International Journal of Research in Engineering, Science and Management
Volume-1, Issue-7, July 2018
www.ijresm.com
ISSN (Online): 2581-5782

Lean Implementation Using Root Cause Analysis Approach in Machine Tool Industry

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***Abstract*: The aim of this paper is to implement lean manufacturing in the production of central lathe in a machine tool company using root causes analysis. The work was done at one of the largest machine tool company in the country. Various problems occurring in the production were found from the non-conformity reports. Pareto analysis was conducted and the major problems were identified. A cause and effect diagram is formed and root causes of the major problems were found by conducting likert analysis. Once the root causes are identified corrective methods incorporating lean tools like poka-yoke, SMED were suggested for eliminating the occurrence of the problems.**

Key Words: Root cause analysis, lean manufacturing, machine tool industry, cause and effect diagram, pareto chart.

1. Introduction

In the present era of manufacturing, due to the very high competitive nature of the market, companies have started to think about production techniques to reduce wastages, since wastages affect the production cost and thereby the profit level of the firm. Lean manufacturing is one of the most popular manufacturing techniques employed by various firms across the world to achieve wastage reduction. Lean manufacturing involves the elimination of all such activities that does not add value to the customer. Lean manufacturing can be implemented by accessing the current situation to find the areas that needs to be improved and to design a manufacturing process that eliminates the non-value adding activities.

One of the most effective ways by which lean manufacturing can be implemented is by the root cause analysis. Root cause analysis in lean implementation involves identifying the root causes of various occurring defects and finding suitable methods to prevent further occurrence of the defect. This paper presents a case study done for the implementation of lean manufacturing in a machine tool company. Presently in the production of central lathe, which is the major product of the company, there is a need to do a large amount of rework due to quality issues in the production. The sale of central lathe was found to be decreasing over the years. This paper aims to find the various problems in the production, to find the major occurring problems using pareto analysis, to find the root causes of the major problems and finally suggest suitable methods to eliminate the root causes.

2. Literature Review

Lean manufacturing according to Womack et al. (1990) is a philosophy that focuses on the usage of less of everything. According to Rose (2012) lean manufacturing is the best manufacturing technique in 21st century. The primary focus of lean manufacturing is to find and reduce the waste in terms of non-value adding activities (Womack and Jones, 1996). Lean manufacturing aims at simplifying the various processes and eliminating the non-value adding activities (Radnot, 2010). Works done on implementing lean manufacturing are analysed for this study.

Sudipta and M Sumon (2015) intended to increase the productivity of furniture manufacturing industry in India, by reducing the processing time. Lean tools like Short Interval Control, SMED, were used for problem solving. The work resulted in significant reduction of processing time for different lots of items. Verma and Sharma (2015) in their work identified the waste related problems like cause of bottleneck problems, equipment failure and rectify them by the implementing lean manufacturing. Process were analysed in relation with rejection control, waiting time, set time, inventory control and eliminating non value added time or activities. The advantage due to this study was that no new machines were purchased nor were the operators expected to work faster or harder, here only procedures and layouts were improved.

A. Lean Implementation by Root Cause Analysis

Root cause analysis is a method employed for investigating and finding the root causes of a problem. Root cause analysis can be used for identifying the root causes of various problems, and once the root causes of problems are identified, counter measures can be applied to implement lean manufacturing. Root cause analysis as defined by Andersen and Fagerhaug (2006) is: “Root cause analysis is a structured investigation that aims to identify the true cause of a problem and the actions necessary to eliminate it”. A large number of tools are available for doing root cause analysis, Mark (2004) reveals some of the tools like Cause and Effect Diagram, 5 Why Analysis, Interrelationship Diagram etc. Pareto Chart and Cause and Effect Diagram are used in most of the works for the identification and categorising the problems. Lean can be implemented using root cause analysis using Pareto chart and Cause and Effect diagram. Many works involving waste elimination works were done by using this method, some of those are given discussed here.

Hossen et al. (2017) used root cause analysis to examine various losses in a yarn manufacturing company in Bangladesh. Data were collected based on stoppage losses, a Pareto chart was prepared to prioritise the various losses due to stoppages From the Pareto chart the major problems were

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found to be idling and minor stoppages and breakdown. Ishikawa diagram was formulated to find the various causes of stoppage losses. From the analysis, the root causes responsible for the problems were found. Once the root causes were obtained, corrective measures were taken and future suggestions were recommended to increase the productivity.

Perera and Navaratne (2016) used root cause analysis to identify the various causes of defects and analyse its causes in a powder filling and packing company. Primary data were collected by measurements and observation and secondary data were collected from the production records. The major defects were identified and were analysed using the pareto chart and the wastes were prioritised based on their impact. Cause and effect diagram was formulated and the various causes of the defects were identified. Using brainstorming sections corrective measures were suggested.

Mahto and Kumar (2008) employed root cause analysis method to find and reduce the causes that resulted in dimensional imperfections in cutting operation by the CNC oxy flame cutting machine. Fishbone diagram was used to find the effect of possible causes. The work resulted in significant reduction of defects. Ahmed and Ahmad (2011) discusses about lean implementation in a lamp production company to reduce wastes and defects occurring in the lamp manufacturing process. Using pareto analysis the major causes for the defects were found. The causes were sorted based on their importance. Fishbone diagram was prepared and causes were analysed. Corrective measures were suggested to solve each major cause.

B. Lean in Machine Tool Industry

According to Eswaramoorthi et al. (2011) the level of lean implementation by machine tool industry in India is very low. About 68.4% of the total machine tool companies have not implemented any lean techniques. The production mostly follows high variety low volume system in the machine tool industry, also these companies does not usually produce standardised products, which makes lean implementation a very tedious process. Jay et al.(1997) discusses about the difficulties in implementation of lean in companies which have high variety and low volume. Only few works has been done on lean implementation in machine tool industry. Chiou et al. (2014) discusses about the concept of Theory of Constraints and lean was implemented in a machine tool company in order to improve the due date performance of the company. The work by John et al. (2012) is about lean implementation in machine tool industry. The work focussed in modifying the layout of operation of central lathe manufacturing. The problems encountered in current processes were found by plotting a value stream map. The results indicated significant improvements.

3. Methodology

The study was conducted in one of the biggest machine tool company in India. The methodology used for this work involves literature study of various works done on lean manufacturing, lean in machine tool industry and lean implementation works done using root cause analysis, data collection involving identifying the various problems encountered in the production of central lathe, which can be obtained from the non-conformity reports of the company, identification of the major problems among all the problems by pareto analysis, finding the root causes of major problems using cause and effect diagram, providing suggestions to solve the major problems and finally analyzing the various corrective measures suggested. A committee of 20 members was formed consisting of the Joint General Managers, Deputy Chief Engineers, Supervisors, operators, apprentice for the execution of this work. The methodology flow chart is shown in Fig. 1.

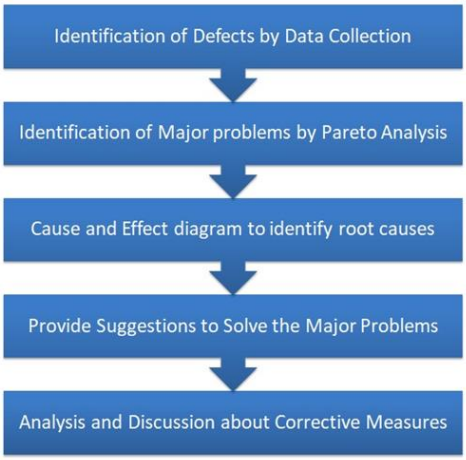

Fig. 1. Methodology

4. Data Collection

Data collection involves the identification of various problems occurring in the production of central lathe. This was done by examining the non-conformity reports of the company. The problems identified from the non-conformity report is given in Table-1.

Table-1
Defects in central lathe production

Problems	No. of Defects per 104 units
Cam Issues	82
Coaxiality Error in Headstock	85
Gear Damage	26
Casting Error	60
Improper Material Cutting	92
Dimensional Mismatch	11
Damage to bearings	12
Bending of bed or lead screw	6
Feed box Tripping	9
Electrical or Lubrication system error	6
Alignment problem	4

5. Data Analysis

Data analysis is done using pareto chart and Ishikawa diagram. Pareto analysis is done to identify the major problems in the production of central lathe and Ishikawa diagram is used to find all the possible causes for the occurrence of the particular problem. The pareto chart obtained is shown in Fig. 2.

It was found from the pareto chart was that 81.2% of the total problems were due to four major problems namely:

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- *Coaxiality Error:* center of bored holes of lathe headstock that are supposed to be along same axis deviates from the axis.
- *Cam Issues:* Sharp corners in barrel cam resulting in tight gear shifting.
- *Casting Errors:* Blow holes, cracks etc.
- *Improper Material Cutting in Preparatory stages:* Large amount of material loss due to taper occurrence.

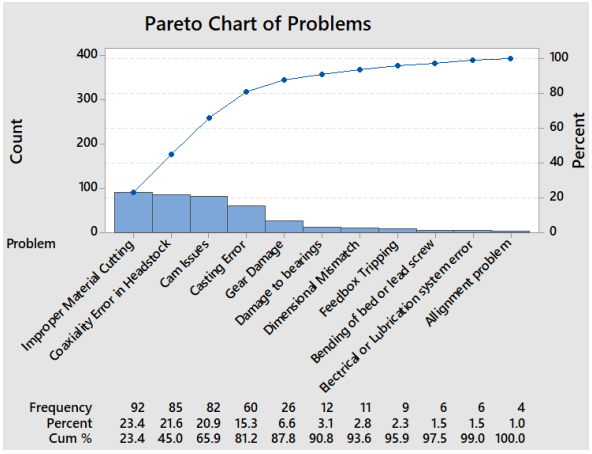

Fig. 2. Pareto chart for problems

A. Root Cause Analysis

The root causes of the major problems can be identified by root cause analysis. Root cause analysis for this study can be done by making cause and effect diagram for all the major problems. The possible causes for the occurrence of a problem are found by conducting brainstorming sessions among the committee members formed for the execution of this study. The cause and effect diagram obtained for the major problems are given in Fig. 3, Fig. 4, Fig. 5, Fig. 6.

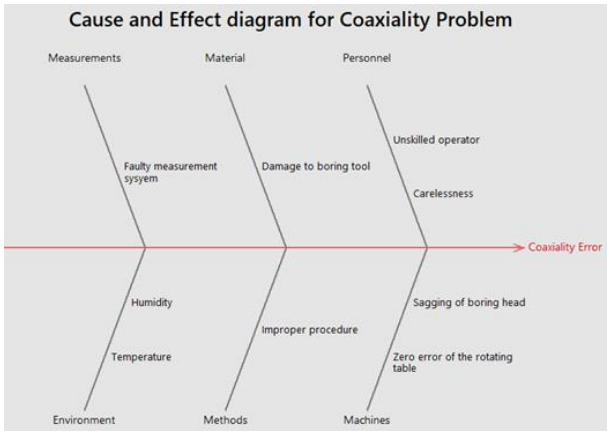

Fig. 3. Cause and effect diagram for coaxiality problem

Once all the possible causes for the occurrence of major problems are found using the cause and effect diagram, the root causes of the problems are found by conducting likert analysis for the causes obtained from cause and effect diagram among the committee members.

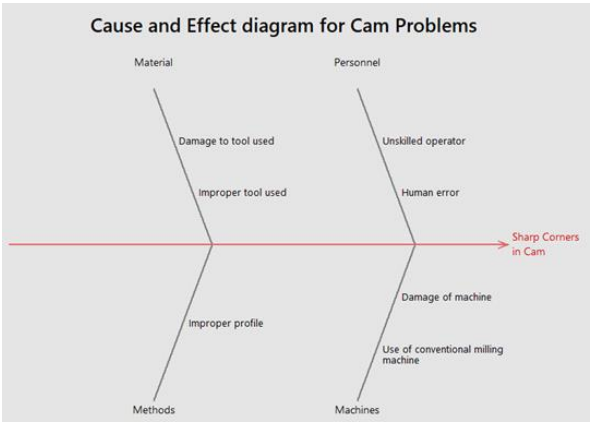

Fig. 4. Cause and effect diagram for cam problem

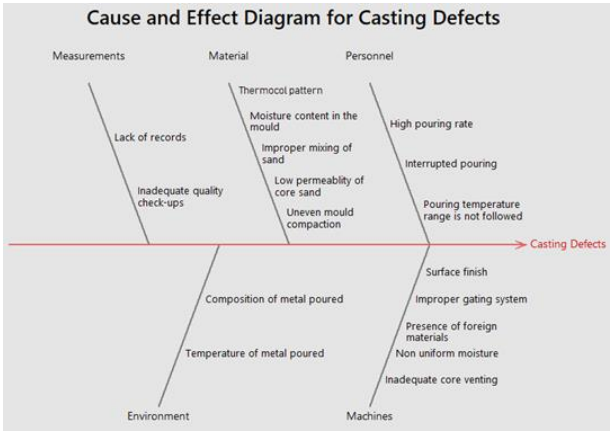

Fig. 5. Cause and effect diagram for casting defects

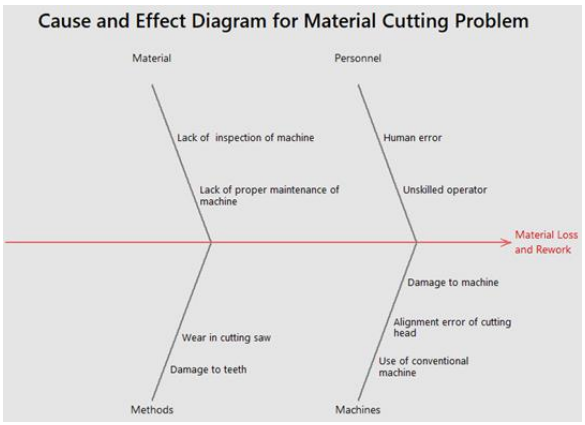

Fig. 6. Cause and effect diagram for material cutting problem

The root causes identified by conducting likert analysis among the committee members are:

- *Coaxiality Problem:* Zero error of rotating table in the machine used for boring operation of the headstock and sagging of boring head along the length.
- *Cam Problem:* Use of conventional machine for milling and improper tool used.

- *Casting Errors:* Use of thermocol mould, inadequate quality checkups, uneven moisture of mould and foreign inclusions like sand.
- *Improper Material Cutting in Preparatory stages:* Use of conventional bandsaw machine, squareness error of cutting head and wear and teeth breakage of saw.

6. Results and Discussion

The problems associated with the production of central lathe were identified from the non-conformity reports of the company. Pareto analysis was conducted to find the problems that contributes significantly or major problems. It was found from the pareto analysis that 81.2% of problems are due to four major problems namely: coaxiality problem, cam problem, casting errors, improper material cutting in preparatory stages. The root causes of these problems were identified by cause and effect diagram and likert analysis. Once the root causes are identified corrective actions are suggested for eliminating the root causes for the occurrence of problems. The corrective actions proposed are:

- *Coaxiality Problem:* Provision of jig support using poka-yoke concept and improved boring bar with multiple tools for each holes to be bored, following the SMED procedures.
- *Cam Problem:* Replacement of conventional milling machine with CNC milling machine manufactured in the company itself.
- *Casting Defects:* Replacing thermocol pattern with wood, quality check-ups before accepting using radiographic inspection machine, Proper inspection of mould, provision of sufficient vents etc.
- *Material Cutting Problems:* Repairing the existing machine, ensure regular check-ups are made on the machine, ensuring the cutting saw is in perfect condition.

7. Conclusion

The study focused on implementing lean manufacturing in the production of central lathe manufactured by a machine tool company. The problems faced during central lathe manufacturing was identified and corrective measures were suggested for eliminating the major problems to reduces the wastages in production of central lathe, there by implementing lean manufacturing. The level of lean implementation in machine tool industry is very low as there hasn't been much works done. So this study can be considered as forestep work in this field. This work can be extended to the manufacturing process of other machines in the company.

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