Value Stream Mapping at XYZ Company

by

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ABSTRACT

A value stream includes all activities required to transform a product from raw material into the finished goods. Value Stream Mapping scrutinizes business processes from beginning to end and a visual representation map is drawn of every process involved in the material and information flows. Then a future state map is drawn to show how things should work for best competitive advantage. Value Stream Mapping helps to identify the current flow of material and information in processes for a family of products, highlighting the opportunities for improvement that will most significantly impact the overall production system.

The purpose of this study is to develop a value stream map for a manufacturing company in Minnesota. The goal is to identify and eliminate waste which is any activity that does not add value to the final product, in the production process. In order to collect the information needed to complete the project, the researcher will take a tour of the production facility. This will enable the researcher to be familiar with the activities being performed at the shop floor. It would also help in getting a vivid idea of the production flow. In addition, a classroom environment would

be set with leads from the various departments of the company so that the researcher can observe and collect information related to product families for the practical mapping and product/process flow from start to finish. This information would highly assist the researcher to visualize the current state of the process activities by mapping the material and information flow and looking for opportunities to eliminate wastes and to improve the process flow. Based on all the information gathered, the company would utilize these results as a plan to map the future state and implement lean manufacturing techniques so that wastes can be eliminated, flow maximized and throughput increased.

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Chapter I: Introduction

Every organization is striving hard on getting more work done in less time and with greater ease. The fundamental aim of any organization has been to continuously minimize waste and maximize flow which would ultimately lead to customer satisfaction by providing right product at the right time in the right quantity and the right quality at a reasonable price. This can be achieved greatly by adopting lean manufacturing system which is more than a cost reduction program. It aims at eliminating wastes which could be in the form of excess production and inventory, redundant movement of material, waiting and delays, over processing, excess worker motion, rework and corrections.

Part of lean manufacturing is assessing operations and processes or products that add cost rather than value (Tapping, Luyster & Shuker, 2002). Each step of the manufacturing process is examined to determine if it adds value to the product. If it does not add value, the process could be assigned to a subcontractor or outsourcing company in order to focus the workforce on value-added operations of its core business. This is known as value stream which is a set of processes required to transform raw materials into finished goods that customers value (Womack & Jones, 1996).

This study aims at developing a value stream map for XYZ Company. It is a lead acid refining and recycling company located in Minnesota and servicing in North America. More than 98% of all automotive batteries are recycled as the state law requires reclamation of used battery for each battery sold. As a result, the demand for lead-acid batteries is growing. Most of the lead reclaimed and refined is purchased and used to manufacture the next generation of automotive and industrial batteries. Recycled lead products are also used for sporting goods equipment, x-ray shielding, pipes and cable sheaths, roofing materials, back-up electrical power, and much more. With the growing demand of lead, the company is seeing a dramatic increase in sales which demands the need to accelerate production in such a way so that there is minimal of waste and increased flow with ease thereby increasing throughput.

The company manufactures several product families. This research is focused on the product family of soft lead pigs that comprises 65% of the total demand. XYZ Company adopts the traditional concept of mass production in batches where the product is produced in full capacity despite the quantity of product ordered. This creates high level of inventory, long lead time and a reduction of available floor space.

Statement of the Problem

XYZ is a manufacturing company that recycles used automotive lead-acid batteries. With the growing demand of lead- acid batteries and uses of recycled lead in other products, XYZ Company wants to introduce and implement lean flow technologies in the company so that customer demand can be met by increasing throughput and capacity. It presently works on the batch processing system with longer lead time and cycle time. This has thereby led to increased inventory and higher cost.

Purpose of the Study

The purpose of the study is to identify non-value added activities and waste so that it can be gradually reduced and eliminated, compress production lead time, switch from big batches to small batches and one-piece flow wherever it is possible in the process flow. Its ultimate aim is to introduce lean flow in the workplace of XYZ Company so that continuous improvement can be made and determine adequate inventory based on customer demand.

Assumptions of the Study

1. The result of the study is limited to XYZ Company

2. All data is reliable and accurate
3. The research is limited to one product family
4. The research includes the development of current and future state map but not how to implement the recommended process improvement.

Definition of Terms

Batch. A mass production approach to operations in which large lots or quantities are processed and moved to the next process despite the actual quantity needed (Rother and Shook, 2002)

Continuous Flow. The movement of product from one manufacturing operation or machine to another without stopping (Tapping et al. 2002)

Current state map. A chart that depicts the present day situation of a manufacturing process or a product family.

Customer demand. The quantity of products required by a customer.

Cycle time. The time that elapses from the beginning of a process or operation until its completion.

Flow. The movement of material or information.

Future state map. A chart that suggests ways to adopt lean techniques in order to reduce and eliminate non-value-added activities and increase throughput.

Heijunka. Balancing the amount of work to be done during a shift with the capacity to complete the work.

Just-in-time production. A production paradigm which ensures right product in the right quantity, at the right time to the customer.

Kanban. An inventory control card at the heart of the pull system specifying what is needed in terms of product and quantity and at the time required to achieve just-in-time

Kaizen. Small daily improvements performed by everyone in order to eliminate waste.

Lead time. The time taken by a product to be transformed from raw material to finished goods.

Leveling. Evenly distributing the work required over a shift or a day to fulfill customer demand.

Muda. A Japanese word for waste which means any activity that consumes resources without creating value for the customer.

One piece flow. See continuous flow.

Product family. A group of parts that share common equipment and processing attributes.

Pull production. A method of production control in which downstream activities signal their needs to upstream activities.

Supermarket. A system used to store a set level of finished goods inventory or work-in-progress and replenish what is pulled to fulfill internal and external customer demand.

Takt Time. The pace at which the process needs to run in order to meet customer demand. It is calculated by dividing available production time by customer demand.

U-shaped cell. The location in U-shape of processing steps for a product immediately adjacent to each other so that parts, documents can be processed in a closely continuous flow.

Value stream. All of the actions, both value-creating and non value-creating, required to bring a concept to launch and from order to delivery.

Value Stream Mapping. A visual representation of the material and information flow of a specific product family.

Waste (muda). Anything within a value stream that adds cost or time without adding value.

Chapter II: Literature Review

This chapter gives an overview and information of lean manufacturing and value stream mapping which would help the reader in understanding the details of the study in the later chapters.

Definition of Lean Manufacturing

Lean manufacturing is a systematic approach to process improvement. It is based on identifying and reducing waste coupled with continuous improvement. According to Womack, Jones and Roos (1990), the term "lean" represents a system that utilizes fewer inputs to create the same outputs than those created by a traditional mass production system, while increasing the variety of finished goods for the end customer.

Lean manufacturing is also popular by the name Just-In-Time Manufacturing developed by Toyota, the Japanese car manufacturer. This concept is now applied by diverse industries and businesses including engineering, administration, project management, manufacturing and administration. Lean manufacturing aims at transforming an organization into an efficient, smoothly running, competitive and profitable organization that continues to learn and improvise. The application of lean paves its way to reduce lead time and increase throughput by eliminating wastes which comes in various forms.

Origin of Lean Manufacturing

No new idea springs from a void and so is the case with lean manufacturing. During the post World War II period, Japanese manufacturers were facing the problem of deficiency of materials, financial problems, and human resources (Ohno, 1988). For many decades, America had cut costs by using the mass production system by producing fewer types of end items while for the Japanese the problem was how to cut costs in order to produce small number of many types of end items.

The history of lean is dated back to 1940 when German worker produced three times as much as a Japanese worker and an American worker produced three times as much as a German worker (Ohno, 1988). Therefore, the ratio of production between American and Japanese work forces was nine to one. Striving towards improvement, the Japanese leader Toyoda Kiichiro proposed to reduce the gap with America in three years, resulting in the birth of lean manufacturing. Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company in Japan pioneered the concept of lean production (Womack, Jones, Roos, 1991). It was originally called Kanban and just-in-time (JIT) which are presently the techniques of lean production. Lean production combines the advantages of both craft and mass production. It avoids the high cost of the former and the rigidity of the latter. It strives in attaining perfection; continually declining costs, zero defects, zero inventories, and endless product variety which is an endless quest.

Value- Added and Non-Value Added

Contrary to the conventional business view, all value is defined from the point of view of the customer with regard to lean (Carreira, 2005). It makes to think and analyze whether the activity directly contribute to the customer's product to make it more complete and if the customer is paying for that activity or not. This, in the language of lean is known as value-added and non-value-added activity. The former refers that the product has been physically changed and its value to the customer has increased. The latter refers to the activity that consumes time (people expense), material, and space (facilities expense), yet does not increase its value.

The basic idea of lean is to identify and eliminate non- value added activities from every aspect of the business (Levinson and Rerick, 2002). Businesses are accustomed to waste so identifying waste is an important aspect of lean manufacturing process. The Japanese call waste "muda". Hiroyuki Hirano defined waste as "everything that is not absolutely essential."(Santos, Wysk and Torres, 2006) He also defined work as any task that adds value to the product. Waste is a symptom rather than a root cause of the problem. The seven major forms of waste are the following: (Tapping and Shuker, 2003)

1. The waste of overproducing: It refers to producing more than needed or producing it ahead of time resulting in consumption of materials, people and storage faster than required which thereby results in other kinds of waste.
2. The waste of waiting: It refers to anything such as people, paper, machines or information that causes the workflow to stop. It is the idle time between operations.
3. The waste of over processing: It refers to redundant activities that do not add value and the customer is not willing to pay for it.
4. The waste of inventory: It refers to excess stock of anything from raw materials to finished goods.
5. The waste of motion: It refers to any motion that is not necessary to the successful completion of an operation.
6. The waste of defects or correction: It refers to producing defective work that needs to be redone which disrupts a normal process and leads to productivity losses.
7. The waste of transport: It refers to moving something more than necessary.

Three Phases of Lean Application

Customer Demand Phase

This phase determines who the customer is, what the customer's requirements are so that customer demands can be met (Tapping and Shuker, 2003). It requires the calculation of takt time which is derived from a German word "takt" meaning rhythm. It is the pacemaker which determines how fast a process needs to run to meet customer demand. It is calculated by dividing the total operating time available by the total quantity required by the customer.

Continuous Flow Phase

The heart of lean is just-in-time or continuous flow which means producing only what is needed, when it is needed and the exact amount needed. It is characterized by the ability to replenish a single work unit when the customer has pulled it also called "Move one, make one".

Leveling Phase

Leveling involves evenly distributing the work required to fulfill customer demand over a period of time which could be a week, day or hour. Failure to accomplish work leveling may lead to processing delay or waiting time.

Value Stream Management

Lean utilizes proper tools to make work flow as smooth as possible so that it reaches its end customer (Tapping and Shuker, 2003). Value stream management is a process of planning and linking lean initiatives through systematic data capture and analysis which consists of eight steps.

1. Commit to lean
2. Choose the Value Stream
3. Learn about Lean
4. Map the current State
5. Identify Lean Metrics
6. Map the Future State (using the demand, flow, and leveling concepts)
7. Create Kaizen Plans
8. Implement Kaizen Plans

Value stream Management is a systematic approach that tells people how and when to implement improvements that aids in meeting customer demand. The tools of lean manufacturing such as value stream mapping, supermarket, heijunka, u-shaped cells and point kaizen workshops must be applied in a proven, structured process to attain success. The lean management principles are of great essence to transform an organization into lean. The following are the lean management principles:

1. Define value from the customer's view perspective.
2. Identify the value Stream
3. Eliminate the seven deadly wastes
4. Make the work flow
5. Pull work, don't push it
6. Pursue to perfection
7. Continue to improve

Value Stream Mapping

It is a tool of lean manufacturing that helps to understand the flow of material and information as products make their way through the value stream. The value stream includes the value adding and non-value adding activities that are required to bring a product from raw material through delivery to the customer. In other words, value stream mapping is an outline of a product's manufacturing life cycle that identifies each step throughout the production process. It is a visual representation of the material and information flow of a particular product family (Tapping et. al. 2002).

Value stream mapping is a powerful yet simple tool which allows the user to see the waste throughout the stream (Lovelle, 2001). It consists of sketching the current and future state map.

The current state map charts the present flow of material and information as a product goes through the manufacturing process. It is a simplified visual blue print that identifies value and waste throughout the system and encourages systematic approach to eliminating waste. The future state map is a chart that shows how to create a lean flow. It adopts lean manufacturing techniques to eliminate waste and reduce non-value added activities to the minimum.

The goal of Value Stream Mapping is to move from batch and push to one piece flow and pull through the entire value stream. Introducing a lean value stream that optimizes the flow of the entire system from information, to material, to finished goods arriving at the customer's door is the ultimate goal. It helps in reducing lead time, inventory, and overproduction and improves throughput, efficiency and quality. It aims at continuously improving in a capable, sustainable manner.

Appendix A shows the various symbols for value stream mapping which would enable the reader in understanding the current and the future state map in the later chapters.

Chapter III: Methodology

The objective of this study is to reduce lead time and increase throughput by identifying non-value added activities and striving to reduce and eliminate it at XYZ Company so that customer demand can be met. Batch processing in full capacity and bottlenecks in the production process are key contributors to long lead times. The results of the research would have direct impact on product lead time and inventory which would aid in reducing cost and meeting customer demand.

The research started by taking a three day lean workshop which enhanced the understanding of lean manufacturing and value stream mapping. Employees from XYZ Company belonging from different departments participated in the workshop so that the mapping of the value stream could be done smoothly. After the completion of the certification course,.a company visit at XYZ was scheduled for three days. The research started by taking a tour of the plant and observations were made on the shop floor and the entire plant. Then a classroom environment was set by involving people from different departments of XYZ Company so that further details of the current production process could be obtained and discussed. Information regarding cycle time, lead time, number of operators involved in each process, amount of inventory and work-in-progress between processes were determined. Based on the information gathered, a current state map was drawn which depicts process flow, product flow, information flow and communication flow. Takt time and cycle time are also calculated. Besides, the inventory between each process is also determined. The data is then analyzed to see what areas need improvement by identifying non-value added activities that can be reduced and eliminated. Thereafter, the current state map is expanded into future state map followed by further discussions and analysis. Lean techniques are suggested for improvising the product flow, communication flow and information flow.

Eventually the benefits of lean manufacturing techniques are projected and savings in lead time calculated. The current state map would then be used as a guideline for improvement that can be made. A final presentation is made to XYZ Company demonstrating the areas of improvement required and the positive impact and benefits the company would have by implementing them. A need for change management and employee involvement is also brought to their attention.

Subject selection and description

The study will focus on soft lead pigs' product family as it comprises 65% of the customer demand. There are several other product families but as soft lead product family contributes to a major portion of the customer demand, it is a good product family to focus the study on.

In order to choose which product family to select for the mapping, product family with the highest demand was selected. A product matrix in figure 1 was developed with the different products manufactured on the left hand side column and the process operations toward the right hand row. It enables us to see the different processes followed by different products.

Figure 1: Product Matrix of XYZ Company

Product	Rcv'g	RMPC	Reverb	Blast	MTR	P1	P2	P3	P4	P5	P6	P7	P8	P9	Pig Cst'g	Bill Cst'g	Blk Cst'g	Cooling
PIGs																		X
F140	X	X	X	X	X	X	X	X							X			X
GU3	X	X	X	X	X	X	X	X							X			X
CORRODING PIG	X	X	X						X	X	X	X	X	X	X			X
PB3	X	X	X	X	X	X	X	X							X			X
P4	X	X	X						X	X	X	X	X	X	X			X
1.5% LARGE BILLETS	X	X	X	X	X											X		X
0% LARGE BILLETS	X	X	X	X	X											X		X
10% LARGE BILLETS	X	X	X	X	X											X		X
SMALL BILLET	X	X	X		X											X		X
BOLCKS																		
P3	X	X	X					X	X	X	X	X	X				X	X
Corroding block	X	X	X		X			X	X	X	X	X	X				X	X
RED = BASE KETTLES																		
5,6,9 BASE ONLY—PUMB 7&8 CASTING KETTLES																		
PIG CASTING 4.5 HRS/POT																		
CLK CASTING 4 HRS/POT																		

Instrumentation

Value Stream Mapping was used as a tool to map the process and depict the scenario with the aim of reducing lead time and increase throughput. The main source used to create the maps was the book Value Stream Mapping Workshop (Rother and Shook, 2002). Besides, the three day lean certification workshop and the knowledge gained from the books related to value stream mapping provided the tools to create useful and informative maps.

Data Collection Procedures

In order to collect the data to draw the current and future value stream map a classroom environment was set with employees from all areas of the company. Data was obtained from the respective departments as the value stream map was drawn. Plant tour with the company officials was done prior to the classroom discussion so that the researcher could have a clear understanding of the process and the entire scenario. Active participation in discussions with employees and correct information being disseminated assisted in drawing an accurate value stream map for the company. The figures 2 and 3 below shows the information collected which facilitated in drawing the current state map.

Figure 2: Metrics for each Process

Process	Operators	Cycle Time(hours)	Uptime
Raw Material Processing Centre (RMPC)	9	4.3	90%
Reverb Furnace	3	6.8	90%
Refining	3	36	98%
Casting	3	4.5	90%
Cooling	2	-	-
Shipping	2	2.2	-
Total	22	53.8	71%

Figure 3: Work-In-Progress (WIP) Between Processes

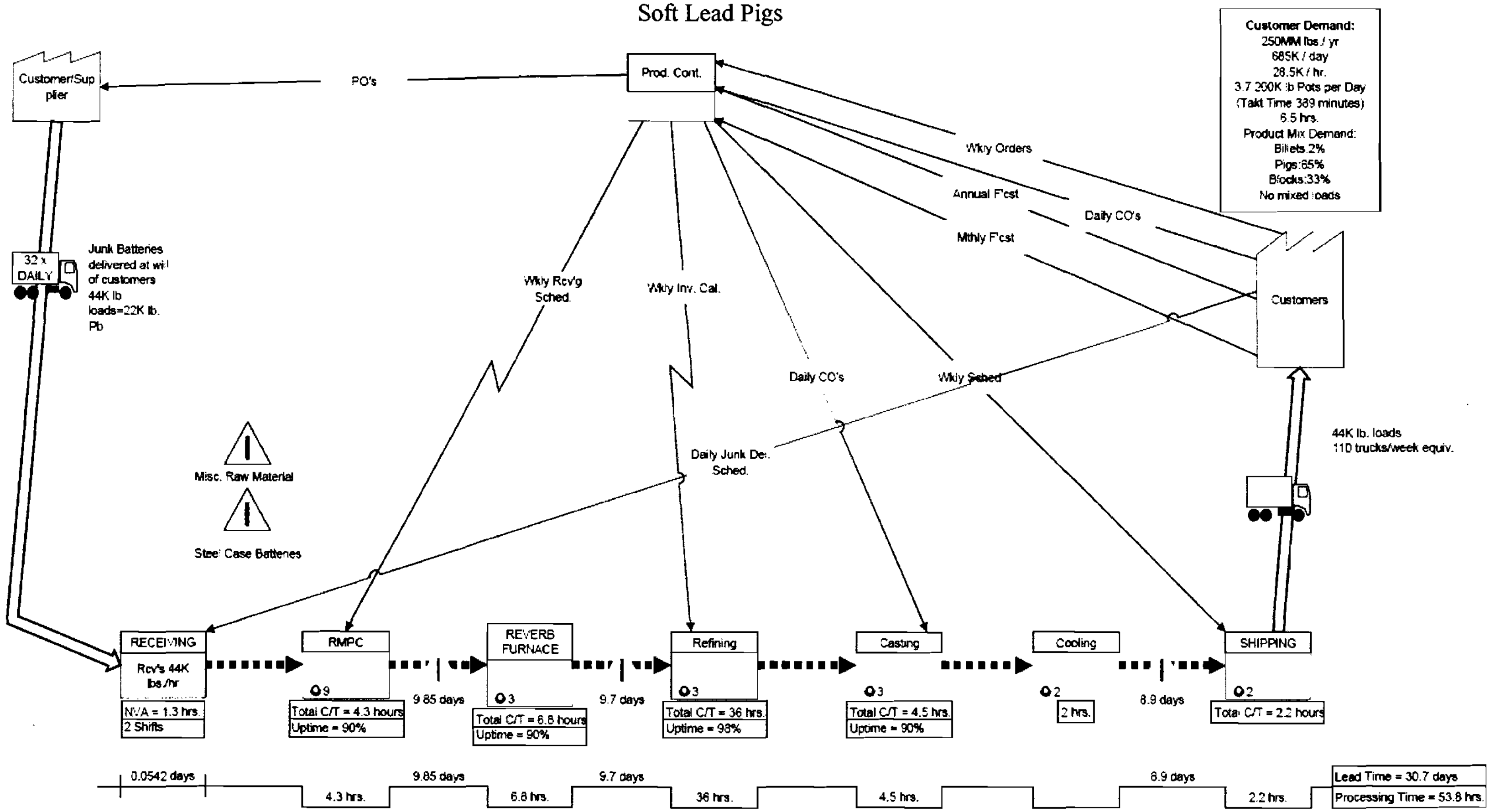
Process	Quantity Produced (pounds) (1)	Quantity Required per Day (Pounds) (2)	WIP in Days (Column1/Column2)
Between Receiving & RMPC	-	-	-
Between RMPC & Reverb Furnace	6750000	685000	9.85
Between Reverb Furnace& Refining	271600	28000	9.7
Between Refining & Casting	-	-	-
Between Casting & Cooling	-	-	-
Between Cooling & Shipping	6150000	685000	8.9
Total			28.45

From the data and information retrieved from the above tables and discussions from the leads of different departments, current state map with material flow, communication flow and information flow was drawn to show the process of soft lead pigs from the point it was ordered until delivered to the end customer. The last step was to analyze the current state map and suggest lean techniques for possible improvements in order to reduce lead time and increase throughput.

Data Analysis

Mapping the value stream always starts with the customer demand. With the product family, soft lead pigs, specified for the mapping, a product matrix (figure1) was made which helps see what family of products follow the same manufacturing process. Figure 2 and 3 aids in the proper and accurate mapping of the current state map. An understanding of the value stream mapping is enabled with the help of value stream symbols and definitions in appendix A. Figure 4 below is the current state map followed by a detailed explanation.

Figure 4. XYZ Current State Map
Soft Lead Pigs



XYZ CO. INC.
Soft Lead Pigs.
Preliminary Current
State

As shown in the current state map above in figure 4, the focal point of all information gathering and dissemination is the production control point. The focus of study for the value stream mapping is soft lead pigs. Daily, weekly, monthly and annual orders are taken by customer service and entered in the ERP System. Thereafter, information is sent to the receiving department as how much raw material, junk batteries need to be delivered at the receiving area. The production control also lets the supplier know on how much raw material is required soon after the order is taken. One interesting factor to be noted is that the company receives the raw material of junk batteries at the will of its customers and also buys them from other suppliers. As it has no control over the amount of junk batteries it will receive from its customers there are times when the inventory for raw material is high. This is a big issue that that the company is facing currently. There is not a proper scheduled flow of junk batteries from sources. When the daily junk delivery schedule is obtained from the customer it is sent to the receiving department. Due to lack of proper flow of raw material, there is non-value added activity between receiving and raw material processing centre (RMPC). Thereafter, the processed raw material is taken to the reverb furnace where all the solids and metal is converted into molten state. Then the metal from the reverb furnace is refined in kettles where the content of trace element is adjusted to produce the desired alloy. Common products are soft lead and various alloys of hard lead. This is sent for casting into pigs, billets and slugs and left for cooling. Then, the product is ready for shipping.

Once the orders are received from the customers, it is entered into the ERP system. It is determined that the demand for soft lead pigs is 65% which is 250000000 pounds per year, 685000 per day, and 28500 per hour. Takt time is 389 minutes or 6.5 hours which is calculated by dividing the available production time 24 hours (1440 minutes) by total daily quantity required (3.7*200000 pounds pots per day). The total available production time per shift is 8 hours (480 minutes). Two 15 minutes break and one 15 minutes lunch is not taken into consideration as everyone does not take break at the same time and there are operators available for service. Thereafter, the production control places the raw material order to the suppliers of junk batteries. The supply of junk batteries is at the will of the customer for which it sends a weekly or daily schedule to the receiving department. Each day, there are 32 trucks with raw material coming into the company. Each truck carries 44000 pounds of junk batteries from which only 50% of lead is obtained. It is recorded that the non value added activity is 1.3 hours.

The junk batteries are then transferred to the raw material processing centre where the cycle time is 4.3 hours and an uptime of 90% with nine operators working per shift. The cycle time is calculated by dividing 190000 pounds of lead divided by 44000 lead per hour. There is an inventory equivalent of 9.85 days which is calculated by total quantity of lead which is 6750000 pounds divided by the quantity of lead required per day which is 685000 pounds. Thereafter, the processed raw material is sent to the reverb furnace to convert into molten state. The cycle time is 6.8 hours which is derived by dividing total quantity of molten metal used which is 190000 pounds by the quantity required per hour which is 28000 pounds of lead. The number of operators in the process is 3. The total cycle time is 6.8 hours with an uptime of 90%. The WIP inventory of slugs after the reverb furnace is worth of 9.7 days. It is calculated by dividing the total quantity of molten metal which is 271600 pounds divided by 28000 pounds of molten metal required per day. Thereafter, the molten metal is refined in kettles. The cycle time is 36 hours with an uptime of 98% with 3 operators. Then it is cast into soft lead pigs for which the cycle time is 4.5 hours with an uptime of 90%. Then it is left for cooling which takes 2 hours with the involvement of 2 operators. It is observed that the total of inventory of soft lead pigs at the end of the process is worth of 8.9 days. This implies it produces 6150000 pounds of finished product while the quantity required per day is only 685000 pounds. Dividing the quantity produced per day (615000 pounds) by the quantity required per day (685000 pounds) gives the finished product inventory of 8.9 days. Each truck has a capacity to accommodate 44000 pounds of soft lead for which the cycle time is 2.2 hours with 2 operators involved. The shipping department receives the shipping schedule from the production control department based on which it delivers the finished product to the end customer. The above process described encompasses the material flow, information flow and the communication flow between the various departments.

After the completion of drawing the current value stream map for the product family of soft lead pigs; it is observed that the lead time for the entire process is 30.7 days whereas the processing time required is just 53.8 hours. The total lead time is derived by adding up the cycle time for each process and the work-in-progress inventory. The total processing time is the sum total of only the time taken in each process. The current map shows the actual value added time is 53.8 hours which is the sum total of the cycle time of each process (4.3+6.8+36+4.5+2.2 hours). The cumulative uptime is the product of all uptime (90%*90%*98%*90%) which is 71%. Value stream work-in-progress in days is the sum total of all the work-in-progress which is 28.45 days.

The current state map was drawn with the help of information collected from XYZ Company. With the information collected, a clear understanding of the entire manufacturing process is depicted for the soft lead pigs' product family. Now, areas associated with non-value-added activities can be traced and waste identified so that avenues of improvement can be seen clearly and suggestions recommended accordingly for a leaner XYZ company in the following chapter.

Chapter IV: Results

Introduction

The purpose of the study has been to use the pen and paper technique of developing a value stream map for XYZ Company for soft lead pigs' product family. It thereafter aims in accomplishing the task of identifying the wastes in the value stream and striving towards reducing lead time and increasing throughput. The next step of this research study is to observe the current state map, make recommendations and draw a future state map for the same product family. This tool of lean manufacturing enables the researcher to document the lead time, cycle time, work-in-progress and the uptime for each process individually. It helps to determine the ratio of value added to total lead time.

March 1st through 3rd of 2006 was scheduled for the research work. A classroom environment was set for the study with the participation of leads from all departments. Data and information for the research was collected through observation during the plant tour and from the information supplied from the respective departments leads. Active participation and involvement from the team of XYZ Company throughout the research work led to sketching an accurate current state map. This would further enable the researcher in understanding the movement of material and information along the value stream, identify and eliminate wastes and assist in developing a future state map for a vision of ideal value flow for the selected product family.

Analysis of the Current State Map

It has been analyzed on the current state map that only 53.8 hours is the processing time while it takes 30.7 days for the product to be transformed from raw material to finished goods till it reaches the end customers. The ratio of value added to non-value added activity is lower. The basic reason behind low rate of value added activity is due to its mode of production. Despite the quantity of product ordered, production continues in batch mode with the utilization of maximum capacity. The company adopts the traditional concept of mass production where production in full capacity leads to low cost and ignores the benefits of lean manufacturing where there are several hidden wastes and non-value activities which when identified can reduce cost, increase throughput and eliminate waste. For example, if there is a customer demand for 200 blocks of soft lead pigs, production would still be carried for 314 blocks as this would save the down time of cleaning up time for kettles, setting up for another product family, cost related with energy consumption. It ignores the fact that lead time increases and customer demand can be delayed accompanied by several other factors of accumulating inventory, more work force required for its management and handling, and inefficient use of floor space.

Another serious issue with the value stream is that the raw material is delivered to the company at the will of the customers. Besides, the quantity to be received is not prescheduled. Therefore, there are variations in the inflow of raw material resulting in excess of inventory which is stored at any available floor space. There is no determined floor space allotted for the raw materials. This leads to waste of motion and time in finding the right material at the right time.

The receiving department has a non-value added activity of 1.3 hours; the reason behind it being lack of level flow of junk batteries from sources. Due to this, the receiving section needs to upload and download the junk batteries to the RMPC which could be done immediately if the schedule for the incoming material was planned.

The reverb furnace is a bottleneck for the following process of refining and casting. The capacity of the reverb furnace is low due to which there is WIP worth of 9.85 days piled up before it. It is also observed that there is WIP of 9.7 days before refining. There is a low or improper supply of lead for refining which leads to the accumulation of smelted metal and proves to be a hindrance in the smooth production flow. The other reason for high accumulation of inventory is the method of production in large batch sizes. At times, there is breakdown of machinery due to which the entire process needs to be stopped. A critical need of total preventive maintenance (TPM) is required so that the down time due to machinery failure does not come in the way of production.

After casting, the product is left for cooling. The excess inventory is stored at any available floor space due to inefficient inventory management and floor space. There is waste of time in handling material from one point to another. There is no organized method of product leveling as per demand.

On the information flow front, communication and information flow is smooth and on timely manner. The only problem that is seen is that the purchasing department needs to closely look at the inflow of junk batteries and negotiate on setting up a standard schedule of receiving it. Slight fluctuations are negligible but prior notice few days before its arrival can be of good help.

From the human factor side, it is observed that there is high employee turnover. Due to this, there are new workforces entering the production floor who may not be very well versed in the job as the existing employees. It adds to extra cost and time to get the new ones acquainted to the job which poses a hindrance in efficiency.

Continuous improvement is what XYZ Company seeks for and always strives for development which is a never ending quest. The observations during the tour, discussions and participation while depicting the current state map made the researcher identify several areas where improvement could be made. The future state map in the next paragraph would discuss on what areas and how improvements can be made.

Future State Map

The future state map is a visionary map drawn to propose suggestions and recommendations for an ideal value flow. Several lean manufacturing techniques are adopted to reduce lead time and increase throughput. With the aim of continuous improvement, XYZ Company is suggested to level the flow of junk batteries from sources so that raw material inventory can be managed in an efficient way. It is also suggested that the three processes, the reverb furnace, refining and casting departments should be combined together as a group of processes so that continuous flow with small batch sizes can be achieved without any hindrance. As the reverb furnace has a low capacity and is a major constraint in the process flow, it is suggested to have another reverb furnace so that the WIP inventory before it can be reduced to some extent and accumulation reduced. Allocation of space for an additional reverb furnace would not pose a problem at all. With an additional furnace and a supermarket for refining material before the refining process, the work-in-progress would be completely vanished and the process would flow without stopping. The purpose is to move a small batch from one process to another without stopping.

The other thing to be brought into practice is total preventive maintenance (TPM) where the operators should be trained on handling the equipment and fixing it if minor problems arise. This requires cross training so that any operator is well versed or capable of doing the others job in his or her absence. The benefit of cross training is that the operator does not need to wait for another person to carry on the work and promote continuous flow. It helps eliminate WIP which would otherwise lead to WIP creation. This would lead to efficient use of available floor space and better visibility while working.

It is also suggested to have a pull system between the casting and shipping department with an electronic supermarket. Casting and cooling would be carried out simultaneously and then moved to the warehouse. An inventory worth of 6 days is estimated to be stored in order to meet customer demand as and when required. The shipping department would pull the quantity required based on daily and weekly customer orders. This would automatically be replenished as information would be updated instantly.

As there is no proper organization of what is stored where, the consequence faced is an increase in material handling distance. In order to minimize this issue, 5S event needs to be started which is a Japanese concept meaning, a process of creating workplace cleanliness and organization. The 5S stand for Sort (Organization), Set in order (Orderliness), Shine (Cleanliness), Standardize (Standardized Clean-up), Sustain (Discipline). This needs to be strictly followed so that the following benefits can be achieved.

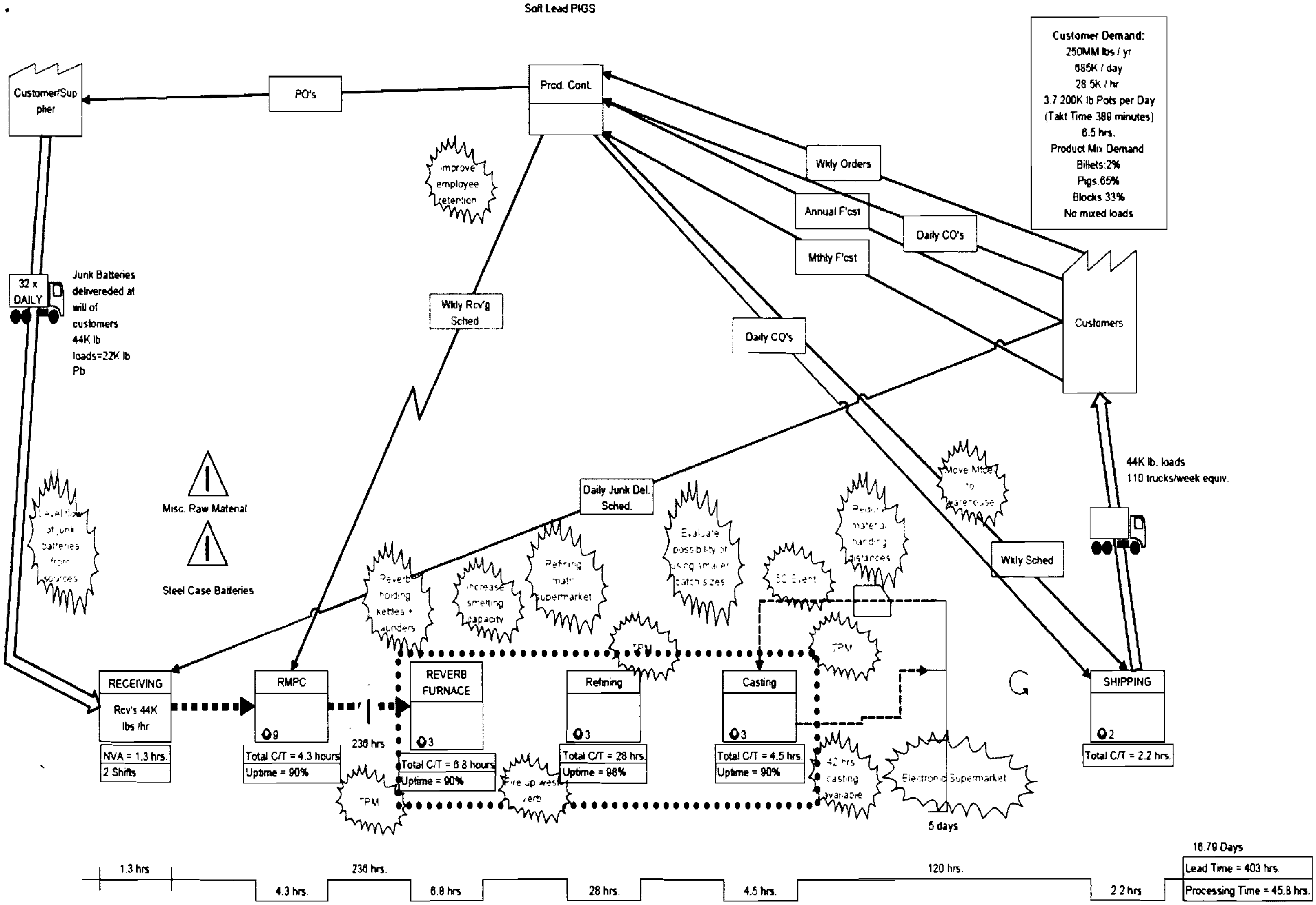
1. Thoroughly eliminate waste due to excess inventory.
2. Reduce space requirements.
3. Adopt better storage methods.
4. Adhere to strict deadlines and on time delivery.
5. Reduce the cost of 4M's- Man, Material, Machines, and Methods.
6. Reduce wastage of time looking for merchandise.

7. Improve and maintain neat and clean warehouses leading to enhanced customer trust resulting in reduced defective products.
8. Improve safety and communication.
9. Increase compliance with process and procedures.
10. Boost morale by creating a pleasant workplace.

It is also brought to the company's attention that the employee retention needs to be improved. Human factor is the only active factor of production without which no other factors of production will work. The efficiency of existing, experienced workforce is higher than the new ones. Time and cost of training new employees will be saved.

The future state map below, also in Figure 5 shows all the areas that need improvement and the ways it can be improved. If all the suggestions are implemented gradually in an incremental way then the lead time for the soft lead pigs' product family will be 412 hours which is 18.04 days. The processing time is 45.5 hours. The processing time is reduced by 15.43%. It is therefore analyzed that there is a reduction of 41.23% in production lead time and 15.43% in processing time. It can be concluded that implementing the above stated lean techniques would reduce the lead time to a large extent and smoothen production flow. The hidden waste, inventory would be reduced an eliminated.

Figure 5. XYZ Future State Map



XYZ CO. INC.
Soft Lead Pigs.
Preliminary Future State

Chapter V: Discussion

Introduction

A value stream includes all activities required to transform a product from raw material into the finished goods. Value Stream Mapping scrutinizes business processes from beginning to end and a visual representation map is drawn of every process involved in the material and information flows. Then a future state map is drawn to show how things should work for best competitive advantage. Value Stream Mapping helps to identify the current flow of material and information in processes for a family of products, highlighting the opportunities for improvement that will most significantly impact the overall production system.

The purpose of this study was to develop a value stream map for a manufacturing XYZ Company in Minnesota. The goal was to identify and eliminate waste which is any activity that does not add value to the final product in the production process. It also aimed at reducing lead time and increasing throughput of soft lead pigs' product family through the use of value stream mapping. A current state map was created to understand the process flow, information flow, document lead time, cycle time and inventory levels. The current state map was also a good tool to identify the wastes in the process. The future state map was developed based on the current map which showed the avenues where improvements could be made. Lean manufacturing techniques were used to create the map that would reduce lead time and increase throughput. Value stream mapping is an excellent tool to analyze the manufacturing process, identify the areas of waste and suggest ways for potential improvement.

Conclusions

It was observed from the current state map that the lead processing time for a product is 53.8 hours whereas the lead time is 30.7 days. The difference between the lead time and the processing time gives the non-value added time. This clearly shows that there is an enormous amount of non-value-added activities in the process flow which is in the form of waiting for materials, moving materials and setting-up time, WIP and piled up inventory.

The mode of production is in large batch sizes. The reverb furnace poses to be a bottleneck which leads to WIP accumulation. It is also a hindrance in the smooth production flow. Overall, it leads to reduced throughput.

The work-in-progress inventory is worth 19.55 days which is 63.68%. This shows that the company has enough stock of work-in-progress inventory to back up customer demand during lead time. At the same time it also conveys that a lot of fund is tied up in this inventory which could be used for other purpose.

There is high employee turnover which conveys that sometimes there are times when enough operators are not there for a particular process which leads to delay in the operation. It also leads to reduced efficiency as new operators take charge of the operation.

Many times the work centre does not run due to mechanical problems and poor maintenance.

The place seems to be disorganized when it comes to storing raw materials, work-in-progress and finished product. There is no specific place for a particular item. Floor space is not efficiently used.

In the future state map, there are no changes made in the number of operators working neither are they expected to work harder and faster. The procedures and layouts are changed emphasizing on smaller batch sizes to allow smooth flow of production.

Recommendations

The goal of this research was to create the current state map and the future state map so that the aim of reducing lead time and throughput is achieved.

In order to have a smooth flow of manufacturing process, the reverb furnace, refining and casting needs to be combined together as a group of processes. This would promote small size batch production in a continuous manner. All the work in progress between the processes will be eliminated.

The flow of junk batteries from sources needs to be leveled so that there is neither excess nor low level of raw materials at stock.

The reverb furnace has a low capacity for smelting which is considered a bottleneck in the flow, an additional investment in another reverb furnace is recommended so that throughput can be increased.

Refining material supermarket is suggested before the refining process so that material can be pulled when required through the pull kanban system and automatically be replenished

In order to avoid unplanned machinery downtime, Total Preventive Maintenance (TPM) is suggested to be implemented. It increases efficiency and useful life of the equipment. It also involves the operator to take care of the work centre, maintain it and report if damages occur.

5S event is suggested to be initiated and implemented so that there is workplace standardization and organization. The finished product storing areas and the warehouse needs immediate attention.

An electronic supermarket worth of 6 days inventory with a pull system is recommended after the casting process so that product can be shipped based on customers' demand and production scheduled for immediate replenishment.

Another recommendation is to reduce material handling distances which lead to waste of time and labor.

The company is recommended to improve on employee retention.

The goal of this research was to study the manufacturing process of XYZ Company for the family product of soft lead pigs. The research was conducted successfully and current and future state map developed. It served as a significant tool in identifying wastes, documenting details of the operation and proposing recommendation for potential improvement. It is hoped that XYZ Company implements the recommendations and the results obtained henceforth is successful as planned and expected.

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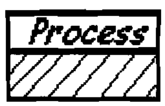
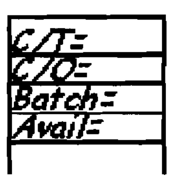
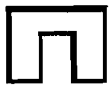
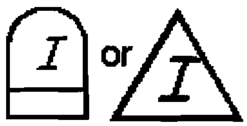
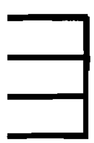
Appendix A

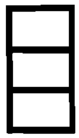
Value Stream Process symbols

 **Customer/ Supplier**	This icon represents the Supplier when in the upper left, the usual starting point for material flow. The customer is represented when placed in the upper right, the usual end point for material flow.
 **Dedicated Process**	This icon is a process, operation, machine or department, through which material flows. Typically, to avoid unwieldy mapping of every single processing step, it represents one department with a continuous, internal fixed flow path. In the case of assembly with several connected workstations, even if some WIP inventory accumulates between machines (or stations), the entire line would show as a single box. If there are separate operations, where one is disconnected from the next, inventory between and batch transfers, then use multiple boxes.
 **Shared Process**	This is a process operation, department or work center that other value stream families share. Estimate the number of operators required for the Value Stream being mapped, not the number of operators required for processing all products.
 **Data Box**	This icon goes under other icons that have significant information/data required for analyzing and observing the system. Typical information placed in a Data Box underneath FACTORY icons is the frequency of shipping during any shift, material handling information, transfer batch size, demand quantity per period, etc. Typical information in a Data Box underneath MANUFACTURING PROCESS icons: � C/T (Cycle Time) - time (in seconds) that elapses between one part coming off the process to the next part coming off, � C/O (Changeover Time) - time to switch from producing one product on the process to another � Uptime-percentage time that the machine is available for processing � EPE (a measure of production rate/s) - Acronym stands for "Every Part Every___". � Number of operators - use OPERATOR icon inside process boxes � Number of product variations � Available Capacity � Scrap rate � Transfer batch size (based on process batch size and material transfer rate)

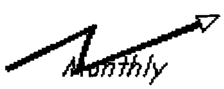
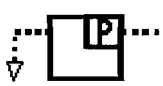
 **Workcell**	This symbol indicates that multiple processes are integrated in a manufacturing work cell. such cells usually process a limited family of similar products or a single product. Product moves from process step to process step in small batches or single pieces.

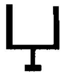
Value Stream Material Symbols

 **Inventory**	These icons show inventory between two processes. While mapping the current state, the amount of inventory can be approximated by a quick count, and that amount is noted beneath the triangle. If there is more than one inventory accumulation, use an icon for each. This icon also represents storage for raw materials and finished goods.
 **Shipments**	This icon represents movement of raw materials from suppliers to the Receiving dock/s of the factory. Or, the movement of finished goods from the Shipping dock/s of the factory to the customers
 **Push Arrow**	This icon represents the �pushing� of material from one process to the next process. Push means that a process produces something regardless of the immediate needs of the downstream process.
 **Supermarket**	This is an inventory �supermarket� (kanban stockpoint). Like a supermarket, a small inventory is available and one or more downstream customers come to the supermarket to pick out what they need. The upstream workcenter then replenishes stocks as required. When continuous flow is impractical, and the upstream process must operate in batch mode, a supermarket reduces overproduction and limits total inventory.
 **Material Pull**	Supermarkets connect to downstream processes with this "Pull" icon that indicates physical removal.
 **FIFO Lane**	First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input. An accumulating roller conveyor is an example. Record the maximum possible inventory.

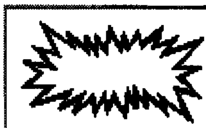
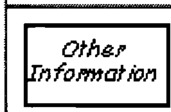
 **Safety Stock**	This icon represents an inventory �hedge� (or safety stock) against problems such as downtime, to protect the system against sudden fluctuations in customer orders or system failures. Notice that the icon is closed on all sides. It is intended as a temporary, not a permanent storage of stock; thus; there should be a clearly-stated management policy on when such inventory should be used.
 **External Shipment**	Shipments from suppliers or to customers using external transport.

Value Stream Information Symbols

 **Production Control**	This box represents a central production scheduling or control department, person or operation.
 **Manual Info**	A straight, thin arrow shows general flow of information from memos, reports, or conversation. Frequency and other notes may be relevant.
 **Electronic Info**	This wiggle arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network). You may indicate the frequency of information/data interchange, the type of media used ex. fax, phone, etc. and the type of data exchanged.
 **Production Kanban**	This icon triggers production of a pre-defined number of parts. It signals a supplying process to provide parts to a downstream process.
 **Withdrawal Kanban**	This icon represents a card or device that instructs a material handler to transfer parts from a supermarket to the receiving process. The material handler (or operator) goes to the supermarket and withdraws the necessary items.
 **Signal Kanban**	This icon is used whenever the on-hand inventory levels in the supermarket between two processes drops to a trigger or minimum point. When a Triangle Kanban arrives at a supplying process, it signals a changeover and production of a predetermined batch size

	of the part noted on the Kanban. It is also referred as �one-per-batch� kanban.
 **Kanban Post**	A location where kanban signals reside for pickup. Often used with two-card systems to exchange withdrawal and production kanban.
 **Sequenced Pull**	This icon represents a pull system that gives instruction to subassembly processes to produce a predetermined type and quantity of product, typically one unit, without using a supermarket.
 **Load Leveling**	This icon is a tool to batch kanbans in order to level the production volume and mix over a period of time
 **MRP/ERP**	Scheduling using MRP/ERP or other centralized systems.
 **Go See**	Gathering of information through visual means.
 **Verbal Information**	This icon represents verbal or personal information flow.

Value Stream General Symbols

 **Kaizen Burst**	These icons are used to highlight improvement needs and plan kaizen workshops at specific processes that are critical to achieving the Future State Map of the value stream.
 **Operator**	This icon represents an operator. It shows the number of operators required to process the VSM family at a particular workstation.
 **Other**	Other useful or potentially useful information.

 **Timeline**	The timeline shows value added times (Cycle Times) and non-value added (wait) times. Use this to calculate Lead Time and Total Cycle Time.