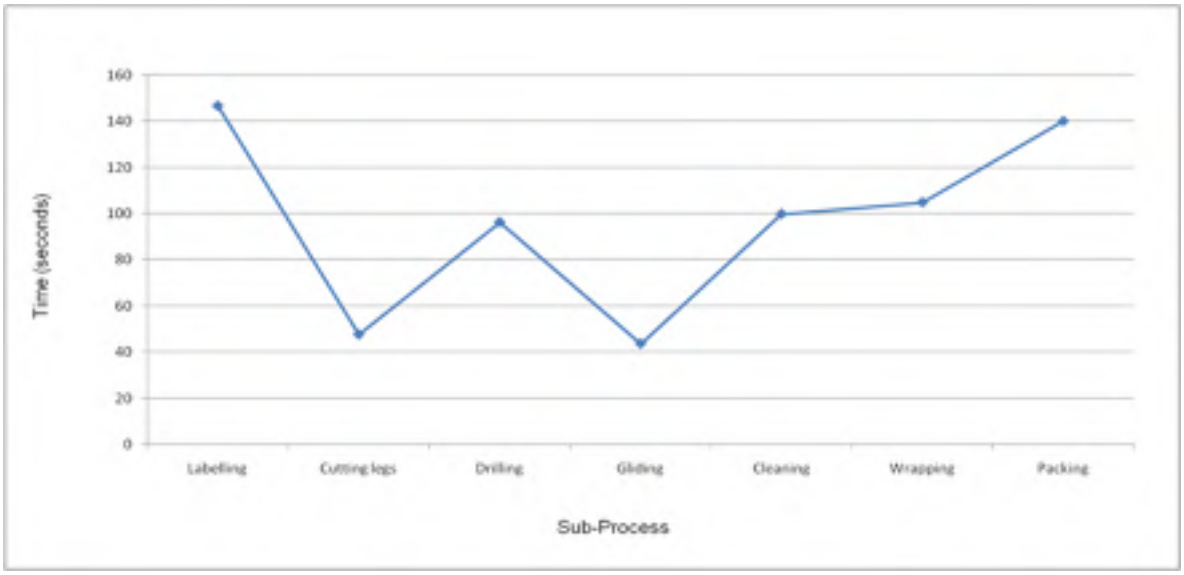


Figure 3.5 Time analysis of packing process for P1

3.5 Space organization

Normally, in furniture manufacturing we need enough space to store all raw materials, equipment and also finished goods. Since the sample of this study is chair, the researcher concentrated only on spaces which P1 has to be there regarding to its production process. Supplies and tools that workers use to do their job are well organized in special places and drawers somehow that they find easily needed stuffs. Personnel clean their workstation at the end of the working time and order tools to use them next day. However, some places such as free spaces under worktables are garbled with fabric pieces, report papers, wood pieces and etc.

The remarkable portion of the area is occupied by chairs which are waiting to go to the next step. The push method in each step causes creating buffers in that place which are considered as waste in a system. Once these buffers become overloaded they form more wastes in two ways. For instance, when the buffer in chair upholstering is full, preparation department has to move prepared frames to another place and in this situation upholsters have to travel more in order to get the frame. On the other hand, accumulation of the chairs makes walking paths narrower that prevents workers to use cart or hand truck to move boxes and chairs. When it is

not possible to use this equipment, they have to choose farther way or move articles by hand which in both cases time will be wasted. Therefore, we can see that push production not only is creating long waiting times, but also it causes that the space of the shop floor is not used in efficient way and people have unnecessary movement within a process which is another type of waste.

3.6 Communication

Communication within the company can be divided in to two categories. One is between responsible and key personnel at the shop floor which is always verbal. The topics of these communications are usually about a common problem between departments or coordination in jobs. Because shop floor is a vast area and it takes time to walk to a section and discuss about something, Therefore, management, supervisors and foremen get in contact with each other via portable, two-way radio transceiver which is called “Walkie-talkie”. This type of communication is well organized and people coordinate their affairs other in the fastest and the most efficient way.

The other type of communication is between administrative and operative sections. Since both parts are busy most of times, usually they are not fully aware about requirements and problems of each other. This unawareness about each other’s situation creates obstacles which hinder production flow and slows it down. For example, in some parts of year company has layoffs because of low volume of orders. After a while, marketing department gets more order without considering the capacity of manufacturing and production line becomes busy but they do not have enough skilled workers to meet deadlines. Another department which should have proper communication with production team is procurement. Fabric is the most important material that has to be provided on time and in sufficient amount. Sometimes delay in buying fabric prevents to deliver final good to the customer before agreed time. Also in some cases, purchased fabric is not complied with the estimation of the production team in terms of quantity because they assume that they can somehow save money by this way. But on the other hand, in the most cases the time that production team

has to spend to do the job with insufficient material costs them more than what they saved. The root of these problems is that departments' managers (silo masters) are working in silos and they have less willingness to share information with each other. So this weak connection leads to know less or nothing about each other's constraints and problems and ultimately this will cause wasting time and losing deadlines.

3.7 Plant layout

Plant layout helps us to better understand how material and process flow through the shop floor in order to make the P1. Figure 3.6 shows the location of each department and also P1 manufacturing steps are specified by arrows and numbers. With investigating the current process flow we can find out if there is any opportunity to make the stream of the process and material smoother. We can reduce or eliminate transportation and movement of the personnel, which are the two main types of wastes, by using the space of the shop floor in optimum mode. This goal is achievable when the departments of the successive processes are located in a way that the workers can connect to each other in the shortest time. In other words, employees should use the shortest distance and spend the lowest time to travel between the departments, handover goods and material to the next station or department and communicate with each other. In this regards, locating departments' locations is one of the important factors in increasing production efficiency.

After consulting with site manager, the researcher found out that the place of departments has been rearranged recently and huge part of the factory such as sanding and painting areas, have special air conditioners and they cannot move them to another location. The position of the packing is also constant because they should be near to shipping port. As it is shown in below figure, with considering mentioned limitations, actually there is no other choice to relocating the rest of the departments. Hence, with current situation the researcher concluded that there is no opportunity to reduce waste and improve efficiency by changing the places of the sections.

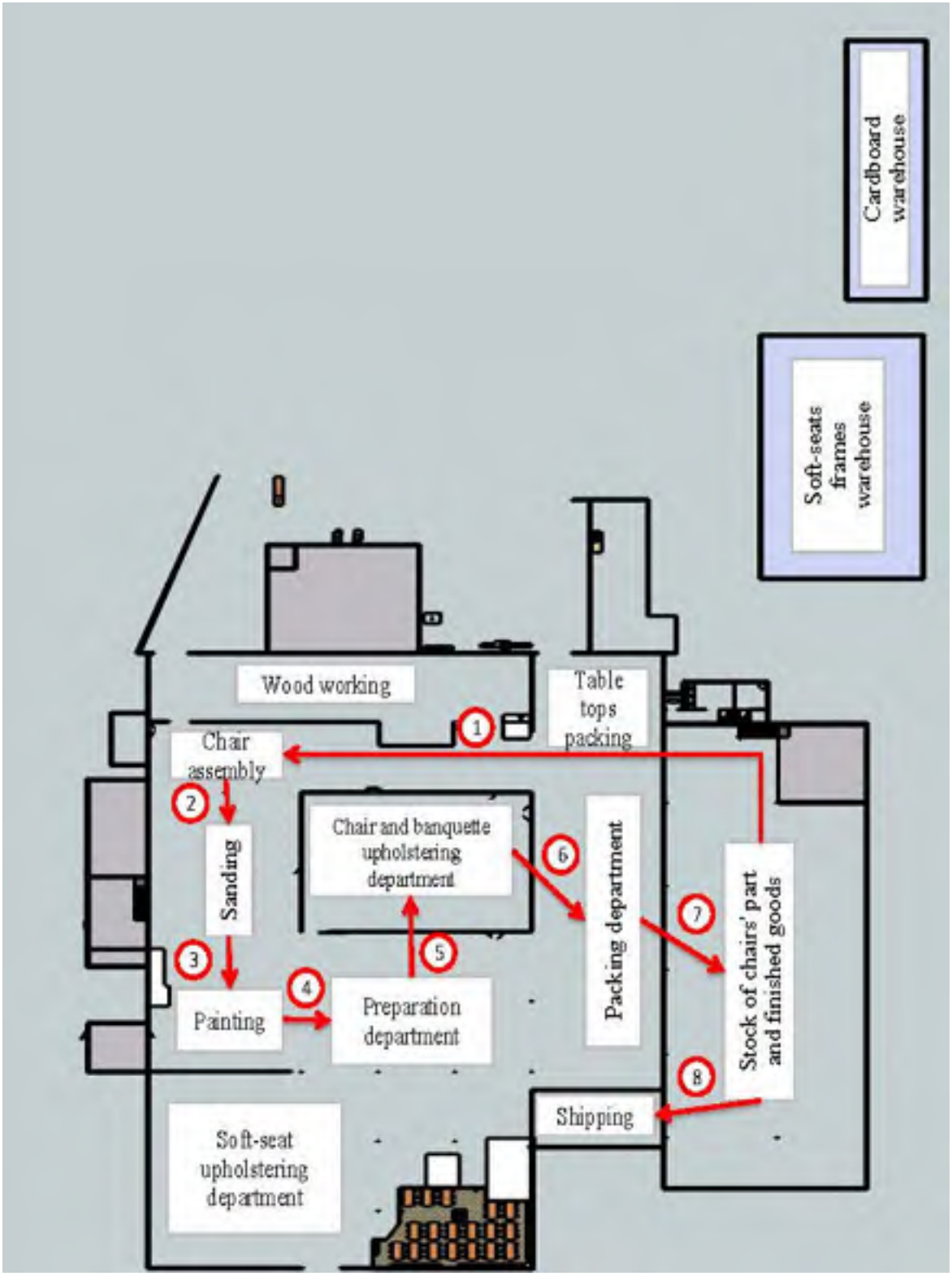


Figure 3.6 Current plant layout

CHAPTER 4

ANALYSIS OF POTENTIAL IMPROVEMENTS

In the previous chapter the current situation of the company X was described with focus on production of a specific model from chairs' product family. To do this end, the researcher followed an order of production of 20 P1 from preparing to packing step and he recorded all related data. In the result of this observation, the details of production process were studied from five points of view. The researcher used all these points together in order to present the current status of the company:

1. Organization of the space in the shop floor;
2. Investigation of individual sub-processes in order to find wastes within them
3. Communication among operative employees in the shop floor and also between production department and administrative part;
4. The overall production steps which led to create current value stream map and detecting major NVA parts;
5. Flow of materials and process through the production line.

The goal of the researcher was to carefully look at the entire production process and find out both VA and NVA activities in every aspect as much as possible and ultimately provide recommendations and road map that lead to raise total process cycle efficiency. Except the last point of view, which the researcher concluded there is no chance to relocate the places of the departments to get improvement, in the other areas opportunities to increase the efficiency of the production were figured out.

In this chapter, as it was mentioned above, we are going to present long and short term solutions based on considering these principles that VA activities should be augmented and NVA activities have to be reduced or eliminated. In the last step, a future value stream map

that can be achievable by applying recommended approaches will be offered. The results of this chapter and suggested road map will be present with the goal of helping management in the third stage of innovation-decision process which is making decision about implementing LM.

4.1 Overview of the problems

In order to provide proper recommendations, we need to have a list of problems and their related areas which is one of those five points of view that mentioned before. Table 4.1 contains the summary of the discovered issues and proposed solution for them. It should be noted that, everything that causes to have any types of wastes in the system, has been considered as a problem.

Table 4.1 Summary of the descriptions of the detected problems

Problem	Area	Impact	Solution	Type of Solution
Lack of available space	Organization of the space	Having unnecessary movements and wasting time.	Applying Kaizenand 5S.	Short term
Wasting time within activities	Individual sub-processes	Having longer total process cycle time.	Applying Kanban, one-piece flow technique, unification of the work procedure and automation.	Long term
unawareness about mutual issues	Communication	Slow down or stop the process of doing some activities.	Holding regular meetings to improve communication	Long term
Large numbers of WIP in each process	Overall production process	Long waiting times between the processes which causes to have longer lead time.	Applying real pull production system.	Long term

The problems described in the table above have been already discussed in the previous chapter, along with their impacts on the overall production process. In the following, we are going to explain about proposed solutions and suggest a road map to rectify these issues.

4.2 Proposed solutions

In this section, the researcher uses the content discussed in the first chapter to give appropriate recommendations about the current problems of the production line. However, it was not possible to re-evaluate the system's performance after applying these suggestions due to time constraints of the project; the purpose of the researcher was to provide a realistic and practical look at these solutions.

4.2.1 Introducing lean culture

Although this item is not listed in the table 4.1, the researcher believes that before attempting to apply any tools of lean, all employees should be familiar with lean culture. For sure, management plays a critical role in this way. Reaching to lower waste, better performance and higher profitability in a system are not those that can be achieve in a short period of time and need accurate planning and wise investment. Managers in all levels should get known with rules, steps and benefits of lean implementation but a common problem in most of manufacturing industries is that managers think lean is just set of tool and they have tendency to directly jump into using these tools, but when they do not get their desirable results they completely become disappointed from lean production. Hereon, getting help from an external consultant can be useful in order to save time. Consultant is a neutral party which can evaluate the current system and identifies values in all over the production line. Therefore, it is part of consultant’s duty that proposes a logical methodology by which it convinces the management that lean implementation does not mean just applying several tools such as Kanban, Kaizen, 5S and etc. and then expecting massive transformation in production, but it is about to changing the entire culture of the company to lean. It is important to provide

conditions which management trusts to this matter attaining success in increasing production rate and cycle efficiency via this shift is possible and relatively time consuming.

Even though by hiring lean consultant company X will pass through the journey of cultural change faster, we cannot overlook the factor of management commitment in this plan. Actually, this subject is the first and most important challenge in the process of changing culture. However, the role of senior management in setting up new rules, regulations and behaviour expectations and also engaging employees to continuous improvements which is a critical factor in introducing a lean production system is inevitable (Alefari et al., 2017), they have to be the first ones who are following and applying these procedures. Without commitment in management level, we cannot expect that other employees demonstrate positive attitude to new conditions.

When top managers accepted that there are opportunities for improvements and they became eager to invest time and money in this way and they acted as pioneers in respecting to new rules, in the next step it is time to integrate mid-level managers and other employees with the new culture. All employees have to be properly educated with these new principles somehow their ideology in working alter into produce more with less waste. Once they learned how facilitate their affairs by considering some simple procedures and removing mudas from their activities, this changes the way they look at their work, which may be doing a task just to accomplish it such as a typical operator. Gradually and after gaining even small progresses, employees become more willing to have creativity in doing their jobs within lean frame. Holding 10 to 15 minutes morning meetings one or two times a week between foremen and the workers under their supervision in order to organize daily jobs and discuss about obstacles in applying lean system, is a helpful manner to dissemination of the lean culture. Certainly, this procedural change requires thorough and coherent planning and is considered as a long-term solution. In this regard, management should patiently wait for the outcome of new culture in the future.

4.2.2 Applying Kaizen and 5S

Within lean culture employees are the most valuable property in an organization. Moving toward pure lean production starts from employees themselves. The places where the work is produced have to be neatly organized and be free of unusable stuffs as much as possible. This item includes the rooms of managers too. Only needed tools for each product should be available on the work table and all other things have to be in toolbox or designated drawers. This matter is important particularly in furniture manufacturing because various specialized works which need different tools are done in it. However, most of work stations in shop floor have specific drawers for tool, sometimes worker waste their time in finding or barrowing tools that they need.

Free places under tables where are filled which unnecessary materials and wastes should be organized and be used in proper way. Workers must have the discretion to decide whether to keep or discard anything that they do not need. Since the company is suffering from the lack of space and most of times materials which are going to be used is work stations block walk ways, these places can be used as temporary stores in order to facilitate movements in shop floor. Among all other solutions, because applying Kaizen and 5S is some kinds of personal actions and they should be done daily, the results will be sensible every day. Therefore, we consider them as short term solutions.

4.2.3 Applying Kanban, one-piece flow technique, unification of the work procedure and automation

Once work places got ordered and are ready to produce jobs in full capacity, it is time to evaluate activities within production process and reduce waste into minimum level in them to have the maximum efficiency and lower cycle time. Accordingly, the researcher detected several notable mudas in sub-processes during his observation and in this section related recommendations will be provided.

Kanban visual boards: In each work station operators may use various materials such as stapler, glue, cutter and etc. that needed to reload some often or some other things which are needed to install on chairs like roller, socket, and glide and so on. Usually these items are enough averagely for 30 to 50 chairs and they have to be refill one or two times a day. Therefore, employees must leave their position to go and ask for required materials from inventory. When the researcher was recording time for doing each activity, he measured NVA times separately and in these cases he saw workers waste 5 to 10 minutes to replenishment of their requirements. Since everybody uses these materials then we have this kind of time wasting in all departments. With applying a Kanban board for material refilling in each department and dedicate one person to check these boards two times a day and take necessary actions according to the orders, we can significantly prevent losing time in this area. Figure 4.1 is the suggested Kanban board which can be mounted in each section and be updated by operators at the beginning of the day and also the person who is responsible to provide materials from inventory.

MATERIAL REPLENISH KANBAN						
Item	Date	Ordered	Available	Required	Provided	Shortage

Figure 4.1 Kanban board for material refilling

Working with this boar is not complicated and it can be taught by supervisors of each part to their workers in a short meeting. “Item” column is constant for each department. Any day that they want to update the board they have to submit the “Date” in the second column. The next one is quantity of the item based on that day’s order. “Available” is the amount of what they have right now and “Required” is the result of subtraction of ordered and available. Last

two columns have to be updated by person who is in charge of providing material every day. “Provided” can be as much as “Required” or less. In case of being less because of lack of material in inventory or anything else, he or she has to write the “Shortage” amount that normally equals to result of “Required” and “Provided” subtraction.

One-piece flow technique: As it mentioned before, most of operators are not familiar with the term of “One-piece flow”. During the researcher’s observation he found out that if an activity needs to be done in multi-steps, operators have this tendency to accomplish one step for several chairs and then start the next step. For instance, in the operation of foaming at preparation department, the operator first puts three pieces of foam on the table, then sprays glue on them, then pastes seats on the foam and at the end takes all foamed seats and poses them on the other table. By this method, he has extra movements that caused to wasting time. The researcher found this way of doing activities mainly in preparation and packing department. However, one-piece flow is one of the most basic rules in lean manufacturing, it usually disregarding in production activities. For beginning, within the morning meeting that was recommended before, foremen and supervisors can introduce the technique of one-piece flow to the workers and by emphasizing on that during the day it will become a culture among all of employees. From the time that they attempt to use this method until it becomes as a culture and affect on cycle time we can consider it as a mid-term solution.

Unification of the work procedure: the researcher discovered that some sub-processes specially in upholstering department are done by several operators. When he measured the cycle time of an activity for each operator, he realized that there are significant differences between the fastest and slowest person in seat and back upholstering and piping activities (see the table for chair upholstering in Annex II). Since in entire production line of P1these are the most time consuming operations, the researcher decided to calculate the average time for faster workers in them. Then he spotted these workers in each station and observed their performance again three times in different orders for P1 (see Annex III). However, there is only one person for each of piping parts it does not mean that they are constant. For example, in some cases if an upholster finishes his or her job, he or she will starts helping in piping to

accomplish the order. This depends on supervisor's opinion. Hence, it is possible that we have slowest and fastest mode even for piping part.

In figure 4.2 we can see the average of cycle time's differences between first and second observations for upholstering operations. The total cycle time for these four activities is 3142.5 seconds (52.37 minutes) in the first observation and in the second one which is done by faster workers has been reduced to 1939.67 seconds (32.32 minutes).

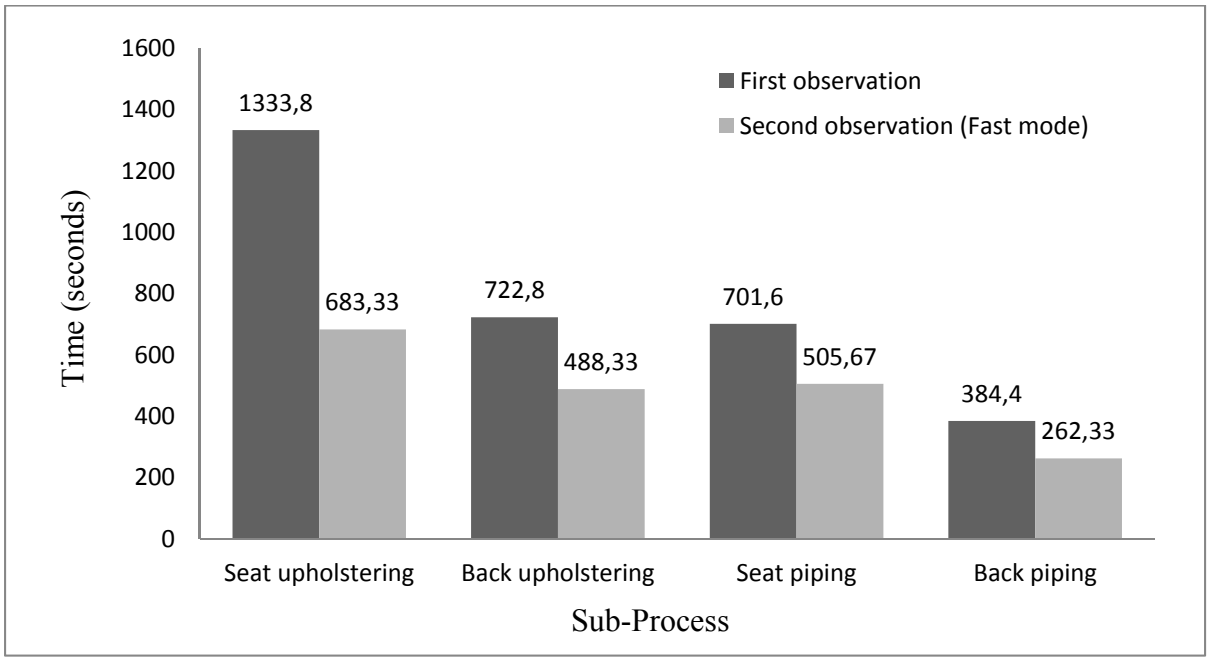


Figure 4.2 Comparison between two observations for upholstering operations

The result of this comparison shows that there is an opportunity to save time at least up to 38% by changing the procedure of the working for these activities. Almost all the operators move and act with the same speed. Hence, the reason that some operators finish one chair sooner than the others is not their swift movements but their technique. Operation manager with cooperation of foremen should issue work procedures and train all related employees with them in order to unify the way of working in the shop floor. This action causes to spend an optimum time to fulfill activities like upholstering operations and reach to lower total cycle time in all departments. Since preparing mentioned procedures required accurate

studying and planning, furthermore it will takes time workers get adopt with this new system, we consider this recommendation as a long term solution.

Automation: Fabric cutting is the other sub-process which is very time-consuming not only in chair production, but also in soft seat production line. As it was explained before, there are two methods for generating patterns to cut fabrics. One is by using cardboard handmade templates and drawing figures of pieces on the first layer of the fabric by chalk. Other method is getting help from computer and software to design and print a large paper in which the shape of pieces have been drawn in real scale and cutter can put this paper on the fabric or pile of fabrics to use as a seamless pattern. There is no doubt that drawing by hand and chalk on the fabric wastes a lot of time and causes NVA activities and the second method is more economical in every respect. As a result, the question arises as to why the second method is not always used? To find the answer the researcher did an interview with the person who was in charge of software and fabrics. Based on her opinion, in some cases, one of the following factors prevents the cutter from using the Marker:

1. Dimensions have not been imported to computer yet;
2. Design process has been blocked because of modifications on the templates;
3. Fabric is defective because of stain or damage;
4. Matching problem;
5. Fabric is purchased less than the estimation of the Marker;
6. Fabric is purchased as much as the estimation of the Marker but in multiple rolls.

Most of times, chairs' department supervisor refuses to use Marker because he believes traditional method has less trouble according to above factors. It is needed to convince the supervisor that his team will be able to save remarkable amount of time by using Marker but first production manager with help of fabric cutting coordinator have to rectify obstacles. They are working on factors number 1 and 2 to complete the library of the software. For our sample which is P1, it has been already imported and is ready to use. Although numbers three and four occur less likely than others, they are the hardest and most technical problems in the

field. When there is a defect on fabric, it is difficult to edit layout in the system regarding to the defect location on the fabric and sometimes they have to print two Markers. When there are several defects, they usually quit with Market and prefer to use handmade templates. Challenge of “Matching” is related to those fabrics which there are stripes or special shapes in their design. In these cases the pieces have to be cut in a way that at the end when they mount on the chair, all these stripes and shapes place in a regular mode. Considering this order with computer is very grinding but the coordinator of the fabric cutting states that she can handle it most of times if they tell her before. Numbers 5 and 6 are the problems between the operation team and administrative personnel. Recommendation for these types of issues will be discussed in the next section.

Currently the supervisor has a strong trend to cut in old way and never checks whether there is possibility to use Marker or not. Certainly if they work hard to solve these problems and prepare the conditions to use Marker without any discussion, there will be no excuse to refuse applying this way. For the samples of this study, there was no obstacle to use Marker for fabric cutting of 20 P1 but it was done by handmade templates. Normally cutter follows several steps in the process of fabric cutting which was describes in details in the previous chapter. Table 4.2 is the summary of these steps with their duration. The researcher recorded these times while he was observing fabric cutting for 20 P1.

Table 4.2 Duration of steps for fabric cutting

Step	**Duration (min)**
Fabric checking	5
Drawing	23.1
Preparing for cutting	24.5
Cutting	37.4
Total time	90

The only value added activity here is cutting step and as it is obvious that it was possible to save the drawing time by using Marker.

On the other hand, the last step of cutting is done with lots of movements around the table and is the longest part of every fabric cutting. There is a possibility to buy an automatic cutting machine which is able to synchronize with the Marker's software and currently management board is evaluating the conditions to provide this equipment. Their plan is to collect all cutting tables in the factory and perform cutting for any kinds of material in one place by one or two of these machines. By approving and implementing this plan and also increasing the efficiency of the Marker by rectifying its problems, it is expected that in the future the process of the cutting will be done smoother than now and these actions are somehow long term solutions.

4.2.4 Communication improvement

Administrative part and operation team are the two arms of each organization in order to reach to high efficiency. Marketing, receiving orders, customer service, suppliers' coordination and material procurement are some of the important responsibilities of the administrative part which it is not possible to accomplish them without close cooperation with executive branch. Their activities should be complementary to each other otherwise inconsistency and lack of knowledge of each other's situation will directly impact production process. In the last chapter it is mentioned that getting orders without being aware about the capacity of the production will cause to miss deadlines and having long delays in delivery times or late arrival of the material to the shop floor will interrupts production process. Also in previous section two factors which prevent using Marker (number 5 and 6) relate to existing imbalance in relations. The procurement team should become familiar with mechanism and limitation of the Marker and provide conditions to facilitate the process. This is not achievable unless with holding bi-weekly or monthly meetings to have up to date information about the status of the production. For instance, recently operation manager, procurement responsible and fabric cutting coordinator had a meeting with this subject that

saving money by buying fabrics less than estimation of the Marker will cost more to the company in the other hand by spending more time to play with handmade templates. Now, procurement section knows what will happen if something arrives to shop floor late or less than estimations and also production team is aware about the conditions and constraints of suppliers. In this way, both sides can plan and prepare themselves in case of occurring problem. The managers are looking for a consensus to purchase material in an optimum manner. By working across the silos, they improve communication with each other and increase synergy attitude in the organization and ultimately prevent additional costs.

4.2.5 Implementing pull production

In the production line chairs are moved to the next station disregarding of its status. This leads to create WIP in all parts which is a kind of waste in the system. Therefore, occurring long waiting times between departments in the current VSM is because of the push production method. Once company X decides to change their system into lean manufacturing, in the first step they develop new culture which comprises all staff, then within the created culture they attempt to organize the space and work stations, reduce mudas in activities and ameliorate the overall way of working by various methods. The next step which is the most important one is gradually decreasing the volume of the WIP in each section until remove it completely and moving toward implementing pure pull production in entire system.

The basic principle which must be observed in all stages is that product enters to downstream process only when it sends signal to upstream process. According to this rule it is needed to implement a withdrawal Kanban between successive processes to adjust flow of work and material. The choice of department where the first Kanban signal will be issued from there to prior section in order to ask for the next work is the main decision. Based on the structure of the production in the shop floor, since the packing department is the place where all finished goods from other groups have to pass through it and it is the last part of the production line, it can be selected as the start point. In fact, the output of the company is the same as the output

of the packaging sector and its speed controls the overall pace of the production. They have to do orders based on delivery time priorities which are given by customer service and send signals to the others in order to state their readiness for the next jobs.

For the value stream of the P1, first packing team has to indicate prior sector which is chair upholstering that they are ready for packing the chairs. Then upholstering group will take necessary actions and ask from preparation part to send the frames and at the end the signal will be sent to assembly and painting departments to prepare the frames. In all these steps the downstream process can withdraw the job from upstream one by highlighting the done jobs in work orders' list at each department. Implementing this procedure in order to completely remove WIP may be happen only in ideal status but managers should be patient and let it works to gradually regulate the levels of buffers and inventories in the system.

4.3 Future value stream map for P1

After proposing potential solutions and recommendations for the problems and hinders which the researcher recognized in the production process, in this section future VSM will be presented. As seen in figure 4.3, the things that have changed in this map are:

- Kaizen burst has been considered for all parts of the shop floor to organize work stations and prevent blocking of walk ways;
- 280 minutes waiting time in preparation process for foaming has been removed, because within lean culture we expect to not have this kind of waste anymore. Hence, total cycle time and NVA time in this process have been reduced to 197 and 35.3 minutes respectively;
- Inventories between processes have not been removed completely and there are safety buffers (supermarkets) instead;
- Push production has been replaced by pull one and works are withdrawn from preceding process by sending Kanban signals;

- Since the pull production is the dominant procedure, there is not any WIP in the system and to the point of it the largest part of mudas, long waiting times between steps, have been eliminated.

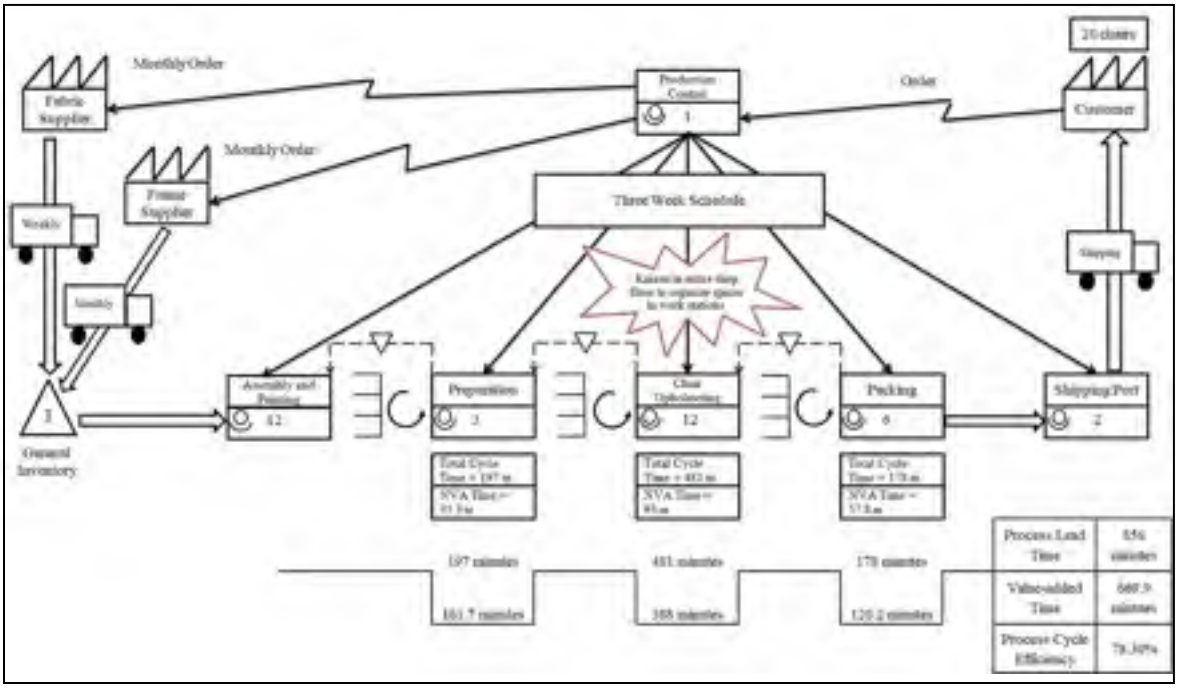


Figure 4.3 Future value stream map for P1

As it is shown in the figure, if the conditions are met, the Company X will have this chance to significantly improve process cycle efficiency, almost 2.7 times better, from 29.40% to 78.30%. It is even possible to go beyond this amount by reducing total cycle time at chair upholstering with applying unified work procedures and automation in the future. It is estimated that by deploying work standardization and automation, process cycle and NVA times in upholstering department can be reduced from 481 and 93 to 326 and 45 minutes respectively. Therefore, process cycle efficiency can be raised up to 80.30%.

4.4 Inductive generalization model

The aim of this study was not to evaluate the final results of applying lean tools in a case study. During this research we were looking for a global procedure in order to facilitate the adoption of lean in a late lean adopter. In the early steps of observations, after it was

confirmed that the company belongs to laggard category, we found out they do not have favourable attitude toward lean implementation in their organization. In this situation, first it is needed to recognize the root cause of unwillingness and find solutions to rectify it. Applying 5 whys is a robust technique to identify causes relating to a particular problem. By this approach, it was understood that the unwillingness of the manageress toward lean manufacturing is because of their unawareness or existence of silo management in the system. Figure 4.4 clearly indicates how this conclusion is attained thorough the 5 whys.

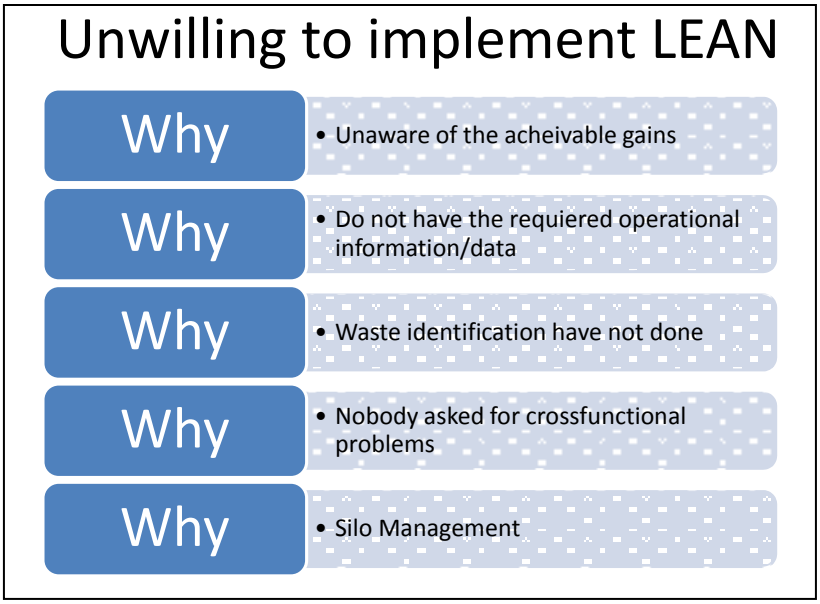


Figure 4.4 Finding the root cause of the unwillingness thorough 5 Whys

According to the findings of this research, the process of adoption in laggards is longer than other groups. These categories pass the steps of innovation decision process faster because of being teamwork sprit among workers and having global view on the situation. In case of facing with a problem, laggards or late adopters ask for more resources to solve it rather than seeking for better collaboration. Figure 4.5 is a model which shows all these differences and also the comparison of the adoption process speed between laggards and the cases with higher rates of innovativeness.

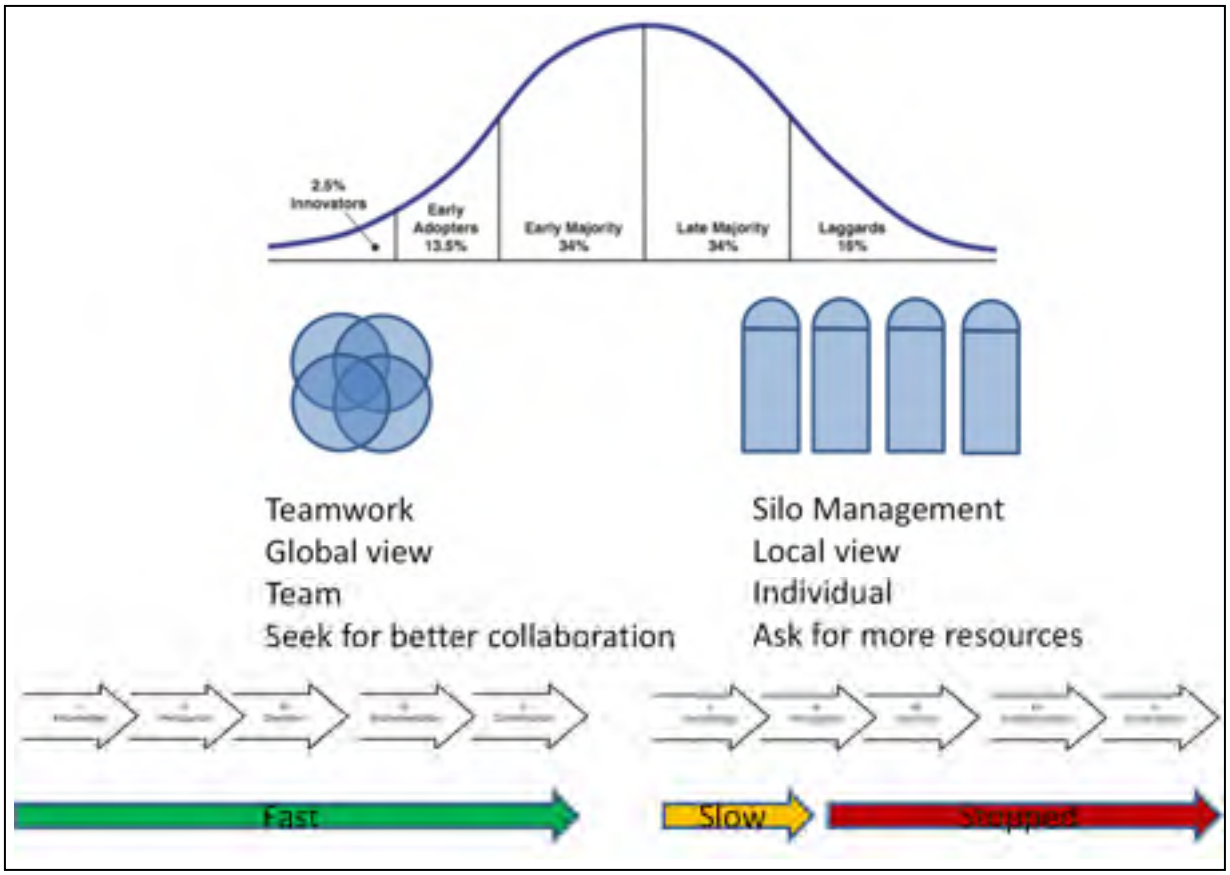


Figure 4.5 Adoption model

After we understood that the main obstacle in adoption process is being silos, we have to develop procedures to breaking them down and foster collaboration in the system. Attempting to eliminate silos in all cases almost follows same instructions. The summary of them are as follows (Gately, 2016, April 27):

- Start from the top: Encouraging board of management to build a collaborative organisation and helping them to understand their role in breaking down the silos and better leverage their team. On the other hand senior managers' duty is to see their organization as a holistic and united organization and be as an effective member of the executive team.
- Changing the culture: Silos are created by personals' mindsets. In this situation supervisors measure success on achieving what they and the people under their supervision are responsible for. So it is needed to remove this mentality and define

collaboration in all over the company. Setting clear expectations and articulating what successful behaviours look like are useful to changing the old culture. Besides these, it is essential to hold people accountable for their behaviours. Driving any behavioural change requires alignment matter. We have to recognize and reward only wanted behaviours and take remedial action to address those that are not.

- Recruiting well: This step can be done in two ways. First using the existing employees in other areas. This is a good opportunity to build their skills and experience and will enable us to retain them. Moreover, when hiring new staff it is necessary to select person who is motive to be a team member and has an open mind.
- Developing relationships: This item is about building relationship skills. We have to reinforce team's ability to build and maintain great relationships by helping them to understand how to develop connection with their colleagues and communicate effectively. Also we have to take early and definitive steps to address conflicts that people are unable to work through on their own.

CONCLUSION

In this thesis, we tried to investigate proper road map to implement LM in a late lean adopter which was a furniture producer in Quebec. To accomplish this mission we had to convince the management by showing the existing wastes and the power of lean in eliminating them that leads to reducing delivery time and improving overall efficiency. Lean production is about defining value from customer's standpoint in a system and then detecting all kinds of wastes and attempt to decrease or eliminate them according to that. According to the subject of the research, we had to find answer for following questions:

- Why LM has not been implemented until now?
- What is the current VSM?
- What are the VA and NVA activities in the production?
- What is the roadmap to improve the current situation?
- What is the proposed future VSM?

In order to attain the answers of aforementioned questions, first we conducted literature review on the theory of the DOI, characteristics of the innovation adopters, LM and its principles and tools. The main objective of the literature review was to introduce lean and its goals and state that lean is a time taking procedure which needs managers' fortitude and commitment. To have a true lean production it is needed to alter the whole way of thinking in an organization and this is what we call lean culture.

In the next step the methodology which the author took was explained. The confirmation of the characteristic of the company as a laggard and also identifying the problem point in the adoption process were done in this part. Since the case of this thesis is a furniture manufacturer company which produces various types of products such as chairs, sofas, tables and etc. and they have different production processes, it was not possible to study all of them in this research. Hence, the researcher had to choose a sample from one of the product

families. The chosen sample was from chairs' category and the current status of the company's production was described by following the sample through the related steps.

With the current system of the production in the company which is customized mass production, even though, top managers may be familiar with basic concepts of the lean, but they have not moved toward it until now. The reason for this is that today, most executives are seeking to take advantage of modern technology to solve problems quickly. They are looking for innovation and applying quick solutions rather than incremental and continuous improvements which are the results of LM implementation. The other reason is that they are not fully aware about the occurring wastes, their impact and also the role of lean in controlling them in the system especially in their own industry.

This observation helped the author out with drawing current VSM, so the second question was answered. VSM is one of the most useful tools in lean's toolbox that clearly indicates which parts cause problem in the system. The main reason of long lead time and consequently late delivery time is WIP and waiting times between the processes. By identifying these spots from VSM, the sub-processes of each sector were investigated in more details to figure out the roots of those problems. This resulted in finding VA and NVA activities within the production line, Therefore, the third question got answer. Discovered items which were the causes of major mudas in the shop floor and also recommended solutions based on discussed concepts in literature review are as follow:

- *Disorganized work stations:* Some spaces are not used in optimum way and walking ways getting block by materials. Although it is temporary but prevents the smooth flow of process and materials.
  Solution: Introducing workers with Kaizen and 5S meanings and apply them in all over the work stations at shop floor.
- *Different styles of working:* Some operators work faster than the others because their procedures are different. This significantly impacts total cycle time in departments.
  Solution: Issue work procedures to unify the way of working.

- *Disregarding the principle of one-piece flow:* Their habit in working in traditional way at some places causes losing time.
  Solution: Educate workers with this technique and emphasize to adopt themselves with that at morning meetings.
- *Leaving work station:* Sometimes operators leave their position to find tools or material replenishment and this is another source of time wasting;
  Solution: Applying Kanaban boards in each department and educate operator how to work with that.
- *Using old way to cut fabrics instead of using software:* This item is another reason of having long cycle time in upholstering process.
  Solution: Rectify hinders on the way of using the Marker.
- *Weak communication:* The relation between operative and administrative branches is not well developed and this sometimes causes interruption in production.
  Solution: Holding bi-weekly or monthly meetings to get updates from status of the production, working on solving problem and follow up the results.
- *Push production:* Parts are moved to the next station in anyway and this is the main reason of having inventories and WIP between steps.
  Solution: Provide conditions to implement pull production. Each sector has to withdraw job from the preceding one by sending Kanban signals.

The road map was proposed with the goal of efficiency improvement and in this way the fourth question was answered. To answer the last question, a new VSM was presented according to gain expected progress in the future. It is concluded that by applying lean manufacturing and changing the culture of the organization, the company can considerably reduce the lead time and also improve total cycle efficiency approximately 2.7 times more than current situation.

By presenting results from chapter 3 to the decision makers and indicating several wastes in the production line which caused to have longer delivery time, their attitude toward the new idea (implementing LM and CI) became favourable. An example to observe this change was

their attempt to computerize all hand-made templates in order to save time in the process of fabric cutting. The results of chapter 4 can help them in the next stage of innovation-decision process to accept or reject the adoption of lean concepts.

Contribution of the research

The results of this thesis, contrary to similar studies in the field of LM, are not about evaluating the effects of implemented tools. The contribution of this study is to generalize the used roadmap and processes which were applied to convince decision makers to decide about adopting lean in their organization to other laggard cases. People in an organization with traditional structure, tend to work in silos and they have poor communication with each other. According to the results of this study, in order to convince senior managers to implement lean concepts in a company with laggards' characteristics, we have to break down the silos, let them work with mutual cooperation and help them to have smooth information flow. When they become aware about existing wastes and their remarkable impacts in the system, they will be motive to understand mutual problems and constraints and help to rectify them with each other. In order to prevent friction between people and have more effective communication, it's better to talk with managers one at a time and explain the problems to them. Then connect these individual problems to each other so they will conclude that there are some common issues which won't be solved unless they communicate with each other and share their information. This is what happened during this research. When procurement and operational departments became aware about the impacts of problems related to providing fabrics, they tried to find root causes and solve them together by contributing their knowledge.

Based on findings of this research, unwillingness of the decision makers to accept LM as an innovation and a procedure to improve the situation is because they are not conscious about existing wastes in the system. When they are not aware about the problems, naturally they also do not have any idea how the system will work without them. Therefore, showing wastes and weakness points in the value stream do not work alone, but it is needed to

estimate their impacts and amount of imposed costs and presents results to the board of management and let them know how the process flow will be improved by eliminating wastes. The researcher tried to generate valuable information which can be applicable specifically in manufacturing sector to those cases, like company X, who are not interested to turn from traditional methods into lean.

Recommendation for future studies

The first recommendation of the researcher for the future studies is about investigating solutions to help laggards or late adopters to pass through the other stages of the innovation-decision process which are implementation and confirmation in order to adopt them to LM. The other suggestion to the next studies is about focusing on improvement of furniture manufacturing. Lean manufacturing is a method that can apply in most of industries especially those with production line to gain better performance and quality with low investment. Furniture industry is one the important part of the manufacturing sector in the region and because of its wide range of products there are potential chances to extend lean studies in them. While the author was doing this research, he found out that other production lines are following different procedures but there also some similarity between them like fabric cutting. Soft seat is one these production lines which is more complicated and also normally its lead time is longer than chairs. It is recommended to the future studies in this field, concentrate on these types of products and the possibility of combining similar parts to save space and time.

ANNEX I

DATA COLLECTION FOR CREATING VSM

Sub-Process	Process	Start Date	Finish Date	Duration (Min)	Waiting Time (Min)	Total Cycle Time (Min)	NVA (Min)	Workers	WIP	Remarks
Webbing	Preparation	12-04-2018	12-04-2018	83.8	505	477	7.6	1	60	280 min waiting time to start foaming is included in total cycle time.
Covering	Preparation	12-04-2018	12-04-2018	26.2			6.4	1		
Foaming	Preparation	12-04-2018	12-04-2018	15			5.8	1		
Seat installation	Preparation	12-04-2018	12-04-2018	72			15.5			
			Subtotal	197			35.3	3		
Fabric cutting	Chair Upholstering	16-04-2018	16-04-2018	90	290	481	52.6	1	80	Sum of durations are more than total cycle time because of overlap between the sub-processes.
Sewing seat pipe	Chair Upholstering	16-04-2018	16-04-2018	49			2	1		
Sewing back pipe	Chair Upholstering	16-04-2018	16-04-2018	37			2	1		
Seat upholstering	Chair Upholstering	16-04-2018	16-04-2018	90			2.6	5		
Back upholstering	Chair Upholstering	16-04-2018	16-04-2018	120			4.1	2		
Seat piping	Chair Upholstering	16-04-2018	16-04-2018	236			16.3	1		
Back piping	Chair Upholstering	16-04-2018	16-04-2018	128			13.4	1		
			Subtotal	750			93	12		

DATA COLLECTION FOR CREATING VSM (CONTINUED)

Sub-Process	Process	Start Date	Finish Date	Duration (Min)	Waiting Time (Min)	Total Cycle Time (Min)	NVA (Min)	Workers	WIP	Remarks
Labelling	Packing	17-04-2018	17-04-2018	50	350	178	18.7	1	80	Sum of durations are more than total cycle time because of overlap between the sub-processes.
Cutting legs	Packing	17-04-2018	17-04-2018	16			2.5	1		
Drilling	Packing	17-04-2018	17-04-2018	34.5			15			
Gliding	Packing	17-04-2018	17-04-2018	15			4.2			
Cleaning	Packing	17-04-2018	17-04-2018	34			2.3	1		
Wrapping	Packing	17-04-2018	17-04-2018	35			1.6	1		
Packing	Packing	17-04-2018	17-04-2018	49			13.5	2		
			Subtotal	233.5			57.8	6		

ANNEX II

INDIVIDUAL OBSERVATION TABLES

Sub-Processes of Preparation		Observations					Average	Remarks
		1	2	3	4	5		
Webbing	Cycle Time (S)	240	230	240	225	200	227	
	NVA (S)	19	26	23	21	20	21.8	
Covering	Cycle Time (S)	65	75	80	60	70	70	
	NVA (S)	16	18	21	15	19	17.8	
Foaming	Cycle Time (S)	44	41	43	44	44	43.2	2 by 2
	NVA (S)	19	22	16	18	17	18.4	
Seat installation	Cycle Time (S)	237	187	206	203	203	207.2	2 by 2
	NVA (S)	76	37	40	38	42	46.6	
Total	Cycle Time (S)	586	533	569	532	517	547.4	
	NVA (S)	130	103	100	92	98	104.6	

Sub-Processes of Chair Upholstering		Observations					Average	Remarks
		1	2	3	4	5		
Fabric cutting	Cycle Time (S)	284	600	743	407	220	450.8	Observations were done on 20, 24, 40, 126 and 33 P1 respectively.
	NVA (S)	158	325	563	283	109	287.6	
Sewing seat pipe	Cycle Time (S)	184	167	122	115	113	140.2	
	NVA (S)	4	2	2	10	2	4	
Sewing back pipe	Cycle Time (S)	103	102	120	110	99	106.8	
	NVA (S)	3	3	10	2	2	4	
Seat upholstering	Cycle Time (S)	1275	1643	762	976	2013	1333.8	
	NVA (S)	150	30	25	26	47	55.6	
Back upholstering	Cycle Time (S)	918	546	675	955	520	722.8	
	NVA (S)	90	35	45	20	25	43	
Seat piping	Cycle Time (S)	656	1055	474	805	518	701.6	
	NVA (S)	113	93	40	90	45	76.2	
Back piping	Cycle Time (S)	580	438	390	274	240	384.4	
	NVA (S)	170	30	60	34	20	62.8	
Total	Cycle Time (S)	4000	4551	3286	3642	3723	3840.4	
	NVA (S)	688	518	745	465	250	533.2	

Sub-Processes of Packing		Observations					Average	Remarks
		1	2	3	4	5		
Labelling	Cycle Time (S)	150	161	120	210	92	146.6	
	NVA (S)	60	72	55	90	36	62.6	
Cutting legs	Cycle Time (S)	54	50	42	46	46	47.6	
	NVA (S)	13	10	8	10	7	9.6	
Drilling	Cycle Time (S)	92	98	98	96	97	96.2	
	NVA (S)	46	44	49	41	50	46	
Gliding	Cycle Time (S)	42	55	42	41	38	43.6	
	NVA (S)	13	10	18	15	17	14.6	
Clearing	Cycle Time (S)	99	88	90	80	142	99.8	
	NVA (S)	5	6	5	4	29	9.8	
Wrapping	Cycle Time (S)	119	125	110	90	80	104.8	
	NVA (S)	8	7	10	9	6	8	
Packing	Cycle Time (S)	145	118	122	170	145	140	Observations were done on 5, 5, 6, 4 and 3 P1 respectively.
	NVA (S)	76	36.6	48.3	57.5	30	49.68	
Total	Cycle Time (S)	486	465	430	556	476	482.6	
	NVA (S)	187	158.6	157.3	192.5	145	168.08	

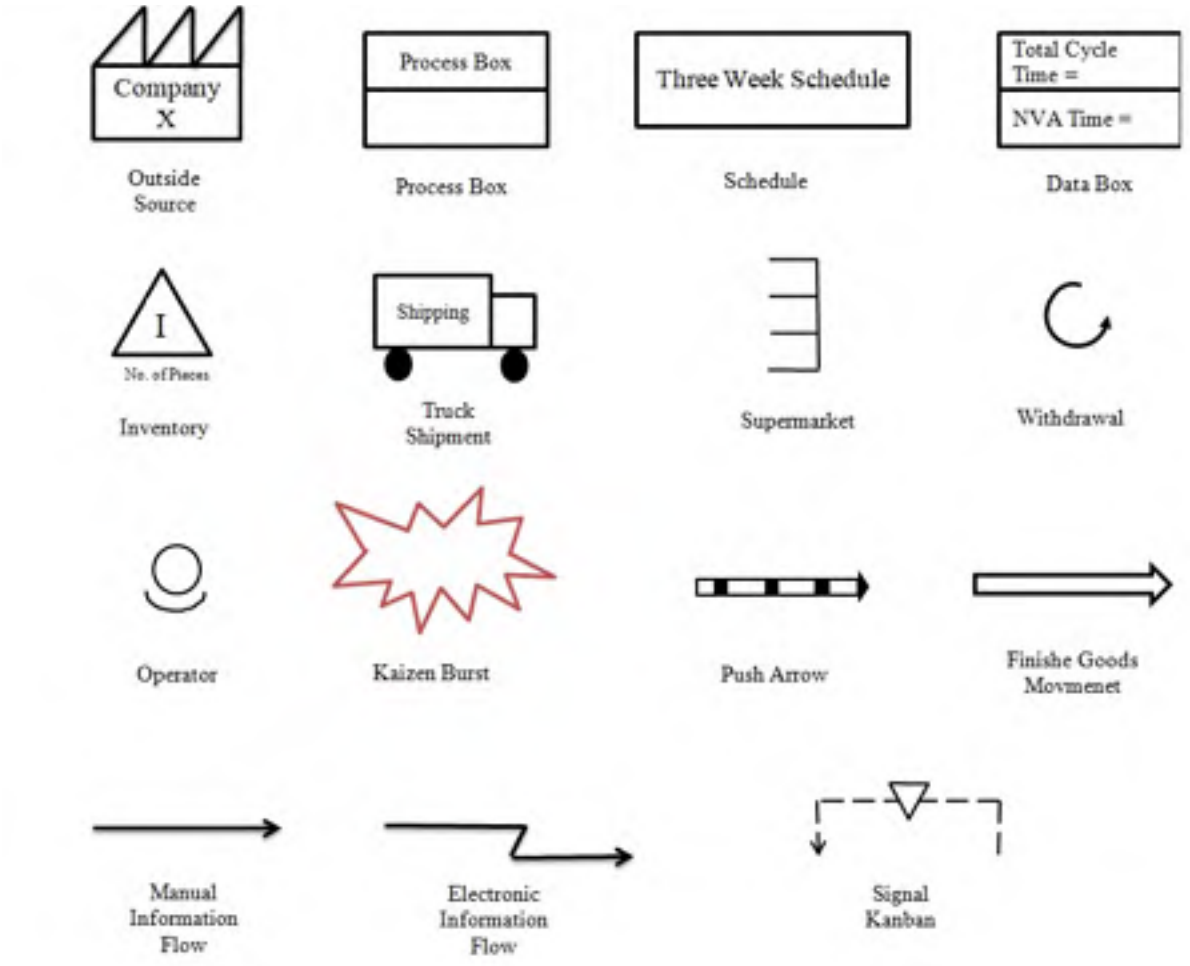
ANNEX III

CYCLE TIMES FOR UPHOLSTERING IN FAST MODE

Upholstering Operations		Observations			Average	Remarks
		1	2	3		
Seat upholstering	Cycle Time (S)	670	720	660	683.33	
	NVA (S)	20	27	26	24.33	
Back upholstering	Cycle Time (S)	493	552	420	488.33	
	NVA (S)	25	50	20	31.67	
Seat piping	Cycle Time (S)	480	530	507	505.67	
	NVA (S)	30	31	23	28.00	
Back piping	Cycle Time (S)	290	262	235	262.33	
	NVA (S)	35	28	24	29.00	
Total	Cycle Time (S)	1933	2064	1822	1939.67	
	NVA (S)	110	136	93	113.00	

ANNEX IV

VALUE STREAM MAP SYMBOLS



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