

# Implementation of Lean Principles and Concepts in Pump Manufacturing

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**Abstract-** Lean an emerging technology is implemented in many manufacturing industries for the identification and elimination of waste and to enhance productivity. The pump manufacturing industry has been selected to imbibe lean into their production process. The problems that existed in the industry, which were effecting company's production were due to increase in lead time, absence of inventory classification and disorganized storage area. Hence the goal of the project was to reduce the lead time and classify the inventories by implementing suitable lean techniques and concepts. In this paper the area of lean has suggested that the best and most pertinent way is to use the technique of value stream mapping (VSM) for reducing lead time, selective inventory control approach for inventory classification and 5S for redesigning the storage area. Hence these techniques were applied in the pump manufacturing unit, so as to identify the non value added activities and hence to reduce the cycle time

**Key words:** Cycle time, VSM (Value stream mapping), VSD (Value stream design), Productivity

## I. INTRODUCTION

In this lean principles and techniques applied in various manufacturing sectors across the world. A thorough literature survey was conducted and based on understanding derived, emerging trends were jot down and a research methodology was framed to accomplish the objectives of the project.

In 1950's Toyota Motor Corporation created Toyota Production System, then it formatted a new kind of Management concept 'Lean thinking' Graban, Mark. (2009). Lean is single most powerful tool available for creating value while eliminating waste in any organization (Womack and Jones, 1996). In a commercial setting, this is normally indicated by whether or not the customer would be prepared to pay for the activity. Lean in manufacturing is extremely common. What is less common is the consideration that lean manufacturing can be applied not just to factories, but also to areas such as production engineering and planning. When lean is applied in manufacturing, it has a positive impact on the lead-time of the whole supply chain, as well as on product costs and quality

Value stream mapping is one of the lean principles and techniques which are adopted by most of the organization to identify the value added and non value added activity in the process. The use of value stream mapping is not limited only

in the manufacturing process; it starts right from the suppliers till the customer get the desired product. All the material and information flow is identified and the cause for not meeting the demand is identified. By doing the value stream mapping in the organization helps to identify the critical path and redesign the factory layout and material handling and even to adapt selective inventory control approach.

### 1.1 The manufacturing process:

A submersible pump set consists of two components, a motor and a multi-stage pump. These are coupled together to form one working unit. The motor which is the prime mover consists of two major parts, a stator and a rotor. The manufacture of stator starts with a SS 202 grade pipe of 2.5mm thickness which is cut to different lengths depending on the HP of the motor. The stator laminations are pressed into the tube using a 70 ton capacity hydraulic press. The stator is completed with electrical winding which goes into 24 slots present in the laminations.

The rotor starts as a SS 410 grade rod of 45mm diameter. These rotor laminations have 18 slots which are filled with copper rods and brazed on either side using copper rings. The rotor is further machined to accommodate bushes, thrust bearing and coupling rings. The rotor is fitted inside the stator using flanges and housings to complete the motor. The pump is assembled with different items procured from different vendors. The SS 410 grade impellers are fitted inside individual cast iron stage bowls. A central SS 304 grade shaft facilitates the rotation of all the impellers. Motor and pump are coupled together and tested in a test tank using the computerized digital testing panel.

### 1.2 Purchasing process:

The purchase process is initiated as soon as an inventory item gets below its minimum quantity. This is maintained by inventory control software. The purchase order is acknowledged by the vendor who sends a return mail informing the expected date of delivery and the present price of the item. Partial amount as agreed by both parties is deposited to the vendor's account in some cases. In other cases a credit period for the amount is given by the vendor.

The vendor then sends a Performa invoice when he is ready to ship the items. As and when this is acknowledged, the items are dispatched.

### 1.3 Distribution process:

At present about 30% of sales is through the company's exclusive showroom in Shimoga. The remaining sales are achieved through a vast network of mechanics and electricians at both district and Taluk levels. The company plans to expand its distribution network in sync with the increase in production capacity.

## II. LITERATURE REVIEW

The aim of a literature review in the report was to verify the relevant theories as a knowledge base and help the reader to understand the relevant concepts and theories, in term of lean principles and techniques. These cover themes of lean manufacturing that are widely used in different sectors. The sources used are based from printed books, journals and articles.

James.P.Womack et.al(1990) has explained about differences in lean and mass production and how effectively non value added waste can be eliminated in lean production by using different strategies.

Chandradeep Grewal (2008), has described the methodology of lean and VSM that can be applied for a small company and also stated that it is a powerful tool to identify the inefficiencies and improvement areas.

Bhim singh et.al (2011), depicted about value stream mapping that is used as a lean tool in a particular case study. The paper focuses on simulation model that are used in construction material to enhance the lean principles and have depicted effectively about reducing the lead time.

Jayaganthan (2014) where he has effectively described about the ways to reduce the non-value added activity in the company. Karthikeyan Iyer (2006) suggests about the use of value stream mapping to reduce the lead time and to meet the customer demand on time and different lean techniques associated with it. Keskin (2012) has emphasized on the energy utilization in a small scale and medium scale industry by the application of value stream mapping tool.

A literature review has been carried out on lean supply chain using a structured content analysis by Paschal Ugochukwu, Jon Engström, JosteinLangstrand (2008) speaks about lean techniques carried out in different perspectives.

From this literature survey, it is understood that implementation of lean concepts will help the organization to reduce the lead time and also improves the overall efficiency of the organization.

## III. PROBLEM DEFINITION

From the systematic review of literature and observation in pump manufacturing industry the problems that existed and noted were the improper layout of storage area and absence of inventory classification. Further, to enhance productivity in the company it was imperative to identify the defects in production and assembly line before completion of the product. Hence non value added activity and value added activity were crucially observed and identified and lead time was found to be increasingly high.

### 2.1 Objectives

Based on the problem identified in the industry, the primary objective of the project was

1. To implement lean principles and techniques in a pump manufacturing industry.
2. To reduce the lead time of the manufacturing process.

## IV. VALUE STREAM MAPPING

The purpose of this project was to identify the wastage in the manufacturing process and reduce wastage by identifying value added and non value added activity. Hence to identify the wastage and enhance the wastage there was no better lean tool other than value stream mapping.

Value stream mapping is an efficient lean tool and a technique to map the flow of information and material and simultaneously visualise the key improvements area to map the future state. The methodology that is carried out to implement value stream mapping in pump manufacturing industry is show

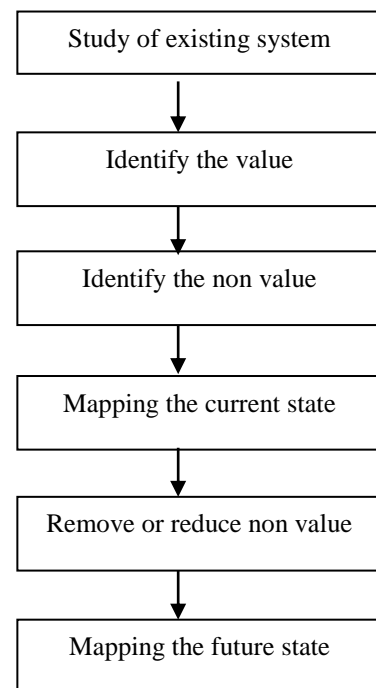


Fig 3.1: VSM procedure

Basically lean is about identifying the value added and non value added activity and reducing those waste that does not add value to the customer. It is a continuous process which must be followed in the organization

### A. Value stream mapping:

Value stream mapping termed as the “language of lean is an efficient lean tool that is used to map the value added activity and non value added activity in the process to depict the flow of information and inventory and to identify the lead time”.

- *Lead time*

This is one of the most important concept used which helps to analyze the total time taken to deliver the product back to the customer from the day he had placed an order.

This helps the company to track the inventory level and place an order to the supplier before they run out of a shortage. In this report it is defined mathematically as the summation of value added activity in the process and the non value added activity in the process measured in hours or minutes.

$$\text{Lead time} = (\text{value added} + \text{non value added})$$

• **Takt time**

Takt time is derived from a German which means “pace or a rhythm”. It is defined as the available time that is required to produce the product to the actual customer demand. It signifies the actual production that is necessary to carry out to produce a particular product so that the monthly demand can be met or fulfilled. Takt time and cycle time can be plotted using a bar chart.

This helps to identify the manufacturing process that is lesser or greater than the takt time and helps to identify if they can possibly meet the customer demand on time or there is a delay in the process. Mathematically it is expressed as follows.

$$\text{Takt Time} = \text{Available time} / \text{customer demand}$$

• **Cycle time**

The cycle time is calculated usually using a stop watch. It is the time required to complete a certain task from start to finish. The cycle time helps to identify the value added and non value added activity.

IV. METHODOLOGY

4.1 Present Value stream map of 5/8hp pump

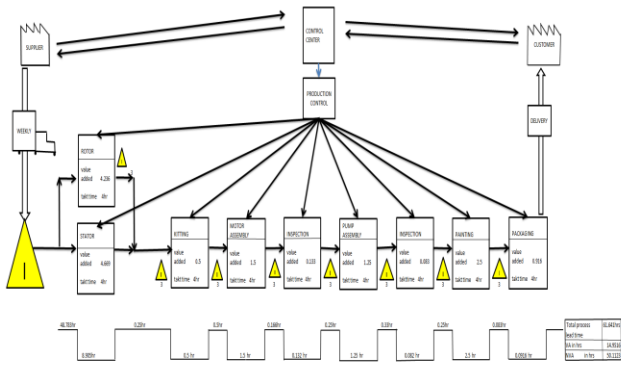


Fig 4.1 Present Value stream design for 5/8hp Pump

The current state map for stator, rotor, assembly process of motor and pump production is shown below in the figure 4.4. This highlights the material flow and information flow from suppliers to the customers. The lead time to produce entire 5/8 hp submersible pump was 61.641 hrs. The value added activity was found to be 14.951 hrs the non value added activity observed was 50.112 hrs. The current state map was drawn below which explains about the material and information flow and highlights the total process lead time in hours

	Stator	Rotor	kitting	Motor assembly	Testing	Pump assembly	Testing	Painting	packaging
VA hrs	4.66	4.236	0.5	1.5	0.133	1.25	0.083	2.5	0.91
NVA hrs	47.9	48.78	0.25	0.5	0.166	.25	0.033	0.25	0.08
Takt hrs	4	4	4	4	4	4	4	4	4
uptime %	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1

Table 4.1 Value added and non value added for current state

The production lead time is calculated by adding value added and non value added activity. The table below shows the summary of lead time for stator rotor and 5/8hp submersible pump.

Total process Lead time in hrs	Stator manufacturing	Rotor manufacturing	Assembly process	5/8hp pump assembly
	52.645	51.33	8.214	61.641

Table 4.2 Total process lead time for current state 5/8hp pump

4.2 Proposed Value stream design for 5/8hp pump

The future state is designed for entire production of submersible pump in a path to reduce the lead time to a greater extent so that the customers are benefitted with the value and quality. In mapping the value stream, the lead time to produce entire 5/8 hp submersible pump was 61.641 hrs. The value added activity was found to be 14.951 hrs the non value added activity observed was 50.112 hrs. After implementing lean techniques and concepts the lead time reduced to 41.662 hrs and the non value added reduced to 30.669 hrs.

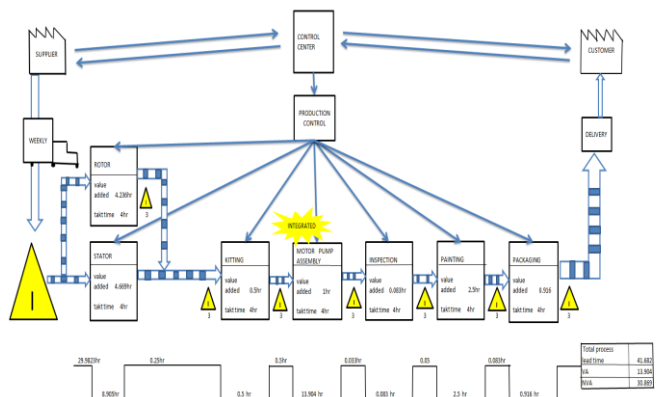


Fig 4.2: Proposed Value stream design for 5/8hp Pump

The table 4.3 shows value stream design calculation of value added and non value added time for stator, rotor and entire assembly process of motor and pump.

	Stator manufacturing	Rotor manufacturing	Kitting manufacturing	Motor & pump assembly	Inspection	Painting	Packaging
VA hrs	4.669	4.236	0.5	1	0.083	2.5	0.916
NVA hrs	29.98	26.63	0.25	0.5	0.033	0.05	0.083
Uptime%	92.11	92.11	92.11	92.11	92.11	92.11	92.11
Takt time hrs	4	4	4	4	4	4	4

Table 4.3: Value added and non value added activities of future state

The total lead time process for each component such as rotor, stator and assembly process and 5/8hp complete product is tabulated by adding value added and non value added activity. The table 4.4 below gives a clear picture reduction in lead time for each component in hours.

Total process Lead time in hrs	Stator manufacturing	Rotor manufacturing	Assembly process	5/8hp pump
	34.649	30.871	5.915	44.773

Table 4.4 Lead time of 5/8hp Motor and Pump

## V. RESULTS AND DISCUSSIONS

The goal of this project was to implement lean principles and concepts in pump manufacturing industry. The primary objective was to analyze the lead time of a manufacturing process. The secondary objective was to implement selective inventory control approach and redesign the storage area by suggesting and implementing the 5S technique.

### A, Value stream mapping

The value stream has been mapped and designed for a particular product. The product that was selected here was 5/8hp submersible pump since it is the fastest moving pump as per the record. The table 6.1 below gives a clear picture of lead time for current state and the future state.

	Value added in hours		Non value added in hours		Lead time in hours	
	VSM	VSD	VSM	VSD	VSM	VSD
Stator	4.66	4.669	4.236	4.236	52.645	34.649
Rotor	47.9	29.98	48.78	26.63	51.33	30.981
Assembly process	6.883	4.999	1.332	0.916	8.214	5.915
5/8hp pump	14.9516	13.904	50.112	30.869	61.641	44.773

Table 4.5: Implementation of value stream mapping and value stream design of 5/8hp pump

## CONCLUSION

Lean is an effective and efficient way to enhance competitiveness of manufacturing sectors. This project addresses the different lean concepts applied in pump manufacturing industry with an aim to reduce the lead time of the manufacturing process.

Value stream mapping has been carried out at the production line to estimate the value added and non value added activity and to calculate the lead time. For 5/8 hp submersible pump the lead time was found to be 61.641hrs and after implementation of lean technique it got reduced to 44.773 hrs, a difference of 16.868 hrs was reduced which helped the industry to improve their productivity.

The classification on inventory was carried out by applying selective inventory control approach such as ABC, VED and FSN analysis. This has helped to analyze the criticality and cost effective components and a strict vigilance must be done to check the inventory level frequently. This project also emphasize on the storage area layout to implement the 5S technique since all the raw materials were disorganized. The auditing has been carried out to check the 5S implementation level which has facilitated the industry to adopt for new technology and to be in a competitive market.

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