

Production and Quality Improvement Using Through Lean Technique In A Monoblock - SWJ1HP Pump Assembly Line

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ABSTRACT: Value Stream Mapping has the reputation of uncovering waste in manufacturing, production and business processes by identifying and removing or streamlining value-added steps and eliminating non-value-added steps. The various process times for manufacturing a mono block pump were obtained from a pump manufacturing industry. A flow diagram showing the process is drawn to reflect the current state of the operation. The non-value actions are identified in each step and between each step by their waste of time and resources. The process is analyzed for opportunity to drastically reduce and simplify it to the fewest actions necessary. By reducing wastefulness the proportion of value adding time in the whole process rises and the process throughput speed is increased. This makes the redesigned process more effective (the right things are being done) and more efficient (needing fewer resources). The reengineered process is flow charted in its future state with process steps and information flows redesigned, simplified and made less expensive. This paper addresses the application of lean manufacturing concepts to the pump manufacturing industry.

KEYWORDS: Lean Manufacturing, Value Stream Mapping, Defect Rate, Layout Modification.

I. INTRODUCTION

Lean operating principles began in manufacturing environments and are known by a variety of synonyms; Lean Manufacturing, Lean Production, Toyota Production System, etc. It is commonly believed that Lean started in Japan (Toyota, specifically), but Henry Ford had been using parts of Lean as early as 1920's, as evidenced by the following quote: "One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost." [Roberto Panizzolo]. In order to set the groundwork for this paper, let's begin with the definition of Lean, as developed by the National Institute of Standards and Technology Manufacturing Extension Partnership's Lean Network. A systematic approach of identifying and eliminating waste through continuous improvement, flow the product at the pull of the customer in pursuit of perfection. Keeping in mind that Lean applies to the entire organization. Although individual components or building blocks of Lean may be tactical and narrowly focused, and achieve maximum effectiveness by using them together and applying them cross-functionally through the system. In its most basic form, lean manufacturing is the systematic elimination of waste from all aspects of an organization's operations, where waste is viewed as any use or loss of resources that does not lead directly to creating the product or service a customer wants when they want it. In many industrial processes, such non-value added activity can comprise more than 90 percent of a factory's total activity. The objective is to make the production flow through the system quicker and in more predictable manner. The intent is to eliminate waste thereby permitting better wages for workers, higher profit for owners and better quality for customer. Value stream mapping is a set of methods to visually display the flow of materials and information through the production process. The objective of value stream mapping is to identify value-added activities and non-value-added activities. Value stream maps should reflect what actually happens rather than what is supposed to happen so that opportunities for improvement can be identified. Value Stream Mapping is often used in process cycle time improvement projects since it demonstrates

exactly how a process operates with detailed timing of step-by-step activities. It is also used for process analysis and improvement by identifying and eliminating time spent on non- value-added activities. Lean Manufacturing is a buzzword. More often it is used with the terms like benefits, cost reduction, lead-time reduction etc. but if you have not started implementing lean manufacturing yet and if you have not started benefiting from lean manufacturing yet, you will need some numbers to be motivated. We shall look into some quantified benefits of lean manufacturing where the principles of lean are implemented successfully.

The Objective of this research was to:

- Understand the “current state” of the pump manufacturing
- Identify the key area of waste, problem and opportunities across the process.
- Develop of “future state vision” of each process.
- Increase the productivity.
- Develop an action plan to achieve the higher production and lead time reduction.

II. LITERATURE REVIEW

Lean manufacturing has received ample attention in academic literature and practical performance, from how the lean production concept was formulated and disseminated until recent comprehensive literature review. In them, a common topic appears, that is, the need to explore the implementation and performance relationship with a practical focus and with a definition of the context because the results depend on the manufacturing environment.

Numerous literatures have extensively documented the implementation of lean manufacturing into various manufacturing sectors, but very few have addressed the assembly environment. Soderquist and Motwani successfully mapped the quality management concepts of lean production in a French automotive parts supplier company. They outlined an integrated approach for quality, including customer relationships and operations, and thereby achieving a competitive advantage for automotive manufacturers. Bamber and Dale explained the application of lean to a traditional aerospace manufacturing industry. They revealed that a number of methods of lean production were found to be not as effective as in the motor manufacturing sector. Shah and Ward studied the effects of three factors, plant size, plant age and unionization status on the feasibility of implementing the key facets of lean production systems. The results indicate that lean implementation contributes significantly to the operating performance of plants. Pavnaskary et al. have proposed a classification scheme to serve as a link between manufacturing waste and lean manufacturing tools. The proposed scheme classifies all well-known lean manufacturing tools and metrics. Also, it suggests the tools and metrics that will help to meet manufacturing problems. McDonald et al. applied value stream mapping (VSM), enhanced by simulation, in a manufacturing plant.

They have strongly suggested that simulation can be used to enhance the utility of VSM. VSM is prescribed as part of the lean toolkit and has been applied in a variety of industries. In this paper, application of VSM was described in order to identify the various forms of waste to a dedicated monoblock pump assembly line.

III. METHODOLOGY

Methodology is based on the continuous improvement. Consequently, it will be a continuous process of status study, calculation of metrics, implementation of progress, observation of the results, and new decision-making of improvement.

A first design of VSM is realized according to the original data from production processes and the layout, identifying the key times of each workstation. This design represents the starting point of improvement. Next, the map of the parts flow is shown to verify the materials movement between the workstations, calculating the productive and unproductive times, stocks and metrics that will help to characterize the process, and marking some targets of progress. This design of the VSM allows the beginning of the progress in the manufacturing line. Metrics used are DtD and LR. DtD depicts the material flow through the value stream, the time it takes for material to flow from the receiving dock (or order entry point) to the shipping dock (Eq. 1). LR is the ratio of working time of added value to DtD or throughput time (Eq. 2):

$$DtD = \text{Time for material flow through value stream} \quad (1)$$

$$LR = \frac{\text{Value added work time}}{DtD} \quad (2)$$

Another important issue is to regulate and reduce the accumulated stocks. Consequently, it will be necessary to establish a control of the accumulated stock. The control will be accomplished easily in accessible stores and shelves. This activity facilitates the management of parts waiting to be processed because the visual control is more effective. It will use the takt time, a fully known lean metric (Eq. 3) defines:

$$\text{Takt time} = \frac{\text{Total time available for production}}{\text{Required no. of parts per shift}} \quad (3)$$

Once the takt time is defined, it is possible to establish the cycle time, a basic parameter in pull system. So, traditionally, objectives such as high machine utilization and high production volume are less important when the takt time is defined because the aim is work within the time. However, a better materials flow can conciliate both objectives: work within the takt time and higher LR.

Next, the necessary progress will be implemented to achieve the desired state of the manufacturing process. There are two main improvements: firstly, it is a system to control intermediate stores (kanban system), and in addition, it allows improving the material flow between work-stations to obtain a more flexible process, optimizing the job of each workstation. Every 2 months, a new VSM is checked and metrics are recalculated and analyzed to control improvements.

Product Description

The product is Monoblock shallow well jet (SWJ) pump single phase - 1 HP. This paper deals with the assembly process of the whole pump. It is mainly of two divisions namely motor assembly and pump assembly lines. There are totally 8 stages in the main assembly line and followed by a testing process and then the pump is packed and dispatched. The stator is brought to the main assembly line and the assembly is carried over it. The main parts are assembled in the sub assembly section and it is assembled to the rotor in the main section. Finally after 8 stages the pump is assembled and it is taken to the testing stage where it is tested and if it is to the required parameters it is dispatched to the next section. The pump dealt in the paper is shown in Fig 1.



Fig. 1: Monoblock SWJ - 1 HP

Value Stream Mapping

Preparation of current state map: Interaction with the industry the information of the customer's requirement per month is obtained. The company has a wide range of customer requesting for a wide range of product from (induction motor). Requirement of motors are 9085 motors / month.

Customer Order	9085(per month) - Feb 2014
Demand	400 (per day)
Working Hours	Two Shifts 16 Hours(per day)
Break	One Hour (per Shift)

Table 1, VSM input data

The main processes are identified first. The main Processes are Shaft machining, Die casting, Bracket machining, Impeller machining, Drilling doom cover, Motor body machining, Stator winding, Case machining, Rotor machining, Bearing assembly, Assembly, Testing, Painting and Packing. The data box envelopes the following data like cycle time, change over time and number of operator. The inventory triangle envelopes two data work in process between each process and respective inventory.

PROCESS	CYCLE TIME (Minutes)
Stud & Stator assembly	3
Rotor & Bearing assembly	3
Rotor in Stator assembly	3
Capacitor assembly & Testing	3
Impeller & Cooling fan assembly	2
Terminal Box assembly & wiring	2
Jet plate assembling	3
Pump & Motor assembly	3
Testing	3
Packaging	4

Table 2 Process and cycle time

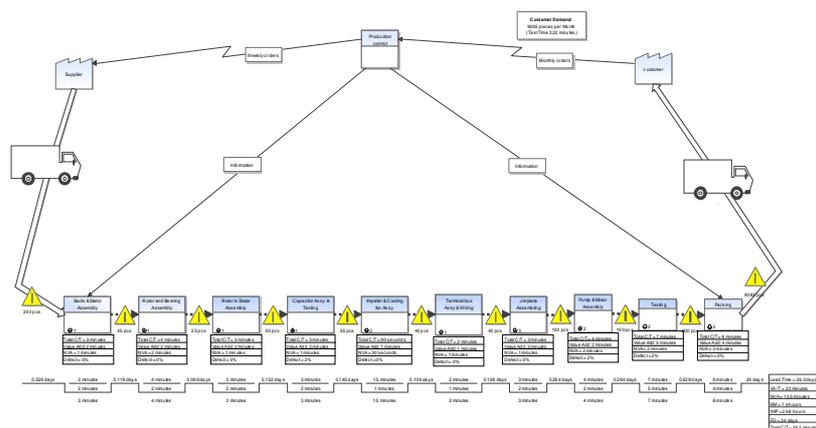


Fig.2,Current State Map

Takt time: Takt demonstrates the rate at which the customer buys the product. TAKT reflects the frequency at which the product has to come out of the manufacturer to meet the customer demand. From Table 1Takt time is calculated by dividing available working time per shift (in min) with the customer demand per shift.

$$\text{Available Time} = \frac{\text{Working hours} - \text{Breaks}}{\text{Customer Demand per Shift}} = \frac{(8 \times 60) - (1 \times 60)}{400} = 420 \text{ mins}$$

$$\begin{aligned} \text{Takt time} &= \text{Working time per shift} / \text{Customer demand per shift} \\ &= 420/200 = 2.1\text{mins} \end{aligned}$$

Takttime of 2.1mins represents, every motor has to be completed in every 126seconds.

Preparation of future state map: Process improvement by adding additional resources to increase capacity of the bottleneck (an additional machine can be added in parallel or automate the operation to increase the capacity). Minimize non-value adding activities (decrease cost, reduce lead time).

When cycle time for each process is compared with takt time it is found that cycle time of Stator winding exceeds the takt time, so there is need to improve the process capability of stator winding process to meet the demand of customer within the time. So it can be improved by using various lean tools but here we are improving the cycle time of the process in the following area such as Stator winding, Shaft machining and assembly section. Here we suggested a advanced machining technology for improving the cycle time,

The suggested alternatives are:

- Machining using CNC
- Movable table for assembly to reduce the transportation distance and time
- Discharge test using Rotometer

These improvements are made to reduce the lead time of the motor manufacturing.

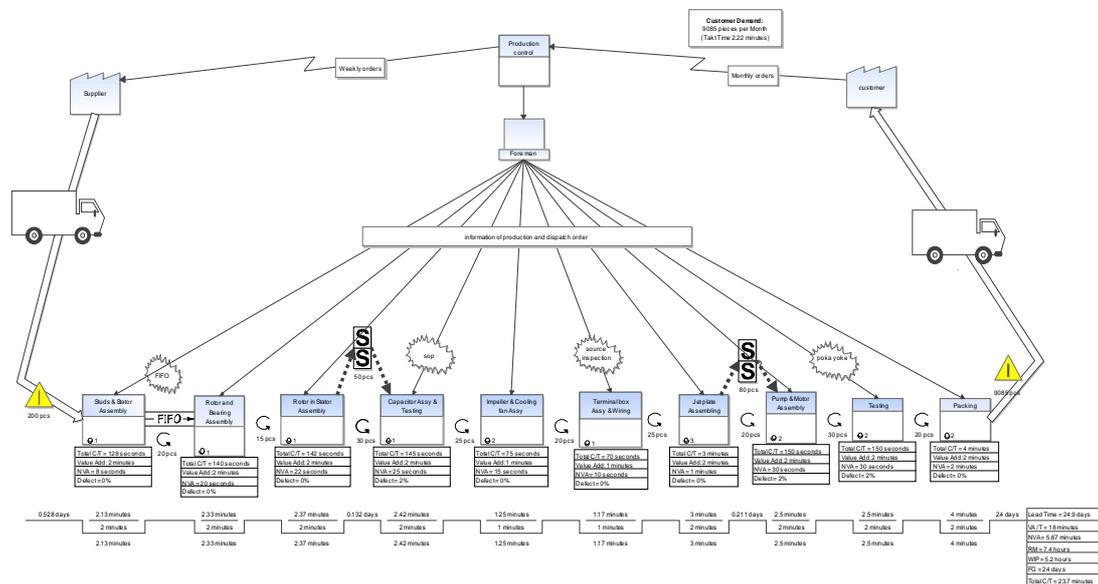


Fig.3, Future state map

Results and Discussion

This case study results have been evaluated across VSM diagram. The calculation of several critical magnitudes indicates if the manufacturing process improves or deteriorates according to the criteria previously established in Table 3.

Table 3. Comparison of existing versus proposed (lead time)

STUDY PARAMETERS	BEFORE IMPLEMENTATION	AFTER IMPLEMENTATION
Lead time (Days)	26.3	24.9
Total cycle time (minutes)	36.5	23.7
Total Value added Time (minutes)	23	18
Lean Rate (%)	16.66	25
Defect (%)	3	1

The above table shows the comparison of the existing system and the improved system. The production lead time has been reduced from 26.3 days to 24.9 days and lean rate is increased from 16.66% to 25% respectively.

III. CONCLUSION

By using value stream mapping the process time and the value added and non value added activities are identified. Lead time is reduced by improvement made in the pump industry. The suggested improvements lead to reduction of production lead time from 26.3 days to 24.9 days and lean rate is increased from 16.66% to 25%. Production per month can be improved up. Finally the defect rate is reduces from 3% to 1%. So the customer demand is easily satisfied with this production rate. Lean production means continuous improvement, we must keep on changing future state into current state that will not end during our life. VSM have been proven to be a greatly useful tool to eliminate some waste in a cycle and find there are more waste to eliminate in next cycle during which lean become a habit or culture.

IV. FUTURE WORK

This paper gives only a cycle time and inventory data of the pump industry. The VSM is used to identify the waste. Future work of this paper is collecting the distance travelled by the WIP and layout of the plant. From this we can use VIPPLANOPT software to optimize the plant layout. The unnecessary movements and non value added activities are eliminated.

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