Standardization of a production process

A case study at Husmuttern AB

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ABSTRACT

In order for companies to survive and stay competitive in today's market, it is very important to ensure consistency in their operations because it increases efficiency. However, because of different ways of executing the same process by different workers, due to different skill levels, education or experiences, it is hard to maintain the required consistency and that might result in variations in the produced products or services. The aim of this report is to study the creation of standardized work according to Lean, as well the training process of unskilled personnel to perform production tasks in an efficient way. By performing a literature review and conducting a case study, this report is going to answer the following questions:

1- How to standardize a production process?
2- How can the standardization contribute to the training of new personnel?

The results show the prerequisites of standardized work and the main tools used in implementing it, and that standardized work provides a foundation for personnel training, through the standardized work tools.

Keywords: Standardization, Standardized work, Lean.
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List of abbreviations

JIT Just-in-time
PQCDSM Productivity, Quality, Cost, Delivery time, Safety and Morale
TPS Toyota production system
TWI Training within industry service
WIP Work-in-process

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1. Introduction

*This chapter presents, the background of the problem, the problem formulation, the aim of the study, research questions and project limitations.*

1.1 Background

Companies all over the world are trying continuously to enhance their service level and lower their costs, due to the high competition level in the global market. There are many strategies and tools that can be implemented by organizations to accomplish these goals. One of the methods that was implemented by many organizations in different fields is Lean approach or Toyota production system (TPS). The attraction towards Lean principles has increased, and according to a survey by Industry Week in November 2007, Lean manufacturing was adopted as an improvement approach by approximately 70% of all plants in the United States (Pay, 2008).

For decades, the construction industry had been interested in taking advantage of the manufacturing technologies, motivated by the impressive productivity improvements made in the manufacturing field. That led to the development of the industrialized methods in the construction field such as modular buildings (Yu et al, 2013).

According to Liker (2004) it is essential in Lean approach to have standardized tasks in the production process. Because maintaining regular output and timing and predictability by standardization is the basis for creating continuous flow and using pull system. As well standardization ensures continuous improvement process and work force growth and empowerment by continuously incorporating the employees’ creative improvements into the system.

1.2 Problem formulation

In order for companies to survive and stay competitive in today's market, it is very important to ensure consistency in their operations because it increases efficiency. However, because of different ways of executing the same process by different workers, due to different skill levels, education or experiences, it is hard to maintain the required consistency and that might result in variations in the produced products or services. If the best way of performing the task is captured and documented as a standard to be followed by all workers, it will help in getting less variations and guarantee higher quality in the output. Therefore, many organizations are interested in standardizing their processes (Ungan, 2006).

1.3 Aim

The aim is to study the creation of standardization according to Lean system, as well the training process of unskilled personnel to perform production tasks in an efficient way. Then applying it in a case-study company for producing modular houses.

1.4 Research questions

This study is going to answer the following questions:

- How to standardize a production process?
- How can the standardization contribute to the training of new personnel?
1.5 Research limitations
This study is a final thesis for a Bachelor of Science in Production and Logistics at Mälardalen University. The study comprises 15 credits and is expected to be completed by the end of May 2018.

Due to the time framework only one case study has been conducted.

The company of the case study will be producing various products such as ceiling, wall with a window, wall with a door, wall without a door or windows. This study will be limited to focus only on the process of assembling a wall without a door/windows.

The company of the case study is in its initial stages of establishment and there is not a real production processes running at the time of this study, therefore some measurements related to the study as the time measurements could not be conducted and have been estimated instead.
2. Research approach and methods

This chapter presents the used methods in this study.

2.1 Research approach

Bryman (2012) explains the difference between the two research approaches, the deductive and the inductive approach. In a deductive approach the researcher derives hypothesis based on a known theory related to a specific domain and based on that, the data will be collected and empirically analyzed to test the theory. This approach is usually linked with the quantitative method. On the contrary, in the inductive approach, out of the collected data the researcher derives generalizable conclusions and the outcome of the research leads to forming the theory. This approach is usually linked with the qualitative method.

This report is based on a deductive approach, where the theoretical frame work about standardization is the basis of this study.

2.2 Quantitative and qualitative methods

The quantitative method employs measurements and numerical data, so the quantification is emphasized in the processes of collecting and analyzing the data in this method which tends to be connected with the deductive approach, thus on testing theories. By contrast, the qualitative method is involved with words rather than numbers in the processes of collecting and analyzing the data, which tends to be connected with the inductive approach, thus on generating theories. However, the qualitative and quantitative methods can be combined in a one research (Bryman, 2012).

In this report both the qualitative and quantitative methods have been used.

2.3 Literature review

To gain knowledge about the topic of the study and achieve the aim of it, a literature review has been conducted. The literature review is mainly based on recommended books in Lean approach, besides some relevant scientific articles found in the databases, Google scholar and Emerald insight. The following keywords (standardization, standardized work, Lean) have been used to find the articles.

2.4 Case study

A case study is associated with a certain place such as an organization or a society. It involves a detailed examination of the case. Case studies can be employed in both qualitative and quantitative researches (Bryman, 2012).

This report is based on an existing problem in a start-up company. The work began with the case-study company by collecting information.

2.5 Data collection.

The primary data has been collected in form of interviews and observations to the current state of the case-study company.

2.5.1 Interviews

Collecting data by conducting interviews is an important strategy in both qualitative and quantitative research. Structured interviewing means preparing precise questions with a certain order in advance and asking all interviewees the exact same set of questions, which are often provided with close-ended or pre-coded answers. By contrast, unstructured interview is similar to having a conversation with the interviewee, where the interviewer may ask only one
question and then continue responding to the points he/she wants to follow up. Semi-structured interview means the interviewer has prepared some questions usually called an interview guide however, the interview is flexible. The questions don’t have a specific order and maybe some additional ones be asked (Bryman, 2012).

Unstructured interviews have been conducted with the owner of the case-study company to get a deeper understanding of how the work is done and what problems the company has.

2.5.2 Observations
In a participant observation, the observer becomes a member of a group of people for a period of time. The observer observes their behavior, listen to conversations and ask questions (Bryman, 2012).

The author of the report has participated in four concept-proofing trials in the case-study company as a participant observer, to gather more detailed information about the company’s working methods and production processes. During these observations the performed processes were documented, measured and photographed.

2.6 Analysis
Based on a comparison between the literature review and the collected data, an analysis has been conducted.

2.7 Reliability and validity
Reliability and validity are important criteria for evaluating a research. Reliability of a research refers to whether the produced outcome is repeatable, namely if the same results would be generated if an identical research was conducted. It is usually associated with measures consistency and quantitative researches. Validity of a research refers to the integrity of the generated results (Bryman, 2012).

In this report high reliability and validity are considered to be achieved, through the chosen resources, used methods and data collection processes.
3. Literature review

This chapter presents the theoretical part that this project is based on. Initially Lean approach, then standardization including types of standards, myths of standardized work, prerequisites of standardized work, standardized work documents and work training.

3.1 Lean

The world's attention was caught by Toyota, through its special Japanese efficiency and quality, for the first time at the 1980s. The Japanese cars needed less repair and lasted longer than the American cars. Autos designed by Toyota, at competitive costs, were more reliable. Toyota could amazingly solve its problems and come back even tougher each time it had some kind of weakness and looked vulnerable to its rivals. Toyota's way of engineering was behind the incredible consistency in its products and processes (Liker, 2004).

Toyota production system, also known as Lean production, is the result of operational excellence, which is based on quality improvement methods and tools such as one-piece flow, kaizen, just in time (JIT). And Toyota's philosophy of understanding people's motivation, being a learning organization and focusing on a long-term thinking, is behind the success of implementing its tools and methods (Liker, 2004).

Lean production is summed up in five points: defining the value, identifying the value stream, making the value flow, making the value be pulled by customer, and chasing excellence (Womack & Jones, 1996).

According to Liker (2004) the basis of the TPS includes 14 principles that can be split into 4P groups: Philosophy, Process, People and Partners and Problem solving. Figure (1)

The philosophy of eliminating "muda" or waste is the heart of Lean production. Many of Lean's principles and tools are derived from the idea of getting rid of the non-value-adding activities, according to the costumer's perspective, or at least minimizing the time spent on these activities in the production process. For example, in a case of an assembly operation, the time spent on the activity of getting materials and tools by an operator can be minimized by positioning them as close as possible to the assembly point (Liker, 2004).
3.1.1 (7+1) Waste

According to Liker (2004) there are (7+1) wastes or non-value-adding activities that can be identified in a production line:

1-Overproduction: when producing products without having any orders, which leads to wastes such as access inventory, less storage area and more transportation costs.

2-Waiting time: when operators are watching an automated process or simply just waiting due to delays, bottlenecks, stockouts, machine’s downtimes.

3-Unnecessary transport: when materials and finished goods are moving between processes in inefficient way, and work in process(WIP) is carried out in long and unnecessary distances.

4- Incorrect processing or over processing: the waste can be created because of bad product design, or when poor tools are used, or unnecessary and useless steps are taken in the production process or when producing products with higher quality than it is needed.

5-Excess inventory: many production problems such as long set up times, defects, late supplier’s deliveries, production imbalances and many more can be hidden by excess inventory. Excess inventory also causes longer lead times and storage and transportation costs.

6-Unnessecary movement: any unneeded or unnecessary motion performed by operators during their job, such as walking and looking for tools or materials, is a waste.

7-Defects: producing defective products and repairing them is a waste of effort and time.

8-Unused workers creativity: when not engaging workers and listening to them, many ideas, improvement opportunities, skills and time can be lost.

3.1.2 TPS house:

The symbol of Toyota production system, the “TPS house” in figure (2), is very recognizable in modern manufacturing. The roof of the house represents the goals of best quality, shortest lead time, best safety and lowest costs. The pillars of the house are Jidoka (making problems visible) and JIT (getting the right part in the right amount and in the right time), and in the center of the house comes the people who are continuously striving to improve the system and eliminate waste. Then the foundational elements of the house are having stable and standardized processes, leveled production line and visual management, besides the philosophy of the long-term thinking. All the elements of the TPS house need to be strong because any weakness in any of them will weaken the entire system (Liker,2004).
Whitmore (2008) declares that if workers are allowed to choose their own way of performing a job or the sequence of performing the job elements, Lean’s principles will not work well. It would be impossible to create flow and a pull system when the outcome of the process is unpredictable.

Stability and standards are foundations of production. Stability begins with visual management, and 5S system that support and maintain standardized work and total productive maintenance(TPM). Standard is a clear picture of a wished-for situation, and it is a source for comparison to distinguish the out-of-standard actions and make them obvious, so that a countermeasure can be taken (Dennis, 2007).
3.1.3 5S:
According to Liker (2004) 5S is a visual control tool used in Lean systems to support a smooth flow in the production line. It includes a list of actions, shown in figure (3), used to create a continuous improvement process and to eliminate accumulated waste that leads to defects, errors and injuries in the work environment.

The 5S’s are:

1-Sort: sorting through items in the work area, to separate what is rarely or never used from what is often used during the work. Then marking the unwanted objects with red tags to dispose them.

2-Straighten: making a specific permanent place for each of the remained items according to how often they are used, so that workers can easily reach the usually needed tools and parts while performing the work tasks.

3-Shine: trying to keep everything clean, so that any pre-failure conditions or abnormalities that might influence quality can easily be exposed.

4-Standardize: creating rules and procedures to maintain the 3 previous points.

5-Sustain: supporting the 5S by making the work place stabilized to continuously improve the processes.

![Figure 3 - The 5S’s (Liker, 2004), pg. 151.](image-url)
3.2 Standardization

The principles of industrial engineering presented by the "father of scientific management" Frederick Taylor, are the source of much of the modern standardization (Liker, 2004).

According to Dennis (2007) the practices of industrial engineering are built on the following beliefs:
1-There is only one best way to accomplish the job.
2-Operators are not engaged in designing or improving the job.
3-Standards are seldom changed and can only be changed by experts.

The main difference between Taylorism and Lean system is that the first one is a coercive bureaucratic system where workers are viewed as machines and supposed to be blindly executing the standards, generated only by managers. While Lean is an enabling bureaucratic system that provides flexibility and innovation and the worker, who is viewed as a problem-solver and analyst, is considered to be the most valuable resource (Liker, 2004).

The traditional standardization method precludes the possibility of improvement because it considers achieving the standards as a main goal as if they are the ultimate and optimum level of performance. Lean method views the standardization as the basis for improvement and the standards are expected to continuously develop (Liker & Meier, 2006).

Toyota`s way of standardization was, to a certain extent, influenced by Henry Ford`s perspective: current process standardization is the basis of future improvements, and standards should not be considered as confining, rather as the best way of performing at the present time, but which is to be improved in the future (Liker, 2004).

As well, the philosophy and the methodology of the American military`s Training Within Industry (TWI) service had a big influence in standardization. During WWII, the TWI program was created to support the allied forces by increasing the production. This program was established on the idea that standardization should be a cooperating work between operators and supervisors. After WWII, standardization processes were taught to Japanese businesses by TWI trainers, during the U.S. takeover and repairing attempts in Japan. The philosophy of Toyota’s way of standardization was based on TWI`s principles (Liker, 2004).

In any system as shown in figure (4), the 4Ms (Man/Women, Machine, Material and Method) are used to meet the necessary level of customer expectations. The output (goods or services) should meet the requirements in Productivity, Quality, Cost, Delivery time, Safety and Morale (PQCDSM). Standardization is a system to develop and improve the method or the process, that is a mix of Man/Women, Machine and Materials and tells the workers what to do, when and in what sequence (Dennis, 2007).
Lean method focuses on reducing waste that comes from randomness and inconsistency in activities and methods. Therefore, reducing or eliminating waste necessitates reducing variation in the process and establishing standardized work procedure. Standardization with visual control methods will make a baseline for abnormalities to stick out. Then quick adjustments can be made to achieve performance consistency (Liker & Meier, 2006).

In order to continuously improve production processes, they need first to be standardized and stabilized, because if the process is changing all time, any improvement attempt will just create another variation of the process, that will only be used sometimes and ignored most of the time (Liker, 2004).

To eliminate root causes of problems, it is necessary to develop a detailed understanding of the steps required for completing the job tasks. A detailed understanding cannot be developed when workers uses different ways to complete the job tasks. Therefore, Standardization gives the basis needed for continuous improvement (Whitmore, 2008).

Standardization means a detailed documentation and visualization in a system. It presents for the workers the current best way of completing their work. Standardized work should be followed and developed by workers and used in all the jobs that contains a series of tasks (Whitmore, 2008).

Standardized work removes the unnecessary motions and decreases the variations of performance in the work steps, which means it leads to waste reduction, productivity enhancement and ease in problem solving (Whitmore, 2008).

Whitmore (2008) considers standardized work the secret weapon of being Lean. Standardization sustains the made improvements and prevents going back to the unimproved state.
Lean systems concentrate on maximizing people utilizations. Maximizing machine utilization might lead to engagement in wasteful activities such as running machines continuously and generating over-production Muda. Human movement is being focused on in standardized work in Lean systems, where efficient human-centered processes are being developed to maximize the utilization of people. Labor density is Lean’s efficiency measurement.

\[ \text{Labor density} = \frac{\text{work}}{\text{motion}} \]

The numerator is decided by customer demands. And continuously minimizing the denominator is what Lean’s approach is striving for (Dennis, 2007).

Lean has changed the negative idea of standardization from being a management tool that is being forced coercively on the employees and might lead to conflicts between the work force and the management, to a positive way for creating innovation and employee empowerment in the work environment. Lean approach enables those performing the job to design and write the standardized task procedures themselves (Liker, 2004).

Standardization facilitates building in quality and ensuring zero defects. In case of detecting any defects in the output, the first question directed to the worker, as part of the problem-solving process, is if the standardized work was followed. Then the supervisor will monitor the operator while performing the job and check the standardized work sheets to discover any deviations from the standards. If all standards are being followed and the defects are still appearing, then the standardized work should be changed (Liker, 2004).

The benefits of standardized work according to Dennis (2007) are:

1- Process stability: providing repeatability to always ensure the PQCDSM of the output.

2- Clear start and stop points for all processes: this besides the takt time will help in checking the production condition quickly, whether it is behind, ahead, or if there are any problems.

3- Organizational learning: standardization preserves the knowledge so that expertise won’t be lost when experienced employees leave.

4- Audit and problem solving: standardization helps in evaluating the production, tracking processes steps, investigating whether job elements are performed smoothly or not, and defining problems to solve them.

5- Employee involvement: employees in the Lean approach, supported by engineers and supervisors, contribute in developing standardized work, and also in recognizing possibilities for simple error-proofing devices.

6- Kaizen: once the work is standardized the act of eliminating waste start with the process of continuous improvement or (Kaizen)

7- Training: standardized work creates the foundation for the worker’s training process.
Standardization is very beneficial to organizations, but it is very hard to be implemented and maintained. It requires high-detailed and understandable documentation after accurately studying the work process, breaking it into smaller tasks and choosing the best way of performing the job. Getting the management support and having a very good communication with workers are very important to effectively implement standardization (Martin, 2007).

Standardized work provides the best method of accomplishing the job, and work floor layouts and diagrams that demonstrates how to efficiently carry out the job. Standardization of a work starts with analyzing the job steps, then establishing standardized times for performing them by workers, and listing all the used tools (Martin, 2007).

Developing a "pilot team" is the innovative approach of standardizing work for a new product launch. This team consist of workers from all different areas of the factory cooperating together with engineers to develop the initial standardized work. Finding balance between giving the workers rigid procedures to go after and at the same time giving them the freedom of innovation to continuously improve, is the critical mission when standardizing a work task. Therefor the way of writing when establishing the standards needs to be specific yet general enough to give some space for creation, also the ones who are performing the work should be the ones improving the standards (Liker, 2004).

According to Liker (2004) standardized work in Lean system comprises of three elements: 1-Takt time: the required time of finishing a job at the pace of client requirement. 2-Sequence of processes. 3-Stock on hand: the needed amount of inventory for the worker to complete the standardized work.
3.2.1 Types of standards

According to Liker and Meier (2006) there are various types of standards that are incorporated into the standardized work method as shown in figure (5). All these different standards support the main goal of defining the best method of completing the job with the least waste. They also help developing operator’s skills and knowledge by providing them with detailed information. However, the standardized work document doesn’t contain all the standards, it only includes the way of achieving them. The detailed information are contained in the worker’s instructions and training documents.

![Figure 5 - Relationship and purpose of standards (Liker&Meier,2006), pg.119.](image)

**• Quality-safety-environmental Standards**

The quality standards depend on the customer requirements. They might be, for example, general appearance of products, surface quality, gaps, etc. The worker instructions sheets include the quality standards. They have information describing the desired condition, where exactly to check and how to judge if it is good/not good. High quality at the source is granted by creating incorporated inspections, to ensure that areas with most common problems are checked. Written quality standards can be subject to interpretations, therefore providing tangible examples, also called “boundary samples”, may be necessary in some cases (Liker&Meier,2006).

Safety and environmental standards should follow the state’s regulations, therefore specific engineering departments creates them. Then workers responsible for establishing the standardized work will be provided with these requirements to achieve the desired safety and environmental goals. In standardized work documents the safety cross is the symbol for potential safety concerns (Liker&Meier,2006).

**• Standard specifications**

Industrial or manufacturing engineering provide these specifications. They contain technical information of processes and equipment required for production. They can be, for example: dimensions and tolerances or equipment operation parameters (time, temperature, etc.) that need to get checked regularly, for correct condition verification for the equipment in the standardized work. These verifications can be conducted various times during the day.
depending on the equipment nature, and usually before the shift start to make sure that the equipment is ready for use (Liker&Meier,2006).

Sometimes it gets confused between standard specifications and standardized work. These specifications don’t provide the worker information about job steps, timing and how to achieve the work in the best way (Liker&Meier,2006).

• **Standard procedures**

Manufacturing groups develop these procedures. They can be, for example, standard WIP, 5s requirements, color coding, Kanban parameters, etc. These procedures are not documented in the standard work documents. They should be self-explanatory and visually identified in the job floor (Liker&Meier,2006).

3.2.2 Myths of standardized work

Liker and Meier (2006) have debunked several popular myths regarding standardized work:

**Myth:** “*If we have standardized work, anyone can learn everything about the job by looking at the documents*” (2006, s122).

Standardized work documents describe the work elements in basic terms. There is not a detailed description of the work or enough information to completely understand it. It takes long time to learn everything about the job and become a qualified associate. There are too much to learn and the job instruction method is used for that purpose (Liker&Meier,2006).

**Myth:** “*If we have standardized work, we can bring anyone of the street and train them to do the job in a few minutes*” (2006, s122).

That might be possible only in learning particular small tasks in the job. It takes significant effort to get the complete understanding and knowledge of the entire job (Liker&Meier,2006).

3.2.3 Prerequisites of standardized work

According to Liker and Meier (2006) the prerequisites of standardized work are the following:

• Repeatability of the job tasks. It is impossible to standardize if the tasks are not repeated.
• Stability and reliability on the production line and tools. Standardization requires low rate of stoppages and interruptions.
• Low level of quality problems. If defects are occurring very often and workers are continually correcting them, that will affect the time and the standardization will not be possible.

3.3.3 Standardized work documents

According to Liker and Meier (2006) there are three main documents for standardized work and they are:

• Standardized work chart.
• Standardized work combination table.
• Production capacity sheet.
**Standardized work chart/sheet** shown in figure (6) contains work elements sequence, work elements times and a diagram showing the work movement in the layout. This tool is used to create a base for improvements. After recording the work steps and drawing the work movement, the waste should be identified and eliminated by identifying the needed improvements. Then creating balance with other processes in the line by meeting the Takt time. After new improvements are documented, the sheet is posted in the job place for a standardization’s adherence verification by the management as a visual control method (Liker & Meier, 2006).

![Standardized Work Sheet](image)

Figure 6 - Standardized work sheet, (Liker & Meier, 2006), pg.127.
Standardized work combination table/sheet shown in figure (7) contains work elements sequence, work elements times including worker and machine times. This sheet is for jobs with combination of manual and automated activities. It would be a waste of effort and time to use this sheet for analyzing jobs that doesn’t utilize automation. The purpose of this sheet is to understand and analyze the worker/machine relationship in terms of time, by showing what work elements occur simultaneously and to how utilize the human element efficiently. It is not accepted for the worker to wait for the machine to finish but the other way around, because by waiting the worker is wasting his/her value (Liker & Meier,2006).

![Standardized Work Combination Table](image)

**Figure 7 - Standardized work combination table, (Liker & Meier,2006), pg.129.**

Production capacity sheet is used to define capacity of machines used in a production process. Its purpose is to check if the capacity meets the production requirements and to identify bottleneck operations. This sheet is mostly used in operation that involve machine tools changes. It contains manual time, machine time and tools changing time (Liker & Meier,2006).
It is important to audit the standardized work by the management when noticing any problem in the line to find the root cause of the problem and correct it. It is also important to regularly audit the standardized work as a preventive action to discover any deviations from the standards and the reason behinds them (Liker & Meier, 2006).

According to Liker and Meier (2006) having visual control when developing a standardized work is very essential to support adherence to standards and quickly find out any abnormalities from the desired normal state. Figures (8) & (9) demonstrates the difference between the use and the lack of visual controls.

![Figure 8 - Lack of visual awareness leads to incorrect methods, (Liker & Meier, 2006), pg. 139.](image1)

![Figure 9 - Visual standards support adherence to correct method, (Liker & Meier, 2006), pg. 142.](image2)
3.3 Work training

According to Liker and Meier (2006) despite the significant importance of learning how to perform a job effectively, job training for workers is not given high priority by leaders. Letting employees pick up the necessary skills with time and without appropriate training will lead them to develop their own ways of performing the job tasks and might not be the preferred ways of performance.

Few common methods for training:
• "Sink or swim". This method of training is unfortunately very common. Workers have to learn the hard way. It is inspired by the old way of teaching how to swim, where people are thrown into the water and are expected to learn swimming.
• "Give workers time and they will learn". Giving new employees time to discover how to perform the work tasks by themselves, meanwhile suffering from poor performance until they learn.
• "The Microwave way". The training of workers goes very fast like "do this and do that" and that’s it. It takes a few seconds and the training is done.
• "Finding the best employee and following him". The worker may not know how to train and explain the work clearly or maybe he doesn’t know all the safety and quality aspects or maybe he might not want to take the responsibility of training someone else.

3.3.1 Job Instruction training

According to Liker and Meier (2006) Toyota uses a very powerful method to train and develop exceptional workers. This method, which is called the job instruction training, has helped in training thousands of workers to produce high quality products. It is a replica, with a few small additions, of the TWI materials that had been developed in the US during WWII. It was developed to quickly and effectively train unskilled employees who took the jobs of the skilled men who were on active duty, and after the war it had been transferred to Toyota among other Japanese companies. The job instruction training is a secondary lean tool for establishing standardized processes and its basic outline is as follows:

1-Breaking down the job.
Analyzing the job and breaking it into what are called "important steps " and developing a job break down sheet, shown in figure (10), is the first stage in the training process. The Job break down sheet is built on standardized work with taking the training into consideration, so the advanced job steps in the standardized work can be divided into smaller training steps, so the trainees can learn without being overwhelmed. Defining the training steps improves through experience. The trainer while training and observing the trainees can adjust the training method if he finds that the trainees are facing difficulties in learning. After breaking down the work into important steps, each one of them is analyzed to identify the "key points" that clarify critical aspects of the job regarding quality, safety, cost and technique. Key points are considered the heart of this training method. They should be considered cautiously because they are very important to accomplish the job successfully. Previous experiences with problems and the right way of performance to avoid them contributes in developing the key points in most cases. For establishing key points for new processes, potential problem areas are considered initially and after performing the new process, depending on the results, can more key points be added (Liker & Meier,2006).
2-Presenting the operation.
According to Liker and Meier (2006) before presenting the operation, enough time should be assigned for the training activity, and the work area and tools should be organized and arranged as they are expected to be kept. Because the employee’s first impression will set their expectations of how the workplace should be, therefore it is important to demonstrate that randomness and chaos are not acceptable in the work place and only top-quality work is expected. The worker training process contains at least three stages:

- The first one is only describing what is done by teaching all the important steps in the job breakdown sheet, so during this stage only the steps will be stated by the trainer without any additional information about key points or the reasons behind them. It is important for the trainer to assure the trainees, who might be concerned about not getting enough details about the work and fear that they will see the steps only one time, that they will be getting more information in the following cycles and as much time as necessary to learn (Liker & Meier, 2006).

- The second stage is explaining how the work is done by repeating the steps again and explaining the key points for each one of them. The key points are essential elements that describes critical issues about how to perform the tasks to assure getting minimal safety and quality problems, therefore if the key points were properly defined and conveyed to the trainees, that will lead to much better results (Liker & Meier, 2006).

- The third stage is repeating the steps and the key points one more time and demonstrating the reasons for the key points to give them validity. The reasons of the key points contain quality
needs, accident avoidance and the impact of the wrong performance on the next process or the
customer. The training process can be divided into several sessions based on the length and
complexity of the work. The importance of not overloading the trainees is stressed in the job
instruction method. Usually the training session takes from 30 to 60 minutes (Liker &
Meier, 2006).

3-Try out performance.
After presenting the work or part of it completely to the trainees, they should be requested to
try it out themselves without describing the steps. It is very important for the trainer to
carefully observe the trainees while they are performing job, to support them and make
corrections if needed. The trainees might develop wrong ways or habits during their first try
out, therefore this is a critical phase for the trainer because he should coach and correct the
trainees directly, otherwise it would be hard to correct them later (Liker & Meier, 2006).

After a basic skill of job performance is shown by the trainees and has been verified by the
trainer, they are asked this time to explain the steps while they are performing the job to
confirm the understanding. On the third time the trainees are requested to repeat the job and
explain the steps and the key points as well, and the trainer will still correct and assist the
trainees. In this stage the trainer will decide if the trainees can perform the job by themselves
and how much help they will require. Trainees will have different levels and abilities of
learning. The trainer should evaluate each worker individually and never leave the
assessments of performance ability to the workers themselves. The training outcome is the
trainer’s responsibility (Liker & Meier, 2006).

4-Putting the trainees on the work and providing support.
Trainees will be put to work when they appear to be efficient enough, but they will still be
getting some assistance from the trainer and will not be left alone. Sometimes the trainees are
not able to perform at the required speed, so they carry out only parts of the entire job. The
trainer completes the remainder, gives more support if needed and verify the quality and
safety. The portions of the job performed by trainees will increase gradually and the support
of the trainer will reduce as the trainee’s performance level improves. The expectations of
accomplishing the job successfully and fulfilling the quality and safety requirements should
be clear and focused on when initially putting the trainees of on the job. And as the
performance speed gets better it will be focused on achieving the productivity goals (Liker &
Meier, 2006).
4. Case study

4.1 Company description

Husmuttern AB is a start-up company in Eskilstuna, Sweden. Its concept is to produce module buildings by manually assembling standardized components such as walls and ceilings in microfabrics. Then the components will be transported and assembled in the construction sites. The produced buildings will be demountable and recyclable, and through diverse designs can serve as schools, facilities...etc. See Figure (11) (Husmuttern AB, 2018).

The vision of Husmuttern is to make the process of producing the modular components as simple as possible to the point that anyone regardless of experience or education level should be able to perform the production process using the tools available by the company (Tjernell, 2018).

The demands of providing residential buildings, schools and daycares in Sweden have increased in the past couple of years, and the big immigration waves to the country has played an important role in that. In addition, it is difficult for the lower-educated groups of immigrants to find jobs, Therefore, it was asked by the Swedish government to create "simple jobs" for immigrants (Kurdve & Goey, 2017).

Husmuttern AB values are stated as the following “Be good – do good - fair deals”. The company is trying to address both of the previously mentioned challenges, the residential need and the unemployment among the immigrants with lower or no education. The idea is to target the mentioned category of society by making both processes of producing modular parts and learning to perform the production process by the workers as easy as possible, through adopting standardization, low automation and high digitalization (Tjernell, 2018).
4.2 Current state

4.2.1 Tools:
The used tools in the company are:

1- Fixture used in assembling the different components of the wall. Figure (12)

![Figure 12 - Fixture](image)

2- Tool board containing power drills, screwdrivers with different bits, different screws and even a first aid kit and a fire extinguisher. Figure (13)

![Figure 13 - Tool board](image)
3-Screen used for guiding the workers and showing them the different steps of assembling the products. Figure (14)
4.2.2 Current system

Husmuttern AB current system is still in the pilot production state. A few trials of concept proofing have been conducted. The participated members in the trials were the owner of the company, two male and two female unexperienced workers from different ages and national backgrounds and even suppliers and students in some occasions. The concept of Husmuttern AB was presented by the owner of the company, and some parts of the assembly process were performed by the workers during the trials. Figure (15) shows a sketch of the cell. The layout of the cell shown in figure (16) was designed in a previous study. In each assembly cell two operators will assemble the components into the final product using a module fixture, a screen and a tool board and a third operator will be responsible on the logistic support. The screen is supposed to be showing the job instruction for workers in the future, therefore the workers will need to check it out before each step. However, how to perform the assembly process by workers is still not defined or documented. In other words, the assembly process is not standardized, which means variations in performance. Variations implies potential jeopardy in the quality of the products, safety of workers and safety of equipment. The current system lacks visual control tools such as 5S and color coding. Using a wrong equipment or not knowing how to use the equipment efficiently might damage the equipment and causes defects in the products. Producing defective products means wasting extra time and effort in repairing them, and that's one of the (7+1) wastes or non-value adding activities that should be avoided. The assembly process contains a frequent lifting of wooden beams. Lifting beams in a wrong way can easily damage the back of the workers, which are the most valuable resource in the process. Also, some components like plaster beams and plywood boards are fragile and can easily be broken if lifted in a wrong way, which means a waste of material. Generally, the current system of the company has high potential of creating wasteful or non-value adding activities.

![Figure 15 - sketch of the cell](image)
4.3 Establishing a proposal for standardized work

Establishing a standardized work for the assembly process of a wall without a door/windows is the goal. The standardization process started with observing the performed parts of the assembly process of the wall during the conducted trials. Initial description of the process has been established and then broken down into main steps.

**Initial description of the steps of building a wall without door/windows in Husmuttern:**

1. Closing the two opened sides of the fixture by closing the three hooks on the corners.
2. Rotating the fixture upside down, (automatically), to place the beam support parts in the fixture.
3. Adding 3 beam supporting parts to the fixture.
4. Rotating the fixture to its normal position.
5. Placing 1 beam (2446) in the bottom side of the fixture.
6. Drilling 8 holes in the beam (2446).
7. Placing 8 lock pins inside the previous holes in the beam (2446), to fasten the beam to the fixture.
8. Placing 5 beams (2453) in the fixture, so that they are vertical on the previous beam (2446).
9. Screwing 10 screws in the beam (2446) to fasten the 5 beams (2453) to it, (each beam 2453 will have 2 screws).

(To see all the steps, check the appendix 9.1)
4.3.1 Standardized work documents

After breaking down the process into steps, the time of some of the job elements was measured and estimated for the ones that were not performed during the trials. Also, the time of the screen checking by workers was estimated to be 60 sec.

According to Liker & Meier (2006) there are three main documents for standardized work and they are:

- Standardized work chart.
- Standardized work combination table.
- Production capacity sheet.

The **standardized work chart** was established. The assembly process is performed by two workers who perform almost all the steps together and do identical job, therefore the movement of only one worker was demonstrated in the standardized work chart. More details about the workers movement will be demonstrated in the job instruction sheet. The tables (1 & 2) shows samples of the standardized work chart. To see the whole chart, check the appendix 9.2.

<table>
<thead>
<tr>
<th>Work elements</th>
<th>Work time (sec)</th>
<th>Walk time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>checking the first step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>checking the mean value and total work</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>checking the last step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>checking the last step on the screen</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>checking the mean value and total work</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>picking the screw supporting panel</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>loading the fixture</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>picking the screw supporting panel</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>loading the fixture</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 1 Standardized work chart**
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Pick up beam supporting part</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Load in fixture</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>checking the next step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>13</td>
<td>Rotating the fixture (automatically)</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>checking the next step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>Pick up beam (2446)</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>Load in fixture</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>checking the next step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>18</td>
<td>Pick up power drill and pen</td>
<td>3</td>
</tr>
<tr>
<td>19</td>
<td>Drill holes and place the peg inside the holes</td>
<td>60</td>
</tr>
<tr>
<td>20</td>
<td>checking the next step on the screen</td>
<td>60</td>
</tr>
<tr>
<td>21</td>
<td>Pick up a beam (2453)</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>Load in fixture</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>Pick up a beam (2453)</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 Standardized work chart
The production capacity sheet is used to define capacity of machines used in a production process. The production process in Husmuttern Ab is a manual assembly, therefore this sheet was not established.

As well the standardized work combination table is for jobs with combination of manual and automated activities. All activities in the assembly process in Husmuttern AB are manual activities, except for the rotation of the fixture, it happens automatically by pressing a button. The rotation of the fixture occurs only few times in the assembly process, therefore this sheet is not very valuable in this case, however it has been established for the first few work elements of the process (see Table 3) only to demonstrate that the time of the rotation will be utilized by workers in the following step, that is “checking the next step on the screen”. The rotation time of the fixture is 30 seconds while the screen checking time was estimated to be 60 sec.

![Standardized work combination table](image)

**Table 3 Standardized work combination table**
As well a **Job instruction sheet** has been established. Figures (17 & 18) shows samples of it. The whole document of the job instruction sheet is available in the appendix 9.3

![Job instruction sheet sample](image-url)

<table>
<thead>
<tr>
<th>Work instructions sheet</th>
<th>Product number:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product name</strong>: wall without door/windows</td>
<td></td>
</tr>
<tr>
<td>Number of operators: 2</td>
<td></td>
</tr>
<tr>
<td>Version: 1.0</td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td>Note</td>
</tr>
<tr>
<td>#</td>
<td>Picture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work elements</th>
<th>#</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Close the two opened sides of the fixture.</td>
<td></td>
<td><img src="image-url" alt="Image of fixture construction" /></td>
</tr>
</tbody>
</table>

*Each worker will stand at a corner of the fixture and they will move up the two opened sides at the same time, then they will connect the parts of the fixture together at the three corners by:

1. Placing the hollowed part (that is connected to one side of the fixture) on a hook (that is connected to the other side of the fixture) then 2- Pushing the red grip 90 degrees.*

**Figure 17 - Work instruction sheet sample -1**
<table>
<thead>
<tr>
<th>Step</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Rotate the fixture upside down.</td>
</tr>
<tr>
<td></td>
<td>(automatically by pressing a button)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Add 3 beam supporting parts to the fixture.</td>
</tr>
<tr>
<td></td>
<td>The two workers will carry each part together, each one from each side and put it in the fixture. Installing the parts in the fixture happens through sticks on the sides of each part.</td>
</tr>
<tr>
<td></td>
<td>The mechanism of installing each of the three parts in the fixture is as follows: Carrying the part and placing it on the fixture so that the two screws in the fixture enters the two big holes on the sides of the stick that is linked to the part then pulling the stick up then sliding the part to the side while...</td>
</tr>
</tbody>
</table>

Figure 18 - Work instruction sheet sample-2
5. Discussion

This chapter presents the results of the literature study and the case study.

5.1 Discussion from literature study

The different resources from the literature study showed the same results regarding standardized work. Liker (2004) and Whitmore (2008) confirms the importance of standardization in creating continuous flow and using pull system, through maintaining regular output and predictability. It is clarified by Whitmore (2008), Liker and Meier (2006) that eliminating waste, which is the heart of Lean production, necessitates reducing variation in the work process and establishing standardized work. According to Martin (2007) and Whitmore (2008) Standardization is a detailed documentation and visualization in a system and it provides the best current method of accomplishing the job.


Liker (2004) and Dennis (2007) states that standardization ensures continuous improvement and work force growth and empowerment by involving employees in the process of developing the standardized work.

Standardized work according to Dennis (2007) preserves the knowledge in the organization and creates the foundation for the workers training. Liker and Meier (2006) agrees, however debunks popular myths regarding standardized work and workers training.

5.2 Discussion from case study

An initial standardization for the assembly process of a wall without windows/door has been established. The sequence of the steps of the process has been determined and the stock-on-hand needed to complete the standardized process has also been figured out, which is necessary to create a flow and pull the material according to takt time. Having a standard stock on hand will also make any variations visible and any problems instantly discovered. The company is not producing, therefore there is not a takt time. However, the time of some of the steps that have been performed during the trials has been measured and been estimated for the rest of them. That resulted in knowing the total time of assembling one wall and it is 70.05 min, which is useful to knowing how many walls one cell can produce during a certain period of time.

The main documents of standardized work have been created and the work instruction sheet as well, which will lead to stabilizing the assembly process and creating a basis for future improvements, if followed by workers. The job instruction sheet demonstrates how to perform the assembly tasks and contains critical points regarding quality issues, and safety issues such as the ergonomic way of lifting. The job instruction sheet will be useful in guiding the workers while preforming the assembly process. The instructions will be converted to films or sketch-films and be shown to workers on the screen. The created instructions can also be used in the process of training new workers because they are the basis in the job instruction training method that was presented earlier in the theoretical part.
6. Analysis

This Chapter presents an analysis.

The results of the literature study were tested by being applied on the case-study company. The report is based on an existing problem in a start-up company that produces modular houses. The case study shows that the company strives to achieve consistency and maintain regular output and high quality in its products. Which relates to what Liker (2004) and Whitmore (2008) said about the importance of standardization in creating flow, through maintaining regular output and predictability, and how standardization according to Liker (2004) facilitates building in quality and ensuring zero defects. The company wants to make their assembly processes more effective and as simple as possible, since its workers have different skill and education levels, which might risk the consistency of the production. That can be linked to what Liker and Meier (2006) said about Lean method that focuses on reducing waste that comes from randomness and inconsistency in activities. Therefore, reducing or eliminating waste necessitates reducing variation in the process and establishing standardized work. By comparing the results from the literature study to the needs of the case-study company, it is believed that the introduced solution from the case study will put the company on the right track toward achieving its goals of eliminating waste and continuously improving.

7. Conclusions and recommendations

This chapter presents the answers to the research questions and recommendations to the case-study company.

7.1 Research questions

- How to standardize a production process?

The results of this study showed that the stability of the system should be secured before establishing a standardized work. The job tasks should be repeated, otherwise it will be impossible to standardize. The production line and tools should be reliable and having a low rate of slowdowns and stoppages. As well a low level of quality problems in the product is required. Developing a standardized work starts with defining its three main components:

1-Takt time: the required time of finishing a job at the pace of client requirement.
2-Sequence of processes.
3-Stock on hand: the needed amount of inventory for the worker to complete the standardized work.

The main tools that are used in establishing standardized work are the following three documents: Standardized work chart, Standardized work combination table and Production capacity sheet. And the secondary tools that are used are visual controls, boundary samples, Job instruction training and process check sheets. The purpose of standardizing a process is to capture the best way of performance at the present time and create a basis for future improvements. Therefore the standardized process should be continuously improving by the ones who are performing it.
• **How can the standardization contribute to the training of new personnel?**

The results of this study showed that standardized work gives a foundation for personnel training, through the standardized work tools. However, establishing standardized work doesn’t imply that personnel will learn how to efficiently perform job tasks just by looking at its documents. A respectful training method as the job instruction training is necessary to develop highly competent personnel. The two key factors that ensures the effective training process via the job instruction method are the document and the teaching pattern.

7.2 Recommendations

• The standardized process established in this report is only the first step toward a complete standardization. It is very essential to use visual control methods such as 5S and color coding to eliminate the wasteful activities, the possibilities of errors and to establish standardized procedures. These procedures are not documented in the standard work documents. They should be self-explanatory and visually identified in the job floor, and their purpose is to make any abnormalities from the desired standard state discovered quickly. A few suggestions would be to draw lines on the floor to identify the locations of the material and define the standard quantities, coloring the different sides of the fixture in different colors to distinguish them from each other, coloring the different holes in the fixture to distinguish the ones that will be drilled from the ones that will be screwed, coloring the screwdrivers that have different bits in different colors so that workers can directly pick the correct ones.

• A proper training using the job instruction method is recommended for workers.

• The purpose of standardizing a process is to create a basis for future improvements. Therefore, the standardized work should be continuously developing, and the established documents should be updated regularly. Regular audits, at least once every hour or two hours, are recommended to check on whether workers are following the standardized work process or not, and if not why. Worker’s change suggestions to the standardized work process, in order to improve it, should be encouraged. In case of detecting any quality issues, the standardized work should be checked if it is being followed or not. If the standardized work is being followed and the problems are still appearing, then that’s an indicator that there is a need for change in the standardized work or the visualization.
8. References

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Literature


Website


Oral references

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