Improvement in Product Design through Lean Manufacturing and Value Stream Mapping

C. S. Jawalkar*

Abstract

This paper discusses on the integration of Lean Manufacturing and Value Stream Mapping. Taking a practical industrial example as case study in manufacturing of hydraulic actuators, a current value stream was plotted; the future value stream was generated applying the lean principles. While generating the new value stream, superior processes, manufacturing technologies and concurrent engineering methods were used, thereby eliminating technical problems, reducing time, enabling better mechanical properties and improved surface finish on the product. The results showed improved performances on application of Lean and Value Stream Mapping Techniques and reduction in overall process time by around 26.4%.

Keywords: Lean Manufacturing, Value Stream Mapping, Value Engineering, Burnishing, Grinding.

Introduction

The traditional manufacturing methods relied more on past experience and human skills and were predominantly human oriented, thereby prone to chances of human-errors, fatigue and it consumed more time in processing as it was person dependent. In the present context, large scale uses of computers and customized packages have dominated the manufacturing segment. It has led to decrease in processing time and errors have also reduced. Two such techniques namely Lean and Value stream mapping are illustrated in this paper along with an actual case study from a reputed hydraulic cylinder manufacturer. The processing activities chart for this industry is illustrated in figure 1.

Lean Manufacturing

Lean manufacturing is the systematic approach of identifying and eliminating wastes(non-value added activities) by continuous improvements and making the system pull-type in pursuit of perfection for quickly meeting the customer demands. The major wastes are in the form of rejections, inventory carrying and costs incurred on it, handling, movement of materials, processing time, waiting time, transportation, under-utilizing the available potentials etc.

Value Stream Mapping (VSM)

It is all the actions(both value and non-value added) required to bring a product, a group of products that use many of the same resources in much the same way, through the main-flow essential to every product, from raw- materials to the arms of the customer. VSM is a simple and visible tool which can be represented like a chart on a paper [1]. It shows the flow of material and information as the product which make sits way through the value stream. It helps the supervisors, engineers, customers, vendors and management, realize the wastes and improve upon it. It is done in two steps, in the first step a current state map is drawn to take a view of how the things are being done currently and the second is to draw the future state map [2], of how the things need to be done. Identifying the differences between these two, leads to a road-map and path,towards improvement.

* Department of Production & Industrial Engineering, PEC University of Technology, Chandigarh, India.
Email: csjawalkar@gmail.com

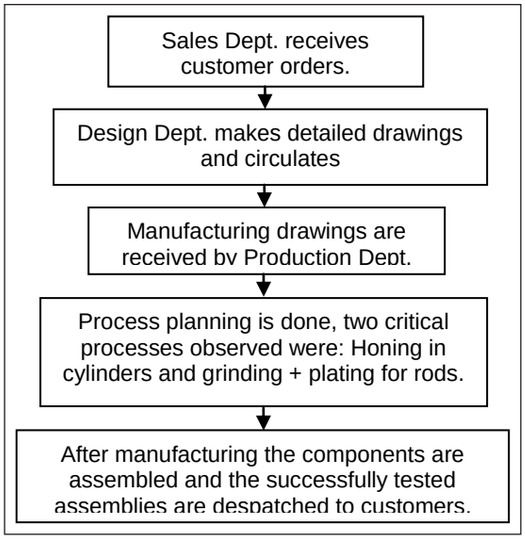

Figure 1: Activity Chart for Customer Orders

Case Study of an Actual Industrial Problem

The components were designed as per customer requirements for various customized products, the basic processes remain same and the manufacturing process chart for actuator rods is as shown in table1. The main parts in the actuator manufacturing were the piston rods and cylinders. The cylinder is turned, bored and honed accurately on a precise honing machine. The other parts like piston-heads, seal-retainers, end covers are manufactured on a CNC turning centre or by a skilled operator on a precise lathe. The main part considered in this case study is actuator rod, which is very critical and important.

The case-study describes present state of working and future state along with use of better processes such as burnishing [3-4], a super-finishing process. Initially all activities were routed through planning, hence there was over-all time delay. The column two in table 2 indicate the standard time required for each process, prepared by referring company standards and practices.

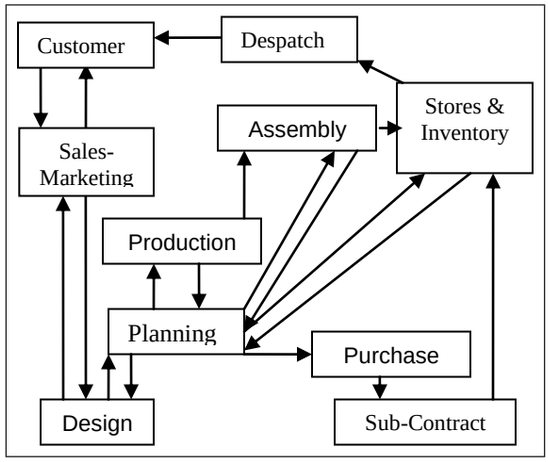

Figure 2: VSM Description of Process Flow

Table 1: Manufacturing Steps for Piston-Rod

Sl. No	*Process Name*	*Machine used*	*Facility*
1	Step Turning	Lathe	In-house
2	Grinding	Cylindrical Grinder	Sub-contract
3	Hard Chrome Plating	Electro-plating set-up	Sub-contract
4	Buffing	Lathe	In-house

Table 2: Actual Flow Process and Times Before & After VSM and LEAN Implementations

No	*Activity*	*Time (days)*	*Revised activities*	*Revised time(days)*
1	Receipt of order and preparation of sales order packet	2	On-line order receipt &processing through ERP	1.5
2	Detailed Designing and BOM preparation	7	Designing &BOM through use of new 3-D works	5
3	De-centralized Planning & purchase order requisitions in co-ordination with all departments.	3	Centralized planning through the use of ERP computer packages	1
4	Preparation of detailed process plans by Production	1	Revised process planning using customized software	1
5	Purchasing & receiving the materials	5	Using on-line purchase order processing	4
6	Manufacturing components as per drawings	8	Manufacturing through CNC's & smart software's.	6

No	*Activity*	*Time (days)*	*Revised activities*	*Revised time(days)*
7	Inspection and testing of the produced components	1	Inspection & testing using comparators &calibrated instruments	1
8	Interaction with design for technical problems, difficulties and design review/ changes etc.	2	on-line interaction with design departments and through imaging software	1
9	Assembly and testing process	2	Assembly, testing& simulations	2
10	Interaction with designing for fine-tuning results with theoretical results & design reviews.	2	On-line interaction with design departments using intranet	1
11	Preparation of the actual test reports and validation of the tests with authorization of the design team.	1	Validation and on-line testing	1
12	Painting, packing and despatching to the customer.	2	Revised processing in painting and despatching	2
	Total Time	36	Revised time	26.5

The figure 2 describes the value stream mapping of actual flow of process as per the company standards and practise. The figure 3 describes the new VSM after the changes made and after cutting off the wastages and making the process leaner, as per column 4 in table 2.

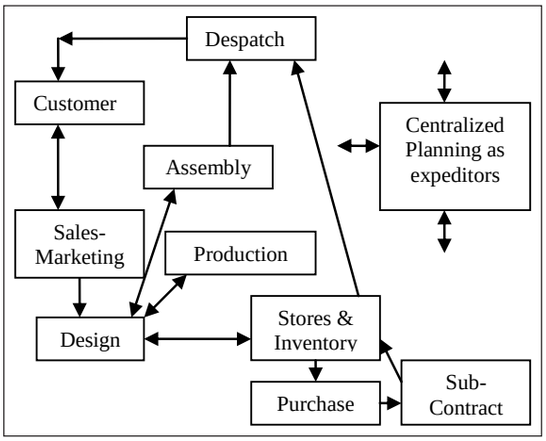

Figure 3: Value Stream Map after Changes

The figure 4 indicates the cumulative distribution and share of process times as earlier process (column 2 in table2), while figure5 indicates share of revised process (column 4 table 2).

Implementation of Lean Manufacturing:

As per the recommendations of the team of lean technologies, a major technological change was suggested, the piston rod specimens resembling the actual ones were manufactured and similar steps were performed on them, as done on standard actuator rods [5-6]. The results of the process for grinding and burnishing are as shown in the table 3-5. The aim to introduce a better process was proved successful which was further evidenced through the improvements in surface hardness as indicated in figure 6.

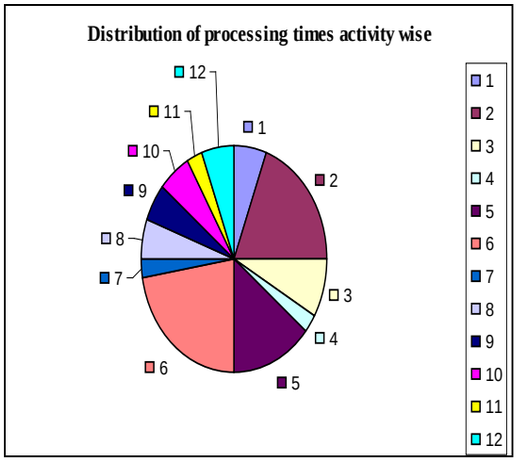

Figure 4: Graph of Earlier Processes (Table2)

Table 3: Revised Steps in Manufacturing of the Actuator Rods

Sl. No	*Process Name*	*Machine Used*	*Facility description*
1	Step Turning & Finishing	Lathe	In-House
2	Burnishing	Lathe	In-House
3	Hard Chrome Plating	Electro-Plating set-up	Sub-Contractor
4	Buffing	Lathe	In-House.

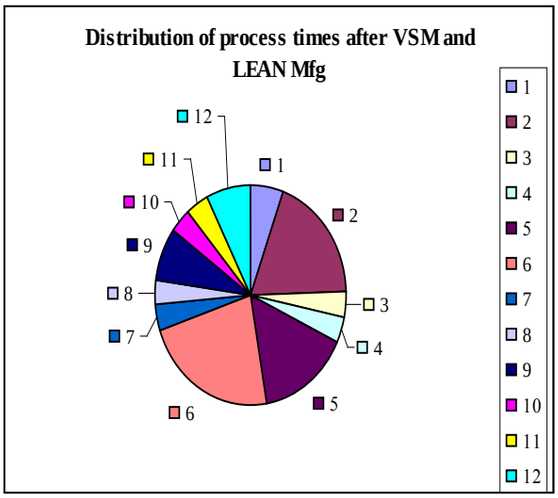

Figure 5: Graph of Revised Processes (Table2)

Table 4: Hardness Values before Plating [6]

Typical Samples	*Micro-Hardness (Turning)*	*Micro-Hardness Grinding (Hv)*	*Micro-Hardness Burnishing (Hv)*
1	255	255	261
2	241	232	237
3	231	250	254

Table 5: Hardness Values After Plating [6-7]

Typical Samples	*Micro-Hardness Grinding(Hv) After Chrome Plating*	*Micro-Hardness Burnishing (Hv)*
1	873	975
2	965	995
3	980	1022

Experimentation Results

On doing pilot experimentation and batch processing, it was observed that work-hardening phenomenon existed in the burnishing process [3], wherein the material resisted deformation leading to improvement in mechanical properties [5, 8]. Due to this the deformities got entangled and the flow of materials was locked after a certain initial period. This improved the overall product quality and reduced processing time.

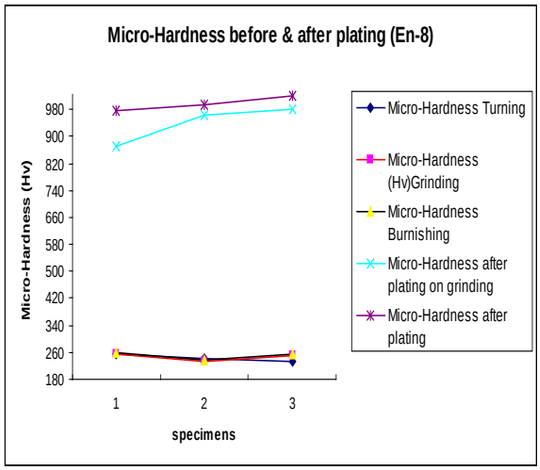

Figure 6: Improvement in Surface Micro-Hardness

Changes Evidenced from the Revised Value Stream Mapping:

- Whenever there is a customer feed-back or a technical query, it is directly addressed by the design team, thereby reducing time and efforts. Only when the query involves economical aspects the sales team is approached. Thereby the new value stream saves time. Total time saving is about half a day in average.
- The design team can directly interact through computerized system and new internal electronic communication system (Lotus notes) thereby saving about 2 days in average.
- Production teams can directly interact with design for errors in drawings and get drawings revised for the practical problems, thereby saving time and bottle-necks. Use of burnishing reduces set-up times and vendoring, thereby the overall saving is about 2 days average.
- Assembly team can directly interact with design for errors in assembly drawings and revising drawings for practical problems. Thereby saving time and bottle-necks. Total saving is about one day in average.
- Using a better process, burnishing replacing grinding gives improved mechanical properties and saves time in set-up changes and movement to vendors.
- In the revised value stream mapping, the planning acts only as an expeditor to solve problems and han-

dling of queries rather than acting as a regular intermediate link. The total time saving here is about 2 days.

- There was an overall reduction of 9.5 days after implementing the Lean and V.S.M concepts.

Conclusion

The company dealt with specialized and customized orders for hi-technology applications in defence, state of art technologies and heavy processing units. The implementation of Lean and V.S.M alongwith specialized processes like 'burnishing' helped to immensely reduce the time and costs involved in the processing activities. Further improvements could be done by standardising some of the products and developing in-house technologies for surface treatments. Through this case study about 26.4 % of reduction in time was observed after implementation of these relatively new concepts in such specialized and customized core manufacturing areas.

Acknowledgement:

The author acknowledges the support and co-operation from Polyhydron Systems Pvt. Ltd, Belgaum, Karnataka (formerly OTPL, a joint venture of the Oilgear group, Milwaukee, USA).

References

Soundhararjan, K., & Li, Y. (1999). *Developing a maintenance Value Stream Maps*. University of Teneessee, Knoxvillee.

Sararah, M., Kahalid, S., & Kilani, L. (2009). *Component Based Modelling and Simulation of Value Stream Mapping for Lean Manufacturing Systems*. College of Engineering and Technology, Alexandria, Egypt.

Jawalkar, C. S., & Walia, R. S. (2008). Experimental Investigations into Micro-Hardness in Roller Burnishing Processes on En-8 and aluminium specimens using design of experiments. *In proceedings ofthe 2nd international and 23rd AIMTDR, Conference,* IIT Chennai, 733-739.

Lee, S. S., Tam, S. C., & Loh, N. H. (1993). Ball burnishing of 316L Stainless Steel. *Journal of Material Processing Technology,* 37, 241-251.

Jawalkar, C. S., & Walia, R. S. (2009). Study of Roller Burnishing Process on En-8 Specimens using Design of Experiments. *International Journal of Mechanical Engineering and Research,* 1(1), 39-46.

Jawalkar, C. S., & Walia, R. S. (2009). *Experimental Investigations In Roller Burnishing Process onAluminium Samples International Conference: 'INCAMA'* March 2009, Kalasalingam University, Tamil Nadu, India.

Jawalkar, C. S., & Walia, R. S., Singh, I., & Kumar, P. (2011). Comparative study on surface finish in cylindrical grinding and roller burnishing processes using Taguchi methods. *International Journal of Production and Quality Engineering,* 2(1), 1-7.

www.polyhydronsystems.com, doi, 20/12/2015.