Lead Time Reduction

Case study: BEAB etikett & system AB

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2008

The Thesis comprises 30 credits and is a compulsory part in the Master of Science in Mechanical Engineering with a Major in Logistics, Nr 3/2008
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Master Thesis

Series Number: Mechanical Engineering with a Major in Logistics, Nr 3/2008

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Key words: lean production, lead time reduction
Abstract

In today’s competitive business world, companies require small lead times, low costs and high customer service levels to survive. Because of this, companies have become more customer focused. The result is that companies have been putting in significant effort to reduce their lead times.

The purpose of this master thesis was to reduce lead time at BEAB etikett & system AB (BEAB) by focusing both on ordering and production times. In order to achieve this all processes from receiving an order to shipment of the order are mapped in a current state map. Some changes based on the Toyota Production System (TPS) were implemented. The results were then mapped in a future state map.

BEAB has more than 30 years experience of producing labels in different sizes and shapes. The products’ range varies from hanger labels on clothing to self adhesive labels for pallets. Due to globalization and stiff competition, the 8 days lead time at BEAB has to be reduced so that they could maintain their customers, and even increase their customer base.

It was found that the most appropriate mapping method for lead time reduction was Value Stream Mapping (VSM). From the results achieved by VSM it was obvious that the press machines were bottlenecks. In order to increase their capacity, their change over time should be reduced. Another observation derived from the VSM, was that a new order passing through the ordering department is an unnecessary step. Some other recommended changes based on applying TPS are:

- Reduction of work in process inventory (WIP)
- Reduction of waiting time between press and converter
- Stop the process to build in quality (this sounds awkward)
- Collect more information
- Implementation of the 5S methodology

By implementing these changes, the future state map was created and the total lead time was reduced from 8 days to 6 days. The production lead time reduced from 4.35 days to 4 days.
# Lead Time Reduction at BEAB

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1 Introduction

The main focus of companies in the 20th century was the customers. It has become more and more competitive to satisfy customers (Gaither 1994). For instance, to perform in a global market, short lead times are essential to provide customer satisfaction. Organizations that have focused on cycle time as a productivity measure can reduce delivery time and improve quality, thereby creating more satisfied customer. Cycle time or lead time is from the time a customer release an order until the time they receive the finished product. (Gaither 1994)

Before 1980, customers tolerated long lead times which enabled producers to minimize product cost by using economical batch sizes. Later, when customers began to demand shorter lead times, they were able to get them from competitors. This is when the problem arose and companies started to look for changes to be more competitive. In an attempt to reduce lead time, businesses and organizations found that in reality 90% of the existing activities are non-essential and could be eliminated. As soon as manufacturers focused on processes, they found waste associated with changeovers, quality defects, process control, factory layout, and machine down time. So they tried to find ways to reduce or eliminate waste. By eliminating the non-value adding activities from the processes and streamlining the information flow significant optimization results can be realized (Harrington 1996)

The purpose of this master thesis was to reduce the lead time at BEAB etikett & system AB (BEAB), a manufacturing and consulting firm in the labeling industry. They have 30 years’ experience of producing labels in many different sizes and shapes. The products’ range varies from hanger labels on clothing, to self adhesive labels for pallets. Due to globalization and stiff competition, the 8 days lead time at BEAB had to be reduced so that they could maintain their customers, and even increase their customer base. This was accomplished by focusing on both the ordering and production lead times. In order to achieve this though, all processes from receiving an order to shipment of the order were mapped in a current state map. Some changes based on Toyota Production System (TPS) were implemented and the results were mapped in the future state map.

1.1 Background

In this section of the thesis, the problem definition and introduction to BEAB is presented. This section will be concluded with delimitation and an outline for the thesis.
In today’s competitive business world, companies should have small lead times, low costs and high customer service levels to survive. Recently low cost countries have huge share in market and they are growing to great extent (Gaither 1994).

To achieve high service levels, companies should make the flow of information, material and resources as efficient as possible. Therefore it is important to know how a company performs its business and communicates with its suppliers and customers. Having a good relationship with ones supplier and customer is a key success factor in today’s business world.

This study was based on the work accomplished for BEAB. The main products of this company are labels and etiquettes. At BEAB, the lead time for each repeated order was approximately 8 days, and for new orders the lead time was 10 days. BEAB’s goals were to reduce this lead time to less than a week with a corresponding reduction in cost thereby improving of performance of company.

Value stream mapping was selected because it was a good methodology to visualize a company’s performance. By creating current state map, value adding and non-value adding activities were determined. Areas of improvement could be distinguished and proper actions for waste elimination could be taken. To achieve a future state map, different lean principles could be implemented.

1.2 Problem definition

One important issue in producing labels was the variety of labels. Labels are different in shape, size and pattern. Therefore it was impossible to produce labels before an order was released, in other words labels were produced according to order or Made To Order (MTO). Most of the time customers were unsure about the quantity and the delivery date, so they waited until the last minute and then made their order. This has put pressure on BEAB to rearrange their production schedule to deliver orders on time. Due to the nature of labels, implementing a postponement strategy in production was not feasible. Since labels are so different from one another, they cannot be supplied from stock. So the only solution was to locate ways to decrease lead times. In this case, the lead time consisted from the time an order is received until that time when finished labels were ready to be shipped to customers.

The main purpose of this thesis is to find ways to reduce the lead time from 8 days. The strategy is to implement lean principles to distinguish and allocate areas of waste. In order to find waste, all processes were mapped by Value Stream Mapping tool. The
current state map represents how orders were fulfilled presently, and after implementing changes, the future state map was created.

This project has developed some recommendations, at the end, to help reduce non-value adding time and improve lead time with the help of lean production principles.

1.3 Delimitation

Because of the time limitation, the investigation focused on two main departments: BEAB’s ordering department and production department. All of the activities that were performed by other departments such as marketing, finance, invoicing and etc., were out of the scope of this master thesis. Additionally, due to lack of time only some random samples were selected and traced to create the VSM. At BEAB, employees did not save any information on static waiting times, which complicated the investigation. The only general information that was readily available was that it took 8 days to complete an order, but they were unable to separate this time into working time, waiting time, and idle time.

Lastly, since production was not in batches but in roles, each order was completely different from the previous one, thus most lean principles were not applicable. This resulted in all calculations being based on orders. This means that instead of inventory and WIP, the quantity of orders was taken to consideration.
2 Theoretical frame of reference

There were several different approaches when discussing lead time reduction. The one approach that was selected for this master thesis was implementing lean principles to eliminate wastes. Therefore it is important to understand the lean philosophy, lean principles, the definition of waste, and different kinds of waste. To properly and thoroughly discover those areas with waste, all processes must first be mapped. There also were many different types of process mappings with each possessing its own level of suitability for particular situation.

The following theoretical frame of reference is comprised of theories on both lean manufacturing and process mapping. In the next section the history of lean manufacturing and the Toyota principle are discussed. After an introduction to lean manufacturing, different types of process mapping are discussed along with their strengths and weaknesses.

2.1 Theoretical frame work on lean manufacturing

2.1.1 History of lean production

Lean thinking and lean production become more and more popular in western industry as a means to improve productivity. One reason for this was that the Japanese industries, during the last decades, have far exceeded the western industries in productivity and quality (Womack and Jones 1990).

The most visible product of Toyota’s quest for excellence was its manufacturing philosophy, called the Toyota Production System (TPS). TPS was the next major evolutionary step in efficient business processes after the mass production system invented by Henry Ford. TPS has been documented, analyzed, and exported to companies and industries throughout the world. Outside of Toyota, TPS is often known as “lean” or “lean production.” (Liker, 2004)

After the Second World War, Toyota and other Japanese organizations suffered from the effects of the war. Resources were strained and Japan needed to rebuild its manufacturing industry (Askin and Goldberg 2002). Many of the Japanese companies turned to western industries to gain ideas and inspiration on how to build up their industry. (Womack et al 1990) In the United States, the call was for mass production to satisfy the needs of a large populace that saved and sacrificed during the war. The Japanese market on the other hand was much smaller and investment capital was scarce. With smaller production volumes per part and limited resources, there was a need for developing a manufacturing system
that was flexible and used less resource (Metall 2002). The solution was to develop a lean production system, and the production genius Taiichi Ohno at Toyota is said to be the man behind the development of lean production (Sohal and Egglestone 1994).

In the beginning of 1980, the western automotive industry began to realize that the Japanese way of manufacturing vehicles far exceeded the methods that were used in the European and American industries. Japanese companies achieved higher productivity and better quality using less resources (Metall 2002). A major research project was therefore initiated at the end of 1980 by Womack, Jones and Roos, at the Massachusetts Institute of Technology. The research showed a significant gap in productivity and quality between the Japanese vehicle assembler and the rest of the vehicle assemblers in the world. The term “lean production” was then developed to describe the Japanese production philosophy (Sohal and Egglestone 1994).

Lean production was not confined to the activities that took place in the manufacturing function of a company, rather it related to activities ranging from product development, procurement and manufacturing to distribution. Together these areas defined the lean enterprise. The ultimate goal of implementing lean production in an organization was to have the customer in focus when improving productivity, enhancing quality, shortening lead times, reducing costs, etc.

2.1.2 Elimination of waste

Lean production was about creating value for the customers with a minimum amount of waste and with a maximum degree of quality. Waste was defined as any activity that consumes resources and creates no value, i.e. lean thinking. Identification and elimination of waste makes it easier to focus on value adding activities and to become more cost efficient.

The Toyota production engineer Taiichi Ohno described seven sources of waste commonly found in industry (Askin and Goldbergs 2002). The sources of waste included:

1. Overproduction
2. Defects
3. Unnecessary inventory
4. Unnecessary processing
5. Unnecessary transportation between work sites
6. Waiting

7. Unnecessary motion in the workplace

These seven sources of waste will now be explained in detail together with tools to detect and reduce them.

**2.1.2.1 Overproduction waste**

The most significant source of waste is over production. This means producing more, sooner or faster than what is required by the next process. Overproduction causes all kinds of waste, not just excess inventory and money tied up in inventory. It results in shortage, because processes are busy asking the wrong items. Traditionally supervisors were judged by the quantity of production. The thought was that resource utilization was to be maximized. This led to overproduction waste. According to lean philosophy Machines and humans should only be busy when they have useful tasks to accomplish (Askin and Goldberg 2002). Lean production accentuates on production according to customers’ demand, otherwise products would have to be stored and the risk of becoming obsolete increases.

Overproduction is more common when products are made according to forecasts instead of customer’s order. Therefore it is reasonable to produce according to customer’s orders. Since customers demand for delivery is often shorter than the production lead time, forecasting is inevitable in most cases. As a result, the customer order point should be moved upstream in the production flow.

**2.1.2.2 Defect waste**

The lack of quality is another source of waste. When a product or a part is found to be defective, it should be rebuilt. This means the consumption of more resources, higher costs also provides for a negative impact on the customers perception. It is important to find the root of the quality problem and remove the problem from its source.

The bigger the batch size, the more time it will take to detect a defect. This can cause the entire batch to be scraped. In one piece flows, defects are detected immediately and the operator causing it can get instant feedback from their downstream customer.

**2.1.2.3 Unnecessary inventory**

Keeping parts and products in inventory does not create any extra value for them. When this occurs, it only hides the problem and prevents a solution. Additionally, keeping
inventory means higher tied up capital. However, it is not advisable to eliminate inventory mindlessly. Instead, the reason for the existence of the inventory must first be found (Karlsson and Åhlström, 1996).

Two types of inventories are existed: work in process (WIP) and parts storage. WIP are the parts stored between each process and parts storage are the raw material which were brought from the main warehouse to the production area to be processed.

Lean manufacturing always emphasizes on reducing inventory. This can be done either by reduction of buffer inventory or the reduction of batch sizes, or both. Buffer inventory is reduced by eliminating unwanted variations. The positive points for reducing inventory are listed below:

- Reducing tied up capital
- Shortening throughput time
- Lessening risk of obsolete material
- Smoothing production flow
- Lowering space rental costs
- Decreasing the time needed to detect quality problems

The list above indicates that reducing inventory is related to other sources of wastes such as the waste of time, defective products and unnecessary transportation. It also indicates that reducing inventory helps in reducing other areas of wastes.

2.1.2.4 Unnecessary processing

An incorrectly designed process could also be a source of waste. Activities in an organizational process can be divided into 3 categories: value adding, non-value adding but necessary, and non-value adding and unnecessary. Lean production emphasizes reducing this non-value adding and unnecessary process. Changing design of parts, limiting functionally unnecessary tolerances and rethinking process plans can often eliminate and simplify process activities in the manufacturing process (Askin & Goldberg 2002).

A tool for determining non-value adding activities is process mapping. All steps in a process are indicated by graphical symbols with different activities linked by arrows. A
detailed map of a process often reveals unnecessary stages and sequences, and can be used to improve the process design (Brassard & Ritter 1994).

2.1.2.5 Unnecessary transportation between work sites

Transportation waste includes all types of unnecessary transportation of material, work in process and components, which do not add value to the products. Most unnecessary transportation is due to the inappropriate layout of a factory. As such, it is difficult finding methods to optimize the layout of a factory. One method to address this is the traditional view in accordance with the mass production perspective. This means that machine and equipment are often grouped on a functional basis. This layout maximizes transportation efficiency between functional areas. This is in keeping with a lean manufacturing layout that is based on product families and dedicates equipment to each product family. This is necessary to achieve a flow with minimal transportation.

One tool that can be used for analyzing transportation waste is spaghetti mapping (LEIS 1999). A spaghetti map indicates physical flow of material, products and humans. Basically, all movements are drawn on a current layout map in order to reveal unnecessary transportation. The map often looks like a pile of spaghetti before the layout is improved. This is the reason it is called spaghetti mapping (LEIS 1999).

2.1.2.6 Waiting

Waiting may be due to different reasons such as waiting for correct information, products waiting to be processed, machines waiting for their operators and machines waiting for material to arrive (LEIS 1999). One such common type of waste is waiting associated within inventories. Research has showned that products spend most of their time in warehouses.

Value Stream Mapping is a tool for identifying the product flow through the factory. Processing time, throughput times, set-up times, inventory levels, etc., are mapped with standardized symbols. The map reveals the relationship between waiting and processing times. It is not uncommon to find that the value adding time is only a few percent of the total lead time.

2.1.2.7 Unnecessary motion in the work place

Motion consumes time and energy. It is essential to eliminate all motion that does not add value, such as stretching for tools and moving materials within a station. This objective
should be guiding when designing workplaces, processes, operation procedures, etc. Reducing waste as the result of unnecessary motion encompasses everything from describing detailed hand motions in an assembly process to the selection of machines and design of fixtures to reduce the time for set-ups and material handling (Askin & Goldberg 2002).

2.1.3 Toyota Production System

To implement the Toyota Production System (TPS) it is important to understand what is known as the “Toyota House”. It starts with the goal of best quality, lowest cost and shortest lead time, representing the roof. The outer pillars are Just-in-Time (JIT), which is probably the most famous aspect of the TPS, and Jidoka. Jidoka emphasizes the visibility of a problem. In the center of the house are people. Finally there is the foundation that is stable and standardized processes, Visual management, Toyota Way Philosophy, and heijunka, which means smoothing the production flow in terms of both volume and mix.
Each part of the house is important, by itself, but when they work together, they reinforce each other. One piece flow means that one unit at a time is processed at the customers demand rate, which will enhance judika. In mass production when a machine goes down, the maintenance department will fix the problem. Inventory is then used to fill the production gap during these times. Thus, there will not be any urgency. Whereas in lean production when a machine goes down other operations will soon stop production, so there is always some urgency to fix the problem. (Liker 2004)

2.1.4 14 principles of Toyota Production System

Most companies in the world claim that they are lean. Although, what exactly is a lean enterprise? It is the result of applying Toyota Production System (TPS). TPS is Toyota’s unique approach to manufacturing. Lean manufacturing is defined by James Womack and Daniel Jones as a five step process: defining customer value, defining the value stream, asking it “flow”, “pulling” from the customer back, and striving for excellence.

This chapter provides a brief summary of the 14 principles that constitute the Toyota Way. The principles are divided into four different categories: (1) long term philosophy, (2) the right process will produce the right result, (3) add value to your organization by developing your people, and (4) continuously solving root problems drives organizational learning. (Liker 2004)

Section 1: Long term philosophy

Principle 1. It is essential to make basic management decisions according to the long term philosophy, even at the expense of short term financial goals.

• It is better to have a philosophical sense of purpose that supersedes any short term decision asking. Staff must work, grow and align the whole organization toward a common purpose that is bigger than asking money. They should understand their place in the history of the company and work to bring the company to the next level.

• The starting point is to generate value for the customer, society and the economy, therefore every attempt is made to achieve this goal.

• It is crucial to be responsible and strive to decide the company’s fate. Actions must be made with self-reliance and trustworthiness.

Section 2: The right process will produce the right results

Principle 2. Creating a continuous process flow will bring problems to the surface.
In order to achieve a continuous flow, work process should be redesigned. This means the amount of time that any work project is sitting idle or waiting for someone to work on it, should be reduced to zero.

The created flow must be such that material and information move as fast as possible thereby bringing problems to surface.

The flow should be made evident throughout the organizational culture. This is the key to a true continuous improvement process.

Principle 3. Using the “pull” system will avoid over production.

Customers in the production process have to be provided by what they want, when they want it and in the amount they want. Material replenishment initiated by consumption is the basic principle of Just-In-Time.

Work in-process and warehousing of inventory must be minimized by stocking small amounts of each product and frequently restocking a base on what the customers actually take away.

It is necessary to become responsive to the day-by-day shifts in customer demand instead of relying on computer schedules and system to track inventory.

Principle 4. The work load has to be leveled out. (heijunka)

Eliminating waste is just one third of the equation of making lean production successful. Eliminating unevenness in the production schedule is just as important —yet generally this is not understood at companies attempting to implement lean principles.

All manufacturing and service processes should be leveled out as an alternative to the stop/start approach of working on projects in batches that is typical at most companies.

Principle 5: To get quality right the first time, a culture of stopping to fix problems should be built.

Quality for customers is derived from a company’s value proposition.

All modern quality assurance processes should be used.
The capability of detecting problems must be built into equipment, such that they stop when a problem occurs. A visual system needs to be developed to alert the team or project leader when a machine or process needs assistance.

The organization support system should quickly solve problems.

The culture of stopping to get the quality right the first time should be built, to enhance productivity in the long run.

Principle 6: The foundation for continuous improvement and employee empowerment is standardized tasks.

To maintain predictability, regular timing, regular output of process, stable andrepeatable methods should be used.

Creative and individual expression must be in a way that improves standards and incorporate it into new standards, so that when a person moves on, the learning can be handed off to other people.

Principle 7: Visual control will surface hidden problems.

With the help of simple visual indicators people can determine whether they are in standard condition or deviating from it.

Using a computer screen may move the worker’s focus away from the work place.

It is better to reduce the report to one piece of paper, even for most important financial decisions.

Principle 8: Only reliable, thoroughly tested technology that serves people and process should be used.

Technology must be used in a way that supports people not to replace people. It is better to work out the process manually before adding technology to support the process.

New technology is often unreliable and difficult to standardize. It is preferable to use a proven process that works generally than to use a new, untested technology.

Actual tests must be conducted before adopting new technologies business processes, manufacturing systems, or products.
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Actual tests must be conducted before adopting new technologies, business processes, manufacturing systems, or products.

It is essential to reject or modify technologies that conflict with the company’s culture, or might disrupt stability, reliability or predictability.
Nevertheless, it is good to encourage people to consider new technologies when looking into new approaches to work.

Section 3: By developing people and partners, values are added to the organization.

Principle 9: Leaders should be grown in a way such that they understand the work, live the philosophy, and teach it to others.

• It is better to grow leaders from within, than buy them from outside the organization.

• Leaders must be role models of the company’s philosophy and way of doing business.

• Good leaders must understand the daily work in great detail so they can be good teachers of the company’s philosophy.

Principle 10: Exceptional people and teams who follow the company’s philosophy have to be developed.

• A strong and stable culture in which company values and beliefs are widely shared and lived out over a period of time, should be created.

• Exceptional individuals and teams have to be trained to work within the corporate philosophy to achieve exceptional results.

• To improve quality and productivity, it is better to use cross functional teams. Empowerment occurs when people use the company’s tools to improve the company.

• People should become aware of the importance of team working. They should learn how to work with team members to achieve a common goal.

Principle 11: It is important to respect the extended network of partners and suppliers by challenging them and helping them improve.

• It is essential to respect partners and suppliers and treat them as an extension of the business.

• Outside business partners should be given a chance to grow. This shows that they are respected and valued.

Section 4: Organizational learning is gained by continuously solving root problems.
Principle 12: To thoroughly understand the situation, leaders need to go and see for themselves.

- To solve problems and improve processes, managers should go to the source and personally observe the situation and data instead of theorizing what people are describing or what a computer screen is telling them.

- Managers should think and speak based on personally verified data.

- Even high-level managers and executives should go and see the situation for themselves. This ensures that they will have more than a superficial understanding of the situation.

Principle 13: It is important to make decisions slowly and thoughtfully, and implement them rapidly.

- Managers should not pick a single direction and proceed down one path until all alternatives have been thoroughly considered. When a direction is picked, they should move quickly and cautiously down the path.

- All personnel affected in the decision should be asked for their ideas and opinions before implementing a course of action. Although this process is time consuming, it will help to broaden the search for solutions. Once the decision is made, the stage is set for rapid implementation.

Principle 14: To become a learning organization, the most important tools are continuous improvement and relentless reflection.

- Once a stable process is established, continuous improvement tools should be used to determine the root causes of inefficiencies.

- Processes must be designed in ways that require no inventory. This will make wasted time and resources visible for all to see. Once waste is exposed, employees must use continuous improvement tools to eliminate it.

- Standardizing the best practices is an important way of learning, instead of reinventing the wheel with each new project and each new manager.

The next question is: “how does TPS apply to each business?” Not all businesses produce cars in high volume. Most of them produce low volume specialized products. Besides, some companies are professional service organizations, so they might think that
TPS does not apply to them. This question means they are missing the point. Lean is not about imitating tools used by Toyota in a particular manufacturing process. Lean is about developing principles that are right for an organization and practicing them to achieve a high performance that continues to add value to the customers and society. This means being competitive and profitable. (Liker 2004)

Despite many companies claim of being lean, most companies’ attempts to implement lean are superficial. The reason for this is that most companies are busy with tools such as Just-In-Time and 5S, without understanding lean as an entire system that needs management’s commitment as an important base.

### 2.2 Theoretical framework on process mapping

It is important to understand the definition and importance of a process. Ron Anjard (1998) defined a process as “a series of activities (tasks, steps, events, operations) that takes an input adds value to it and produces an output (products, service, or information) for a customer. Customers are all those who receive the process output.” In order to understand, document, analyze, develop and improve process steps, a process map is vital. A process map is a visual aid for depicting the work process. It shows how inputs, outputs and tasks are linked. (Anjard 1998)

A process map can be drawn at various levels of detail. Some have described it as “peeling the onion.” All process maps should be developed from a top-down approach. One should begin mapping at the macro level of the process. This level determines the scope of the system. Then the process should be “peeled” down to the mini-level of the process. A single process may break down into 5-15 mini-processes. (Anjard 1998)

According to Aguiar and Waston (1993), process mapping can improve the customer focus of the process, assist in eliminating the non-value added activities and reduce the process complexity.

Process mapping is usually consisted of the following steps:

1. Identification of products and services and their related processes. The starting and finishing points of processes are identified at this step.

2. Data gathering and preparation.

3. Transforming the data into a visual representation in order to identify bottlenecks, wasted activities, delays and duplication of efforts. (Soliman 1998)
2.2.1 How to conduct process mapping

Different steps in process mapping were introduced by Savory and Olson (2001) as follows:

1. Defining the purpose for developing a process map
2. Establishing the team
3. Mapping the “As Is” process
4. Establishing a measure for improvement
5. Proposing changes
6. Mapping the “Should Be” process

Step 1: Defining the purpose for developing a process map

It is extremely important to know the goal and aim for creating the process map. It identifies the depth and the level of process mapping.

Step 2: Establishing the team

The team should consist of representatives from different levels of the organization. Some key suppliers and customers can also be engaged with mapping.

Step 3: Mapping the “As Is” process

In this step the process is mapped exactly the same way as it occurs at the present time. This is done by interviewing key personnel involved in that particular process. It is necessary to understand that this map is never 100 percent correct by first trial, but it will provide some idea about opportunities for improvement in the future.

Step 4: Establishing a measure for improvement

Having the “As Is” map without any performance measurement is useless. Since the goal is to improve the process, there should be some way to measure the improvement. A direct link has to be established between the target for improvement effort, the organization’s strategy and competitive position.
Step 5: Proposing changes

After preparing an “As Is” map and establishing an improvement measure, the improvement areas should be determined. Some of these improvement areas are described by Savory and Olson (2001):

- Eliminate duplicate activities
- Combine related activities
- Eliminate multiple reviews and approvals
- Eliminate inspections
- Simplify processes
- Perform activities in parallel
- Outsource inefficient processes
- Recognize worker teams

Step 6: Mapping the “Should Be” process

The “Should Be” process map presents the ideal situation. It describes the process after all non-value added processes are eliminated. It shows a new or improved process that meets the goals established and eliminates deficiencies.

2.2.2 Different mapping tools

In this chapter different mapping tools and their descriptions are presented. Among existing mapping tools, flowcharts, Supply-chain Operation Reference-model (SCOR), Value Stream Mapping (VSM), and Time Based Process Mapping (TBPM) are taken into consideration.

2.2.2.1 Flowcharts

According to the Six Sigma dictionary (http://www.isixsigma.com/dictionary/), a flow chart “is a graphical representation of a process, depicting inputs, outputs and units of activity”. It shows entire processes from the starting point to the end and can be drawn at different levels of observation. Four particular types of flow charts have proven useful when dealing with a process analysis: top-down flow chart, detailed flow chart, work...
flow diagrams, and a deployment chart. Each of these different types of flow charts tends to provide a different aspect of a process or a task. Flow charts provide an excellent form of documentation for a process and quite often are useful when examining how different steps in a process work together.

2.2.2.2 Supply Chain Operation Reference Model

The SCOR model was developed by the Supply Chain Council (SCC). This model provides a unique framework that links business processes, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities (SCOR model version 8).

This model consists of five primary management processes: plan, source, make, deliver and return.

In the plan process, the resource is balanced with the requirement, besides the plan for the entire supply chain including return, source, make and delivery is also established in this process.

The delivery, reception and transfer of raw material is scheduled in the source process where supply sources are identified and selected. In addition, inventory, capital assets, incoming products, supplier network and supplier agreement are managed in this process.

All activities in the production area, from scheduling production to packaging and releasing product to delivery, are part of the make process.

The deliver process includes all order management steps, warehouse management, product reception and verification at the customer site, and customer invoicing. It manages the deliver business rules, performance, transportation and product life cycle.

The return process consists of two parts, raw material returns and receipt of returns for finished goods. These returns may be due to defective products, maintenance and repair, and excess production.

SCOR model is consisted of three level of process detail:

- Top level
- Configuration level
• Process element
• Implementation level

1. Top level

This level defines the scope and content for the supply chain operations reference model. In this level, the basis of the competition target is selected.

2. Configuration level

Through the configuration level, companies apply their operation strategy. It defines the core process categories that are possible components of a supply chain.

3. Process element level

It defines company’s competitiveness in its chosen markets and consists of the following:

- Process element definitions
- Process element information inputs and outputs
- Process performance metrics
- Best practices, where applicable
- System capabilities required to support best practices

4. Implementation level

This level defines all works need to be accomplished to achieve a competitive advantage and to be applied in response to changing business conditions.

2.2.2.3 **Value Stream Mapping (VSM)**

VSM is a tool to understand the material and information flow as a product or service makes its way through the value stream. VSM takes into account not only the activity of producing the product, but also the management and information systems that support the basic process. This is especially helpful when working to reduce cycle time and to gain insight into the decision making flow, as well as the process flow. This is actually a Lean
tool. The basic idea is to first map the process. Then above that, map the information flow that enables the process to occur.

The value stream map takes into account different measures such as cycle time, set up time, lead time, value added time, size of batch, number of operators, number of products, shipment volume, labour hours, rework of products and cassations. Different steps exist within VSM. First, the current state map is created to show the current production situation. Business and manufacturing waste that occurs in this process can be easily identified. Once the current state map has been created, it then becomes the baseline for improvement and for the creation of a future state value stream map. After all, VSM is only a tool unless the future state is achieved. (Rother 2003)

The purpose of VSM is to identify, demonstrate and remove waste in processes. Waste is defined as any activity that creates no value for the customer. VSM can be a starting point to help management engineers, production associates and suppliers to recognize waste and identify its causes. As a result, VSM is a tool for communication, but it can also be used as a strategic planning tool and as a change management tool. In this regard, mapping out the activities in the manufacturing process with cycle times, down times, in-process inventory, material moves, information flows, helps to visualize the current state of the process activities and helps the development of the future desired state.
3 Methodology

The aim of this project is to reduce lead time by implementing lean principles; therefore the output of this project should be applicable in improving the current situation. To be able to accomplish this, first theories were studied, and then those theories were implemented into a case study using BEAB etikett & system AB, in Borås, Sweden. Data were collected from different sources and in different ways. Most information was gathered by interviewing different employees. At the beginning, some brief information was collected from the production manager concerning different departments and their activities. Next, the staff of each department was interviewed which provided general knowledge about each section’s roles.

To create the VSM some orders were followed directly from the order point to shipping. This was done by interviewing operators, walking the shop floor and collecting information, to include the gathering of information from computers. In the beginning, maps were drawn with pencil on paper and later transcribed to electronic format. Times for each process step were measured using a stopwatch and calculations were performed when necessary.

The theoretical framework consisted of two different parts:

1. Lean principles and Toyota production system
2. Different methods of process mapping

The theories were obtained from literature existed at University College of Borås library. The *Toyota Way*, a book about the 14 principles for the Toyota production system, was the base for first part. *Learning To See* was the main information resource for second part. *Learning To See* is a guide that shows all the steps required to create a value stream map; it also contains information about different types of wastes. Additionally some articles and papers were studied to broaden the idea of lean thinking. Some relevant master theses were also looked through in order to learn gain knowledge about different concepts in process mapping and lean production.

After putting theories into practice, for the BEAB case study, some results were driven and analyzed. Recommendations concerning different ways to reduce lead times and various production improvements were derived from the future state map, and were presented to the company.
To create the VSM for BEAB, a map was created according the instructions in the book, *Learning To See*. Almost all of the different steps were covered. Some assumptions were made during creation of the first map. This was mainly done for the sake of simplicity. One such case concerned the fact that there were not enough statistics and information on waiting times, idle times and other timings. Different orders were followed from the ordering point to the production point and afterwards to the shipping point. No trend was found between different time divisions. Therefore one of the orders was randomly selected and used for creating the necessary maps.

To acquire some knowledge about change-over actions, different change-over steps were observed three times. The operators were interviewed about different methods to reduce changeover time. Some data collection was made from interview, observation, literature studies and by following orders.

The next chapter discusses the VSM created for BEAB and the different steps within it. Different waste areas were identified and some solutions were recommended to reduce lead times, which resulted in the creation of a future state map. The future state map shows the process as it should be in the future after implementing some specific changes. The most important step, though, is to make the future state map work in practice and see the corresponding results.
4 Evaluation of methods and data

The methods used for data collection and information gathering were mainly based on interviews. The accuracy of these interviews depended mainly on the precision and depth of the interviewee and interviewer. In this case most of the data were also saved in an electronic format which has ensured the accuracy and security of the data. One difficulty with gathering information at BEAB was that order data were not retained for future analysis. In most cases the order information that was saved consisted of: ordering date, work duration, change-over duration and delivery date. Waiting time, idle time and other pertinent order information were not kept. Also, there were no statistics concerning different orders. All conclusions made in this thesis are based on several orders that were tracked and traced.

The methods used in this study were mainly process mapping and VSM. These methods were accurate methods used by many other researches. They are basically strong methods but still the accuracy depends on the precision of the collected data and the capabilities of the person collecting the data. The recommendation and conclusion portion of this thesis is primarily based on the related principles found in the Toyota Way. These principles have been used by Toyota for years with brilliant results. There has been a tendency for small and medium size companies to use these principles, and good results were achieved in small and medium size companies. The reason for this is due to the principles being sufficiently general and thus applicable to different situations.
5 Empirical Work

5.1 BEAB Company

Labels are important tools for transferring information. With the help of ERP systems, all the information that is put on a barcode becomes accessible to each operator in the entire supply chain. This means that labelling systems are developing and are as important to the supply chain as is IT.

BEAB has more than 30 years’ experience of producing labels. They have provided customers with different capabilities required to produce labels: from designing steps to the shipment of labels. Apart from producing labels, BEAB has also sold printers and ribbons so customers can print their own labels. It is sometimes more convenient for the customer to have their own printer and place it close to their manufacturing site. By owning a printer customers can request that BEAB supply them with neutral labels and ribbons. The result would be a postponement in printing information, and reducing the risk of errors to great extent since the customers do not have to consider the transportation time form BEAB to their production site and they can print on neutral labels last minute. It means that as long as customers have a computer with Internet access, they can print labels anywhere in the world.

BEAB works together with several of the world’s leading suppliers of printers, scanners and communication solutions. They also provide their customers with services such as staff training, operational support and etc.

BEAB head office is located near Borås and has 36 employees. Its customers are located all around the world and include large companies like IKEA, VOLVO and HEMTEX.

5.1.1 Product and order type

BEAB offers labels in different sizes and shapes. Their product range varies from hanger labels for clothing to self-adhesive labels for pallets. They are mainly made of cardboard, paper and other synthetic materials, and are supplied either in rolls or fan folded. Labels vary in color from no color up to a maximum of 6 different colors. All products are Made-To-Order (MTO), therefore no production can be made before an order has been released.

BEAB also has different types of materials and ribbons to meet adverse conditions like heat, chemicals, excessive wear and etc. BEAB offers six package solutions, which can be adjusted to meet most customers’ demands, as follows:
The primary purpose of this thesis was to find a solution to reduce BEAB’s lead time from eight days to six days, or less. This was achievable by implementing lean principles, because the elimination of waste is also considered apart of lead time reduction. In this section, different steps were required in the fulfillment of an order, are also discussed. Different departments and their roles in meeting customer’s demand are also presented in this chapter. This information will be used later in the analysis section where the combination of theories and observation leads to some recommendations for reducing lead time.

A description of each department and its role is presented in the following sections.

### 5.1.2 Ordering Department

Each order was received at the ordering department by way of three means: telephone, fax and mail. Some orders were new and some were repeat orders. After receiving the orders, the costs and quantity were calculated by order handlers. Then the invoice was sent to the customer. The order map, which consisted of the order quantity, label size, stereo covering, label design and sample of previous labels (for repeat orders) was prepared and sent to the next department the same day. Each order was kept, at most, one day in the ordering department. Two personnel worked in ordering department. There were ten days lead time for new orders and eight days lead time for repeat orders. Order handlers assigned Delivery dates for each order. The lead time was calculated from the day that the order was received at BEAB. Thus if an order remained more than one day in the ordering department, production would have had to be rushed. One copy of the processed order, an acknowledgment, were sent to the customer. New orders were then
sent to the pre-press department for designing and ordering of stereo coverings. Repeat orders were sent to the material planning department. If an order arrived at the material planning department in the afternoon, the order was processed the next day by the material planner.

5.1.3 Pre-press Department

The pre-press department was responsible for equipping the production machines with new stereo coverings and die cutters. They were also in charge of designing new orders and creating proofs. BEAB ordered die cutters from three different suppliers and stereo coverings from two different suppliers. One of the die cutter suppliers was located in Denmark with the remainder of the suppliers located in Sweden. Two different kinds of dies are used, known as plate and solid dies. The delivery lead time for plate dies was three days and for solid dies was five to seven days. Among three die suppliers one was the main solid die supplier and the other was the main plate die supplier.

Orders were all initially received at the ordering department. After the orders were registered and assigned an order number, the new orders were sent to the pre-press. At the pre-press, labels were designed according to the customers’ needs. It took between 15 minutes to one hour to create a new design. The new design’s proof was then sent to the customer for confirmation, either by email or post. For neutral labels and some colored labels, the confirmation was done by email, but for labels with new colors that have not been printed before, the proof was sent by post. After the customer confirmed the proof, die cuts or stereo coverings were ordered, if required. Once the confirmation had been received, the order proof and new designs were sent back to the ordering department for re calculation and preparation of the order map.

Some orders were sent by the marketing department directly to the pre-press department; thereby skipping the ordering department. After customer’s confirmation had been received, all orders had to be returned to the ordering department for registration.

When the die cutters and stereo coverings arrived at the pre-press department, they were confirmed by the pre-press personnel and if everything was correct, the orders were then sent to material planning and control. The repeat orders already had stereo coverings and dies so they automatically were sent directly from order handling to the material planning and control department.
5.1.4 Material Planning and Control

In the material planning and control section, the availability of raw materials was checked against the material requirements. First, the amount of required raw materials was calculated. Then the label quantity, that should be produced, and the amount of raw materials that should be ordered from the supplier are measured in meters. If sufficient materials were in stock, the material planner determined the proper press machine for production. The EDI system used at BEAB was called Concorde XLA. It was used only inside the company for checking the availability of raw materials. Ordering the raw material from the suppliers was accomplished either by email or by phone. As it is shown in Table 1, six different pressing machines were available. Each machine differed in the number of colors it can print. The five colored machine was UV based whereas the others were water based.

<table>
<thead>
<tr>
<th>Machine name</th>
<th>Number of colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>6</td>
</tr>
<tr>
<td>M2</td>
<td>3</td>
</tr>
<tr>
<td>M3</td>
<td>4</td>
</tr>
<tr>
<td>M4</td>
<td>0</td>
</tr>
<tr>
<td>M5</td>
<td>3</td>
</tr>
<tr>
<td>M6</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Different Press machines

Order maps were handed over to the appropriate press machine operator. Operators used different methods in scheduling orders. Usually orders were sorted by the delivery date. Orders that had a closer delivery date were processed sooner. Sometimes orders were scheduled according to the color, pattern or raw material. This meant the orders with the same colors, raw materials or patterns are produced simultaneously, regardless of the
delivery date. Therefore the production schedule was developed by the operator from experience. No other means or methods were used for scheduling.

On the other hand, if there were insufficient raw materials, such a deficiency was corrected by ordering the requisite raw materials from established suppliers. Different suppliers have different delivery lead times, which could vary anywhere from three to 27 days. The primary two raw materials were cardboard and self-adhesive. The cardboard supplier had a delivery time of approximately 27 days, which was rather long. Additionally, most suppliers would only accept high volume orders. This meant that cardboard had to be stored in a warehouse in order to avoid a shortage. Self-adhesives had a shorter lead time, which was about 3 days. Thus there was no need to retain a large quantity of them in the warehouse. It was not a common case to postpone the production because there was not enough raw materials. Raw materials were checked twice a day. At least once a day, orders were sent to suppliers, which meant that the warehouse inventory management and resupply of raw materials were continually being validated and updated. Once the order map was sent to the press machines, production began.

5.1.5 Production Department

Each order was produced by an assigned press machine. Depending on the customer’s request, orders may have gone through a converter to reduce the rolls’ diameter or orders have been fan folded by special machines. The waiting time before pressing varies between one and six days, depending on the number and type of orders of previous orders. This was one of the limitations in mapping the process. There were no information or rules concerning wait times before pressing. Sometimes wait times can become so long that the material planner decides to move the order to another press machine, which had less work load at that time.

Each machine had one operator who controls every step. That assigned operator should not leave the machine when it is running. The work day consisted of one shift lasting for 7.75 hours. The press should have been set up according to what is required for each order. The setup time differed from 15 minutes to 2.5 hours, depending on the order. This variance depended mainly on the number of colors for a particular order. If the order consisted of a small quantity of labels, then the running time maybe shorter than the setup time. Long setup times were the main reason for long wait times before the press.

Since only two converters existed, it may take from one hour to two days for rolls of labels to be converted. The waiting time before the converter varies significantly, also.
Sometimes it takes a few minutes and sometimes rolls have to wait for one day to be converted.

The final labels may have remained in the warehouse for a few days or shipped immediately after production. Orders in which the supplier had assigned a specific delivery date may have stayed in the warehouse until the desired delivery date. Others were shipped sooner, if they were ready.

5.1.6 Shipping Department

After the labels were produced, they were carried by a lift truck to the shipping department. Packages for the same customer were put on the same pallet and a plastic film covers them. A delivery note was printed and attached to each pallet. Three main transport companies were responsible for the shipment of labels produced at BEAB: DHL, SCHEMKER, and the Swedish Post. When an order was provided by a customer, the name of the transport company is also indicated. The three aforementioned transport companies sent their trucks to BEAB each work day in the afternoon. They would collect the consignments and transport them as required.

Labels that were ready before noon were sent the same day and labels that were finished in the afternoon were shipped next day. This resulted in labels being kept in the shipping department at most one day. Some orders had a later delivery date and were later sent appropriately.

5.2 Reverse flow

Labels could also be returned to BEAB for many reasons. It was estimated that each week one order was returned to BEAB and that three orders out of 100 had problems that lead to their return. (Returning was not always due to a defect in production. It could also occur from an error in ordering or designing). Some returns were due to problems in production, material or color mismatching. Most of the returns were from new orders. Even though customers had to confirm the order proof, when they received the labels, they sometimes complain about the direction of the labels or their colors and return them back to BEAB.

Some of the more prevalent reasons for returns are:

- Inappropriate direction of labels for printers
- Wrong core diameter of labels’ rolls
• Mismatches between label specifications and what they should be according to the order map

• Self-adhesive labels stuck to the other side of the rolls. This resulted in problems when printing. This was usually the result of poor self-adhesive quality.

• The color was not what the customer expected

In all those cases, customers were asked to return the labels by FedEx. A form was filled in to describe different reasons for the return. This information was used as a guide for production afterwards. It meant that if the material was of low quality or inappropriate, BEAB would not use that kind of material any further. Sometimes customers were extremely critical about the exact color that they ordered. Although BEAB and its customers use the same color guide, same colors have been known to look differently on different materials. This has caused some problems and resulted in returned labels that have no further value or use. The Staff at BEAB would then check the labels and decide whether to reprint the labels, fix the problem or send back the money to customer. The decision was made by the material planner and could include the help of the production manager. When the problem was the print direction, BEAB could often fix the problem, but this would cost extra for the customer. The wrong core diameter also fixed easily by changing the core.

5.3 WASTE

According to a survey made in 2002, the masking of 1000 labels resulted in about 0.185 kilos of waste material. Waste was categorized into several different types. Some waste was recyclable like papers and were separated and recycled. Other waste was transferred to be burnt. Usually raw materials were purchased according to a specific quantity to qualify a high volume order. These materials were often used for low volume orders as well and produced significant amount of waste because of cutting to a less dimension. There were no restricted policies in BEAB to reduce the amount of waste. All the rules and regulations regarding separation and recycle of waste are observed at BEAB.
5.4 Photos from production site

Figure 2: Press Machine

Figure 3: WIP between press and converter
Figure 4: Press machine

Figure 5: Waste
6 Analysis

6.1 Value Stream Mapping

VSM is a tool to visualize both information and material flows. It pictures all steps from the time an order is released until the time when labels are ready to be shipped. VSM contains all lead times and value adding time. The purpose of mapping is to find an area of waste and then focus on that area to eliminate it, if possible.

To create a VSM for BEAB, some orders were followed from the ordering point to their delivery point. Different steps, as well as the duration for each step, were carefully observed and recorded as part of the current state map.

Two random orders were selected from the ordering department. One was a new order and the other was a repeated order. The steps were combined so that all of the orders and processes could be observed on one map. It was more practicable and useful when all the steps were presented on one map instead of two maps. In this way everyone could follow the steps and their duration for each order.

The repeated order was received at BEAB on 13 April with a due date of 23 April. The label was for one color and required 5400 labels. During the production, the press machine availability was 84% and for the converter availability was 72%. The M2 press machine was assigned to handle this order. According to the statistics in 2006, it took 0.0015 of a minute to produce one label (Takt time). The production carried out on 18 April, were converted the same day. They were then shipped the next day before noon.

One of the most time consuming processes was the press change over. Therefore the different steps involved in the change-over process were carefully observed and recorded as follows:

1. Remove dies, cylinders and color buckets
2. Separate stereo coverings from cylinders
3. Rinse dies, cylinders and buckets
4. Attach adhesive role around the cylinder
5. Stick the stereo covering to the cylinder
6. Dry cylinders, splashguards and buckets and put them back to their proper locations

7. Prepare paints, and add water if needed, in the plastic bucket

8. Transfer raw material from the warehouse to the press machines and insert the rolls into their correct locations

9. Turn on the machine so that the material rolls once

10. Set the cylinders, with stereo coverings, back to their position

11. Pour the paint into buckets for each cylinder and check the labels to see if the colors match

12. If the color is not similar with the sample’s color, adjust the color by adding either water or more paint

13. Repeat step 11 and 12 for each stereo covering (for each color)

14. Put the dies to their locations.

6.1.1 Current state map

Figure 2 below, shows the current state map. This map includes all timings such as the setup time, cycle time and wait time. It indicates different processes and the links between them. It illustrates information flows as well as material flows. The inventory between each process is also depicted.
The production lead time was 4.37 days with a total lead time of 7 days for this particular order. The cycle time for the assigned press machine was 15 minutes and 6 minutes for the convertor. The wait time before the press machine was 3 days, which was evident that the press machine was the most important bottleneck of all the processes.

It is also obvious, from the above map that passing through the ordering department is an unnecessary step for new orders. This can been seen as a waste of time and creates no value to the order. With this said, new orders require a short cut.
7 Recommendations

In this section different recommendations concerning reducing waste and shortening lead times are discussed. These recommendations are based on lean principles, as elaborated on in the “Toyota way”. Each recommendation’s section will first briefly describe the problem, followed by some possible solutions for improvement.

7.1 Reduction of change over time

From the analysis section, it was apparent that the pressing machines were the most significant bottleneck. The production was impeded before the press by two to three days. There was a significant amount of work backlogged in front of each press machine. To reduce this wait time, the solution should focus on reducing the press change-over time. To accomplish this, two personnel would be required to work on each machine during the change-over process instead of one person. One person could do the preparation for the next order and the other could clean and wash the cylinders and stereo coverings from previous order and take them back to their storage locations, simultaneously. Since six different press machines exist at BEAB, one operator could work between the machines and help the other machine operators during their setup process. This would mean that there would be no additional requirement to recruit and hire another operator.

If two operators work on each machine during the setup process, the press would no longer be a bottleneck and the work queue in front of the press machines would be reduced, significantly. This would mean a much less wait time and a quicker response to meet the customers’ needs.

7.2 Implementing 5S methodology

To conduct a rapid change over, all fixtures and component varieties should be kept near to the operator so the operator does not require additional time to locate the needed components or fixtures, thus minimizing waste. The 5S methodology is an appropriate methodology to apply here to assist in organizing the work place. Essentially, the idea behind the 5S methodology was: by assigning everything a location, time is not wasted by looking for things. The 5S methodology, according to Peterson, was (Peterson 1998):

- Separating: this means to separate the useful tools, materials, etc, from nonessential items and keep only the essentials. The nonessential tools should be kept in separate area or discarded.
• Sorting: means arranging tools and equipment in an order that promotes workflow. Tools and equipment should be kept where they are needed and the process should be arranged in an order that eliminates extra motion.

• Shine: indicates the need to keep everything clean and neat. Cleaning must be part of the operators’ activity after each and every shift. Everything must be restored to its original places.

• Standardizing: this means operating in a consistent and standardized manner. This will help everyone to know his or her responsibilities.

• Sustaining: once all of the above 4S’s mentioned above are have been accomplished, it is necessary to stick to them and not allowing decline back to the old ways of doing things.

At BEAB there are some rules and regulations regarding cleanliness. Although, if BEAB implements the 5S methodology and rearranges all components and equipment appropriately to reduce change-over time, the entire production process will be more efficient and less time consuming.

7.3 Reduction of work in process (WIP) and wait time between the press and converter

After the press process, label rolls had to wait approximately an hour to one day before being converted. The basic philosophy was that the next order to be converted was the one with the closest delivery date. At that point the labels were ready to be packed and shipped. The converting by itself was not a time consuming task but the wait time between the press and converter could be significant. This produced a rather large WIP in front of the converter. Another problem was that both the press and the converter produced some waste, such that the total waste was usually quite significant proportionally when considering small orders.

In order to reduce the WIP inventory and the wait time between two processes, a special kind of converter could be used. It is attachable to the press machine, so that the two processes are combined into one process. The key point in lean production was to reduce the number of processes thereby reducing the wait time and WIP. The attachable converter has a setup time of about an hour. One of these attachable converters is already being used by BEAB, but to increase the efficiency and reduce the lead time, two more were required. Since these converters had a long set up time, it would be more reasonable
and appropriate to use them for high volume orders. For low volume orders, the old converter would be best used. The amount of waste in the new process would be less than the total amount of waste produced by each process. The merging of the two processes would create a one piece flow. In this way excess inventory and excess movement would be removed.

7.4 Stop the process to build in quality

Like many other companies, operators at BEAB did not stop the process to fix problems. They tried to fix the problem while machine was still running. This created large amounts of scrap and increased the process time. In order to reduce the amount of scrap, autonomation could be used. Autonomation is one of the TPS principles, which means: “stop a production line any time a problem occurs” (Liker, 2004). Operators at BEAB need to stop the machine and fix the problem, instead of repairing the problem while the press is still running.

One important principle of TPS was to built in quality. This meant that defects should be detected when they occur and production should automatically be stopped so that an employee can fix the problem before the defect continues downstream. In-station quality (preventing problems from being passed down the line) was a much more effective and less costly process than inspecting and repairing quality problems. Solving a quality problem at the source saves money and time. At BEAB, when a problem occurs, operators need to stop the machines, look for the cause or causes of the problem and take appropriate actions. After that, they should continue with production.

7.5 The new orders should arrive at pre-press

All orders were first received by the ordering department. The orders would then remain there for a short time until they were picked-up by order handlers. If there were new orders, they would be transferred to the pre-press department. The new orders were then kept in the pre-press department until they were processed by the personnel at the pre-press. During this time, which was about one to two days, no value adding activities were accomplished.

To solve this problem, new orders must first be received by the pre-press department. Then necessary actions must be taken to prepare the new design or order the dies and cylinders. Afterwards the orders could be sent to the ordering department for registration. In this way, a significant amount of time would be saved and the wait time would categorically be decreased.
7.6 Collect and store information about performance:

Information was not kept, categorized or utilized in an appropriate way at BEAB. Information concerning lead time, real demand, returns, customer satisfaction were not available. Without sufficient information on how events occur, it was difficult to find solutions for improvement. There should be some measurements and parameters to determine the current performance in order to determine how to improve in future. It is so important to collect and save information that is essential to measuring a company’s performance. These information and statistics can be reviewed monthly and provide the basis for decisions for future improvements. The lack of information was a substantial issue during the writing of this thesis as well.

7.7 Improve relations with customers

To reduce the lead time, it was important to improve relations with customers. Manufacturing planning and control (MPC) activities depended on information availability and production lead time. To enhance MPC, it is important to have information concerning the demand in advance. This could have been feasible through improved customer relations. Some customers submitted orders annually with three or four deliveries per year. This would provide an opportunity for BEAB to process these orders during low demand times and then put them in stock. If all customers submitted their orders on an annual base, BEAB would be able to make a very detailed schedule and produce, as well as deliver, all orders on time.

7.8 Future state map

The future state map is shown below in Figure 3. It illustrates the different processes after implementing the aforementioned recommendations. The lead time would be reduced to approximately 4 days. The main reason for this reduction would be based on the change-over time reduction and the combining of the press and converter into a one machine process.
Figure 7: Future State Map at BEAB
8 Conclusion

The purpose of this master thesis was to provide some proposals for reducing lead time at BEAB. BEAB is a medium sized company that manufactures labels. Current production lead time at BEAB was eight days for repeated orders and ten days for new orders. In order to remain competitive in today’s market, BEAB needed to reduce their lead time. In this study all processes from receiving an order to the shipment of an order were mapped in a current state map. Some recommendations based on TPS were provided. The main goal was to find the waste areas and reduce them. Implementing the above changes would result in the creation of the future state map. The mapping method used in this study was VSM.

The recommendations based on the TPS were:

- Reduction of change-over time
- Implement the 5S methodology
- Reduction of work-in-process inventory (WIP) and wait time between the press and converter
- Stop the process to build in quality
- Collect and store information about performance
- Improve relations with customers

By implementing the above recommendations, the total lead time would be reduced from eight days to approximately six days. The production lead time would be reduced from 4.35 days to four days. The main difference between the current and future situations was the reduction of the change-over time. This was shown as a kaizen burst in the future state map. By reducing the press change-over, the press machines would no longer be considered a bottleneck. The other effective change would be to combine the press and converter. It would save time and reduce WIP inventory.

Most of the above recommendations for BEAB focus on becoming leaner. Those recommendations were primarily tools such as TPS. It must be remembered though that TPS is not only tool, it is a philosophy. To make continuous improvements feasible, all employees should understand the concept behind TPS. In the Toyota Way it is the people
who bring things in to reality, therefore it is important to remember the role of the peoples’ engagement in all of the above changes.
9 References


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