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Lean Implementation through Enhancing Productivity in a Pump Industry

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ABSTRACT—Lead time is the time spent between the original customer order and final delivery of the product. Project work is being carried out in a pump manufacturing industry located in Coimbatore. Lead time is calculated by adding value added and other Non-value added time. The primary data is collected by conducting survey of past data in which the project conduct questionnaire sessions at the respondents include officers, engineers, managers and senior managers from planning production, purchase, quality control, maintenance, human resources, store, supply chain, and material department of the Company. The lean tools that are applied in this project are Kaizen, Layout optimization, setup time reduction and Line Balancing which eliminates inventory which in turn reduces the lead time. Value Stream Mapping (VSM) has been used as a tool to map the present and the future state process. Application of these lean tools has resulted in the reduction of lead time by 8.26days.Empirical data was collected through a comprehensive literature review of earlier studies over this topic.

Keywords—Lead time, Value Stream Mapping, Kaizen, Set up time reduction, Line Balancing.

1. Introduction

Lean manufacturing system (LMS) is a philosophy or concept that aims to improve productivity and reduce waste. Lean manufacturing endeavours to use less of everything: less investment in equipment and tools, less manufacturing space, less workers, and less engineering time in product and process design [1].The concept of lean manufacturing was introduced in the Toyota production system and they were the first to use lean practices in the factory shop floor. The objective of lean manufacturing is to reduce waste in terms of waiting time, setup time and work-in-process (WIP) inventory throughout the process flow. The stable and standard work is absolutely essential for any organization wanting to practice lean manufacturing. Unless the work practice is standardized, it is not possible to improve the process continuously and sustain improvement. Kaizen as a structured part of an organization provides a frame work for people to get involved in the endeavour of continuous Improvement. The involvement of people can be achieved by motivating them to propose ideas for improvement by systematically implementing it and sustaining those ideas. [2].This Paper is a case study explaining about the successful implementation of lean manufacturing tools and techniques in the manufacturing system at the industry and the outcomes were illustrated and discussed.

2. Literature Review

The production flexibility and the change over time have been improved to 50% with the application of Single Minute Exchange of Dies concept. Because of SMED additional capacity gained from the reduction of setup time [3].Lean is focused at cutting non value-added activities from the whole production. To improve the pump productivity of the company by identifying bottlenecks and non-value added activity through reducing cycle time. Reduction in lead time, cycle time and inventory level achieved from value stream implementation .[5] The use of lean manufacturing Techniques in reducing waste and a 35% reduction in Through-Put Time is achieved to increases the productivity in a Pump manufacturing Company [4]. By implementing lean manufacturing the production of the pump set has increased from 3200 to 8000 [6]. Application of these lean tools which eliminates inventory which in turn reduces the lead time from 14.60 days to 13.60 days and Value Stream Mapping (VSM) to map the present and the future state[7].The efficiency of the centrifugal pump manufacturing industries is to be increased considerably by applying the Lean Manufacturing System and Kaizen Technique [8].Several lean techniques and analysis were applied and Performed, i.e., VSM, OEE, spaghetti diagrams, work balance, and discrete event simulation gives promising improvements primarily in lead time and work cycle efficiency [9]. The productivity improvement is made through modification of shop floor layout and streamlining the material flow in between machines. The analysis of machine utilization and layout of machinery is made to enhance the machining capacity of the shop floor [10]. VSM focuses on value in the context of what the customer is willing to pay or what makes the product gain customer satisfaction [11].

3. Methodology

The identified method of work was taken for preparation of future state value stream map from the current state value stream map. Various tools and techniques of Lean Production System were used to establish a continuous flow in the line, by implementing kaizen. Several continuous improvements were made for reducing the cycle time, lead time, number of workers, work in process inventory and non-value added time.

4. Manufacturing plant, product, and processes

The pump manufacturing Plant located in Coimbatore is equipped with latest manufacturing Technologies and quality standards. The plant employment in 2015 was 430 that included 75 management staff and 355 operators. The plant's functional departments include Manufacturing Engineering, Production Planning and Control, Quality Control, Maintenance, Reliability, Dispatch, Human Recourses, and Finance. It was well equipped with separate press shop, machining shop, welding shops, sub assembly, main assembly, Packaging and dispatch. The company also manufactures and markets domestic as well as export pumps and motor components cater to the industrial, commercial, and agricultural sectors. The manufacturing process of 4 inch radial flow casing can be divided into four categories: Press shop, Machine shop, Sub assembly, Packaging & Dispatch.

5. Value Stream Mapping

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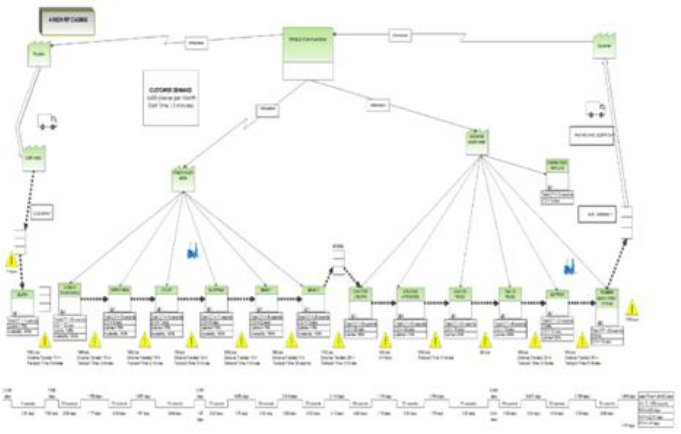
Value stream mapping (VSM) is one of the most powerful tools of lean manufacturing. VSM is a tool which may regarded as the starting point of system improvement practices, as it helps in identifying the areas where the improvement efforts should be concentrated. The main advantage of VSM is that it gives an opportunity to examine the chain of process and focus only on the value added activity. For this particular case study the Current state and future state value stream mapping has been framed using I–GRAFX 2013 software. Here in our case study "fishbone" diagram is majorly used as a tool to find the probable root cause in all stages of the process.



Total lead time: 24.4 days **WIP:** 22.73 days

Fig.1 Current State Value Stream Map

6. Layout Optimization

The actual layout in the workshop is complex and the machines were not properly arranged in a sequence to any of the process flow. A process routing is defined as the set of machines that are visited by a part type in order to process each one of its required operations. The VIP-Plan opt software has been used to optimize the layout. Based on high volume base the routings were found and the layout has been modified. By collecting data about machines, operation sequence and area of the layout the VIP – Plan opt gives a better solution, which proves its ability to solve an industrial layout problem. A process routing is defined as the set of machines that are visited by a part type in order to process each one of its required operations in a scheduled manner.

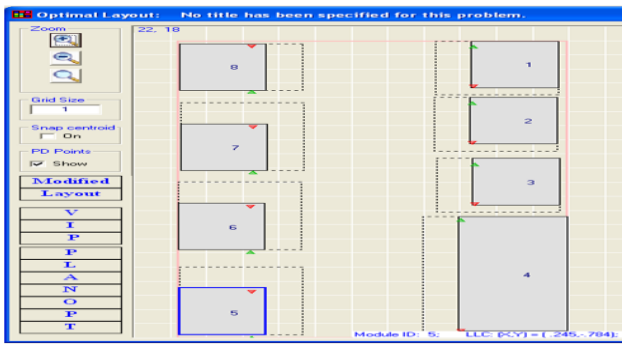


Fig.2 VIP–PLANOPT-Output

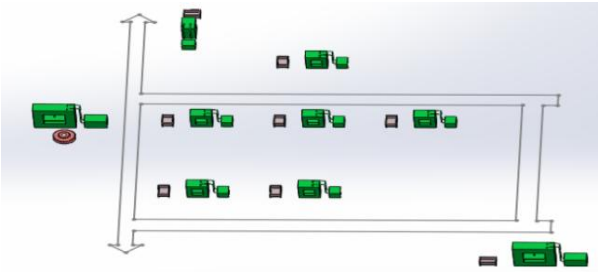


Fig .3 Layout: As - is

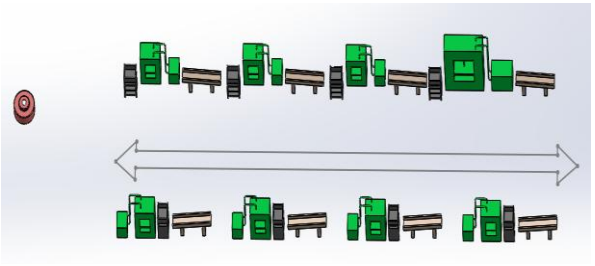


Fig.4 Layout: To - be

6.1 Die stand with Bin set-up

In before conditions the worker carries all the die and fixture from die rack which is located far away from the press shop which causes wastage of time for set-up process. But in after condition we designed a stand which holds the tools, die and fixtures near to the machine itself which resulted in the resulted in transportation time as well as set-up time reduction and safety is improved. In order to reduce the non-value added time and transportation time the brainstorming session was conducted and suitable methods for improvement were discussed. The use of proper bin setup is to reduce the non-value added activities, worker movements and further it reduces the load carried by them which will be ergonomically beneficial to the workers. This stand with bin set up is designed for storing the die and punches near to the machine where the stand is mounted. The bin is placed above the stand which could be direct access to the operator to retrieve parts from the bin. The unnecessary movement of operator has been reduced and the Ideal running time of machine gets improved.

6.2 Setup time reduction

By using functional clamps and adopting parallel activities during the set up the die and punch set up time has been greatly reduced. Collection of standard changeover time data of machines from Industrial Engineering Department of the industry for high Volume based pump components which require maximum change over time on machines. Time study using a check sheet, function checks, and improved transport of dies are some of the techniques to be used for understanding and for analysing the existing practice of set-up changeover. On the basis of past data it is observed that 4inch casing component which holds 60% of total production; hence it is necessary to reduce change over time of the machine, Implementation of SMED based lean techniques will be carried out, as per findings from changeover time study and literature survey. Separation of internal from external operations and the conversion of external to internal operations are among the key

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drivers to improvement. The idle time of worker has been eliminated by adopting parallel activities. By providing necessary tools near to the machines the non-value added time was eliminated. Since the transportation time is being reduced due to the introduction of die stand near to the machine the set up time for four machines have been reduced. Similar time study was conducted for Step form and ID cut process setup and the results are mentioned below. Finally, the Work in Process inventory of press shop has been reduced from 7.3 days to 2.4 days.

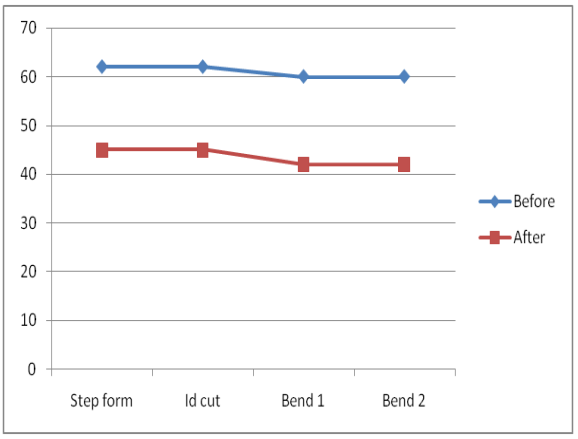

Fig. 5 WIP Reduction in minutes

7. Overall equipment effectiveness

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of the manufacturing process. OEE has become an accepted management tool to measure and evaluate machine productivity.

OEE Before

A = Run time/Total time = 78.09 %

P = Total parts/ Target count = 78.09 %

Q = Good parts/Total parts = 98.47%

OEE=A*P*Q=60.04%

OEE After

A = Run time/Total time = 89.28 %

P = Total parts/ Target count = 89.28 %

Q = Good parts/Total parts = 98.66%

OEE=A*P*Q=78.64%

8. Dividing work content and machine grouping

In the machine shop the major remaining process of 4 inch casing can be done. The grouping of machines, combining relevant tasks and the flow of parts with improvements are made. The work content is equally divided among the operators based on cycle time, work load and physical constraints. After the rearrangement (grouping) of machines the machining and welding tasks was combined and only fewer inventories will be stored in between operations which make frequent delivery of goods to the preceding operations. The distance between machines also been greatly reduced. Hence here the batch processing is converted into single piece movement by the implication of new layout. The work is divided in such a way that each operator gets equal work load.

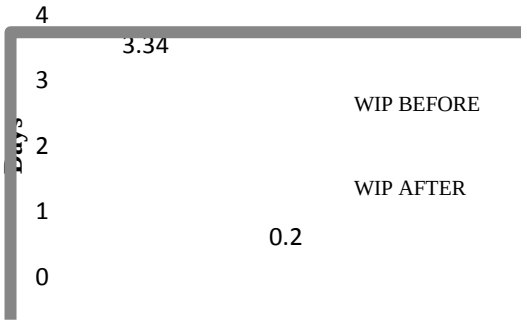

Fig. 6 Work In Process reduction in machine shop

An assembly line consists of workstations that produce a product as it moves successively from one workstation to the next along the line, which this line could be straight, u-line or parallel until completed. The Largest Candidate, Kilbridge and Wester (column) and Ranked Positional Weights (RPW) are different heuristic methods commonly utilized to arrange and distribute the description element time along the workstations in the system. To equalize the work load among the assemblers and to establish the speed of the assembly, line balancing been applied here. . Largest candidate rule been applied here in this study and the line was streamlined by employing each operator to the relevant station by distributing three activities to each operator. In Assembly section the parts produced per hour been improved by 34 %.

Table 1 Station and task description

Station	Task Assigned	Task Description	Time (Sec)
A	1 ,2 and 4	Air blow, Cleaning 1, Placing bush	13
B	3, 5 And 6	Placing ring, Cleaning 2, Gauge check	13

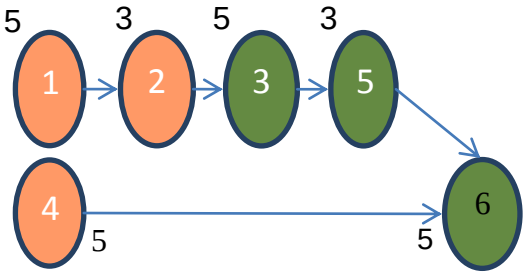

Fig. 7 Precedence Diagram

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10. Results and Discussion

The future state VSM is presented here as a summary of all the improvements. Since, the value added time remained constant and lead time was reduced, the improvement was made to 33.85 % reduction in lead time. Thus, the work in process inventory of 4 inch casing could fall from 24.4 to 16.14 days. Several improvement initiatives were highlighted and stated in the future state VSM. It was also observed from the time study and spaghetti diagrams that the amount of time dedicated to movement is considerable and that it could be reduced in a variety of ways, such as decreasing the distances between machines in the press shop. By making the materials to flow on the production line in a smaller batch size in press shop so that works in process between processing stages can be minimized. The die stand and bin set up introduction will be more flexible to the operators and the NVA's been reduced to a greater extent. In a major rearrangement of the shop floor machines, the CNC and welding operations are directly integrated, so as the work content is equally divided to the operators and, thus, a huge saving is made possible, both in terms of motion and time in the machine shop process.

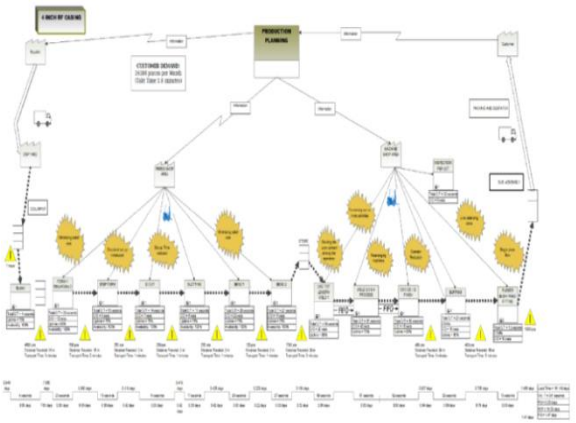

Fig.8 Future State Value Stream Map

11. Conclusion

The following are some of the salient conclusions that are drawn based on the present studies:

It was observed from the current state map that the total lead time for the product is more than value added time. After the improvements been made,

- Process lead time reduces from 24.4 days to 16.14 days.
- Inventory reduces to 8.26 days.
- Continuous flow been created wherever possible.
- Operators reduced from 7 to 3 in the machine shop by balancing the work content.
- Achieved single piece flow in sub assembly.
- Productivity improves to 7.7%.

Certainly, it is hoped that this paper carries its worth for practitioners in the pump manufacturing industries. This case study provides us with the privilege to learn a lot from the specific case study problem and it also provides a scope for further research.

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