Study Value Stream Mapping in Cylinder Block Line: A Case Study

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Abstract— To survive in today's competitive business world, companies require small lead times, low costs and high customer service levels. Lean manufacturing program is being followed by various industries in the recent year which mainly focuses on improving the efficiency of operations by reducing wastes. Value stream mapping (VSM) technique has been used on a broad scale in big companies such as Toyota and Boeing. This work considers the study of value stream mapping technique in MAN Trucks Private Limited, Pithampur. The targeted product is cylinder block. It focuses on product family, current state map preparation, proposed improvements and future state map. The achievements of value stream implementation are reduction in lead time, cycle time, inventory level and improvement in productivity.

Key words: Value Stream Mapping (VSM), Cylinder Block Line

I. INTRODUCTION

This research study has been conducted on one of the emerging issues of every industry in present scenario i.e. "Lean Philosophy", the case company in this study is a multinational company "MAN Trucks Private Limited" with a plant at Pithampur (M.P.) that produces trucks for the Indian market and for export to countries in Asia and Africa since 2006. The targeted product is 'Cylinder Block' and the research is completed in context of machining with the help of one of the Lean Tools i.e. Value Stream Mapping (VSM).

Eiji Toyota and Taichi Ohno at the Toyota Motor company in Japan pioneered the concept of the 'Toyota Production System', or what is known today in the US as 'Lean Manufacturing'. Lean is a continuous improvement process designed for long term maximization of company resources. It utilizes techniques and principles that improve efficiencies of Value added activities. The basic idea behind the system is eliminating waste [Ohno T 1988]. Waste is anything that does not add value to the end product from the customer's perception. The primary objective of lean manufacturing is to aid manufacturers who have a desire to improve their company's operations and become more competitive through the implementation of different lean manufacturing tools and techniques.

Lean manufacturing program is being followed by various industries in the recent year which mainly focuses on improving the efficiency of operations by reducing wastes. Value stream mapping is one of the tools of lean manufacturing. By value stream mapping we identify wastes occur in present production line. Industries which are wants to become lean for those types of industries value stream mapping is best way to implement lean manufacturing. Value stream mapping is powerful tool which highlights process inefficiencies as well as improvement guidance. Value stream mapping is combination of all actions value added as well as non-value added. Value stream mapping shows material flow, information flow etc.

II. LEAN MANUFACTURING

Lean Manufacturing is an approach for achieving manufacturing excellence based upon the continuous elimination of waste, hence has increasingly been applied by leading manufacturing companies throughout the world. It has proven to have many positive outcomes which include such concepts as reduced cycle time, decreased cost, reduction of defects and waste. Lean manufacturing aims to achieve the same output with less input such as less time, less space, less human effort, less machinery, less material and less cost. To better understand lean manufacturing, one first needs to understand the basic principles that guide it.

Some major lean manufacturing principles include recognizing wastes, having standard processes, having continuous improvements [Rother M., Shook J. 1999].

Some of the lean tools are Single Minute Exchange of Die (SMED), Just in Time, Value Stream Mapping, Total Preventive Maintenance And Total Quality Management. When one member of the supply chain becomes lean, other members in the process also have to be lean, in order to reap the benefits. Thus VSM is a powerful tool to spot where the waste is and in the supply chain the actions have to be taken to be efficient. Lean Manufacturing practices have the main objectives as to improve overall productivity, equipment performance, product quality and personal cost, [Womack, J.P. et. al. 1990].

III. VALUE STREAM MAPPING (VSM)

Value Stream Mapping, a lean manufacturing tool, used to visualize where the waste is present in the whole stream from the supplier's raw material delivery till delivering to the end customer. It is a collection of all activities both value added and non-value added that are performed to produce a product. It is also a tool used to identify which lean technique has to be used to cut down the wastes and be more productive [Rother M., Shook J. 1999]. Taking a value stream view means looking at the whole picture, not just individual processes and improving the whole, not just individual parts. Value Stream Mapping is a tool that helps to see and understand the flow of material and information as a product makes its way through the value stream. The meaning is simple: by following a product's production path from customer to supplier, draw a visual picture of every process in the material and information flow. Within the production flow, the information flow must also be considered with material flow since it tells each process what to make or do next, both flows must be mapped.

A typical VSM project involves the development of maps;

1) A Current State Map.
2) One or more Future State Maps thet represent progressive improvements in the Current State Map.
3) Implementation phase.

IV. LITERATURE REVIEW

M. Kishore Kumar et. al. (2014) in their paper "Application of Lean Manufacturing in Mass Production System: A Case Study in Indian Manufacturing Unit" illustrates the application of lean manufacturing to minimize the setup time, cycle time of a reputed manufacturing industry in India. A detailed description of each step of the process is given and is illustrated the results from a case study undertaken during the research. This article focuses on lean manufacturing tools like value stream mapping, method study, and its implementation. It will decrease the current lead time by fifty percent. It also proposes and comes out with measures to improve current operations within the company.

K.C. Ng et. al. (2013) in their paper "Elimination of Waste through Value Add/Non value Added Process Analysis to Improve Cost Productivity in Manufacturing - A Case Study" presents the implementation of VSM in a semiconductor manufacturing company to optimize headcount and improve personnel efficiency in the production lines. Based on the future state of the value stream mapping a new production process flow was implemented. Non value added activities were reduced by assigning these tasks to butterfly operators to perform.

V. SUMMARY OF LITERATURE

Value Stream Mapping (VSM) is used for quick analyses of product flows through a manufacturing system, from raw material to delivery. VSM is a mapping tool that maps not only material flows but also information flows that signal and control the material flows.

From preceding literature reviews VSM proved as an efficient technique of lean that offers advantages with respect to other mapping techniques of lean are summarized as:

1) It shows the link between information flow and product flow.
2) It takes account of information related to inventory levels as well as to production time.
3) It helps to visualize the production process at the plant level, not just at the single process level.
4) It links demand forecast and products planning both to floor shop control and to production scheduling, using operating parameters such as Takt time which determines the production rate at which each processing stage in the manufacturing system should operate.
5) It makes decisions about the flow evident and enabling people to discuss them.
6) It gives managers and employees a common language to communicate.
7) It constitutes the basis of a well-structured implementation plan.

The proper method for data collection should be used, and to apply Value Stream mapping effectively one should not rely on the standard times or information that is not obtained personally. Limitations made some researchers enhance VSM using simulation to consider the dynamic behaviors. Computer simulation is a powerful analysis tool that helps companies to make effective changes because the companies can accurately predict the results of the changes prior to making them. Also, Discrete Event Simulation (DES) is often used for analyses of complex manufacturing systems with several products and a complex planning.

VI. OBJECTIVE

The thesis addresses the application of Value Stream Mapping a lean manufacturing technique for the continuous production/process and ability to meet the Takt time, by reducing lead time in the machine shop (MAN Trucks private limited, Pithampur).

The aim is:

1) To study various lean manufacturing techniques.
2) To achieve process optimization through:

– Identification of Bottleneck operations and actions to remove bottleneck.
– Identification and elimination of all forms of waste.
– Standardization of Inventory for the process.
– Standardization of lead time.

Based on these goals, the objectives of this research are:

1) To model the material and information flow of cylinder block line using value stream mapping (VSM) approach.
2) Analysis of each process activity by dividing it into various sub activities and identifying possible remedies, elimination of bottleneck and optimization of processes.

To model the future state of VSM tool using various technique of lean thereby reducing the production lead time.

VII. METHODOLOGY/PROCEDURE

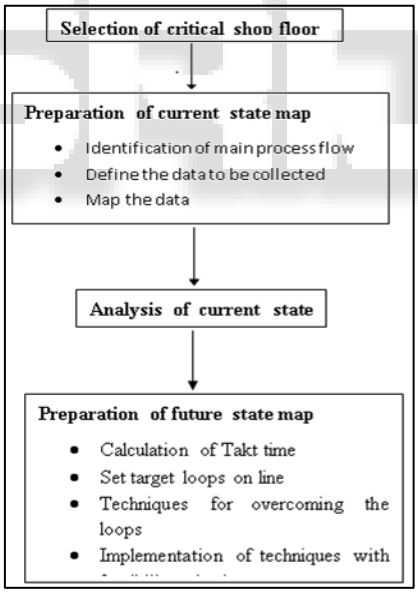


Fig. 1: Steps of Value Stream Mapping

VIII. RESULTS

Assumption is made during data collection for each component that is batch size is considered with same component and no mix match is taken for common work stations.

Available work time is determined as follows:

– Total available time per shift (10 hr.) = 600 min
– Lunch time decided by management = 30 min
– Thereby, available work time can be calculated as: 600 min – 30 min = 570 min (9.5 hrs)
– Hence, available working hours per day = 9.5 hrs

– Daily forecasting demand of cylinder block = 14 pieces

$$\text{Takt Time} = \frac{\text{Net available Production time}}{\text{Demand from Customers}}$$

As the net available production time is 570 min per shift and the demand is 14 pieces per shift. Therefore,

Takt Time = 570/14
= 40.71 min

For simplicity takt time is taken as 41 min.

Ideally, Takt time gives the rate of production meaning that one product must be delivered or come out of the line at every 41 minutes. For a balance line, product could be completed at each workstation with a regular time interval of 41 minutes. But in reality, total production time is longer than that, also the time at each work station varies according to the type of process and this is applicable for every line whether it is semi finish or finish line. Also, ideally the waiting time in between the work stations should be zero.

When the cycle time of each process is compared with the Takt time, it is found that all the CNC operations in Semi Finish line and washing operation of cylinder block in Finish line have cycle time more than takt time, and all the remaining processes have cycle time in accordance with the takt time.

Current Value Stream Map is prepared with the help of EDRAW MAX 8.6 software. The current value stream maps for semi finish line and finish line are given in Fig.2 and Fig 3.

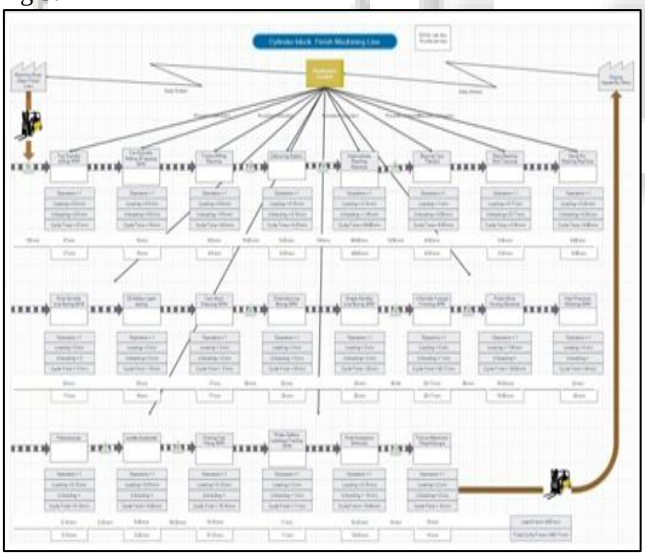


Fig. 2: Semi Finish Line Current State Value Stream Map

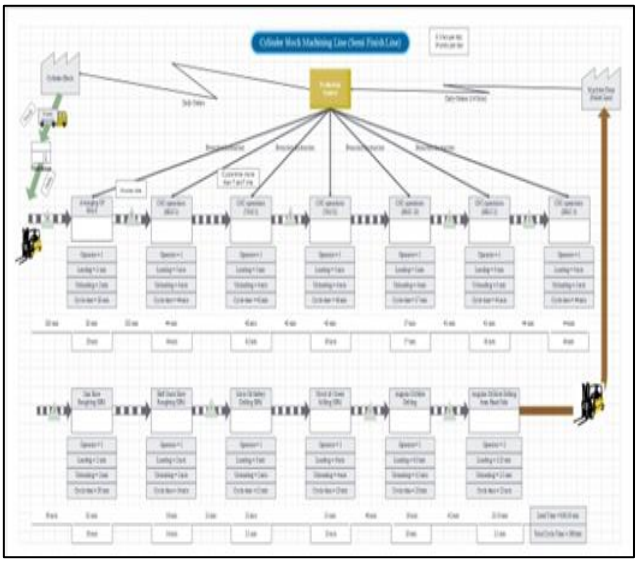


Fig. 3: Finish Line Current State Value Stream Map

Analyses of all the processes are done in depth and useful information like process ratio of engine block is considered in both semi finish and finish line of machine shop so as to find the loophole/gap areas in the value stream. The table: 1 summarizes the efficiency/process ratio for both finish and semi finish lines. The time is taken in minute.

The value added and non- value added time is shown in the pie chart given in Fig.4

The problems identified in the machine line are as:

A. In Semi Finish Line

1) All the CNC operations in semi finish line have cycle time much more than takt time, as the machining is done by CNC not manually therefore to reduce the cycle time loading and unloading time for cylinder block on these machines can be reduced.
2) The cycle time on BFW HMC 1 machine is 44 min, and cycle time on Averaging machine is 20 min. The operator on averaging machine performs averaging on a batch of 6 cylinder blocks and then remains idle for the time the inventory accumulated between the Averaging machine and BFW HMC 1 machine. Hence, to reduce the work in process on some other machine, it is justified to allot him work on that machine.
3) Some of the machines in semi finish line such as Cam bore roughing SPM, Half crank bore roughing SPM, Angular hole drilling machine are cleaned for chips by keeping work in process inventory even though the machines can be cleaned when it is idle.

Machining Line	Production Lead Time	Value added time/work content	Non Value-added time	Process Ratio (% value added time)
Semi finish Line	890.50	386	504.50	43.35
Finish Line	837	348.17	488.83	41.60

Table. 1: Calculation of Ratio for Each Process

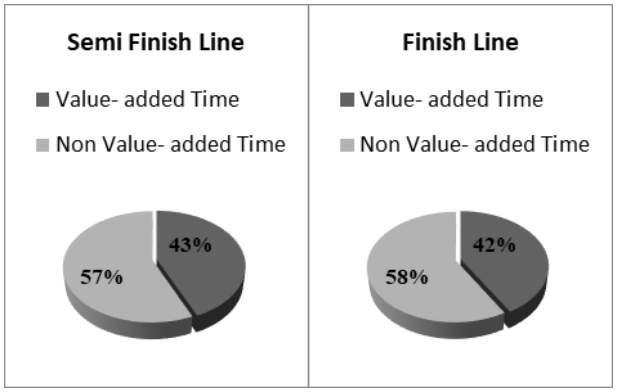


Fig. 4: Pie Chart for VA & NVA Time for Semi Finish & Finish Lines

B. In Finish Line

1) The only bottleneck operation in finish line is the Intermediate washing of cylinder block by Intermediate washing machine. This operation has a cycle time of 46.68 minutes i.e. much more than takt time of 41 minutes. The Intermediate Washing Machine is the Pacemaker Process.
2) The defect for casting is visually inspected at the deburring station, and if there is a block found with casting defect, it is rejected. The machining time before the rejection of the block lost. Average number of blocks rejected due to casting defect is 2 per week. The block should be inspected at the start of the machine line.

Corrective Suggestions to the company are as follows:

A. For Semi Finish Line

1) The operator working on averaging machine can also work on half crank bore roughing SPM after averaging of a batch of 6 cylinder blocks. It will reduce the work in process on cam bore roughing SPM.
   A FIFO lane is used between Averaging machine and HMC1 machine with a maximum of 6 pieces capacity.
2) The loading and unloading on CNC machine should be automated (robotic arm) so that the manual work taking extra time on CNC machines HMC 1, VMC 1, VMC 2 and HMC 10 (expected time saving: approx 4 min for each CNC machine), and CNC machines HMC 3 and HMC 2 (expected time saving: 5 min each) can be reduced.
3) Machines such as cam bore roughing SPM, Half crank bore roughing SPM, angular oil hole drilling machines (from crank bore side & head side) should be cleaned for chips when machine is idle.

B. For Finish Line

1) The Intermediate Washing machine is divided into 9 zones and after the cleaning option in every zone it has an option to load another block to be cleaned in first flood cleaning zone while the previous block will enter into the next zone for cleaning. Therefore the washing machine can be treated as 9 different processes. So, if the inventory before the Washing machine is maintained such that to provide a cylinder block to load after every cleaning zone operation, the machine operation can be synchronized with takt time.
   The Intermediate Washing Machine is the Pacemaker Process. The push system between deburring station and Intermediate Washing Machine can be converted into pull system. The Intermediate washing machine should pull the blocks only when a minimum of six cylinder blocks are available to wash.
2) The block should be inspected at the start of the semi finish line. The operator working at the averaging machine has idle time, so he can inspect the block for the casting defects at the start.

On the basis of above suggestions the expected future state map is developed as given in Fig. 5 and Fig. 6

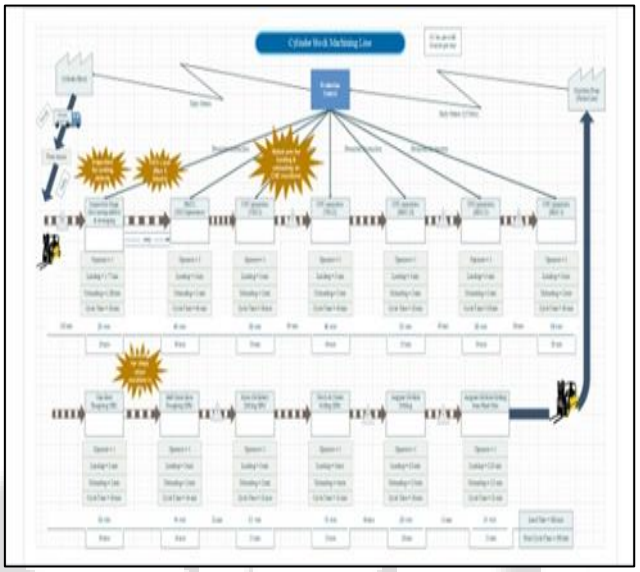


Fig. 5: Semi Finish Line Future State Value Stream Map

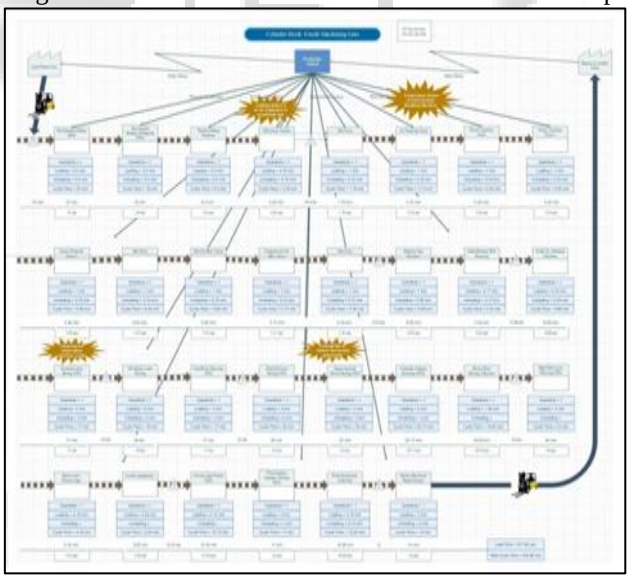
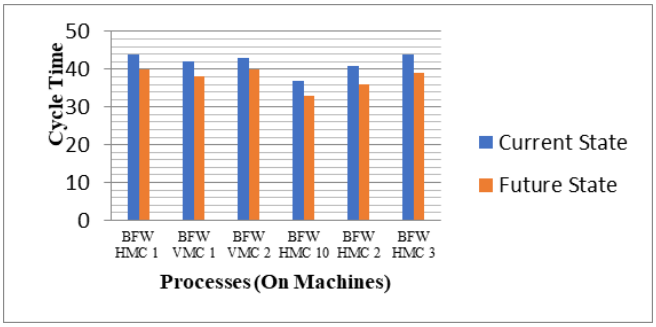


Fig. 6: Finish Line Future State Value Stream Map

On the basis of Future State Maps., the Fig. 7 gives a comparison of cycle time before and after implementation of the improvement techniques i.e. for the current and for future state as well. (For the machine processes which had cycle time more than tact time)



Calculation of Total Lead Time directly depends on two parameters the cycle time and the inventory for each work station. With reduced cycle time and ideal condition of inventory for each process the reduction observed in lead time is summarized in table: 2.

Machining Line	Lead Time (in min)		Percent Reduction
	Current	Future	
Semi Finish Line	890.50	682	23.41
Finish Line	837	617.92	26.17

Table 2: Comparison of Current & Future State Lead Time

IX. Conclusion

The satisfactory results of implementation of VSM in manufacturing proved that it is feasible to reduce the current lead time up to 23.41% for semi finish line and 26.17% for finish line and an average reduction in lead time for overall machining line is about 24.75%. This could further enable an accurate supply of component for assembly and current demand can be achieved. The increase in process ratio can finally reduce the cost of machining of the block to a great measure.

Suggestions to the Company:

1) Proper utilization of workers in semi finish line, due to optimization of machines the workers should not be idle.
2) The pushing of inventory in finish line at intermediate washing machine should be converted to the pulling system to optimize the finish line.
3) The necessary non- value added activities such as cleaning of machine for chips should be performed when machine is idle.
4) Provide training of time management between machines to a worker. Because highly deficiencies of time management in workers to operate many machines.

X. Future Scope

1) The CNC machine tools have the scope to be redesigned to reduce the machining time, and to improve the process quality.
2) Application of various line balancing techniques and other industrial techniques like Group technology can be the future research to improve the productivity in machine shop.
3) Application of VSM simulation software can be the area of future studies so as to provide authentication to the outcomes and search out for the possibilities by altering variables.

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