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Lean Tools Execution in a Small Scale Manufacturing Industry for Productivity Improvement- A Case Study

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Abstract

Objective: To study and implement the lean tools and to reduce lead time without much affecting the current working systems in a small scale automotive component manufacturing industry. **Method/Analysis:** An attempt was made in increasing the capacity of a machining cell with appropriate lean techniques. The enhancement of capacity was to be completed with zero capital investment. **Findings:** A lean approach by using value stream mapping and line balancing was adopted to improve the performance of the manufacturing cell. By collecting the past production data and deciphering the information, gaps were identified for enhancement. Single Minute Exchange of Dies (SMED) was used to regulate the production and Kaizen was also introduced in all work stations. Leveled operator loading for output consistency was suggested. Finally capacity intensification was achieved without any major capital investment. **Application/Improvements:** Implementation of lean tools reduced the setup time and idle time. The overall lead time got reduced from 6.9 days to 3.6 days and total cycle time got reduced from 170 to 140 minutes and the customer demand was also met on time by the execution of lean tools.

Keywords: Cycle Time, Lead Time, Line Balancing, SMED, TAKT Time, VSM

1. Introduction

The word lean means that it is to generate more value for consumers with minimum resources. This has become the modern trend for management of products and services[1]. Continuous improvement with or without capital infusion necessitates competitive manufacturing. Capacity addition is an important metric of a manufacturing facility to meet the ever increasing customer demand. Lean Manufacturing (LM) is a technique to reduce the cost of product and to enhance the productivity by removing Non-value added (NVA) activities[2]. In Toyota's production system, LM can be defined as a systematic approach to identify and eliminate NVA activities during continuous enhancement by manufacturing the goods at the tow of the customer in detection of precision[3,4]. Lean techniques help the manufactures to decrease the lead time, to increase the consumer fulfillment and to diminish the waste. Value Stream Mapping (VSM) is a main tool to identify the opportunities for various lean techniques. Different research articles have discussed the dissimilar applications of VSM technique in different manufacturing industries[5–7]. Work standardization in manufacturing industry leads to decrease in lead time, cycle time and setup time and also increases products with higher quality[8–10]. A summary of elimination of non value added wastes like bottlenecks, setup time and idle time using VSM method was presented. Line balancing and work standardization are the tools of LM[11]. The effectiveness and implementing of an independent maintenance system in a machine shop for enhancing the productivity with the help of lean techniques using a systematic approach to minimize the breakdowns, increase the performance and quality rate of machines so as to improve the effectiveness with higher quality[12,13]. VSM model for manufacturing process of gear shaft used in gear boxes was developed to identify and eliminate waste in which any action, that doesn't add value to the final product and also reduce lead time and increase throughput rate of parts[14,15]. An agile based supply chain model was created to accomplish success,

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where the method should adjust to changes immediately and the stakeholder should acquire knowledge about the different phases of the supply chain and share the data at the right time to sustain the dexterity in supply chain[16]. Author in[17] developed a value stream map for assembly process of motor and pump parts for identifying and eliminating waste that does not add value to the final product in the assembly process. Productivity enhancement through lean manufacturing is an optimization and synchronization of the input resources that would condense the wastes and decrease the overall production cost[18–20]. Execution of lean tools and techniques in the premises of pump manufacturing by initiating required steps in order to accomplish the customer expectations and demand were suggested[21]. A supply chain model was developed to present the necessity of maintaining quality in a medium scale industry relating to cast iron foundry under different delay conditions, rejection rates and also various other activities. The various defects in a cast iron foundry were examined and required recommendations were given to eliminate the defects in the day to day activities[22,23]. Author in[24] suggested that green goods and services are the requirements of country which are feasible only by eco friendly, energy preserving methods and best resource consumption.

A two wheeler engine casing is the part which is being machined in machine shop where the machine shop consists of CNC and conventional machines to fulfill the customer requirements. Also the conversion cost of the part has to be reduced to offset the increase in the production over heads. The need behind this project is to enhance the capacity by reduction of the losses and cycle time, there by meeting the demand with marginal investment. The project focuses on line balancing for effective operator loading and to increase the output per operator there by reducing the part conversion cost. There are 54 numbers of parts and consists of runner, repeater and stranger categories. Theoretically, enough capacity is available to fulfill the customer requirement for the standard time. But due to some major losses 25% of capacity has been lost. Also engine casing which is one of the high volume products is not meeting the customer demand. The aim of this paper is to study and identify bottlenecks in the machined parts, to increase the spare capacity, to achieve leveled operator loading, to implement the Single Minute Exchange of Dies and to analyze the man machine balance after reduction of cycle time. The aim of the study is to improve the spare capacity through elimination of losses through kaizen, line balancing, SMED and to investigate the present state VSM and in turn by reducing the lead time in the two wheeler engine casing manufacturing industry located in Chennai. Based on the above literature this research work shall serve as a pilot in ensuring a sustainable development through implementing of VSM strategy in two wheeler engines casing manufacturing industry, which shall improve the manufactured goods value and also its maintain ability as well as decrease the total cycle time.

2. Methodology

The VSM technique applied in this study is a systems approach, where the entire system is not equal to the total of its components, as their relations are of importance as well. During this research, after attaining knowledge to execute VSM and accomplish the goals of lean manufacturing, a two wheeler engine casing manufacturing company was approached. After obtaining the permission from top management, the task of examining the application of VSM was started in the company. A first round study pointed out that as many as four different engine casings are manufactured and also specified that it would be careful to begin examining VSM on an element used in majority of engine casings manufactured by the industry. The different processes of engine casing are forging, CNC turning, internal grinding, milling, drilling and broaching. The various steps involved in methodology are shown in Figure 1.

3. Sources of Data

The primary data was collected in the industry based on the present manufacturing system. The data was collected to identify the existing scenario VSM which included setup time, cycle time, number of workers, VA and NVA activities. TAKT time was calculated according to the consumer demand and then cycle time was compared with TAKT time. VA and NVA activities were recognized and feasible measures were taken for development. Line balancing was carried out for balancing the work load between the workers and the results was also optimized. There are 54 varieties of components used in the manufacturing system of which 18.52% are runner, 29.63% are repeater and 51.85% are stranger. The total number of volumes of all the parts was 2777, where 61.76% of parts are runner, 31.40% of parts are repeater and 6.84% of parts are stranger as given in Table 1.

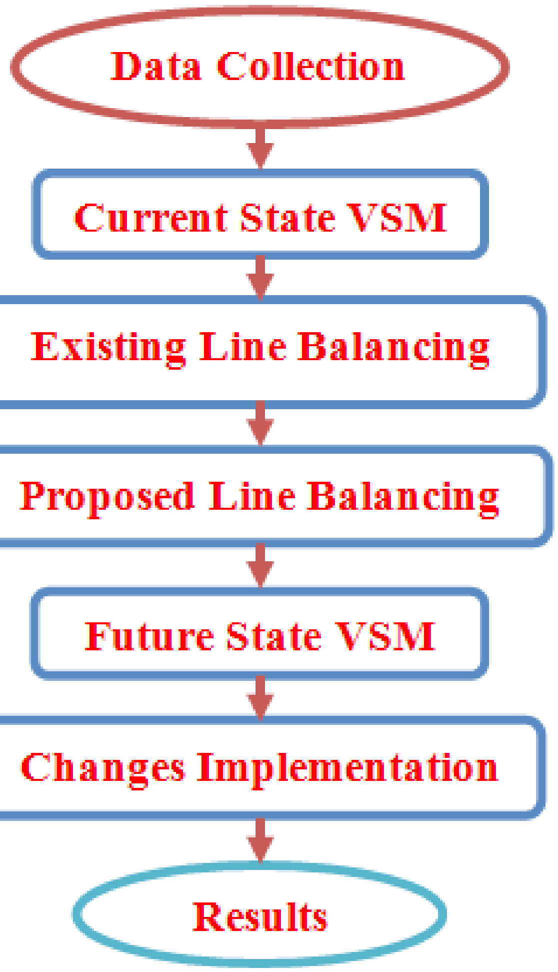

Figure 1. Methodology flow chart.

Table 1. Percentage of runner, repeater and stranger

Parts	No. of Varieties	Varieties in %	Total No. of Volume	Volume in %
Runner	10	18.52	1715	61.76
Repeater	16	29.63	872	31.40
Stranger	28	51.85	190	06.84
Total	54	100	2777	100

In the selected manufacturing industry the machine shop was having advanced CNC machines and conventional machines. Skilled workers were working in the appropriate machines to obtain the maximum output. The description of the machines with their running capacity along with the man power is given in the following Table 2. The cycle time was studied based on the capacity of machines available per day and the maximum capacity used by runners was also studied for each machine. The following Figure 2 shows the graph on the capacity of machines available per day and the maximum consuming time used by runner parts.

From the above statistical information it was found that the reality losses are consuming about 29% of capacity available in the manufacturing point. The major losses have to be identified and the necessary corrective actions are to be taken to improve the capacity available for parts manufacturing. Generally the losses have been classified as fixture setting loss, tool setting/breakage loss, offset/prove

Table 2. Details of machines with capacity

Description of Machine	Working Capacity/ Day (mins)	Man Power Allotted
Linear Tool CNC Lathe (LMW AL 22-B)	1380	3
Vertical Machining Centers (BFW)	1380	3
Vertical Machining Centers (BFW)	1380	3
Center Lathe Machine (8ft, 16 X 14 Inches)	420	1
Internal Grinding Machine (BDU 300/1500 CNC)	420	1
Universal Milling Machine (HMT FN2U)	420	1
Vertical Milling Machine (MITR DRO)	420	1
Bench Drilling- (Itco)	420	1
Horizontal Broaching Machine (HMT- RW 16)	420	1
Hydrostatic Testing Machine	420	1

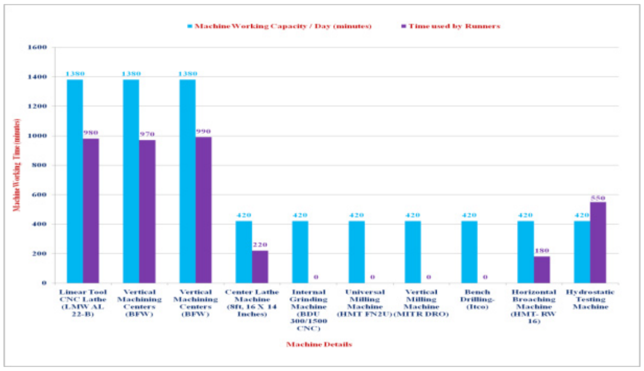

Figure 2. Machine working capacity vs time used by runners.

out, instrument setting, programming and others like absentees of worker/power shut down. The monthly losses in runner model machine were calculated for about six months during January 2016 to June 2016 for different machines. The losses in machining hours for center lathe, CNC lathe turning center, Vertical Machining Center (VMC)-1, VMC-2, and hydrostatic testing machine were calculated for six months to find the average losses of machining hours and are given in Figure 3.

4. Pareto Analysis

The Pareto analysis was carried out to calculate the losses of various operations performed in vertical milling centers-1. The operation losses and cumulative percentage of losses for various operations are given in Figure 4 and it was clearly found that the fixture setting loss of 35 minutes and tool setting/breakage loss of 20 minutes play a major role for minimizing the available capacity. For increasing the available capacity of VMC-1 fixture setting time and tool setting/breakage loss time have to be minimized. Based on the Pareto analysis, the following suggestions were made for taking necessary action to reduce the major losses. To minimize the fixture setting time the zero point clamping system has to be introduced through SMED. A chart for tool setup and cutting parameter standardization has to be displayed in each process to minimize the tool setting and breakage loss time. Online machine programming has to be eliminated by off line machine programming to reduce the programming loss.

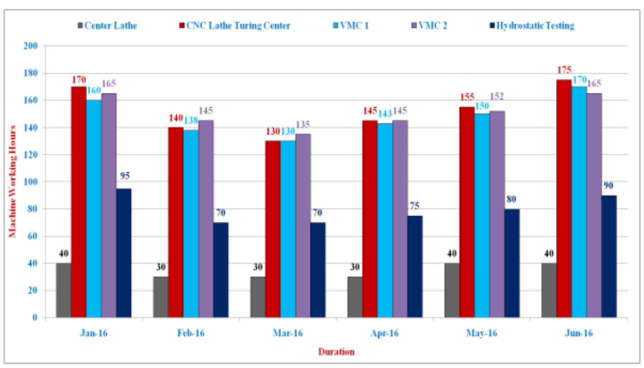

Figure 3. Monthly losses in runner model machine.

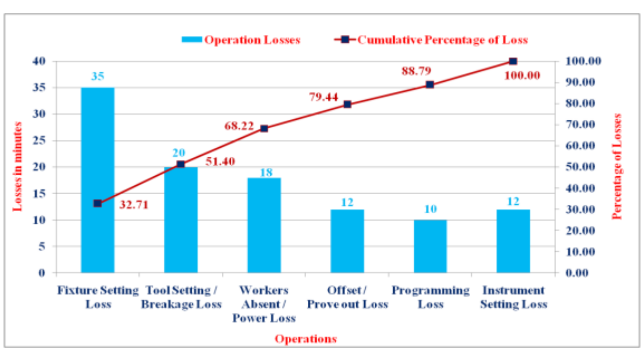

Figure 4. Pareto diagram for Losses in VMC-1.

5. Current State VSM Model

The current state VSM model was developed as per the data collected in the existing system and the same is given in the following Figure 5. The existing VSM processes were studied and the TAKT time was calculated. The unnecessary movements in subassembly, improper workloads in conveyor line activities were identified using the current state VSM. These NVA activities have to be eliminated by using lean tools for improving the overall productivity of the industry. From the current state VSM it was found that the total cycle time for all the processed is 170 minutes and the total lead time is 6.9 days.

5.1 TAKT Time Calculation

Total available time = 3 Shifts/ Day (6 Days in a Week)
Customer demand = 250 Pieces/ Week
Available working time per shift = 480 minutes
Available time per day = [3shifts x {8hoursx60 minutes} - 30 minutes]w
= 1350 minutes
Available time per week = 8100 minutes
Where,
2025 minutes is allotted for machining the engine casing, which is 25% of available time capacity
Required TAKT time = Total available time / Customer demand
= 8100/250 = 32.4 minutes.

6. Line Balancing

Line balancing is the technique used to allot the workload between different work stations. Thus every work station has the same time for its processes which decreases the cycle time and the same has to be calculated before line balancing. The line balancing as a lean tool is used in conveyor line to balance the workload between operators

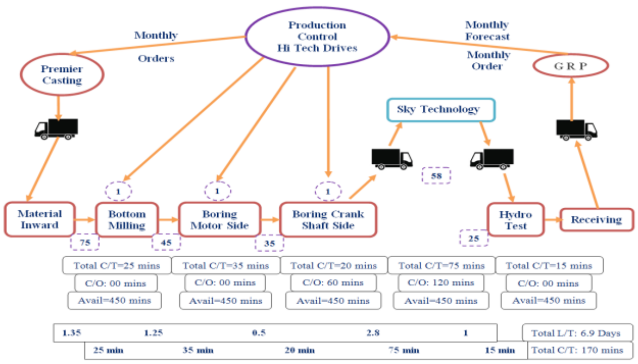

Figure 5. Current state of VSM model.

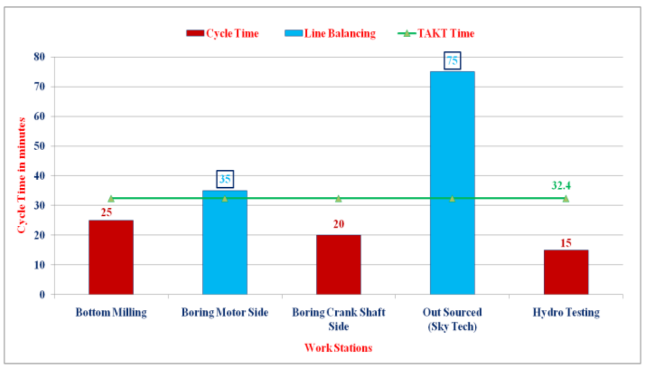

Figure 6. Cycle time before line balancing.

and reduce the NVA activities. Based on data collected for the standardization operations, line balancing ideas were practically applied for the current layout. By evaluating the cyclic activities done by each worker the new idea was proposed to reduce the lead time. From the current layout it was found that the boring motor side and cylinder boring were the bottleneck operations and consumes more cycle time of 38 minutes and 75 minutes respectively. The cycle time for each operation before line balancing is given in Figure 6 with TAKT time.

For reducing the cycle time the cylinder boring operation could be converted to in-house operation from outsourced operation. Due to length constraints with standard tools, it was decided to outsource the cylinder boring operation during development stage. Length constraint could be eliminated by introducing special boring bars. Valve seating operation cutting time is high in VMC, offloading it to HMT-FN2U milling machine with separate fixturing will eliminate the bottleneck. The cycle time for boring motor side was reduced from 35 minutes to 28 minutes and out sourced operation was reduced from 75 minutes to 55 minutes after changing the operation as in-house operation. The cycle time for each operation after the proposed line balancing is given in the following Figure 7. The line balancing is used to balance the workloads between the work stations and thereby reducing the NVA activities. After the line balancing there are six work stations with in-house including cylinder boring and valve seating. Outsourced operations can be converted into in-house based on improvements made. By converting into in-house, though the cycle time exceeds TAKT time it can bead dressed by splitting the operations in to two work stations called cylinder boring and valve seating. After line balancing, the overall cycle time for all the work stations was found to be 140 minutes.

7. Future State VSM Model

The future state VSM model was developed based on the current state VSM model. The proposed suggestions with line balancing for improving the current position of the industry are shown in the following Figure 8. From the future state VSM it was found that, the NVA

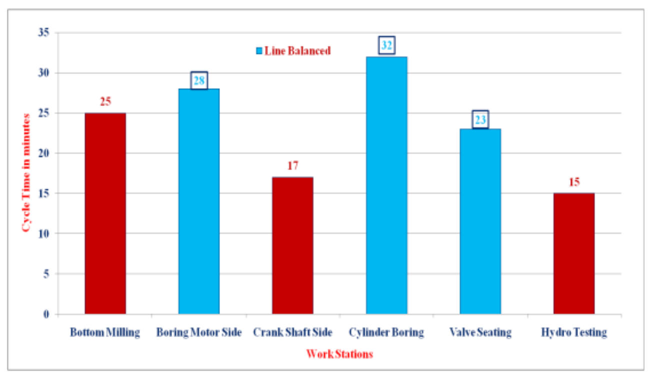

Figure 7. Cycle time after line balancing.

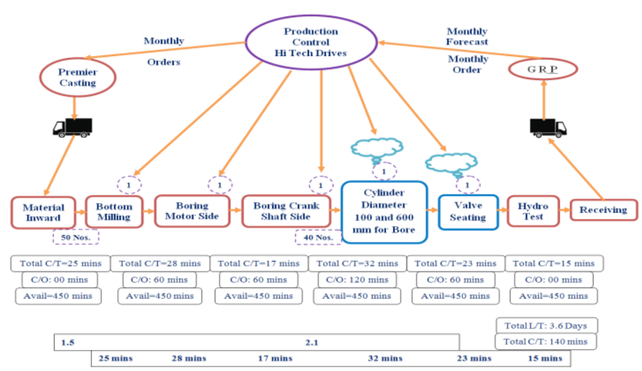

Figure 8. Future state of VSM model.

activities were reduced by using suitable lean tools. Based on continuous improvements the lead time was reduced from 6.9 days to 3.6 days and the total cycle time also reduced from 170 minutes to 140 minutes after implementation of appropriate lean tools like line balancing, SMED etc.

8. Conclusions

The study was carried out in a machine shop in a small scale automotive engine casing manufacturing industry. The lean tool like VSM, SMED and line balancing was implemented to identify and eliminate the non value added activities for reducing the cycle time and lead time. Based on the above analysis and results the following conclusions were drawn.

- The available NVA activities were identified from the current state of VSM and opportunities for improvement were recognized and future state VSM was constructed.
- Operator's disagreement due to parts description was reduced and also customer satisfaction was increased by Kaizen. Since the deliveries of products were made faster, customer satisfaction increased and hence the productivity also increased.
- Lean execution in the excising system reduced setup time and idle time with the help of line balancing.
- By implementing standard operating procedure, total cycle time has been reduced by 18% i.e., from 170 minutes to 140 minutes.
- The study carried out by these tangential activities specified that the application of VSM in engine casing manufacturing has resulted in reducing the total lead time from 6.9 days to 3.6 days and in meeting the customer demand on time.

This research was carried out on VSM in machine shop consisting of CNC and conventional machines only. This could be further extended in the operations of similar manufacturing components with additional lean tools like 5S, TPM, etc.

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