Application of Value Stream Mapping in an Indian Automotive Industry: A Case Study

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Abstract: Lean manufacturing has become important tool in the era of globalization and competition. Everyone is trying to give the product with more values and competitive prices for which “Lean” (Manufacturing without Waste) has proved its importance. Implementation of lean manufacturing needs various tools and techniques, and Value Stream Mapping (VSM) is of them. A major activity in the journey towards lean is the effective management of the flow of products and services through the series of the activities involved in providing value to the customer, known as the value stream. This requires a detailed understanding of all the processes involved so that non-value-added activities can be identified and eliminated. Value stream mapping (VSM) is a technique that can aid in developing this required knowledge. This paper covers the scientific way followed at shop floor for carrying VSM at Gabriel India Ltd. (GIL) Nashik (India) where Lean manufacturing has been implemented successfully. It has resulted in reduction in WIP, Smooth Production flow to meet customer demands, Stress free operations. The said organization is one of the Leading producer Shock absorbers and Front forks for OE customers as well as AM Requirements in Domestic and Export Market.

Keywords: Value stream mapping, present state map, future state map, workcell

1. INTRODUCTION

Lean production is a systematic approach to identify and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection. It is a whole new way of thinking and should be considered much more than a series of programs or techniques and become the whole system approach in order to create a new operating philosophy, which focuses on eliminating all non-value adding activities from order entry to receipt of payment. Lead time and work-in-process reduction, quality improvement, enhanced flexibility, reduced transactions, simplified scheduling, improved communications, reduced costs, better on time deliveries, increased sales and improved space utilization are all possible through the effective planning and implementation of lean production. The basic feature of it is to remove all types’ wastages Table 1.

<table>
<thead>
<tr>
<th>Table 1 Cont’d</th>
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<tbody>
<tr>
<td>2 Transportation</td>
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<td>3 Waiting</td>
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<td>4 Processing</td>
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<td>5 Inventory</td>
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<td>6 Unnecessary Movement</td>
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<tr>
<td>7 Defective Product</td>
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</tbody>
</table>

Lean production is a team based systematic approach to identify and eliminate wasteful or non-value adding activities within an organization. In order to identify waste on non-value adding activities in a manufacturing unit, it is required to map current state so that to visualize both value-added and non-value-added activities. A value stream mapping is defined as all the mapping of value-added and non-value-added actions required...
bringing a specific product, service or combination of products and services to a customer, including those in the overall supply chain as well as those in internal operations [8].

As categorized by Womack and Jones [11], the main tenets of lean are:

**Value:** Providing the customer with the right product, for the right price, at the right time

**Value Stream:** The set of action that bring a product from concept to realization, order to delivery, or raw material to finished good

**Flow:** Seamless movement through value-creating steps

**Pull:** Acting only to satisfy customer needs, rather than forcing, or pushing, a product upon the marketplace

**Perfection:** Continuously and relentlessly improving the value, value stream, flow, and pull in business operations

The objective of this paper is to use a case-based approach to demonstrate how lean manufacturing tools when used appropriately, can help the auto industry to eliminate waste, maintain better inventory control, improve product quality, and obtain better overall financial and operational control.

2. A CONDENSED HISTORY OF LEAN MANUFACTURING

To help increase company profits U.S. manufacturing companies have always searched for efficient strategies that will help improve their output, reduce costs and establish a competitive position to increase their market share. Early attempts can be traced to Eli Whitney and Henry Ford.

Japanese manufacturing leaders like the Toyota Motor Company’s Eiji Toyoda, Taiichi Ohno, and Shigeo Shingo developed a smart disciplined and process focused production system now known as the Toyota Production System (TPS), or lean production. Which incorporated The Ford production, Statistical Process Control and other techniques into a system that minimized the expenditure of resources that added no value to the product?

In 1990 James Womack wrote a book called “The Machine That Changed The World”. Womack’s book was a straightforward account of the history of automobile manufacturing combined with a study of Japanese, American, and European automotive assembly plants. The “lean manufacturing” theory was made popular in American factories in large part by the Massachusetts Institute of Technology study of the process from mass production toward production as written and described in Womack’s book. A new phrase was coined, as to which is now commonly referred to as “Lean Manufacturing”. To implement the lean manufacturing various tools are used like, Just in Time (J IT), TPM, Cellular manufacturing, TQM, SMED, Value stream mapping etc.

3. OVER VIEW OF VSM

A value stream is a collection of all actions (value added as well as non-value-added) that are required to bring a product (or a group of products that use the same resources) through the main flows, starting with raw material and ending with the customer. These actions consider the flow of both information and materials within the overall supply chain. The ultimate goal of VSM is to identify all types of waste (Table. 1) in the value stream and to take steps to try and eliminate these [3].

VSM is a pencil and paper tool, which is created using a predefined set of standardized icons (the reader is referred to Rother and Shook [8] for details). Table 2 gives list of symbols used in this study with their meaning. The first step is to choose a particular product or product family as the target for improvement. The next step is to draw a current state map (Fig. 2) that is essentially a snapshot capturing how things are currently being done.

### Table 2
**List of Symbols Used for the Study**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Exhaustive Meaning of Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="symbol.png" alt="Customer/Supplier" /></td>
<td>It 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.</td>
</tr>
</tbody>
</table>

Table Cont’d
This is accomplished while walking along the actual process, and provides one with a basis for analyzing the system and identifying its weaknesses.

The third step in VSM is to create the future state map (Fig. 4), which is a picture of how the system should look after the inefficiencies in it have been removed. Creating a future state map is done by answering a set of questions on issues related to efficiency, and on technical implementation related to the use of lean tools. This map then becomes the basis for making the necessary changes to the system.

4. PRE-INTERVENTION SITUATION

4.1 About the company
The study was conducted at Gabriel India Ltd Ambad (Nashik) which is one of the leading organization supplying Shock absorbers and Front forks for OE customers as well as AM Requirements in Domestic and Export Market. This organization is a part of Anand Group which is a leading manufacturer of automotive systems and components in India. The range of products include Mono-tube shock absorbers, Twin tube shock absorbers, 16 dia. bore to 25 dia. bore shock absorbers, and front forks. Starting with 3 applications since inception, they now have 60 applications to their credit. The major domestic and overseas customers of the group includes, Caterpillar, Cummins, Daimler Chrysler, Eicher Motors, Escorts, Fiat, Force Motors, Ford, General Motors, HMT, Honda, Hyundai, Indian Army, Ingersoll Rand, L & T John Deere, Mitsubashi, Mahindra & Mahindra, New Holland, Tata Motors, Toyota, Yamaha Motors, Maruti Suzuki, Ashok Leyland and Bajaj auto Ltd etc.

4.2 Process Description
Shock absorber final assembly process has been considered for this study. The various operations required in the assembly are Main cell operations, Bush fitting, Painting, Inspection and packing (Fig.1). The mail cell operations are not discussed in detail due to the company's privacy policy.
4.3 Product Selection for Study

Customers give their demands on quarterly basis. The demand is then broken into month basis, week basis and finally on daily basis by the planning department. As there are more than one customer so to select the product for this study the preference is given to the product which contributes more in volume over the other customers. Table 2 shows the quarterly demand of the customers. From the table it is clear that BAJAJ AUTO LTD’s (BAL) demand around 60%-70% of the total demand. So the product selected is for BAL. Also the demand of BAL consist more one products like two-wheelers and 3-wheelers. So the BAL’s demand is further analyzed into product wise and the higher one in volume is selected for the study. Table 3 Shows the BAL’s product wise demand. So from this the product of PLATINA is selected for this study.

Table 3
Quarterly Orders of the Customers

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Orders (Nos.)</th>
<th>BAL (Nos.)</th>
<th>% of BAL Orders</th>
<th>Others (Nos.)</th>
<th>% of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>146500</td>
<td>87500</td>
<td>60 %</td>
<td>59000</td>
<td>40 %</td>
</tr>
<tr>
<td>Feb</td>
<td>167000</td>
<td>116000</td>
<td>70 %</td>
<td>51000</td>
<td>30 %</td>
</tr>
<tr>
<td>March</td>
<td>194000</td>
<td>135000</td>
<td>69 %</td>
<td>59000</td>
<td>31 %</td>
</tr>
<tr>
<td>April</td>
<td>186000</td>
<td>134000</td>
<td>72 %</td>
<td>52000</td>
<td>28 %</td>
</tr>
</tbody>
</table>

5. VSM: CURRENT STATE MAP

All data for the current state map were collected according to the approach recommended by Rother and Shook [9]. Data collection for the material flow started at the stores department, and worked forward all the way to the dispatch point, gathering snapshot data such as inventory levels before each process, process cycle times (CTs), number of workers, and changeover (CO) times. Figure 2 shows the current state map that was constructed; the small boxes in the map represent the process and the number inside the box is the number of workers at each process. Also, each process has a data box below, which contains the process CT, machine reliability (MR), the number of shifts, and the CO time. It should be noted that this data was collected whilst walking the shop floor and talking to the foreman and operators at each workstation. The processing and set-up times are all based on the average of historical data. After collecting all the information and material flows, they are connected as indicated by arrows in the map, representing how each workstation receives its schedule from business planning.

Table 4
Quarterly Requirements of BAL

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Order (Nos.)</th>
<th>Platina (Nos.)</th>
<th>AD Three wheeler (Nos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>87500</td>
<td>71500</td>
<td>16000</td>
</tr>
<tr>
<td>Feb.</td>
<td>116000</td>
<td>95000</td>
<td>21000</td>
</tr>
<tr>
<td>March</td>
<td>135000</td>
<td>117000</td>
<td>18000</td>
</tr>
<tr>
<td>April</td>
<td>134000</td>
<td>114000</td>
<td>20000</td>
</tr>
</tbody>
</table>
The timeline at the bottom of the current state map (Fig. 2) has two components. The first component is the production waiting time (in days), which is obtained by summing the lead-time numbers from each inventory triangle before each process. The time for one inventory triangle is calculated by dividing the inventory quantity into the daily customer requirements. For example, the lead-time for the inventory triangle ahead of bush fitting is 0.33 days; this is calculated by dividing 900 (the total inventory ahead of the bush fitting) by 2750 (the daily average demand rate for the product). The total observed value for the waiting time is 1.6 days.

The second element of the timeline is the processing (or value-added) time, which is about 70 seconds. This time is calculated by adding the processing time for each process in the value stream. The CT for each process is the average CT, which was determined by using actual data from the company. Thus the total lead time is around 38.09 hours. So the total value added time is too less capered to lead time.

Also from the current map, it is observed that the output of main cell is output 2750 nos. per shift which is minimum dispatch quantity per day. Also the change over time of the mail cell found 27 minutes which is more. The final products are only 1050 nos. are available after the packing operation. So the remaining more than 1050 nos are produced from the offline (Fig. 5). Due to off line processing there is no proper planning for post painting material. Post painting done as per material availability from stores, off line processing going on second or third shift as no pull system due to off line operation is available. So whole system was under pressure due to non smooth production flow.

The inventory between main cell and bush fitting is 900, between bush fitting and post panting is 700. The bush fitting with oil filling and the post painting operations are performed manually. Due to this, cycle times of the these processes is higher (Fig.2).

6. VSM: FUTURE STATE MAP

The process of defining and describing the future state map starts while developing the current state map, where target areas for improvement start to show up looking at the current state map for GIL several things stand out: (a) large inventories, (b) the difference between the total production lead-time (around 1.6 days) and the value added time (80 seconds), which is under 5% of the total., and (c) each process producing to its own schedule. Inventory and lead time may be viewed as two related issues since the more the inventory, the longer any item must wait for its turn and thus, the longer the lead time. In creating the ideal future state map we try to identify lean manufacturing tools to drive both of these down, while looking at the schedule across the entire value stream. We follow a systematic procedure where we try to answer a series of structured questions; this allows us to come up with an ideal future state map that will help in eliminating or at least reducing different types (Table 1) of waste in the current manufacturing system.

Q. 1. What is the takt time?

“Takt time” refers to the rate at which customers are buying products from the production line; i.e., the unit production rate that is needed to match customer requirements. If processing time of any of the operation is greater than your takt time, you have a candidate for a bottleneck or constraint. This may be causing overproduction waste or work in process (WIP) in some areas or extra processing time, such as overtime, to meet demand. It is calculated by dividing the total available time per day by the daily customer demand. The customer requirement in the month of January is 715000 nos. (Table 2). Assuming 26 working days per month, the average daily requirement is thus 2750 numbers per day. The company operates single shift in a day. The shift time is 8.5 hours with one hour lunch and tea break. So total time available is 450 minutes or 27000 seconds. Therefore takt time is 27000/2750 = 9.81 seconds per job.

Q. 2. Are there bottlenecks or constraints?

From the data, cycle times or processing times of the processes, namely bush fitting, post panting, inspection and packing are 15, 26, 15, 14 seconds respectively which are greater than takt time (Refer fig. no.). Then it indicates a candidate for a bottleneck or constraint. This may be causing overproduction waste or work in process (WIP) in some areas to meet demand.
Q. 3. Where can inventory (or queue time) be reduced or supermarkets used?

After looking at raw material, WIP, buffer stock, safety stock and finished goods inventories at shop during Current state map it is clear that the inventories are there in main cell and bush fitting, between bush fitting and post painting. These inventories are of 900 and 700 respectively.

To minimize the effect of these inventories, it makes sense to put in a supermarket replenishment system. A supermarket is a controlled inventory system—the downstream process removes items from the shelf and the process owners upstream replenish that amount to the supermarket. So accordingly two supermarkets were placed (Fig. 1). One between supplier (store) and main work cell and the other for finished products (in house and customer end).

Q. 4. What other improvements are required?

For improvements in the current system the problem of material flow and to minimize the inventory were the two main problems. For this various options were thought like does the reliability of equipment need to be improved? Are the first pass yield or quality levels acceptable? Do we need to perform training in 5S (workplace organization)? Do we need to create a new layout for an area? And after brainstorming among experts, the team has came to conclusion for making layout changes and development of a new work cell for post painting, inspection and packing. Where workcell is a work unit larger than an individual machine or workstation but smaller than the usual department. Typically, it has 3-12 people and 5-15 workstations in a compact arrangement. An ideal cell manufactures a narrow range of highly similar products. Such an ideal cell is self-contained with all necessary equipment and resources. Cellular layouts organize departments around a product or a narrow range of similar products. Materials sit in an initial queue when they enter the department. Once processing begins, they move directly from process to process (or sit in mini-queues). The result is very fast throughput. Communication is easy since every operator is close to the others. This improves quality and coordination. Proximity and a common mission enhance teamwork.

Figure 4 shows the future state map. In this map it is clear that the total process is performed in two workcell only. Two added supermarkets before main workcell and the other after newly formed workcell which were joined by the conveyor control material handling system reduces the inventory in the system.

![Fig. 4: Future State Map](image-url)
Also bush fitting with oil filling and the post painting operations are atomized.

7. RESULTS AND DISCUSSIONS

After the implementation of VSM the review of the system is done which has give nice results. The changes made in layout and atomisation of operation of oil feeling and bush fitting operations have resulted in the Line balancing (Fig. 5).

Continuous flow of material resulted in zero WIP due to elimination of off line processing (Fig. 5).

Main cell inventory in plant has been reduced from 2750nos to 925nos, Post panting inventory in plant has reduced from 2500nos to 925 nos. (Fig. 6)

8. CONCLUSION

The applied method for value stream analysis, and the way it was conducted, appears to have been successful as a first step for restructuring the value stream for the product family that were object of study. Compression of the throughput time was a significant gain in the case. Maybe the method would be even more useful, not at least for priorities, if economy were considered in the same systematic way as time in terms of value added and non-value added. Reduction in WIP and smooth production flow with less stress on production persons and satisfied customers with smooth dispatch are the outcomes of the VSM study.

ACKNOWLEDGEMENT

The authors are thankful towards the cooperation extended by Gabriel India Ltd, Nashik during this study. Special thanks goes to the head of Mechanical Engineering department, Principal and the management of SRES Engineering College Kopargaon for the encouragement received by them during this study which has boosted the moral of the authors.

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