

Lean Tools Implementation for Lead Time Reduction in CNC Shop Floor of an Automotive Component Manufacturing Industry

R. Suganthini Rekha^{1*}, P. Periyasamy¹ and S. Nallusamy²

¹Department of Mechanical Engineering, St. Peter's University, Chennai-600 054, Tamilnadu, India; rekha.mira24@gmail.com, psamy75@gmail.com

²Department of Mechanical Engineering, Dr. M G R Educational and Research Institute, Chennai-600 095, Tamilnadu, India; ksnallu@gmail.com

Abstract

Objective: To examine the existing system of a production line in a shop floor of steering gear box manufacturing industry and to improve the productivity using lean methodology without much affecting current working systems. **Method/Analysis:** An extensive range of lean manufacturing tools are available to take care of all kinds of issues faced by different manufacturing industries. It also helps for successful cost reduction of the manufacturing component and to assure the quality of manufacturer and customer. **Findings:** The critical Non-Value added Activities (NVA) were recognized and probabilities required for development has been recognized. Value Stream Mapping (VSM) has the reputation of finding waste during manufacturing and business process which facilitate to identify and remove or stream the value added steps and to eliminate the non-value added steps. **Application/Improvements:** After accomplishment of appropriate lean tools, it was found that the total setup time was condensed by about 180 minutes and cycle time was condensed by about 98 minutes which ultimately reduces the lead time and increases the productivity.

Keywords: CNC, Gear Box, Lead Time, Line Balancing, VSM, Work Standardization

1. Introduction

Now a day's lean manufacturing technique is used as an imperative vertebral column of the production system in manufacturing divisions. Lean manufacturing has mostly been implemented in manufacturing industries during the last thirty years to identify the waste and to develop suggestions that will eliminate the same in manufacturing companies. The end users expect their manufacturing vendors/suppliers to be responsive in delivering products on time and hence, they are continuously leaning towards cycle time reduction in all the processes. Cycle time is one of the most significant characteristics in manufacturing and it is an interval of time during which a set of consecutive actions takes place repeatedly. In turn cycle, time is defined as the time of longest operation in a sub-

assembly and assembly line in a manufacturing industry. The cycle time will be reduced when the line is balanced properly and sub-assembly layout is optimized. Lean manufacturing has been already implemented in most of the large-scale automotive manufacturing industries. Yet there has been no information on the implementation of lean manufacturing technique in the production line of medium and small scale industries. Due to the high demand in the competitive market, the manufactures has to concentrate in the reduction of cycle time during the manufacturing. Most of the manufactures are interested in utilizing the advanced Computer Numeric Control (CNC) machines for producing the variety of products within the prescribed time to get the required product easily. In this research article, lean tools implementation is focused for steering gearbox manufacturing industry

*Author for correspondence

who is the manufacturer of different steering gearboxes cited in Chennai. Specifically the study was carried out on definite line of gear box manufacturing for continuous improvement through kaizen and other inventions. A brainstorming session was conducted with the different level of persons who was responsible for the whole production process to discuss the various issues. Finally, it was decided to execute the required lean tools to ensure the whole process must be within TAKT time and various suggestions were given to get maximum utilization machines.

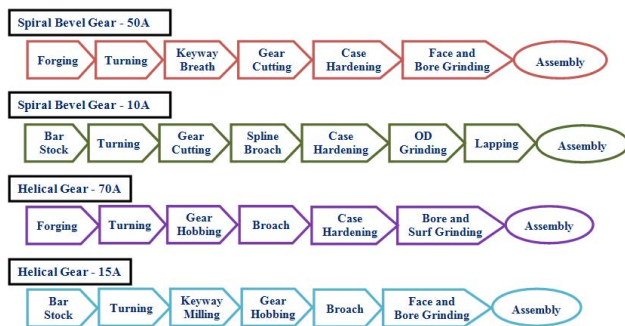


Figure 1. Process chart for a selected steering gear box.

To with stand in the globalized market, it is essential to find different methods to reduce lead time in production and cost so as to improve the operating performance with high quality of product by the manufactures. A predictable problem or challenge faced by manufacturing industries at present is to offer products at competitive prices and to reduce cost continuously which is the need of the hour. VSM is a lean tool used for waste and NVA elimination during manufacturing. The current scenario and future scenario of VSM in manufacturing process leads to signify the non-value added steps and the waste of resources to be removed¹⁻⁴. Lean manufacturing is a performance based process used in manufacturing industries to increase profit and competitiveness through eliminating waste, reducing the cycle time and decreasing the component cost. The basics of lean manufacturing and VSM employ continuous improvement processes to focus on the elimination of the seven wastes or non value added activities within the industries⁵⁻⁷. VSM is used as a main tool to recognize the opportunities for various lean techniques. Different research articles have been discussed already about the applications of VSM technique through different manufacturing industries⁸⁻¹⁰. Another

lean tool of Single Minute Exchange of Dies (SMED) is also used to reduce the setup time during the manufacturing process for getting the product at right time to meet up the demand of customer^{11,12}. Sustainability is very essential for attaining competitiveness. Line balancing is a lean tool used to improve productivity and achieve better utilization of resources¹³⁻¹⁵. The less attention on accuracy of standard time and poor work arrangement were identified as the root cause for low efficiency and increase the usage of layout by inter changing the equipment position or by establishing new machines into the layout. Line balancing is the appropriate method to overcome the above root cause and to enhance the productivity^{16,17}. While selecting the best supplier, many criteria were considered for different manufacturing by different approaches¹⁸⁻²⁰.

To achieve victory in the agile based supply chain a model was developed where the system should adapt to changes instantly and the stakeholder should possess knowledge about the various stages of the supply chain and share the information at the right time to sustain the nimbleness in supply chain^{21,22}. Green products and services are the needs of country which are possible only by environment friendly, energy conserving processes and optimum resource utilization²³. The various defects in a cast iron foundry were investigated and necessary suggestions were given to remove the defects in the day to day activities^{24,25}. Implementing the lean manufacturing tools and techniques in the pump manufacturing premises by taking necessary steps in order to fulfill the customer demand and expectations were suggested²⁶. A model was created for presenting the essential steps to sustain the quality at a small and medium scale industries related to foundry products through various activities²⁷. In a literature it was stated that, through line balancing it was possible to improve productivity and achieve better utilization of resources. The less awareness on accurateness of standard time and poor work arrangement were recognized as the root cause for low efficiency and increase in layout usage. Line balancing is the appropriate method to overcome the above root cause and to enhance the productivity^{28,29}. From the above literature, this research focuses as a pilot to ensure a sustainable development by implementing VSM strategy in a steering gearbox manufacturing industry located at Chennai, which shall improve the product value as well as its sustainability and reduce the total cycle time and setup time.

2. Process Flow Chart

This paper focuses on processes of selected gears with its classification of parts and various models used in automobile vehicles. The different processes for the selected steering gear box with its connecting parts are shown in Figure 1 process flow chart for the manufacturing of steering gear box through a set of spiral bevel gears.

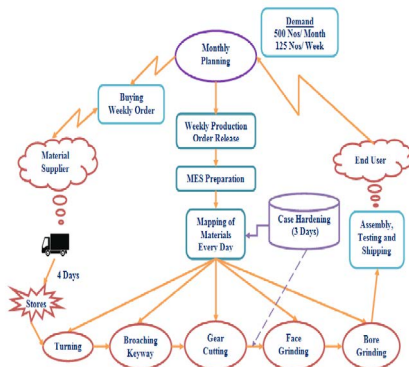


Figure 2. Current state VSM.

3. Data Collection and Analysis

3.1 Current State VSM

Various data were collected based on the existing scenario like cycle time for each process, set up time for every operation and change-over time for tool and component. In addition level of inventory, availability of machines status and total number of workers in the shop floor involved in different operations. Based on the collected data the mapping of various processes was carried out to create the current status of VSM. The following Figure 2 shows the current state VSM created through the existing manufacturing scenario of different levels of spiral and helical bevel gears. Similarly the observations through VSM analysis are summarized and given in Table 1.

The lean tool of kaizen was introduced in the existing method to enhance the productivity by reducing the wastages⁵. A group discussion was conducted with the different levees of people like engineers, line supervisors and skilled labors to get the various suggestions for improvement of the productivity. Similarly for introducing the lean tools of work standardization and line balancing many ideas were collected from them.

Table 1. Observations of current state VSM

Description	Spiral Bevel Gear 50A	Spiral Bevel Gear 10A	Helical Gear 70A	Helical Gear 15A
Customer's Demand / Month	500	500	500	500
Working Days / Month	25	25	25	25
Customer's Demand / Day	20	20	20	20
TAKT Time in minutes	21	21	21	21
Target Cycle Time in minutes	20.5	20.5	20.5	20.5

From the current state of VSM, the total lead time was calculated and was about 7 days per month. Similarly the total cycle time of 57 minutes and 39 minutes of value added time per component was observed during the manufacturing process in current state VSM. And it was also found that the total setup time during the current state VSM is about 425 minutes per day. The change over time was found to be 85 minutes per component and non value added time was 8.5 minutes per component.

TAKT time: Based on the existing data the TAKT time was calculated as follows.

Customer Demand = 20 Nos. per day

Available time per day = $\{[8\text{hours} \times 60 \text{ minutes} - (60\text{minutes})] \times 1\text{shift}\} = 420 \text{ minutes}$

Therefore TAKT Time = Available time per day / Customer demand per day
 $= 420/20 = 21 \text{ minutes}$

3.2 Non Value Added Activities

In the selected shop floor line the processes carried out in existing were studied and checked to find out the non value added steps involved. The appropriate data was also collected to find out the wastes and lead time occurring in the present process. Based on the collected data a detailed description was created about the facility available for manufacturing. More over process time, setup time and the number of workers involved were analyzed to create a future state VSM. Numbers of testing operations have been finalized through the observed data and the trail values were arrived using conservative standard table.

Value added and non-value added steps with Necessary Non-Value added Activity (NNVA) was evaluated by the selected trailing manufacturing process. The required activities were applied after make short the NVA and NNVA steps to completely eradicate the NVA with minimize the NNVA for attaining the customer demand.

The components were categorized as internal and external activities for calculating the exact setup time and again the same has been classified in to significant elements like records collection, displacement data, regulation, manage, shipping etc. In general the setup related components are used to develop and minimize the setup time during manufacturing process by the concept of Eliminate, Combine, Reduce and Simplify (ECRS). For developing the operational procedures with regular office management methods the ECRS system is applied. ECRS is nothing but eliminate unwanted process, combine the mutual operations, reschedule the process based on the availability of machines and make things easier by simplifying the entire manufacturing process during the manufacturing of the component. By implementing the ECRS technique the total NVA have to be eradicated and the required output may be attained within regular time to get the demand.



Figure 3. Line balancing methodology.

3.3 Line Balancing

Line balancing is a lean tool used in conveyor line to balance the workload between the workers and to reduce the NVA process to arrive the maximum product by effectively using all the machines⁷. The proposed line balancing methodology for the selected CNC shop floor is shown in the following Figure 3 with the various steps involved in the existing layout. Through this proposed line balancing method the man power and the machine usage should be increased as maximum for attaining the product at right time to meet the demand. The cycle time for each work station was calculated before line balancing. The conveyor line has seven workstations and seven workers. The cycle time for each station before line balancing was calculated and it was found that the total cycle time for all seven work stations is 57 minutes.

3.4 Work Standardization

Standardization of the operations was carried out based on the defined methodology²² and is shown in the following Figure 4. During the time study there are three sets of process carried out to find out the real time taken for process cycle and setup. There are about more than 160 enhancement ideas were suggested by different level of employees during the Kaizen and the same was applied during the manufacturing process to reduce the overall lead time. The activities have been separated as internal and external and the critical elements were identified for both the activities to apply ECRS for reducing setup time. Necessary allowances were given for each operation to get the product with high quality at right time to attain the demand.

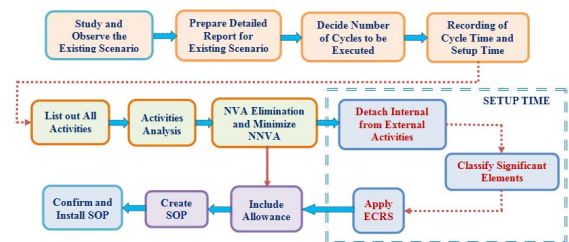


Figure 4. Work standardization methodology.

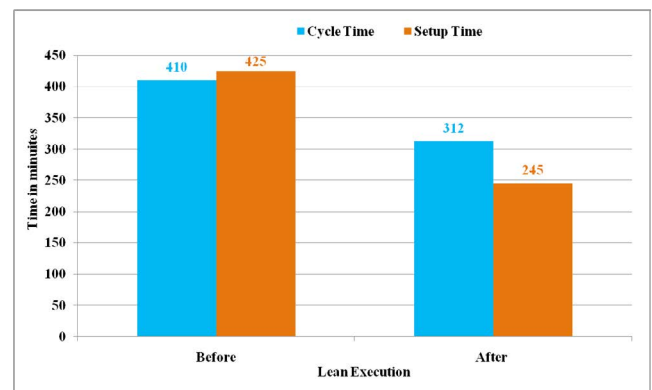


Figure 5. Comparison chart for cycle time and setup time.

From the analysis it was observed that the cycle time was reduced by about 98 minutes and the setup time was about 180 minutes through standardization lean tool. The comparison of cycle and set up time before and after the execution of lean tools are given in the following Figure 5. After introducing the proper allowances for every operation the *Standard Operating Procedures* (SOP) was created to carry out the process for completion of the

product. The generated SOP was authenticated through proper channel for execution. During the process for an easy assessment of the work by the workers a revised copy of the SOP was pasted in every machine. Due to a new deployment of SOP it was observed that the lead time was reduced in the manufacturing line without affecting the required output²⁶.

4. Conclusions

Based on the above analysis and results the following conclusions were drawn.

- From the current state of VSM various significant NVA activities were identified.
- Future state VSM was created by identifying the various advancement opportunities.
- Point to point layout chart was prepared for the current layout and the same was optimized.
- Workload was equally distributed between the operators and the necessary keys were implemented.
- It was found that the cycle time was reduced by about 98 minutes and setup time was also reduced by about 180 minutes.
- The experiments conducted with these activities were specified that the application of VSM in steering gear box manufacturing has resulted in reducing the manufacturing lead time from 7 days to 5.5 days to attain the demand on time.

The research may be continued with different lean tools execution in different manufacturing industries for continuous improvement.

5. References

1. Arslankaya S, Atay H. Maintenance management and lean manufacturing practices in a firm which produces dairy products. *Procedia - Social and Behavioral Sciences*. 2015; 207:214–24.
2. Nallusamy S, Saravanan V. Enhancement of overall output in a small scale industry through VSM, line balancing and work standardization. *International Journal of Engineering Research in Africa*. 2016; 26:176–83.
3. Nallusamy S. Lean manufacturing implementation in a gear shaft manufacturing company using VSM. *International Journal of Engineering Research in Africa*. 2015; 21:231–7.
4. Reddy S, Jagadeeshwa H. VSM in a manufacturing industry. *International Journal of Advanced Engineering Technology*. 2013; 4(2):20–3.
5. Nallusamy S. Frequency analysis of lean manufacturing system by different critical issues in Indian automotive industries. *International Journal of Engineering Research in Africa*. 2016; 23:181–7.
6. Dighe S, Kakirde A. Lean manufacturing implementation using VSM: A case study of pumps manufacturing company. *International Journal of Science and Research*. 2014; 3(6):2492–8.
7. Nallusamy S. Productivity enhancement in a small scale manufacturing unit through proposed line balancing and cellular layout. *International Journal of Performability Engineering*. 2016; 12(6):523–34.
8. Bhalwankar M, Mastud S. Applying VSM for improvements in automotive seat manufacturing processes. *International Journal of Mechanical Engineering and Robotics Research*. 2014; 3(4):164–77.
9. Nallusamy S, ManikandaPrabu N, Balakannan K, Majumdar G. Analysis of static stress in an alloy wheel of the passenger car. *International Journal of Engineering Research in Africa*. 2015; 16:17–25.
10. Nallusamy S. A proposed model for lead time reduction during maintenance of public passenger transport vehicles. *International Journal of Engineering Research in Africa*. 2016; 23:174–80.
11. Shinde S, Jahagirdar S, Sane S, Karandikar V. Set-up time reduction of a manufacturing line using SMED technique. *International Journal of Advance Industrial Engineering*. 2014; 2(2):50–3.
12. Nallusamy S. Environmental sustainability evaluation for an automobile manufacturing industry using multi-grade fuzzy approach. *International Journal of Engineering Research in Africa*. 2016; 19:123–9.
13. Pandit SV, Kadam SJ, Kharat A, Nayakawade CU. Productivity improvement by application of line balancing. *International Journal of Innovative Research in Science, Engineering and Technology*. 2014; 3(4):11495–502.
14. Nallusamy S. Enhancement of productivity and efficiency of CNC machines in a small scale industry using total productive maintenance. *International Journal of Engineering Research in Africa*. 2016; 25:119–26.
15. John B, James J, Rengaraj RM. Analysis and optimization of plant layout using relative allocation of facilities techniques. *International Journal of Emerging Technology and Advanced Engineering*. 2013; 3(8):514–20.
16. Nallusamy S. A proposed model for sustaining quality assurance using TQM practices in small and medium scale industries. *International Journal of Engineering Research in Africa*. 2016; 22:184–90.

17. Belokar RM, Kharb SS, Vikas K. An application of VSM in automobile industry: A case study. *International Journal of Innovative Technology and Exploring Engineering*. 2012; 1(2):231–6.
18. Ramamoorthy, Selladurai. Economical growth in pump manufacturing industries through lean manufacturing system using brainstorming technique: A case study. *International Journal of Advanced Economics and Business Management*. 2011; 2(1):1–8.
19. Nallusamy S, Kumar DSL, Balakannan K, Chakraborty PS. MCDM tools application for selection of suppliers in manufacturing industries using AHP, Fuzzy Logic and ANN. *International Journal of Engineering Research in Africa*. 2016; 19:130–7.
20. Nallusamy S, Satheesh S, Chakraborty PS, Balakannan K. A review on supplier selection problem in regular area of application. *International Journal of Applied Engineering Research*. 2015; 10(62):128–32.
21. Ratheesh PG. Standardization of work in a manufacturing industry. *International Research Journal of Engineering and Technology*. 2015; 2(8):2395–0072.
22. Nallusamy S. Efficiency enhancement in CNC industry using VSM, work standardization and line balancing. *International Journal of Performability Engineering*. 2016; 12(5):413–22.
23. Nallusamy S. Sustainable green lean manufacturing practices in small scale industries - A case study. *International Journal of Applied Engineering Research*. 2015; 10(62):143–6.
24. Kumar P, Gandhi MD. Green manufacturing in foundry. *International Journal of Engineering Research and Technology*. 2013; 2(1):1203–7.
25. Nallusamy S, Umarmukdhar M, Rekha RS. A proposed supply chain model for productivity enhancement in medium scale foundry industries. *International Journal of Engineering Research in Africa*. 2016; 20:248–58.
26. Nallusamy S, Saravanan V. A study on lean tools execution in a small scale manufacturing industry for productivity improvement. *Indian Journal of Science and Technology*. 2016; 9(35):1–7.
27. Nallusamy S, Suganthini Rekha R, Balakannan K, Chakraborty PS, Majumdar G. A proposed agile based supply chain model for poultry based products in India. *International Journal of Poultry Science*. 2015; 14(1):57–62.
28. Roy D, Khan D. Integrated model for line balancing with workstation inventory management. *International Journal of Industrial Engineering Computations*. 2010; 1(2):139–46.
29. Nallusamy S, Balakannan, Chakraborty PS, Majumdar G. Reliability analysis of passenger transport vehicles in public sector undertaking. *International Journal of Applied Engineering Research*. 2015; 10(68):843–50.