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Original Research Article

Application of Lean Tool- Value Stream Mapping (VSM)

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Abstract: Value Stream Mapping is a lean tool used for reducing lead time, uncovering waste in production and supply process by identifying non-value-adding steps first and then removing them. A flow diagram of the process and material is drawn which reflects the current state of the operation. The non-value added actions are identified in each step. The waste of time and resources between the steps are also come to light. The process is then analyzed to reduce lead time and simplify the process by taking some necessary actions or applying some lean tools. By reducing waste the proportion of value adding time in the whole process increases and the process throughput production lead time decreases. After that a new, improved, well planned diagram is made. This is called future state map which makes the redesigned process more effective and more efficient.
Keywords: VSM, Value Stream Mapping, Lean Manufacturing, Lean Tool, Lead Time Reducing

INTRODUCTION

With manufacturing becoming a more and more competitive market, companies globally strive to increase their efficiency. Increasing labor costs in many industrialized countries, as well as reducing and controlling operating costs, are just a few reasons companies choose to move or outsource their operations. Typically, a majority of companies outsource to countries where wages are low and production costs are lower. To reduce cost and remain competitive with manufacturers abroad, companies use a variety of different methods. One of the main methods is called "lean manufacturing." The main principle of lean manufacturing is to reduce waste in an operation, such as long lead times, defects and material waste. In order to visually display where waste occurs in the process, a value stream map (VSM) is drawn.

How to create VSM-

- Identify Product Group
- Identify the Current State Map
- Observe and Confirm Process
- Creating Future State Map
- Creating the Implementation Plan

LITERATURE REVIEW

The term value stream was first used in the book The Machine that changed the World (1990) by Womack, Jones and Roos, and further discussed in Lean Thinking (1996) by Womack and Jones [1]. In a later book by Martin and Osterling, the authors defined "value stream mapping as just a tool to reduce operational waste, the broader use of value stream mapping as a methodology to transform leadership thinking, define strategy and priorities, and assure that customers are receiving high level of value is where value stream mapping earns its brightest stripes [2]. Value stream mapping in the manufacturing environment has been discussed since the technique was used at the Toyota Motor Corporation, and was known as "material and information flows"[3].

VSM was used by Ulf K. Teichgräber, Maximilian de Bucourt utilized VSM to eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services by applying value stream mapping [4].

Value stream mapping is applied by Hines *et al* [5]. to the development of a supplier network around a prominent distributor of electronic, electrical and mechanical component. Brunt [6] suggested an approach to create a picture of the value steam for the whole supply chain in automotive industry. Seth and Gupta [7] used VSM to achieve productivity improvement at supplier for an auto industry, by Seth *et al* [8]. To determine miscellaneous wastes in the supply chain of the edible oil industry. Chowdary and George [9] used VSM to analyze of the problems existing in the production line and improvement of operations at a

pharmaceutical company, by Ar and Ashraf [10] determine how value stream mapping is utilized to help the process industry eliminate waste for engine component manufacturer in Malaysia, by Li *et al*. [11] to analyze carbon emission for electronic manufacturing process.

DATA ANALYSIS

Information Collection

To generate a VSM of any product, at first the information about the product and the manufacturing processes related to it were collected. There are different ways to collect information and relevant data from the manufacturer company. Some basic information about Bata shoe company ltd. and its product were acquired from the ENT (Engineer and Technician) department, then permitted to visit the different job floors.

After that, the floors were explored and different problems were find out which was very effective. By visiting the factory, some great experience and required information and relevant data for our work were gathered.

Time Studies

The time line was created to give information about total process times and lead times for inventory through processes; the inventory were used at each stage and the daily demand to calculate the amount of stock in days and add this to the top of the time line, this will allow us to calculate a total lead time. The cycle time for one product is then placed in the lower portion and this will be added to give a total processing time.

At this point comparing lead times and processing times that are only a few minutes which highlights just how much waste there is in the system. Thus completed current state value stream map is done; now the real work can start. Collecting all the relevant data and understanding the operations, revised time studies were conducted to get exact cycle time of the processes. Different production line were visited to record the cycle time. Time study is a procedure to measure the time of any process practically. A stop watch was used to measure and a sheet to record. Time study was done to calculate the cycle time. Clock was started when work begins on the request and ended when the item is ready to delivery. It means that cycle time is the total production time to produce a single product. The average cycle time indicated that how well the current operation is doing in relation to the TAKT time. The classic calculation for the TAKT time is:

TAKT time = Available time to production / required units of production

Information of Plants

In Bata shoe factory ltd. current condition of the production system is very efficient than any other shoe companies in our country. There are mainly two job floors, where different types of manufacturing process are being held to produce. Some important information collected to generate current state map are given below:

Condition

Plastic Section:
There are total 8 workers are working in this section.
Total lead time: 17.4 sec
Total Value added time: 42.8 sec
Total Cycle time: 56.36 sec/pair
Average production rate: 511 pair/shift

Table 1: Data for Job Floor Plastic

Machine No.	*Capacity (Pair/shift)*	*Production Quantity (pair/shift)*	*Uptime (%)*	*No. of Scrap*	*Scrap (%)*
1	540	522	96	4	0.76
2	490	481	97	4	0.83
3	540	532	93	6	0.88
4	540	530	95	5	1.1
5	540	527	95	3	0.56
6	490	484	96	5	1.03
7	540	530	94	6	1.13

Rubber Section:
There are total 9 workers are working in this section.
Total lead time: 17.4 sec
Total Value added time: 31 sec
Total Cycle time: 48.4 sec/pair
Average production rate: 623 pair/shift

Table 2: Data for Job Floor Rubber

The Overview of All Machines Parameters			
Machine No.	*Uptime (%)*	*No. of Scrap*	*Scrap (%)*
Mixing	2	82.22	0
2 Roller	2	97	0
9 Grams	2	97	0
Hydraulic Press	5	98	0.1
Cutting, Assembly & Finishing	15	94	0.24

Current Situation

The main raw materials for their production are Plastic (powder) & Rubber. All the raw material is ordered and stored in two different warehouses for different materials. There are mainly three job sections, where plastic powder is transformed into granular, other to turn granules into plastic sandals. The collected data are-

No. of Shifts = 3
Work hour per shift = 8 hours
Break time = 30 minutes
Average working days per month = 26
Monthly production hour = 26 × [(8×3) – (0.5×3)] = 26× 22.5 hours = 2106000 seconds

Plastic Section:
Maximum Demand/month = 40000 Pairs
Takt Time= 2106000/40000 = 52.56 sec
Current Lead Time = 56.36 sec
Current Capacity = 2106000/56.36 = 37366 Pairs
Production shortage = 2634 Pcs (6.5%)

Rubber Section:
Maximum Demand/month = 50000 Pairs
Takt time= 2106000/50000 = 42.12 sec
Current Lead time = 48.4 sec
Current Capacity = 2106000/48.4 = 43512 Pairs
Production shortage = 6488 Pcs (13%)

Current State Map

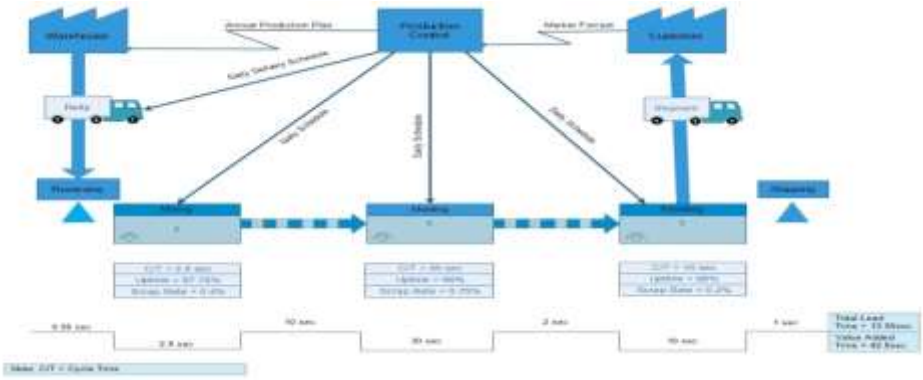

Fig-1: Current State Map of Plastic Section

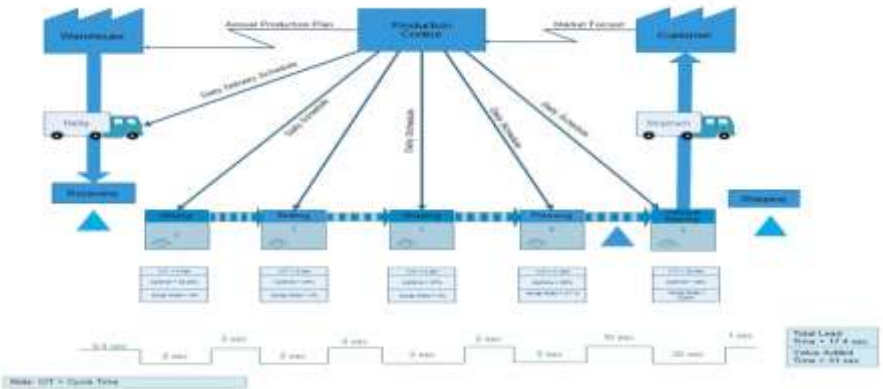

Fig-2: Current State Map of Rubber Section

RESULTS AND DISCUSSION

Waste finding & Suggestions

- *Motion*: Some unnecessary motion of workers and placement of some equipment in plastic section were observed. Workers should be instructed about their movement. Workers move the plastic sandals by themselves which waste some times. If a conveyor were used the time and movement would have reduced.
  Workers have to bend down and turn their body and sandal on assembly desk. The suggestion for new designed tool can be made where sandals can be placed and its height will be parallel to the position of the assembly section to assure good body movements.
- *Defects:* It was noticed that one machine was not working. By regular maintenance the unexpected breakdown and defects in machines can be improved.
- *Inventory:* In both sections workers use different equipment for their work purpose. The equipment's are placed in a section. According to operation type the tools are placed in a side-section. The use of "5S" can ensure improved service, safety and efficiency. 5s is a part of kaizen. Sorting and set in order can ensure better discipline in the use of the equipment. Specific tool box for each equipment can make plastic molding section better.
- There are also some ergonomic errors found in tools like chairs of the assemble section, cutting scissors. This changes can reduce fatigue of the workers and improve productivity.
- Safety measures are not fully followed. The equipment is there but workers are avoiding them due to lack of strictness. So safety manager should be placed there to ensure their safety and avoid interrupts in production.
- Some workers seem to not giving their full effort which increases the cycle and lead time. Proper motivation and reward can reduce this waste and increase production rate.
- Bata can introduce a training department for the workers. Workers can acquire knowledge about the working environment, individual performance, and safety precautions or hazards. It will increase lifetime of worker and most importantly the knowledge of the individual worker.

Future State Map

Future state map gives us the view how a manufacturing plant can operate in improved design comparing to the current situation. Improved stage of information flow, material flow and time flow are displayed in the future state map. Various lean tools to reduce waste throughout the manufacturing plant have been displayed.

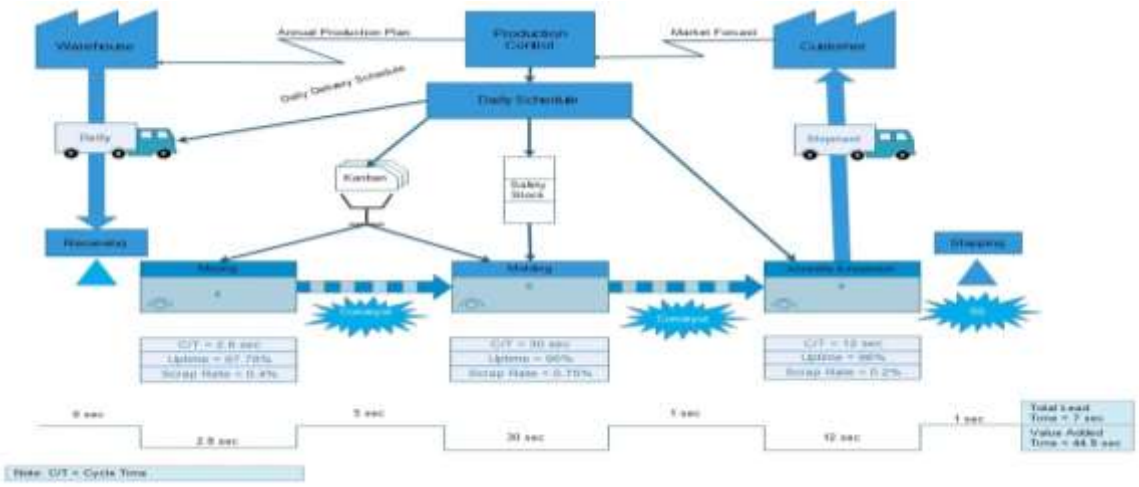

Fig-3: Future State Map of Plastic Section

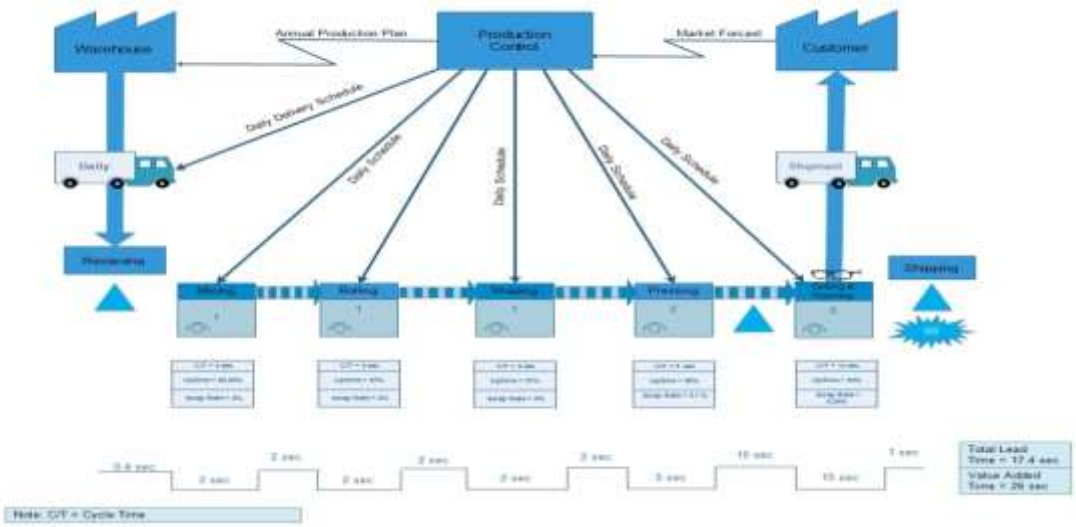

Fig-4: Future State Map of Rubber Section

In Future State Map Suggestions-

Kanban

Kanban is a system to control the logistical chain from a production point of view, and is an inventory control system. Kanban was developed by Taiichi Ohno, an industrial engineer at Toyota, as a system to improve and maintain a high level of production. Kanban is one method to achieve JIT.

Kanban on Mixing to Molding part where maximum time is needed to material flow. If Kanban posts and cards are applied, then materials will be there before the process finishes. It'll reduce the maximum time there.

Safety Stock

It 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.

The whole process will stop if the previous step does. So, a safety stock will make the production to continue during the repair time.

Kaizen

Lean manufacturing concept "kaizen" on plate preparation plant and "5S" on plastic molding section can be applied. The term Kaizen when broken down is defined as follows Kai – To take apart and make new, Zen – To think about so as to help others. You put these two words together within the Lean environment the definition of Kaizen becomes Thoughtful Acts of Continuous Improvement.

The material handling is all manual and it wastes some time. If a simple belt conveyor is applied, then the lead time will reduce and assembly will start earlier.

5S

5S is a basic, fundamental, systematic approach for productivity, quality and safety improvement in all types of business. The use of "5S" can ensure improved service and safety and efficiency. 5s is a part of kaizen. Sorting and set in order can ensure better discipline in the use of the equipment. Specific tool box for each equipment can make Finishing section a decorated one**.**

Go-See

Gathering of information through visual means. Genchi Genbutsu means "go and see" and it is a key principle of the Toyota Production System. It suggests that in order to truly understand a situation one needs to go to gemba or the "real place", where work is done. Genchi Genbutsu is therefore a key approach in problem solving. If the problem exists on the shop floor, then it needs to be understood and solved at the shop floor.

CONCLUSION

By applying the improvements lead time will be reduced and the capacity will be increased so that the maximum demand can be produced by Bata Shoe Company. The improvements are shown in the Improvement Chart below-

Table 3: Improvement Chart

Parameters	*Current*	*Improved*
Demand	40000	Fixed
Takt Time	52.56	Fixed
Lead time	56.36	51.8 *(8%)*
Capacity	37366	40656 *(8.8%)*

Parameters	*Current*	*Improved*
Demand	50000	Fixed
Takt Time	42.12	Fixed
Lead time	48.4	41.4 *(14.46%)*
Capacity	43512	50869 *(16.9%)*

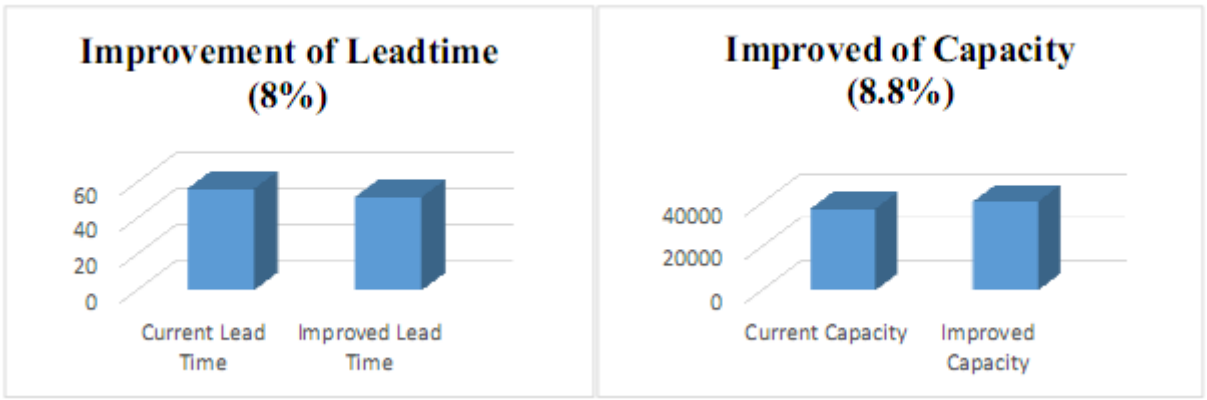

Fig-5: Improvement of Lead Time and Capacity (Plastic Section)

Fig-5: Improvement of Lead Time and Capacity (Rubber Section)

Value stream mapping has been indicated as one of the best tool for Lean Production implementation in a facility. This method is not easy to use in the case of complex production processes characterized by multiple flows that merge. For our thesis work we selected Bata Shoes Company Plastic & Rubber sandal production plant. Value stream map has proven to be effective to analyze Bata's current production state and thus recommendations are suggested.

It is feasible to use value stream map in the current situation. Applying lean tools such as Kaizen, Go-see & 5S- turn out to be helpful for better material and information flow throughout the production system

and can reduce overall value added time. Thus, daily producing more products and fulfilling customer demand in satisfactory manner. We recommend Bata to use our team efforts and to utilize the methods suggested during the project.

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