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# Lean Approach in Modulator Valve Manufacturing Through Value Stream Mapping

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**Abstract:** The globalization of Indian economy is creating both opportunities and challenges for innovative enterprises, forcing them to make radical improvements, not only to compete and prosper but also to survive. Lean thinking is considered as a successful business strategy which employs minimization of process variability and non-value added activities (waste). Lean manufacturing is a systematic approach for identifying and eliminating waste (non-value added activities) through continuous improvement by flowing the product at the pull of customer in pursuit of perfection. Value Stream Mapping (VSM) is one of the strong tool in a lean kit. A value stream map provides a blue print for implementing lean manufacturing concept by illustrating how the flow of information and material should proceed. The objective of this study is to minimize the non value added activities, work in process inventory and lead time of the product by balancing the TAKT Time of individual operation to the demand of the market through implementation of Future Value Stream Mapping (FVSM).

**Key words:** Lean manufacturing, TAKT Time, Value Stream Mapping (VSM), lean approach, process

## INTRODUCTION

The present manufacturing system has been shifted to modern manufacturing such as lean, agile, sustainable manufacturing and fit manufacturing for getting break through performance. Lean Manufacturing System is designed to create efficient processes by utilizing the resources in an optimum manner. Lean manufacturing focuses on the elimination of wastes from the organization. A waste is defined as anything that does not add value to the product. Nowadays market is becoming more volatile day by day, so understanding market dynamics is a crucial factor for those who wants to design manufacturing systems better (Gadalla, 2010). Lean manufacturing believes the simple fact that customers will pay for the value of services they receive but won't pay for mistakes (Rawabdeh, 2005). When lean manufacturing implemented successfully, it results in an increase in production output per person and a reduction in the finished goods inventory and work in process inventory (Seth and Gupta, 2005). It reviewed that the practice of lean manufacturing concept based on the comparison of various model and proposed a review model (a seven step procedure) to infuse the lean concept by Paranitharan *et al*. (2011). The most important tools of lean manufacturing are Value Stream Mapping (VSM), 5S, TPM, Single-Minute Exchange of Dies (SMED), Kaizen, Kanban and Six Sigma, etc., focused to certain aspect of manufacturing process for eliminating waste, to improve quality, to reduce the cost and quick response to the customer needs. Kumar and Abuthakeer (2012) discussed the implementation of lean tools and techniques in an automotive industry exclusively SMED concept in air conditioner evaporator core and conclude that the complete success of the application of lean practice depends on close team work between the shop floor personnel and top management. An effective methodology for implementing lean manufacturing strategies and leanness evaluation metric by Continuous Performance Measurement (CPM) in terms of efficiency and effectiveness of the organization for establishment of lean culture in manufacturing organization (Karim and Arif-Uz-Zaman, 2013). Ghosh (2013) has reviewed that the practice of lean adoption in Indian manufacturing industry and found its practice mainly by influencing on operational performance. Moreover, the results highlight that do it right at first time with right products, reduced lead time and increased productivity are the three main drivers of lean implementation. Dessens and Lopez (2011) focused value stream mapping is a key tool for improving and redesigning manufacturing system to become more competitive, flexible and efficient. Czarnecki and Loyd (2001) defined the various tools of lean manufacturing in which VSM is one among the tool that is used to

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represent the business process graphically and looking for ways to streamline inventory, waste and production time. According to Chen and Meng (2010), VSM is a suitable lean tool that realized the kaizen concept to meet out the competitive requirements. Singh *et al.* (2010) intended that VSM is a supportive tool in lean implementation and to develop the road map for improvement and also bridge the gap between existing and proposed mapping of manufacturing unit for becoming a highly responsive to customer. Singh *et al.* (2011) have studied that the change over time is very high at turning operation of piston pin assembly operation and they proposed the concept of SMED to synchronize the work station cycle time with TAKT Time for streamline the operations to fulfill the market condition. Grewal (2008) proved that the implementation of proposed FVSM leads to reduce the lead-time, cycle time and inventory level in bicycle manufacturing industry. Sahoo *et al.* (2008) insisted that VSM is a substantial one among the various tools of lean manufacturing for achieving the effectiveness of lean principle in a systematic manner. However, lean tool is the principle application of lean thinking process that are been broadly accepted by many manufacturing operations and have been applied successfully across many disciplines (Poppendieck, 2011). Seth *et al.* (2008) identified and addressed various waste in the supply chain of the edible cotton seed oil manufacturing processes by using a VSM approach, to reduce the lead time periods from 244-124 days and increased productivity through capacity utilization in optimum manner. Singh and Sharma (2009) explained that how Value Stream Mapping (VSM) is useful to lean implementation, to develop the road map for minimizing the lead time, to work in process inventory and reduction in manpower requirement in crank shaft gear manufacturing unit. Vinodh *et al.* (2010) highlighted that Value Stream Mapping (VSM) is more supported for enabling leanness practice in Indian camshaft manufacturing organization. Further, they conclude that VSM is an effective lean manufacturing technique which could be deployed in industrial scenario for enabling leanness for achieving competitiveness. According to Xie and Peng (2012), Value Stream Mapping (VSM) is used in operating room in a hospital for reducing patient waiting time and increasing the resource utilization by effective implementation of integrated VSM and Agent-Based Simulation (ABS) in human-centered healthcare environments. Jeyaraj *et al.* (2013) explained how VSM concept is supportive in lean implementation and allows the industry to find out the bottlenecks in rear front pedestal manufacturing process and continuously improve the performance of the system by means of lean principles. The purpose of this study is to provide a road map to illustrate how value stream mapping is used to design a desired future state mapping aligned with lean thinking principle in manufacturing of modulator valve in automotive industry.

## PROBLEM FACED BY THE COMPANY

XYZ industry is one of the leading suppliers of automotive components in India. They manufacture automotive brake components like brake chamber, actuator and Antilock Braking System (ABS) for automobiles. The modulator valve is supported in anti-lock braking system in heavy vehicles which is used to regulate the air flow during braking. The productivity and delivery of the modulator valve is low due to high non value added activities in the existing flow of modulator valve in anti-lock braking system. In this study, productivity as well as lead time period of modulator valve can be improved by implementing lean approach through value stream mapping in the industry. A case study is carried out in XYZ Company.

## METHODOLOGY

Mapping can be drawn in the form of current and future states and it shows how material and information flows from raw material suppliers through manufacturers to the customers. There are various steps which are involved in building effective way of value stream mapping for manufacturing operation. It is shown in Fig. 1.

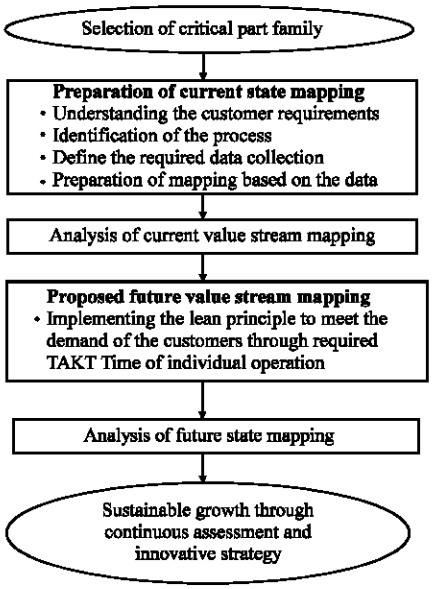


Fig. 1: Methodology of constructing value stream mapping

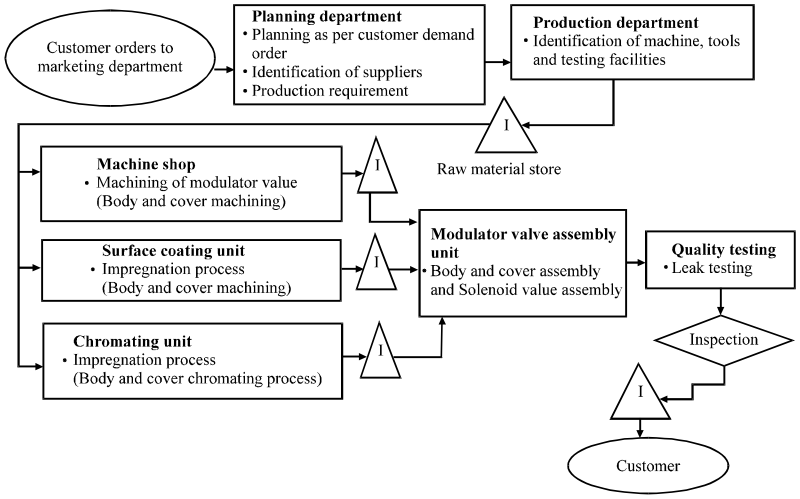


Fig. 2: Process flow of modulator valve manufacturing

**Selection of critical product family:** The foremost step in this methodology is selection of the critical product from various data analysis of the company. In this research, the researchers selected a modulator valve for value stream mapping analysis. The modulator valve is used in automotive brake system and the process flow of modulator valve is shown in Fig. 2. The modulator valve is assembled with supporting parts of solenoid and coil cover assembly directly from raw material supplier.

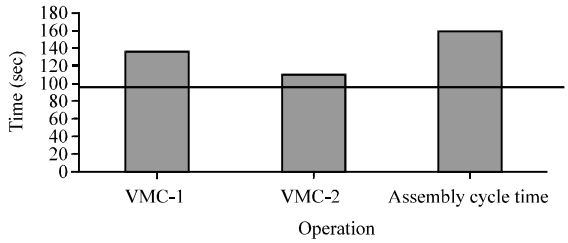


Fig. 3: In-house bottleneck time to TAKT Time

**Preparation of current value stream mapping:** After selecting a critical part, the next step is to draw a current state mapping of the existing process. Current state mapping has been prepared for identifying the bottlenecks in the existing modulator valve manufacturing process. The relevant data are collected for constructing current state mapping according to Rother and Shook (1999). In modulator valve operation, raw materials are moved from stores to machine shop for performing machining operation namely grooving, spot facing and drilling in Vertical Machining Center (VMC-1) and Vertical Machining Center (VMC-2). After machining, the product is shifted to surface protection unit to increase their strength through autoclave and rinsing operations. Then, the product is moved from surface protection unit to chromating unit where as wear resistance and corrosion resistance increased by rinsing, dismutting and scaling operations. Further the product moves to assembly workstation. The main assembly operation consists of various sub assemblies namely body and cover assembly, Solenoid valve assembly and coil cover assembly. Then, it moves for these assemblies one by one for tagging them in order to get complete assembly product and finally it is moved to quality inspection. The product accepted after quality inspection is moved to warehouse place in different locations. The in-house bottleneck time of modulator valve has identified under construction of current value stream mapping, shown in Fig. 3. The production lead time and value-added times of current state mapping are noted. The current value stream mapping provides an opportunity to identify the gap between the demands of customers and manufacturing TAKT Time of individual bottleneck operations. The detailed current value stream mapping of modulator valve is shown in Fig. 4.

**Analysis of current state mapping:** In the existing modulator valve of manufacturing process, the TAKT Time of individual machining operation is identified as high and the usage of men and machines are low, these lead to increase the production cycle time. Since, a proposed value stream mapping is developed which is based on a lean cell that leads to minimize the TAKT Time of individual machine operation and increase the output by effective utilization of men and machine process:

- Number of working days per month = 27
- Number of shift per day = 2

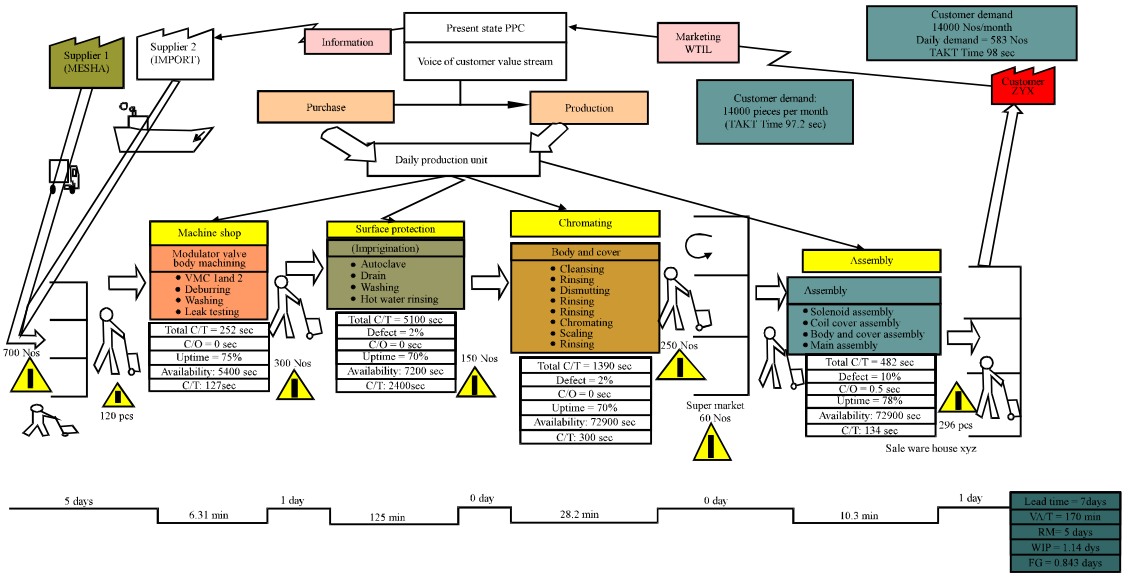


Fig. 4: Current state value stream mapping of modulator valve

- Available time per shift = 7.30 h
- Customer demand per month = 14000 Nos.

$$\text{TAKT Time} = \frac{\text{Available working time}}{\text{Customer demand}}$$

$$= \frac{27\times2\times7.30\times3600}{14000}$$

$$= 98 \text{ sec/product/shift}$$

Regarding the demand for modulator valve, it may reach up to 14000/month and these are derived from past sales data and experience and actual working hour is 7.30 h per shift, number of shift is 2 per day. The customer demand flows from marketing to planning department and the material requirement has planned and communicated to various raw material suppliers through electronic media telephone. The information to current value stream may vary from one shift to another shift and also operator variation is not considered during this study. In this case, the company maintains raw material inventory which is 70 h in stores and actual processing time with value addition is about 170 min. The lead time of current value stream is 7.01 days and it is observed that the first component of modulator valve is waiting for getting value addition at an average of 2.83 h in total lead time (from raw material stage to warehouse).

**Proposed future value stream mapping:** The proposed Future Value Stream Mapping (FVSM) has been prepared and insists that raw material inventory has to be maintained 15.4 h per shift in store for avoiding the ideal storage of material by introducing Kanban System to enhance the material flow of work in process inventory and by improving the process of system. In Vertical Machining Center-1, Talk Time of individual machining operation is not balanced due to high setup time in spot facing and grooving operation, carried out by two different operations of two different tools. This lead to high change over time for each component and it can be reduced by using combined single spot facing tool (performing two different spot facing operations simultaneously) and combined single grooving tool (performing two different grooving operation simultaneously). In Vertical Machine Centers (VMC-1 and VMC-2), modular fixture is preferred instead of conventional fixture in body and cover machining operation for reducing the change over time of each operation. However, it leads to minimize the overall lead time of product through meeting the balanced talk time of in-house bottleneck. The new generating tool is proposed instead of conventional drill for minimizing the cycle time of drilling operation in VMC-2. This reduce operation cycle time by half the existing cycle time and thus machining bottleneck time are balanced to meet the required talk time. For improving existing machining layout in VMC-1 and VMC-2 have operated as a separate cell and it consume high lead time of operation during handling of product from one machine (VMC-1) to another machine (VMC-2) can reduce by combining VMC-1 and VMC-2 as a single cell. During existing assembly layout, assembly operation consist of various sub assemblies to complete final assembly of the modulator valve, among the various sub assemblies; solenoid valve assembly takes much amount of time to complete task than the

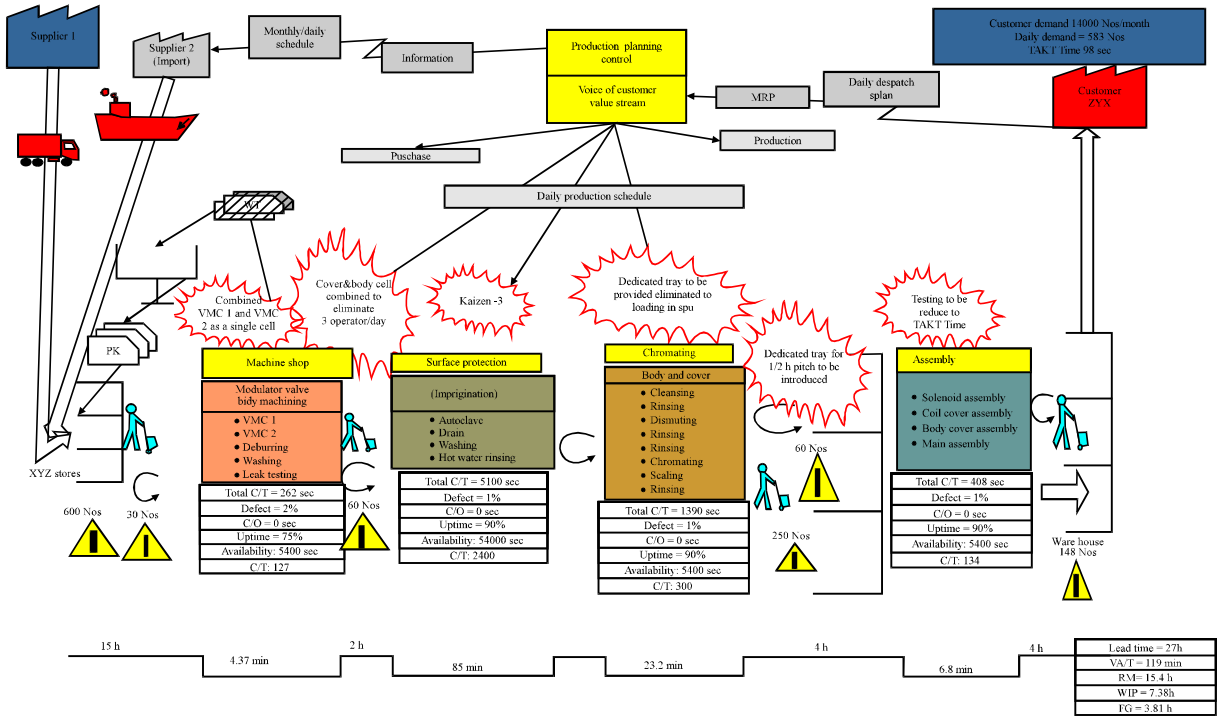


Fig. 5: Future state value stream mapping of modulator valve

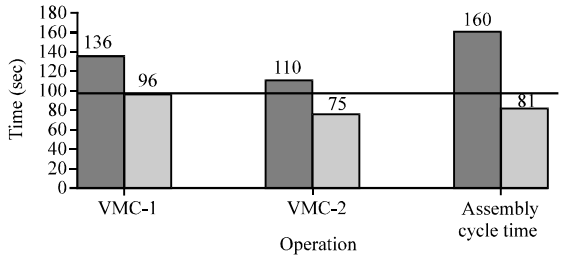


Fig. 6: Balancing of bottleneck time to TAKT Time

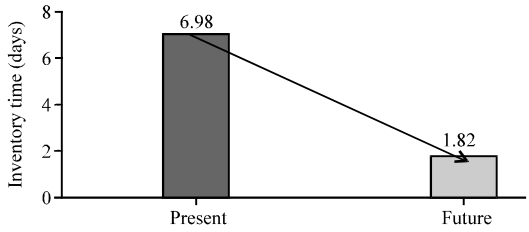


Fig. 7: Comparison of inventory time

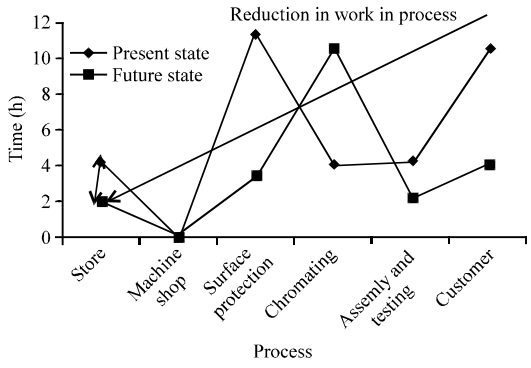


Fig. 8: Comparison of work inprocess inventory time for each process

manufacturing TAKT Time. Here, solenoid assembly operation task split into two stages for balancing the manufacturing TAKT Time to meet out the lead time of customer demand and the improvements made in modulator valve manufacturing are proposed in FVSM as shown in Fig. 5.

**Analysis of proposed future state mapping:** The analysis of proposed state mapping shows the improvement that is made by introducing lean principle and techniques in order to achieve the objectives of mapping. And the in-house bottleneck time are balanced to TAKT Time are shown in Fig. 6. In this case, total inventory (raw material, work in process, finished goods) is reduced from 6.98-1.82 days as shown in Fig. 7. Highly demanded product at XYZ Company is easily achieved with proposed changes and lead to significant cost reduction and improve in quality product. Higher process ratio of proposed changes attained less value addition to complete the product. The reduction of work in process inventory time reduction between each process is shown in Fig. 8. And improved performance of lean system is

Table 1: Comparison of existing VSM and proposed VSM

| Improved utilization | Before implementing future VSM | After implementing future VSM | Improvement (%) |
|---|---|---|---|
| Vertical machining center 1-bottleneck time (sec) | 136.00 | 96.00 | 29.41 |
| Vertical machining center 2-bottleneck time (sec) | 110.00 | 75.00 | 31.81 |
| Assembly bottleneck c time (sec) | 160.00 | 81.00 | 49.37 |
| Process ratio (%) | 2.88 | 7.89 | 36.56 |
| Customer end line rejection (defects) | 4.00 | 0.00 | - |
| Lead time (days) | 7.01 | 1.78 | 74.60 |
| WIP inventory (days) | 6.98 | 1.82 | 74.00 |
| Output per hour (Nos) | 28.00 | 40.00 | 30.00 |

expected to increase their product output per hour from 28-40 Nos. The value addition of product is improved by suitable tools and technique by reducing non-value added activities to achieve higher value addition of product with lesser time and is from 170-118 min. The entire operation of a modulator valve in the value stream is achieving quality products by reducing defects at the customer end (internal and external customer). This approach in modulator valve cell produce a zero defect product. And all the process of implementation is continuous monitoring towards further scope of improvement. The improved result that has to be obtained after implementing lean manufacturing tools and techniques by comparison of the present and future state mapping is given in Table 1.

**Sustainable growth through continuous assessment and innovative strategy:** In this phase after analyzing proposed future state mapping by implement suitable kaizen to eliminate waste (removing bottlenecks) to achieve quality, flexibility and speed are commonly required. And the process can be improved by rearranging the layout to eliminate large amount of inventory between operations, parallel process to increase the capacity and minimize non-value added activities to decrease cost and reduce lead time. After implementing the lean tool for waste reduction technique is continuously reviewed and finding the opportunity for further continuous improvement in process of value stream. The continuous improvement of process is to meet the customer at reduced manufacturing TAKT Time. And, it helps the companies to reach their ultimate goal of sustainability and profitable growth in the future.

## CONCLUSION

The sources of waste and potential benefits of the current state mapping realized by implementing future state value stream mapping of modulator valve and helping the managers to do the process activity in the finest manner. In future state mapping, the modulator valve lead time period is reduced from 7.01-1.78 days. Lean manufacturing is a highly productive way of manufacturing. Lean thinking consists of a body of best practice whose primary aim is to reduce non value added activities and focus only on those activities which add value for customer. Value stream mapping is an extremely valuable tool in lean manufacturing for enhancing the value added activities in manufacturing processes. Researchers have used the value stream mapping concept in a reliable manner to modulator valve of antilock brake system in automotive industry. The future state mapping of modulator valve production line is useful in all aspects.

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