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O'Brien, Steven R. ***Value Stream Mapping in the Supply Chain***

Abstract

As an organization within a highly competitive commodity market, XYZ Company had an opportunity to improve a production line and reduce inventory needed for customer service. The objective of this research was to identify waste within the supply chain by using the value stream mapping tool within a product within XYZ Company. XYZ Company was in the beginning phases of their lean journey to creating a lean culture. The use of new lean tools and strategies to advance their operations towards a more streamline flow to reduce wastes. Value stream mapping allowed XYZ Company to visualize where opportunities were and reinforce the findings with objective data that allowed them to focus on certain areas of their supply chain.

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Chapter I: Introduction

In the national marketplace, manufacturing companies are in a never-ending cutthroat battle to find the highest quality product to be produced at the cheapest price with the quickest turnaround. They are always in the hunt for cheaper materials, advanced technologies, new strategies, and new products to dominate within their own market. Throughout their explorations, companies will overlook improving their current processes to find inadequacies and make the most of what is already there. This has led to adopting lean principles and strategies to improve current manufacturing processing. The United States started to consider quality as part of the customer equation within the last couple of decades (Chen et al., 2010). Lean is a relatively new concept and strategies for American companies. During the 1900's, when a person thought of the United States manufacturing industries, the phrase that best describes it is a quote from Henry Ford. He was reported to say that a customer can have any color they want as long as it is black. The processes are rigid and created room for international manufacturers that can offer flexibility with their products to compete. This brought about a need for the United States to remain competitive by adopting similar strategies from abroad.

The need for better manufacturing practices was needed within the United State because Japan was becoming a manufacturing leader and dominating the automotive market. This paved the way for Jeffrey Liker to write the book *The Toyota Way* (2004) to identify strategies that Japan were using to compete on the world stage. Researching why Toyota was a leader in car manufacturing and how to continuous improve your processes to remove waste. Throughout the book, the Toyota Production System process is dived into and discovering how lean was one of the main drivers.

XYZ Company, the name is not disclosed to protect confidential information, is a high-volume injection molding manufacturing company with different product families such as cups, containers, and lids. They are a commodity company that focuses on low cost goods at the quickest pace for their customer. This has led to scheduling product specifically for inventory that they are required to hold on hand in case customers need it. This has led to overstocking inventory, expiring inventory, and expediting orders for customers.

They are participating in SQF (Safe Quality Food) certification by the FDA (Food and Drug Administration). XYZ Company is still in the beginning stages of their lean journey and are looking to implement lean tools within their facilities to identify muda and deliver a product faster to the customer. With limited space and demand from customers rising, the processes are in desperate need of reduction in any waste possible. With high demand, there is also a large amount of competition within this sector of the industry and keeping customers happy is of the utmost importance. Using lean tools to pass savings onto the customer will improve customer satisfaction and retention of high valued customers.

A tool was needed to visualize their processes from start to finish and evaluate the seven deadly wastes associated with lean management. A lean tool for creating visibility of all current processes is value stream mapping. This tool would take the processes associated with particular product or system a company needs and create a visual. Taking a value-stream perspective means working on the big picture, not just individual processes, an improving the whole, not just optimizing the parts (Rother & Shook, 2009). With added visibility of information and operations, a company can identify problems and find the root causes of delays. XYZ Company fight delays and waiting issues on a daily basis. With a value stream map of a product can

created an unobstructed vision of the current state and then move to create a future state that is desired.

With a proper current state value stream map then an analysis of return on investment could be assessed to understand where the best investment could be made to improve XYZ Company's processes. A proper value stream map would identify where the focus of resources should go to cut down on lead-time of products for customers and in the beginning identify low cost/high potential projects.

Statement of the Problem

XYZ Company had high levels of inventory within product lines due to lack of lean processes. With warehouse utilization levels at 95% and little room to spare, a tool was need to identify where waste was occurring within the supply chain. This allowed for improved scheduling that decreased the lead-time to the customer and in turn lowered the safety stock needed on hand for customer service. After using a value stream map to identified waste, management was able to pursue potential high return, low risk projects for the future.

Purpose of the Study

The research work was focused on compiling all of the best ideas and research currently available for the control of a product within XYZ Company. This research presented the supply chain of a product in the form of a value stream map to identify value added processes and waste. This project influenced the supply chain by identifying one product within XYZ Company to reduce the muda and increase the return on investment. Upon confirmation that value stream mapping would increase the return on investment that helped gain support for future projects.

Since XYZ Company was still in beginning stages of becoming a lean company, it became apparent that XYZ Company and their management needed to understand how to create a value stream map and used trained employees to target waste within their facility. This has future implications toward winning over employees' confidence of adopting lean principles, strategies, and tools for increased productivity for the company and experience of the employees. Once confirmation of increased return on investment helped gain support for future projects. Resources are needed to start and maintain new value stream projects. With evidence to show how impactful value stream mapping will push for additional continuous improvement projects to be created.

Assumptions of the Study

The assumption of this study was that XYZ production systems remained constant throughout this value stream-mapping project. There was no new investments in the system that affected the outcomes of this project. XYZ Company's processes will not be questioned during the value stream mapping. The focus of this study will create a current state value map and make suggestions on the characteristics of a future state map. The view of the processes for this research will be indifferent and neutral. The project strictly for creating the current state and make suggestions for the future state map. New lean projects were created as a result of the this research and those projects will not be reported in this research. The project was only within one of the facilities under XYZ Company. The product family manufacturing processes are specific to this one XYZ Company plant.

Definition of Terms

The following terms were defined for use in this research to provide clarity.

Bottleneck. This is the slowest operation in the production cycle, which dictates the speed of the flow of product through a facility (Rother & Harris, 2001).

Cycle time. This is how frequently a finished unit actually comes off the end of your pacemaker cell (Rother & Harris, 2001).

Inventory turnover. A ratio used to indicate the number of times a company's average inventory is sold during an accounting period (New York Society, 2018).

Kaizen events. When a problem is identified the need to reduce or eliminate muda is at hand. This event takes place to bring cross-functional personnel together along with personnel trained in lean methodology to find solutions to the problem to improve the current manufacturing system (Chen et al., 2010).

Kanban. A Japanese manufacturing system in which the supply of components is regulated through the use of an instruction card sent along the production line (Chiarini, 2013).

Kitting. Is a set of parts that are collected into one container or presentation device (Harris, Harris, Wilson, & Rother, 2003).

Lean. Lean Manufacturing is a manufacturing philosophy that shortens the time between the customer order and the product build/shipment by eliminating sources of waste (Earley, 2016).

Muda. The Japanese word for waste referring to the seven deadly wastes: Overproduction, waiting, transportation, over processing, inventory, motion and defects (Chen et al., 2010)

Pacemaker. This is a segment of the value stream, where products take their final form for you external customer (Rother & Harris, 2001).

Return on investment (ROI). Ratio measure of the profits achieved by a firm through its basic operations. An indicator of management's general effectiveness and efficiency. The simplest version is the ratio of net income to total assets (New York Society, 2018).

Supply chain. The sequence of processes involved in the production and distribution of a commodity (Rother & Harris, 2001).

Takt time. Is a reference number that is used to help match the rate of production in a pacemaker process to the rate of sales (Rother & Shook, 2009).

Toyota production system (TPS). TPS is a manufacturing phenomenon that seeks to maximize the work effort of a company's number one resource, the People. Lean is therefore a way of thinking to adapt to change, eliminate waste, and continuously improve (Earley, 2016).

Value stream. This is all the actions both value creating and nonvalue creating actions currently required to bring a product through the main flows essential to every product.

Value stream mapping (VSM). This is a tool that follows a product's production path from customer to supplier, and carefully draw a visual representation of every process in the material and information flow (Rother & Shook, 2009).

Limitations of the Study

This study was limited to costs associated with purchasing resources and extra labor. The amount of resources associated with this project were limited with expenses and labor. The primary cost savings were the reductions in muda and increases in efficiency as they correlated to reduced cycle times, people, and material. This researched was focused on the overall processes and big picture of a product family process associated with the supply chain.

Methodology

Case studies were used to analyze and comprehend strategies for incorporating value stream mapping of a product system. Adopting strategies taken from these case studies to identifying waste, non-value added work, and value added work. The material research that was gathered helped create the process steps that found the similar operations that each product had. Information was also gathered for the reference for management to use for future projects and teach employees these strategies. The product process steps visually showed the operations and processes that allowed XYZ Company to schedule and manufacture products. This allowed for the evaluation of time, labor, and movement to calculate cost and create projects that eliminate waste in order to create better value for the customer and manufacturer.

After completing the product process step for the containers of XYZ Company then the value stream mapping of a product family began. The time gathered for each operation throughout the supply chain for each container allowed for a critical path step by step of the production. Each of these processes were shown visually on value stream map with a data box that demonstrated elements associated with the process in the form of time, uptime, shifts, or any variable that resulted in process time. After analyzing the value stream, the muda of wasted time and movement throughout the facility was identified and future projects were presented to management for their evaluation and future course for new projects.

Summary

XYZ Company developed methods for inducing change into the supply chain from the implementation of the value stream mapping tool. A metric was needed to evaluate the return on investment projects that were implement through the supply chain. The project cannot be

assigned without an understanding of current processes and business transactions. Chapter II is a literature review to understand the types of source documents needed to conduct this research.

Chapter II: Literature Review

XYZ Company had high levels of inventory. Overproduction led to warehouse capacity reaching 95% and higher operating costs due to the high levels of inventory. Using a value stream map for a product family to identify waste within the supply chain to create shorter lead times and reduce on hand inventory levels needed to satisfy customer orders.

This literature review focused on the use of value stream mapping and lean methodologies intended to identify and reduce waste within XYZ Company's product supply chain. After studying research, articles, and books relating to lean strategies about value stream mapping, this paper includes an analysis of value stream mapping and root cause analysis tools used to identify waste within the flow of production.

Value Stream Mapping Purpose

Value stream mapping identifies opportunities to eliminate waste, increase value added, and improve flow of the main stream supply chain (Chiarini, 2013). This tool needs to be applied within a top-down, bottom up strategic frame with goals and performance indicators. Value stream mapping is the first and most important managing method used to identify what needs to be changed when striving to apply Lean and can be divided into current state and future state value stream maps (Chiarini, 2013). Analyzing value stream maps with key performance indicators that are being targeted defines the Kaizen events that need to be launched, together with other long-term improvement programs that should be applied, such as Six Sigma.

Value stream mapping helps a company visualize more than just the single process level, for example assembly and welding, in production. This visual allows any employee to see the flow of the product through production. It is much more useful than quantitative tools and layout diagrams that produce a tally of nonvalue creating steps, lead time, distance traveled, and the

amount of inventory (Rother & Shook, 2009). This is a qualitative tool by which you describe in detail how a facility should operate in order to create flow.

Value Stream Mapping within Industries

Value stream mapping can be used as communication tool, a business planning tool, and a tool to manage a change process. Value stream mapping is not just concentrated within the manufacturing industries but can be used in a process that is adding value to a product or service (Liker, 2004). Between 1950 and 1970, Toyota developed and incorporated value stream mapping into its operations with the help of Taiichi Ohno (Chen et al., 2010). The value stream map became a very useful tool as part of the successful Toyota Production System process.

The organizational structure of most enterprises is built on the traditional growth model of mass production, mass consumption, and mass waste. With the emergence of resources and energy constraint, mass production mode has been malapropos; furthermore, lean production put forward in the early 1990s, have demonstrated the disadvantages of mass production mode form the perspective of competitive advantage (Xinyu & Jian, 2009).

Value stream mapping is all about mapping the process form the point of view of delivery of value to the customer (Earley, 2016). There are two types of value stream mapping: a current state and a future state. Current state value stream map consists of all the materials and information required in the manufacturing of a particular product and how they flow through the manufacturing system (Chen et al., 2010). The future state map is where the current system is trying to reach. The goal of a future state map is to build a chain of production where the individual processes are linked to their customers by either flow or pull, and each process gets as close as possible to producing only what its customers need when they need it (Rother & Shook,

2009). Figure 1 offers a visual sample of a value stream that incorporates the process flow, the data boxes, information flow, and timeline.

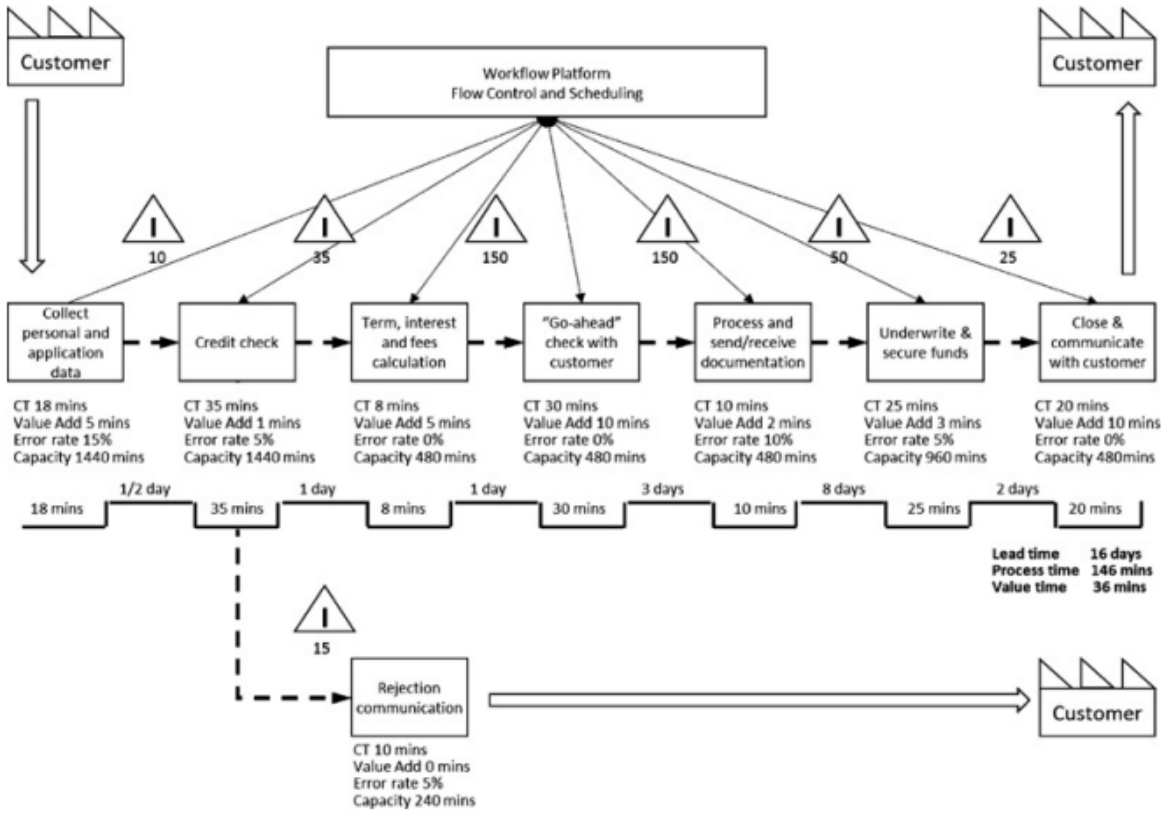

Figure 1. Example of value stream map. Note. Reproduced from The Lean Book of Lean p. 151 Earley, J.A. (2016).

Identification of Work

Any task in a manufacturing facility can be classified into one of three categories: incidental work, value added work, and muda (Chen et al., 2010). Incidental work is processes, such as inspection, that do not add value to the product, but are required in the current production system. Value added processes add value to the product, such as the final assembly of a product or any process the customer is will to pay for (Chen et al., 2010). Finally, non-value-added

processes, or muda, are defined as any process that does not add value to the product is not required by the current production system.

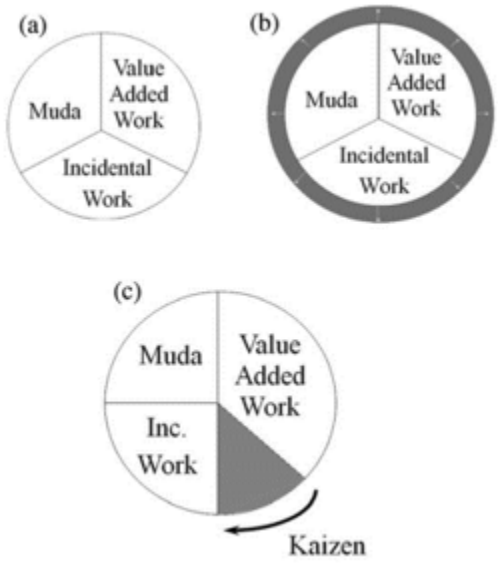

Figure 2. Impact of Kaizen events on waste. *Note.* Reproduced from International Journal of Production Research, p. 1071 by Chen et al., 2010.

Figure 2 provides an example of how the goal Kaizen events are focused on reducing incidental work or muda to only have value added work to a process. The three separate pie charts in Figure 2 describes: (a) Composition of worker's time. (b) Effect of hours increase on composition. (c) Effect of kaizen on composition.

Seven Deadly Wastes

Muda can be classified into seven categories, which are also known as the seven-deadly waste. These seven deadly wastes include overproduction, waiting, transportation, over processing, inventory, motion, and defects (Chen et al., 2010). Too much muda within any process can be detrimental to the organization. Kaizen events are created in an attempt to eliminate muda and incidental work within processes. It is very important to identify and

separate muda from incidental and value added work when identifying each step within the system (George et al., 2005).

Because lean methods are much more efficient, the first conversion problem emerges immediately: fewer employees are needed to get the same number of products to customers. Management has two fundamental choices at this point: lay off workers or find new work by speeding up product development to find new markets (Womack, 1996).

Overproduction Waste

Overproduction is the biggest problem our manufacturing and service industries have to fight: overproducing means, quite simply, producing an amount of products that exceeds the demand too soon or too fast (Chiarini, 2013). Overproduction is the worst kind of waste because it causes other wastes and obscures the need for improvement (Womack & Jones, 2010). Overproduction causes batch sizes, unreliable processes, unstable schedules, unbalanced cells or departments, and working to forecast/inaccurate information that is not actual demand. Overproducing inventory causes you to tie up capital in stock, raw materials, work in progress and finished goods (Liker, 2015). Another cost associated with the waste of overproduction is to do with storage and movement of the inventory that is created, it all requires space (Bicheno & Holweg, 2009).

Takt Time

Takt is a German word for rhythm or meter. Takt is the customer rate of demand-the rate at which the customer is buying product (Liker, 2004). Within manufacturing and service industries, there needs to be an accurate takt time created to meet the customer's needs. Departments need to meet this standard takt time. If any of the departments are off of their takt time, whether it is slower or faster, can cause inventory to land at different position within the

supply chain and start stacking up creating a bottleneck (Liker, 2004). Takt time is calculated by dividing the customer demand rate per day in units into your available working time per day in seconds (Rother & Shook, 2009).

Return on Investment

Return on investment is measured by dividing net operating income by average operating assets, which provide a return on investment figure that is understandable to most executives (Garrision, Noreen, & Brewer 2012). Figure 3 provides a visual of how to calculate if a return on investment is positive or negative.

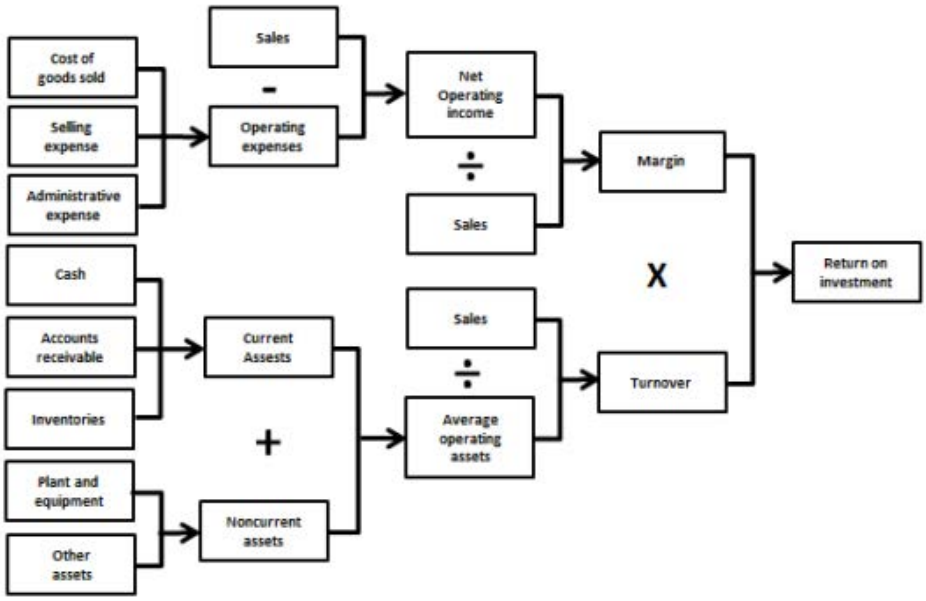

Figure 3. Elements of return on investments. *Note.* Reproduced from Managerial Accounting p. 524, by R. H. Garrison, E. W. Noreen, & P.C. Brewer, 2012, New York: McGraw Hill/Irwin.

Focusing on return on investment as an indicator is common metric. This metric is used, by management, to guide their decision on areas to invest into. Value stream mapping helps to reduce costs and has a positive correlation to return on investment of resources. The cost of

performing value stream mapping needs to be balance with the efficiencies provided and resources used to solve problems.

Root Cause Analysis

There are multiple methods for identifying the root cause analysis. These methods are systematic processes for identifying the root causes of problems or events.

The 5 Whys. The 5 Whys is a basic technique used to push employees to think about a potential cause down to the root level (George et al., 2005). By asking why as many times as it takes to finally drill down to the real root cause of why a particular waste happens.

Fishbone diagram. This is a cause and effect diagram or the Ishikawa diagram, this is a format that helps you arrange and organize many potential causes (George et al., 2005). Fishbone diagram were created by Dr. Kaoru Ishikawa, a Japanese quality control expert, to help employees avoid solutions that merely address the symptom of a much bigger problem. Figure 4 is a visual of a fishbone diagram and how to identify causes of waste, then use the 5 Whys method to break down these causes until the root cause is found.

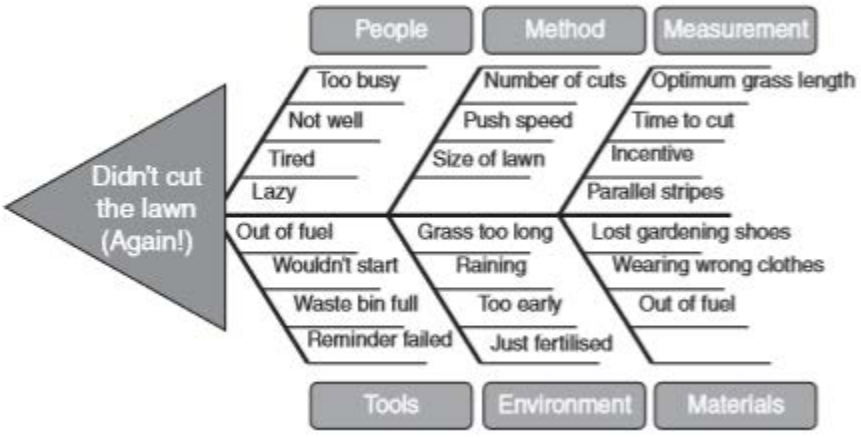

Figure 4. Example of a Fishbone Diagram or Ishikawa Diagram. *Note.* Reproduced from The Lean Book of Lean p.155 by Earley, J.A. (2016).

Summary

Having the ability to effectively identify waste within the production process by the use of current state value stream mapping allows any company to build a future state map that adds value to end user. Building a proper current state value stream map creates a strong starting point in building a culture focusing on continuous improvement and provide the end user with added value. Value stream mapping provides value to the customer, whether they are internal or external, by showing where waste is occurring by providing a visual on what is really going on within their supply chain.

The next step was to provide methodology for the process and disseminate information about value stream mapping to the management team. Chapter III is the methodology section which explains how value stream mapping was applied to provide a visualizing process and assessment of XYZ Company. The problem stated in this report was a beneficial use of value stream mapping in the supply chain for XYZ. The muda identify by the tools explain in the literature review shone a light on otherwise overlooked opportunities. The value stream mapping project guided the implementation and promotion of value stream mapping in the supply chain.

Chapter III: Methodology

XYZ Company was challenged with the ongoing effects of high inventory levels within the manufacturing facility's warehouse. The ideology that created this issue was having the best response to customer needs. While having the best response to customer demand is essential for this business market there were flaws within scheduling due to lack of lean processes. With this ideology, XYZ Company was burdened with overproduction leading to expired or obsolete inventory and higher processing costs by having excess inventory on hand. A need to eliminate waste within the production process was needed to have a lower lead time to the customer to help alleviate scheduling long production runs.

The methods used in this study measured the current state of the supply chain within the walls of the facility. The data that was gathered through time studies and review of current processes to develop a current state value stream map. The current state value stream map identified areas of the value stream with a high level of waste. Using this information to develop a future strategy to reduce waste within the overall process to increase return on investment in the form of material and labor savings.

Subject Selection and Description

The basis of this study was to focus on the values stream map of a plastic container manufacturing line and processes that are included within this supply chain. The value stream map will strictly incorporate the process within the facility and not include the process of acquiring raw materials and delivery to the customer. The steps in the manufacturing process were standardized throughout the process to identify the average time that is needed to bring the containers to a completed finished good that is ready to fulfill safety stock or a customer order.

Identification of process steps through the manufacturing process were gathered by walking the manufacturing process from beginning to end.

Define the Boundaries

Define the boundary of what value stream that is being focused on. For this project, the boundary of this project was within the production floor to the warehouse. Staying within the boundaries of the project was done to not creep to different areas of the facility. Identifying activities that are related to the process will keep the project focus on one process and not allow for time-consuming distractions.

Walk the Process

Identifying the process steps through the plant provided an understanding where to begin gathering data for the value stream map. When walking through process from start to finish within the current state of the manufacturing process showed the various operations where work is added. Identifying the main production steps to create containers for customers. Process boxes are drawn about each process and when material flown to next process push or pull arrow is used to depict, shown in Figure 5. This helped to visualize a push and pull system to find the value added work and non-value added work that is being done.

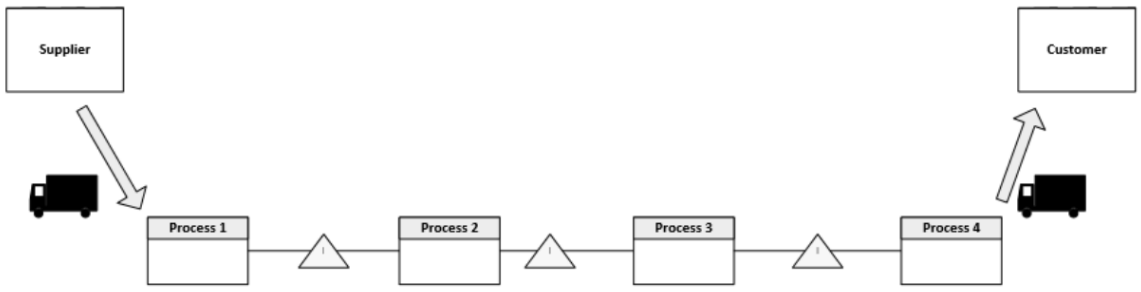

Figure 5. Example of process steps.

Process Data Sheet

A data collection sheet was created for recording process factors of each step in the production run, shown in Table 1. Table 1 records the cycle time, setup time, uptime, and scrap rate. The data sheet was used to gather necessary information to create a standard for the process boxes on the value stream map.

Table 1

Example of Daily Process Data Sheet

Process	Cycle Time	Setup Time	Scrap	Uptime
Mold Change	##	##	##	##
Robot Setup	##	##	##	##
Startup Mold	##	##	##	##
Validation	##	##	##	##
Production Run	##	##	##	##
Pack and Inspect	##	##	##	##

Using process boxes to document the data gathered for setup time, cycle time, amount of scrap, and uptime from the machine, shown in Figure 6. This box created a visual for how much time it took to complete each step of the manufacturing process.

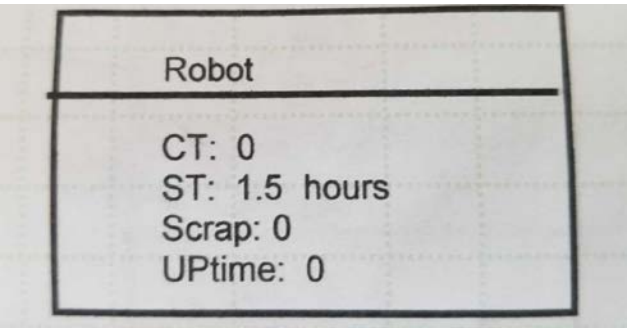

Figure 6. Example of a process box.

This visual incorporated the applicable measurable factors that were used for identifying waste within the value stream.

Timeline

This stage documented processing and lead time of the entire process. This is used to analyze the date and identifying the waste. Shown in Figure 7, the top line measures the process time, sometimes called lead time or reduction lead time in manufacturing settings. This time is based on the entire demand by the customer in the value stream that needed to be completed. The lower line is cycle time which is the sub process time for each process. These times were added at the end of the line to get total process lead time and total cycle time.

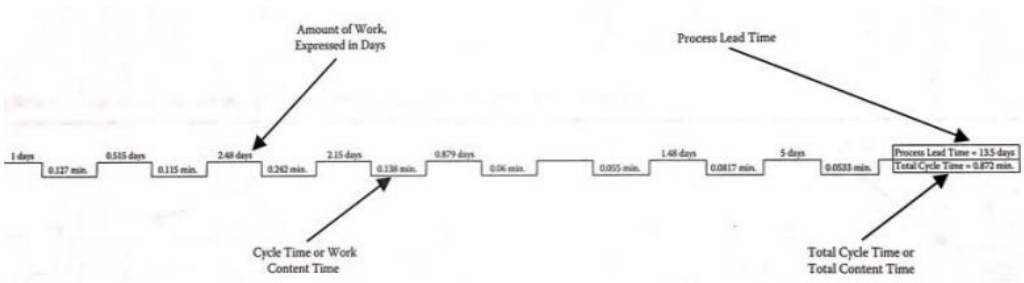

Figure 7. Example of the timeline on a value stream map.

Create a Current State Map

All applicable data was recorded and analyzed in order to create the current state value stream map using process boxes where steps in production provided value added or non-value-added work to the overall process. Using a current state value stream map to identify the current production situation, shown in Figure 8. This was meant to identifying movement of material and information flows throughout the system. The value stream map also allowed for employees to have a visual about where information was gathered. Once an overall flow through the plant

was completed additional projects were created using the current state values stream map in order to reach the goals set by the future state value stream map.

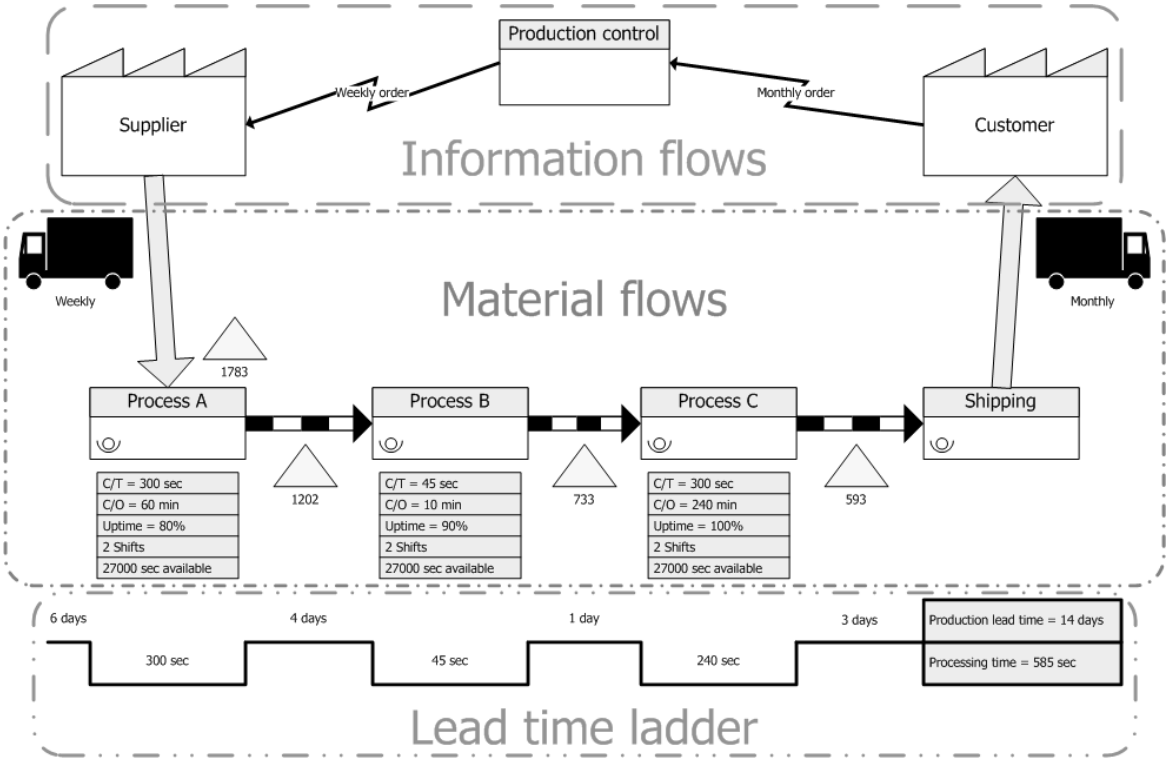

Figure 8. Example of a value stream map.

Future State Map

After the value stream map was completed for the current state of the facility then work on the future state map began. The purpose of value stream mapping is to highlight sources of waste and eliminate them. When creating a future state value stream map needs to be goals that can become a reality within a short period of time. The goal was to build a chain of production where the individual processes are linked to their customer's either by continuous flow or pull, and each process gets as close as possible to producing only what its customers' needs when they need it. This would reach the goal by cutting the non-value-added work and increase the percentage of value added work. The current state identified what was the main contributors to non-value added work and new project could proceed to reduce largest contributors.

Data Collection Procedures

Collection of data consisted of recording time for each process step within the value stream map for the current production system. Time studies were done over a production run of containers. This production run lasted a week and gathered the average times and data for the process steps during the run. Times were manually gathered and visually watching production of the containers. Since the molds were multiple cavity machines, the times needed to be divided by the amount of inventory produced.

The data gathered was entered into the data sheet then converted to a current state value stream map draft. The current state value stream map draft was originally sketched with pencil to create the current state value stream map. The final version of the current and future state value stream maps was created via a flowchart computer program for aesthetic reasons.

Data Analysis

Data analysis began by reviewing the measured information to transform into a visual form that was displayed by the value stream map. Once waste within the processes were identified and reviewed, the unneeded processes were developed into possible actions. These actions were analyzed to find their impacts on the return on investment by calculating the current and proposed future state process.

Bar graphs were used for visual comparison for each process within the current and future state value stream map. This method gave more of a visual of value and non-value added work was being done within the system. Further analysis of pie charts created a cost savings for labor, waste, and return on investment.

Return on investment was needed to be calculated to determine the beneficial action in reducing the amount of waste within the production run. Reducing certain employee interaction

within the system would reduce the costs associated with the manufacturing. Shorter setup times would decrease downtime and increase the uptime with less labor expense. This calculation was concluded by gathering technician's average hourly pay, downtime costs, and uptime revenue creation.

Limitations

With a limited amount of labor to track the processes within XYZ Company, the amount of data gathering was restricted to available time outside of the daily job responsibilities. With limited time for recording the averages, an average was gathered but more recorded data would aid in a better reflection of waste within the processes.

This is some of the first value stream maps done for XYZ Company. Additional training needs to occur to expand knowledge for the identification of waste within the value stream. Additional coaching will allow for easier identification of waste and empowerment of employees to speak up when an inefficiency is present within the supply chain.

Summary

This chapter covered the methods that were used to create value stream map for product line within XYZ Company's facility. A value stream map was created to visualize the production line to determine value added and non-value added steps within the process. Visualizing the process allowed for recognition of wastes that are overlooked.

Define the boundary of the value stream map and the values being recorded was the initial step. Creating where the process occurs and what values will be recorded to identify waste in the system. These values were used to form a data collection table to measure process steps. The data was collected by walking the process from start to finish, identifying tasks where materials and information flowed. The process data was used to create the current state value

stream map where the conditions of the current state identified the value added and non-value added activities. This step led to reconfigure the process to eliminate waste and maximize value to visual the ideal state. Transferring the ideal state to a new map called the future state value stream map that visually showed what XYZ Company is trying to reach in the near future.

After the analyzed data created the current and future state value stream map, financial aspects were generated with associated costs to expenses and revenue creation. Through this method, new projects were identified to reduce the larger wastes within the production line highlighting the return on investment that would benefit the company and employees. Chapter 4 provides how the projects results identified value added and non-value added activities that resulted in overproduction of inventory within XYZ Company.

Chapter IV: Results

The study focused on analyzing an existing production line for manufacturing plastic containers. It was determined that the value stream would reduce waste and increase efficiency for production with minimal investment to lower the utilization of the warehouse. In the current state, a value stream map was drawn to provide a visual on the production line for value and non-value added processes. Time studies on uptime, setup, cycle times, and scrap rate were recorded by daily process data sheets to provide a standard for the value stream. The results from the gathering this data demonstrated that setup times could be reduced to provide an overall better lead-time to customers in turn reducing the amount of inventory needed for customer service.

This chapter reviewed the results of the value stream map, the process data, and analysis of processes in the production line.

Define the Boundaries

The boundaries of this study were defined as the production flow within the walls of facility. This is from the injection molding machine to before sending the finish good to the warehouse. The plastic resin is the main material involved in the process that is sent through a vacuum system to the feeders on top of the injection molding machine.

The plastics containers are a high-volume product for XYZ Company. From January 2017 to December 2017 the number of containers created were around 6.5 million. The production run created 84,494 containers. There were 6,719 scrap units equaling 1,576.25 scrap pounds. The final production units equaled 84,494 containers minus the scrap units for a final unit total of 77,775. Over the production run, 20,700 units were sold throughout the week from the warehouse. On average, the amount of inventory held within the warehouse was 81,000 containers.

Walk the Process

After the boundaries of the project were defined, the next step was to walk the value stream and identifying the processes included in the production run to fulfill this order to the customer. The main processes were broken down into five main steps. These steps were mold change, startup mold, setup validation, production run, and pack and inspect. The initial product changeover to the new containers would include mold change, startup mold, and setup validation. While the production run included pack and inspect which focused on the creation of the container, quality, and packaging of the plastic containers.

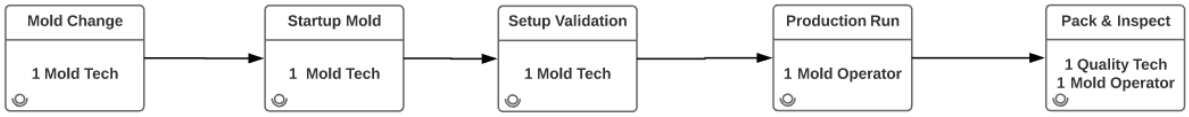

Figure 9. Process steps.

Creating a visual of the process that were recorded throughout walk the process is shown in Figure 9. These process steps were where the recorded data for the process data sheets was gathered. The first process in was to do a mold change by removing the current mold and installing the next scheduled mold. This task was completed by a mold technician and depending on the size of the mold can take multiple hours. For this observed case, the current practice of mold change took three hours to complete. In this step, a high volume of wasted motion was discovered through the mold technician moving back between the mold and the technician's portable toolbox. In addition to wasted motion, the tools were not properly organized and additional wasted motion and time was taken to find tools. Without a proper standardized method for mold changes led to this additional wasted motion. Upon completion of the mold change, the mold technician was required to input the standard settings for the mold, such as temperature, speed, pressure, stroke, shot volume, and time through mold startup. Once the

standard processing inputs were set, an additional waiting time for the hot runner system in the mold to reach processing heat, then the setup validation to ensure the product will be produced without defects taking 30 minutes to complete. The validation process step confirms that the inputs are correct and the machine does not need to be adjusted in the future. After the validation, then production is allowed to run per the schedule. For this semi-automatic operation, a single operator was allocated per shift to run the machine. As production was running, a quality technician was required to check the containers every two hours. For the majority of scrap unit found, the operator visually saw the defects immediately after being ejected from the mold. These defects would be contaminants within the product. The final process was to pack the containers into boxes. For this step, an inline machine that automatically stacks the containers, for the operator, was used thus removing wasted motion and time to stack the containers manually. The operator only had to remove the stacked containers and place them into boxes and tape them shut.

These processes had a high level of waste of motion between them and a simple lean method allowed for the reduction of time between product changeovers and increased efficiencies in the production run.

Process Data Sheet

The information that was recorded for the process data sheet was gathered over the production run. Table 2 shows the averages of each process step that was gathered for the current state. The averages of the production run were used to create a baseline standard for the current process.

Table 2

Average Daily Process Data Sheet

Process	Cycle Time (sec.)	Setup Time (min)	Scrap	Uptime (min)
Mold Change	0	180	0%	0
Startup Mold	0	90	11.5%	0
Setup Validation	0	30	0	100%
Production Run	8.8	0	7.98%	75%
Pack and Inspect	5.5	90	0%	75%

Timeline

The timeline for this production process is shown in Figure 10. Using the recorded averages from the process data sheet to demonstrate the amount of processing lead time and total cycle time. The timeline showed that the most amount of time needed to fulfill the sales order is in the production run. The mold used in this production run is a four-cavity mold. This means that the mold can create four containers per cycle.

Figure 10. Timeline of current process.

The bulk of the time required to complete an order for the customer demonstrated that having a higher uptime percentage would reduce the overall processing lead time, shown in Figure 10.

Create a Current State Map

Figure 11 represents the current state value stream map. The process steps recorded from observing the production run are represented in the value stream map. To identify operational

costs, the averages for the employee labor rates were gathered for this study. The averages of employees within the current value stream were mold technician received $15.00 for five hours, quality technicians received $16.00 for half an hour, and operators received $10.00 for 52.14 hours. Taking the theses labor rate standards to calculate $604.40 for this production run.

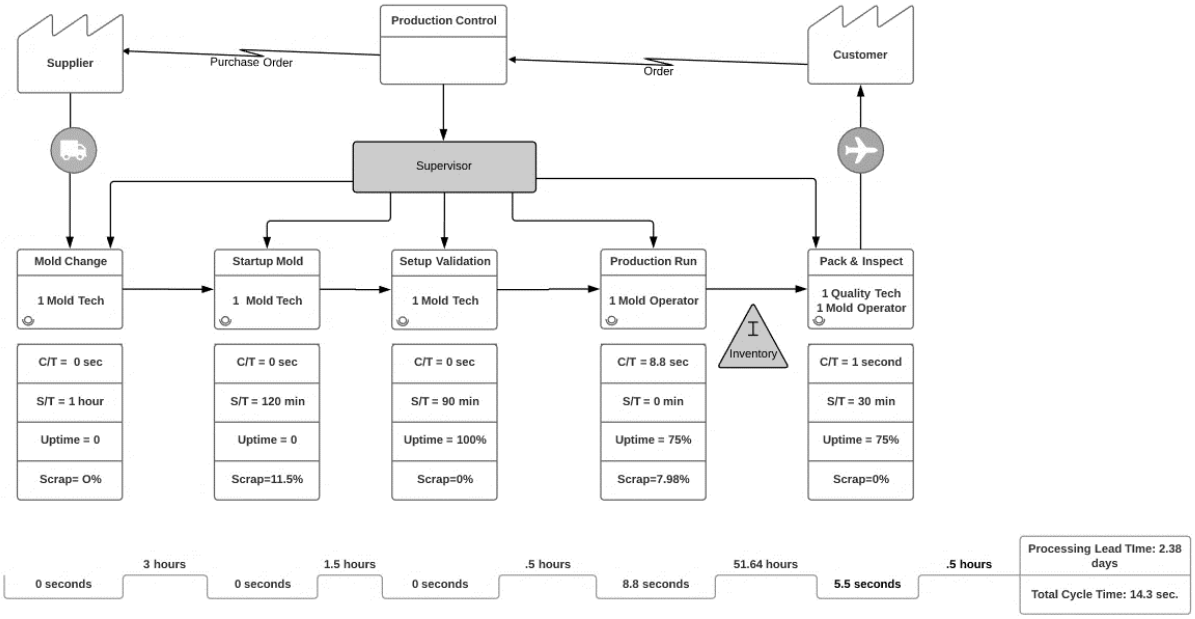

Figure 11. Current state value stream map.

The current state value stream map was used to create a goal for the future state value stream map that could be reached within a short amount of time. Within the current state value stream map, the main time-consuming activity was the production run. This process was where the most value added work was done. Creating any process improvements to increase the uptime of the machine and lower the operational cost.

Future State Map

Based on the observations from gathering process information, the major types of waste that were identified were of waiting and motion. The technician was observed waiting for the temperature to increase before proceeding into validation. While setting up the machine, a large

risk of the tool breaking from mold technician was possible. Without standardized work for molds, each technician potential could miss a critical step and delay production or damage the mold. Creating a certified startup procedure for molds based on machine would decrease the chance of breaking tools and molds. These factors were taken into account when the future state value stream map was created.

For the creation of the future state value stream map, the scope of this has to be within an obtainable goal. Making a goal that was seen as too aggressive would be detrimental to reaching where XYZ Company wanted to be. By setting a goal that was attainable in the near future will created confidence within employees that would continue toward additional continuous improvement opportunities. Table 3 contains the future performance goals for the production of containers within XYZ Company's manufacturing facility.

Table 3

Future Performance

Process	Cycle Time (sec.)	Setup Time (min)	Scrap	Uptime
Mold Change	0	150	0%	0
Startup Mold	0	60	11.5%	0
Setup Validation	0	30	0	100%
Production Run	8.8	0	3%	80%
Pack and Inspect	5.5	90	0%	80%

The goal for the future this value stream was to reduce the overall product changeover and improve processing efficiencies. The production run requires the largest amount of processing time required to fill a customer order. Keeping the molding machine running as much as possible was a goal that would reduce the processing lead time and the amount of downtime was

a major factor in waste within the production run. On the future state value stream map, a Kaizen burst was drawn to show where the improvement needed to occur to reach an improved state. Kaizen burst are drawn to highlight improvement needs and plan for future projects. The Kaizen burst occurred as improved product changeover, standardized mold setups, increased uptime, and reduced waste. Figure 12 is the future state values stream map that was used to created targeted goals for the near future. The reductions of product changeover, mold startup, efficiencies of the overall uptime, and reducing waste were set to be seen as obtainable improvements for this production run.

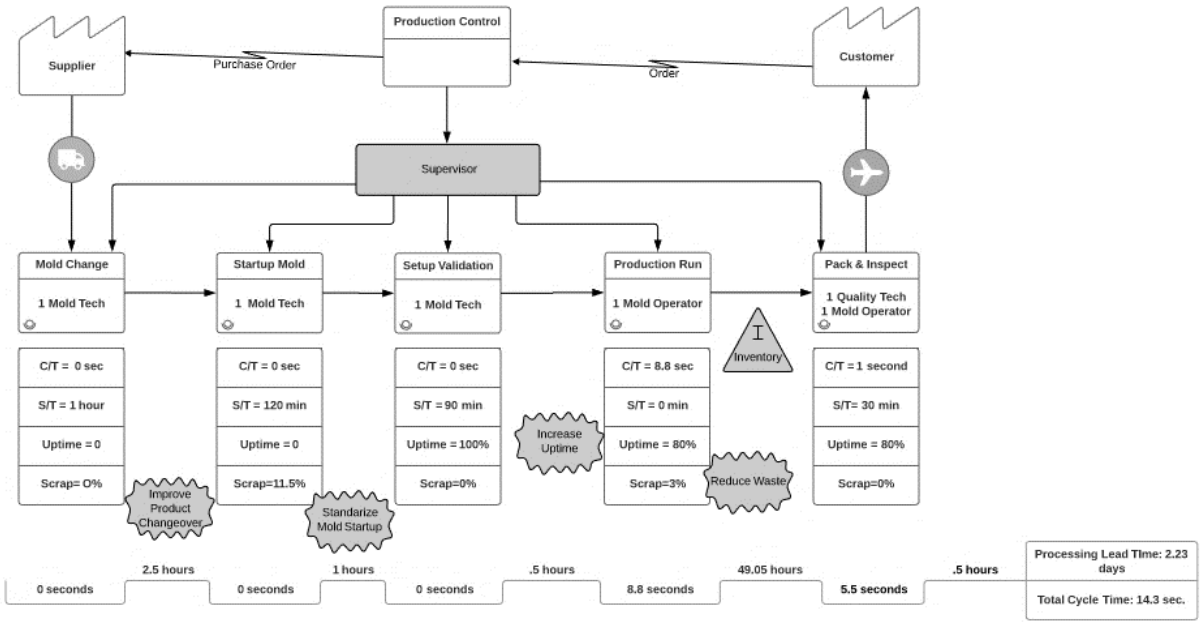

Figure 12. Future state value stream map.

Within this production run a 7.98% scrap rate was recorded which amounted to 6,719 scrap containers. Reducing scrap to 3% decreased the amount of scrap units from 6,719 containers to 2,534 resulting in an increase of 4,185 sellable containers for the production run.

Data Analysis

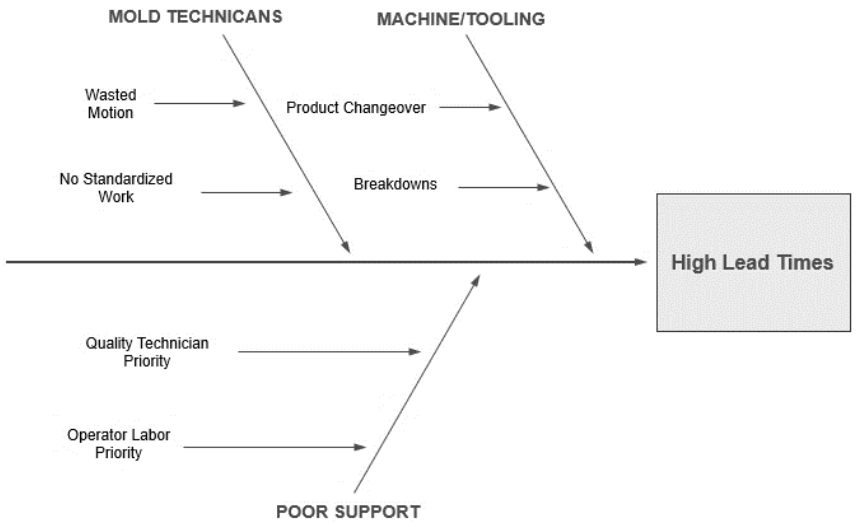

Figure 13. Fishbone diagram for high lead times.

Figure 13 is a fishbone diagram identified the major factors for high lead times within XYZ Company. The fishbone diagram was created by the observations that were gathered throughout the process. Employee priorities, on occasion, were not available and led to downtime of the machine from mold technicians, quality technicians, and operator priorities.

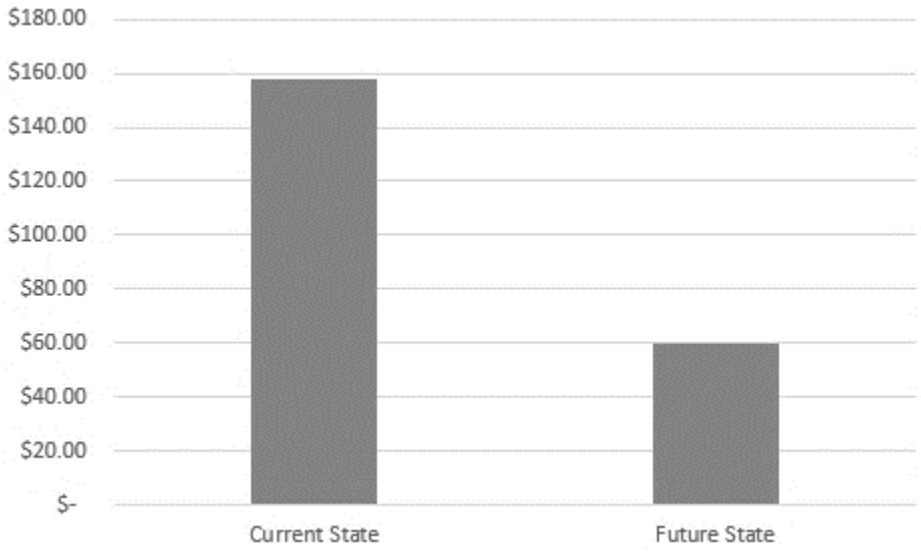

Figure 14. Scrap costs.

The reduction of was reduced to 3% and this led to scrap reduction from $157.63 to $59.86, shown in Figure 14. With this reduced waste and the increase in sellable product per run along with increased uptime and reductions in changeovers a 7% decrease in processing lead time was possible. Figure 15 demonstrates the reduction in lead time and using the average $34.00 an hour for operational cost for the machine running led to a savings of $121.38 per production run.

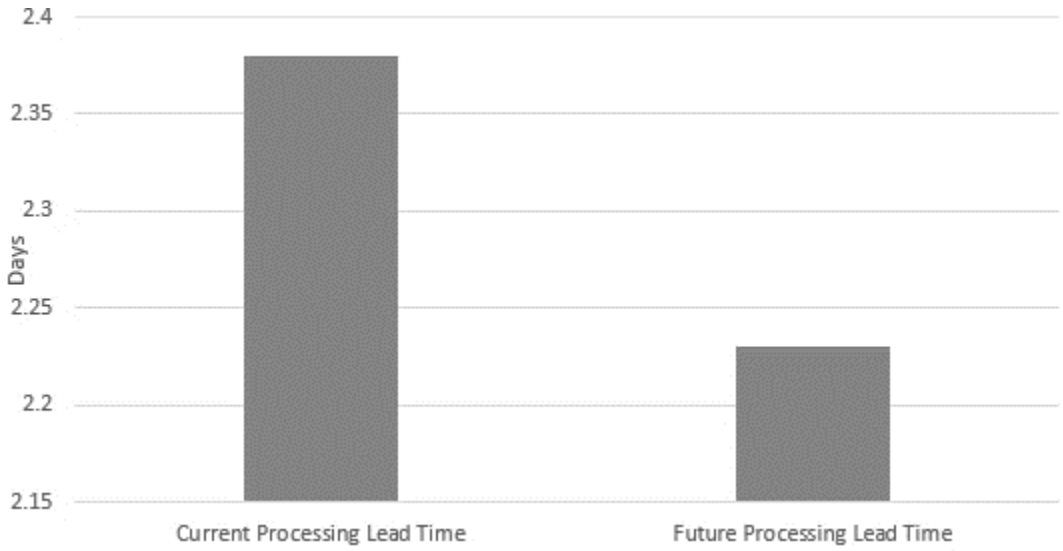

Figure 15. Processing lead time.

The amount of time that was reduced in day is represented in Figure 15. This time was saved for the next product changeover and reduced operating costs. Reducing the overall processing lead time by eliminating waste and reducing non value added work allowed for the keeping less on hand material within the warehouse. By reducing scrap rate to 3% and increasing the efficiencies to reduce processing time, the average on hand quantity that was needed was reduced by 4.9% from 81,000 units to 77,000 units. With reduce levels of inventory needed, utilization of the warehouse was decreased by 35 locations.

Summary

After analyzing the entire value stream and gathering the process information, a current state value steam map was created. After the creation of the current state map, attainable future goals were set to create a future state value stream map to continuously improve toward the best potential future state for the value stream. These goals presented opportunities that were identified to show how much saving could be created by reaching these small achievements. Using setup time, cycle time, scrap, and uptime as the factors being recorded to analyze the current state map. These factors showed the amount of waste that was occurring and needed to highlighted on the future state map. While gathering process information, observations were recorded on wastes that occurred throughout the product changeover and production run. The future state map created standards to be met within the near future. Calculating the savings that could be reached for this production run were to in line with a reduction of 7% processing lead time. With the reduction in non-value added time and scrap material allowed for lowering the average on hand inventory to lower the utilization levels of the warehouse.

The final chapter will discuss the conclusions and recommendations for the XYZ Company that was gathered results of this study.

Chapter V: Discussion, Conclusion and Recommendation

This study analyzed the existing state of a manufacturing process for plastic containers within XYZ Company. Using value stream mapping tools to identify and analyze wastes within the current production system to reduce inventory levels within the warehouse. Using the current state value stream map to create goals that would be reached in the near future were incorporated into the future state value stream map. This study resulted in the decreases in the overall wastes which then led to higher efficiencies that required less inventory on hand to meet the customer needs.

Chapter I discussed how XYZ Company is a manufacturer of plastic containers and with many competitors within this commodity market are on the constant lookout to reduce prices while making a profit and increasing efficiencies within their processes. XYZ Company was in the beginning stages of discovering lean strategies that would improve efficiencies and methods for the future of the company. The goal of the company is to keep the customer happy and their customers' needs are to get their product as soon as possible. Keeping the customer happy with low prices as well as quick product delivery must occur. This led to inventory being stocked up for future consumption and held within the warehouse because of long lead times to the customer. Through this method inventory stacked up and space within the warehouse was becoming scarce.

Chapter II reviewed the literature related to the development of the lean tool of value stream mapping. Through this research of value stream mapping the purpose, applications, and examples of what should be done were gathered. Continuous improvement was the focus on developing and create an atmosphere of growth for new processes that allowed for efficiencies to be improved upon. Through Chapter II, the identification of wastes and how they affect the

value stream were reviewed for observation and gathering data. The inefficiencies and wastes were the main factors for this high amount of inventory. With so much inventory on hand the operation cost of keeping it on hand was rising and loss of sellable product from obsolete inventory created opportunities to save money through the use of value stream mapping.

The methods used to collect, record, and visualize the data gathered throughout the current state value stream were in Chapter III. Taking the critical steps within the process to draw the current state value stream map allowed for visibility of current value added and non-value added work. Gathering the amount of inventory that was accumulated over the production run and wastes that occurred were planned and process data sheets were used. This gathered information created the current state value stream map. After the current state value stream map was created then the goals for the future were created. This future state map was representation of where XYZ Company would get to in the near future.

The results of the current state and future state maps were presented in Chapter IV. Then each map was compared to determine where the improvements could be made. Future performance goals were created be visually seen on the future state value stream map. Creating too aggressive goals would be seen as unobtainable and morale of the employees to reach these goals would lower. These improvements were in the form of lower inventory, lower wait times, increase in efficiencies, and process improvements. Using observations and data gathered to reducing the processing time.

Limitations

Since this is one production run, more observations and data gathering would aid in reflecting the wastes that were occurring throughout the value stream. With a limited amount of labor to track the processes within XYZ Company, the amount of data gathering was restricted to

available time outside of the daily job responsibilities. With limited time for recording the averages, an average was gathered but more recorded data would aid in a better reflection of waste within the processes.

This was the first value stream maps done for XYZ Company. Additional training needs to occur to expand knowledge for the identification of waste within the value stream. Additional coaching will allow for easier identification of waste and empowerment of employees to speak up when an inefficiency is present within the supply chain.

Conclusions

The literature review explained how a manufacturing facility would benefit from the lean processing tool in the form of implementation of future state value stream map projects. Identifying value added and non-value added work. The literature review dictated how to take a process and create a current state value stream. Walking the process from start to finish within the defined boundaries of the project to find the critical process step and visually creating a flow. This visual of the process would then be used to create a future with the goal that will accomplished over a short amount of time.

The labor that was being used for this project was totaled at $604.40 between three employees. From identifying the wasted motion and wasted time spent reduced the operation cost by $34.00 an hour for operational cost for the machine created a savings of $121.38 per production run. A decreased scrap rate to 3% created a saving of $97.77 in material cost and an increase in sellable product.

The results for reducing the inventory levels were a success using lean tools such as the value stream mapping strategy to identify areas for improvement where waste was identified. Production processing time was overall reduced by 216 minutes and the uptime of the machine

was increased to 80%. With an increase in uptime of the machine the scrap rate was reduce by 4,185 unit that will decrease the overproduction of containers and reducing the average container standard of 81,000 units to 77,000 units. By reducing the amount of inventory on hand had a positive effect on the warehouse by liquidating 35 locations and reducing the warehouse utilization.

Recommendations

The recommendations are based on the future state value stream map created through this project. This project was successful example for future value stream mapping projects. This project will still be tracked to meet the future state created. This future state map can still be used to branch off to additional project ideas for the future. A further analysis can be done to set the next set of goals for this production run to increase the overall efficiencies and reduce the non-value added work. There are many more opportunities to

Single minute exchange of dies would drastically reduce the changeover time for this process. This recommendation would be outside the goals of the future state map since they are required to have a short turnaround. This process creates a standardized process for inserting and removing mold from the machine to reduce slow operations of removing bolts and lifting the mold out by a gantry crane. The practices used today have a large amount of non-value added work that can delay production and produce longer lead times for customers.

The production run takes the longest amount of the processing time. Improving the strategies used in this project were lean strategies that should be used in different facets of the company besides manufacturing. Adopting lean strategies such as 5S and Six Sigma to improve the environment and processing data to lower the processing time for the containers in the injection molding process. Mold operators need the freedom to change processing inputs to find

new ways to shorten the overall processing time. Any process can use the value stream mapping strategies to identify where non-value added work is being done and an effort to reduce or eliminate this work should be the focus for the future. Continuously improving operations to remain competitive within our market will drive XYZ Company toward new lean goals that will benefit the organization.

Due to the scope and the amount of personnel associated with this project, limited the value stream map to the general manufacturing operations and with additional labor, the value stream analysis can be expanded to the supplier and customer. With additional resources to expand the scope of the project to the full value stream, from the supplier to the customer, to identify where additional wastes were occurring. This way the overall value stream can identify wastes between the supplier and XYZ Company. Using a cross-functional team from different department with expertise in different forms of waste and ideas for improvement would offer a more in depth look and creation of a current state value stream map and give them the freedom to operate within their own department to reach the goals of their future state value stream map. The goals set within this research were seen as easily attainable. Bringing this cross functional team to create aggressive goals to continuous move towards would keep pushing for an optimal processing of all products within XYZ Company.

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