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Value Stream Mapping as a Tool to Identify the Opportunities for Various Lean Techniques: An Auto Industry Case Study

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Abstract: ***Growth of business world these days created tighter market competition, because the existing industrial market become more global and have penetrated the inter-states boundary. The goal of every company is to satisfy the customer with the exact product, quality, quantity, and price in the shortest amount of time. Those conditions forced manufacturing operations to continually striving to reduce lead time of their operations. It can only be achieved if the company is able to create and to implement effective and efficient processes in each of its line of their business. For this purpose lean tools are used because lean focus on the continuous improvement of a company towards the ideal through the relentless reduction of waste. Value Stream Mapping (VSM) is a Special tool of lean that uses symbols known as "the language of Lean" to depict and improve the flow of material and information. Value Stream Mapping Purpose is to provide optimum value to the customer through a complete value creation process with minimum lead time. This paper presents a case study on Value Steam Mapping (VSM) approach in an Indian auto industry. The research begins with collection of the process information through which the current value-stream map is created and it reflects the current scenario of the operation site. Considering the problems in the current state of production, a future value-stream map was suggested to bridge the gap and to serve as a guide for future lean operations. The future state results in 22 % reduction in processing time, 33.7 % reduction in lead time and 17.6 % addition in value added ratio and 50% reduction in inventory.***

Keywords: Lean, value stream mapping, cycle time, takt time, lead time.

1. Introduction

In this changing scenario of globalization the consumer expectations are increasing and changing very fast and companies must be quick to adapt them if they want to survive and thrive. In a competitive environment which progressively tightens every company claims to own the excellence and competitiveness hence, probabilities to win the competition become greater. These conditions forces manufacturing industry to reduce the waste and process lead time of their operations. For reduction of waste and process lead time lean manufacturing is used. "A systematic approach to identifying and eliminate waste through continues improvement by flowing the product at demand of the customer" [1] is known as lean manufacturing.

Lean production is a conceptual framework popularized in many western industries since the early 1990's. In last few years many literatures work have extensively documented the implementation of lean manufacturing, in several manufacturing sectors. Initially, the publication of the book "The machine that changed the world" [2] started diffusion of some of the lean manufacturing operations developed by the most competitive auto manufacturing industry of the world.

The industries that implement lean manufacturing as their working philosophy can make significant change in terms of their operational performance even if it is in a modified format that best suits their particular organizational culture. To implement lean, organization must have known about different tools of the lean manufacturing, so that they can choose the best suited for their organization. Lean manufacturing uses tools like one-piece flow, visual control, Kaizen, cellular manufacturing, inventory management, Poka-yoke, standardized work, workplace organization and scrap reduction to reduce manufacturing waste [3]. To implement lean in any organization the first step is to apply Value-Stream Mapping (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 [4]. 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 in the value stream and to take steps to try and eliminate these. While researchers have developed a number of tools to optimize individual operations within a supply chain, most of these tools fall short in linking and visualizing the nature of the material and information flow throughout the company's entire supply chain. Taking the value stream viewpoint means working on the big picture and not individual processes. VSM creates a common basis for the production process, thus facilitating more thoughtful decisions to improve the value stream [5]. In the earlier work carried out, value stream mapping approach is applied by Hines et al. [6] to the development of a supplier network around a prominent distributor of electronic, electrical and mechanical component.

Brunt [7] suggested an approach to create a picture of the value stream for the whole supply chain in automotive industry. Seth and Gupta [8] used VSM to achieve productivity improvement at supplier for an auto industry, by Seth et al. [9] to determine miscellaneous wastes in the supply chain of the edible cottonseed oil industry. Singh and Sharma [10] deals with the mapping of crank shaft gear manufacturing line in India. This approach is used by Vinodh et al. [11] for the analysis of a camshaft manufacturing organization in a manufacturing company of India. Chen et al. [12] present a case study of lean implementation at a small manufacturer in the United States using value stream mapping. Chowdary and George [13] used VSM to analyse of the problems existing in the production line and improvement of operations at a pharmaceutical company.

2. Case Study

The case study considered in this research work is one of the automobile industries in India. An attempt has been made in this paper for reduction of muda (waste) and process lead time using value-stream mapping (VSM) to match the takt time of the Yamaha-O6G lock-kit assembly line. This product is mainly supplied to various two wheeler manufacturing companies. To reduce the process lead time, current state scenario of the Yamaha-O6G line has been studied and different waste have been identified. Many bottleneck areas have been identified which needs more attention. For reducing the muda and process lead time, our focus of research was to minimize the non-value added activities (NVAA).

Assembly process of XYZ product line take place in four lines which are explained as:

- **Store** - Store is responsible for receiving incoming material and supplying the material parts to assembly line. The main functions of the store department are bin loading, formation of kits, etc. as per bill of material (BOM). Material is released from store to assembly line as per material resource planning (MRP).
- **Main assembly line**- A complete lock-kit contains three locks which are ignition lock, seat lock and fuel tank lock. Raw material from store was arrived at the assembly workstation where assembly takes place and final lock-kit is prepared.
- **PDQA**- Pre-dispatch quality area is the section where sampling inspection is carried out and accepted items are sending to the finished goods area. The items which are found to have defects have been segregated, and if they were not been able to segregate, then send them to salvage area.
- **Finished goods**- Finished good department store the finished products before being supplied to the customer. After packing the system as per the packing norms, product is dispatch to the customer.

3. Methodology

The steps followed in the research are given below:
Step 1: Data collection and analysis.
Step 2: Creating current state map.
Step 3: Analysis of Current State Map.
Step 4: Creating future state map.
Step 5: analysis of future state map.

3.1 Collecting Data

An essential part in creating the VSMs for the process was to obtain existing data. There were many ways in which we gained information. The first, we acquired data from the company documents. Another method for data collection is observation to the activities that performed in the shop floor. To do this we talked with the operation managers of each plant as well as the floor managers. We met with the managers and remained in contact through e-mail. Quality improvement cell was also helpful in collection of data.

3.2 Current State Map

After gathering material and information flow of the concerned product, we were able to make the current state map. Figure 1 shows the current state map for the Yamaha-O6G product line. It has been prepared by using all the relevant information. It shows both value added time and non-value added time.

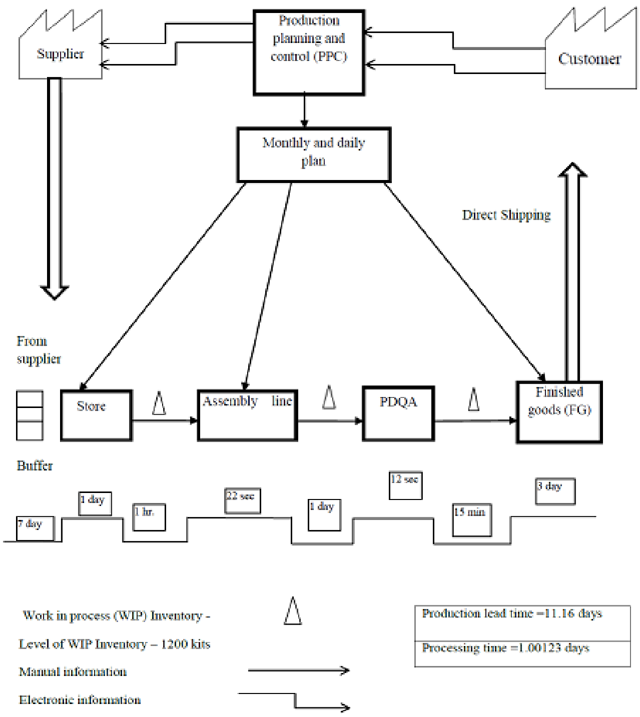

Figure 1: Current state map of XYZ product line

3.3 Analysis of Current State Map

The current state map show all the process steps and sufficient detail on how each step is completed and what happens to the items being processed. This will enable us to find out the bottleneck areas and their root causes. Table 1 shows the current state VSM time summary.

Table 1: Current state VSM summary

Process time	store	Assembly line	PDQA	FG
Cycle time	1 day	22 sec.	12 sec.	
WIP inventory		1200	1200	
Changeover time		15 min	10 min	
uptime	100%	80%	90%	100%
Legend: PDQA- pre dispatch quality audit, WIP- work in process, FG- finished goods				

Main assembly line consists of 15 stations where different assembly operations are conducted.

Table 2 shows the time studies of 15 stations of main assembly line.

Table 2: Time study of assembly line activities

WORK DISTRIBUTION						
ROCES	WORK	WORK ELEMENT		TIME		NET HOUR
NO	NO		H.T	M.T	W.T	ACCUMULATION
1	1	BODY KEY No. PUNCHING AND BODY ROTOR ASSY.	13.34			13.34
2	2	BODY PLATE TIGHTENING.	13.95			13.95
3	3	LOCK BAR AND SWITCH ASSY.	13.37			13.37
4	4	GROMMET AND BODY CAP ASSY	14.27			14.27
5	5	SEAT LOCK COMPLETE ASSY. LK-4435AZ	14.44			14.44
6	6	BODY, STEEL BALL, PAD & CAP ASSY	8.08			8.08
7	7	BODY CAP OUTER CRIMPING	13.14			13.14
8	8	FC BODY LB ASSY.	17.30			17.30
9	9	SEALING RING MOUNTING AND LEVER SUB ASSY	10.68			10.68
10	10	F.T. CAP COMPLETE ASSY.	16.94			16.94
11	11	SWITCH TESTING	17.86			17.86
12	12	BREATHING TESTING	12.99			12.99
13	13	FINAL INSPECTION AND KEY TRANSPARENT SLEEVE INSERTION	17.08			17.08
14	14	Packing 1	15.05			15.05
15	15	Packing 2	11.48			11.48

In addition to above activities, some activities were performed at the assembly lines which were non-Value added. Table 3 gives the time details of non-value added activities.

Table 3: Time study of non-value added activities

		NVA		
		Operation	Activity	Time
Yamaha 06G	Work Station 1	Body Key No. Punching	Unpacking LB From Poly Bag	0.34
			Collecting Bin From Return Conveyor	0.17
	Work Station 7	Cap Crimping	Unpacking Cap Outer Crimping	0.17
			Inspecting Cap Outer Crimping Raw Material	0.69
	Work Station 9	Sealing Ring Sub-assy	Greasing Sealing Ring Manually	0.34
	Work Station 13	FI	Marking Operator Code On seat Lock	0.34
	Work Station 14	Packing 1	Putting FC in Corrogated sheet and Putting Rubber On it	1.38
	Work Station 15	Packing 2	Folding Oversized polybag	0.69

Takt time: Takt time (German for rhythm or beat) is the frequency with which a single piece is produced. Takt time is used to clearly specify and monitor the rate at which a process should be occurring at various production stages. Takt time is calculated based on the following formula.

$$\text{Takt Time} = \frac{\text{Available work time per day}}{\text{Customer demand per day}}$$

Takt time is a pacemaker of the process. In the manufacturing of a product, cycle time of each activity should be parallel with takt time. Takt time in the Yamaha-O6G assembly line is calculated and found out to be 18 seconds. The processes whose cycle time is more than takt time becomes bottleneck points. An effort has been made to remove these bottleneck areas and thereafter future state map has been prepared.

3.4 Future State Map

Figure 2 shows the future state map for XYZ product line. In this state store has been converted into a supermarket. Supermarkets have been prepared after paint shop and LB assembly line. Kanban system has replace MRP system, hence converted system from push to pull. Use of FIFO lanes after main assembly line reduced the WIP inventory.

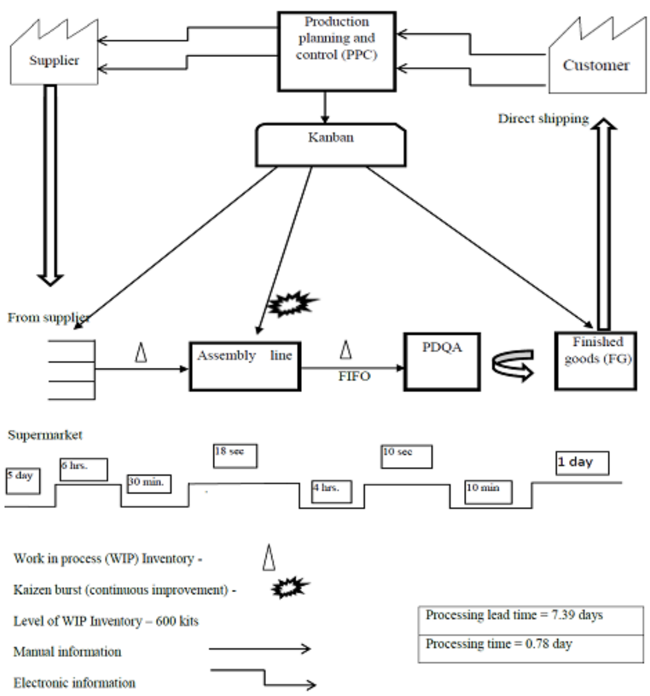

Figure 2: Future state map of XYZ product line

3.5 Analysis of Future State Map

By analysing current state map bottleneck areas have been identified. Corresponding to that a future state map has been prepared to remove those bottleneck areas and to reduce the cycle time and WIP inventory. Table 2 shows the current state VSM time summary.

Table 4: Future state VSM summary

Process time	**store**	**Assembly line**	**PDQA**	**FG**
Cycle time	6 hours	18 sec.	10 sec.	
WIP inventory		600	600	
Changeover time		12 min.	10 min.	
uptime	100%	90%	90%	100%
Legend: PDQA- pre dispatch quality audit, WIP- work in process, FG-finished goods				

4. Result

This research work has been intended to Value Stream Mapping (VSM), which is becoming an essential tool for realizing lean manufacturing in actual production settings.

The results are shown in the form of current and future process Mapping and improvement is shown in the reduction in inventory processing time, production lead time and Value added ratio. The results are shown in table 5.

Table 3: Comparison of Current and Future State Map

Variable	Before	After	Improvement
Processing time	1.0012 days	0.78 day	22%
Production lead time	11.16 days	7.39 days	33.70%
Value added ratio	8.97%	10.55%	17.60%
WIP inventory	1200 kits	600 kits	50%
Legend: WIP- work in progress			

5. Conclusion

Our main objective was to find the non-value added time and cut those as much as possible. For this purpose we have tried to reduce the WIP by convert the push system to pull system. We also tried to improve the process by incorporating supermarkets, First in First out (FIFO) lanes and line balancing.

Because of many limitations, it was not possible to see the total effect of the improvement strategies presented in this study. Future works on lead time reduction consists of using lean tools like 5s, Kanban, Single Minute Exchange of Dies (SMED), Total Preventive Maintenance (TPM) , Root Cause Analysis, Poka-yoke technique, JIT, Heijunka, Jidoka, and Standardized Work etc. for better improvement. Even though, the complete success of the application of lean thinking in the extensive run depends on close understanding between the management and shop floor personnel. Effective management information systems are required for instilling proper organizational values and continuous improvement programs. If these management principles are fully integrated with shop floor principles, then lean systems can be applied efficiently to attain the maximum output. The uneven supply base creates barriers in attaining integration between the links in supply chain. Therefore future studies can be made on supply chain management, to achieve good control, reliability and consistent performance. Further Analytical Hierarchy Process (AHP) fuzzy can be used to select the best VSM tool that will give the highest rate of improvement for a particular case study.

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