International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 2, No. 3, July 2013

Research Paper

LEAN ENGINEERING PRINCIPLES: AN EFFECTIVE WAY TO IMPROVE PERFORMANCE AND PROCESS ON PRODUCTION FLOOR

G Vinoth[1]* and S Raghuraman[1]

Corresponding Author:* ***G Vinoth,* ✉ *vinothhp123@gmail.com*

In the present days, manufacturing industries face many problems due to the increase in waste and non value added work. To compete globally, one has to understand the customers need exactly and always maintain a higher quality standard. Lean Manufacturing concept is to reduce the waste and add value to every process in manufacturing. To survive in today's global market, manufacturers need to find various methods to reduce both time and cost for making a product. Higher quality, Flexibility and Efficient production requires newer ideas in production. Lean Manufacturing Techniques are used to implement such new ideas into the production line to improve the overall production process. Failure Mode Effective Analysis (FMEA) and Value Stream Mapping (VSM) are lean approaches that find direct solution to these problems. Identification of failure and non value added work in the production line was carried out. This paper analyses waste and non value added work on the production floor and generates the necessary action plan to improve the performance. Production floor was observed for three months and the data was taken as inputs for FMEA and VSM. The results show that lean manufacturing can be effectively used to improve performance on production floor.

Keywords: Lean manufacturing, FMEA, RPN, VSM, Current state, Future state

INTRODUCTION

Lean manufacturing often simply "Lean" is a production practice that adds value to a process and removes waste. Lean is centred on preserving value with less work. For any company, customer satisfaction is the end goal. In a production floor, many non value added processes are overlooked which increases the overall lead time of a production process. Lean manufacturing comes from the early Toyota Production System (TPS) principle which focuses on the reduction of seven wastes to improve overall value of the product and process. Failure

[1] School of Mechanical Engineering, SASTRA University, Tanjore, TN 613401, India.

Modes Effective Analysis (FMEA) is an inductive failure analysis used in product development, operations management for analysis of failure modes within a system for classification by the severity, detection and occurrence of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes or based on common failure mechanism logic, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. Risk Priority Number (RPN) is calculated for every failure mode and the necessary improvement plan are generated.

Value Stream Mapping (VSM) is a model based lean concept that identifies the value added and non value added services in the production floor. It consists of current state and future state layouts. The current state model explains the current process of the production floor. The future state layout is the lean implemented model for the production floor that eliminates the non value added services and reduces the overall lead time.

Abdulmalek and Rajgopal (2007) explained the use of linear distribution systems to produce a control systems model for the improvement in quality of products. Push and Pull systems using kanban was designed to reduce the lead time. Inventory management, Production leveling was done to eliminate any non value added work. Doolen and Hacker (2005) addressed the direct problem involved in production floor like operator fatigue, machine failure and product failure. Reliability and validity testing was carried out and implementation of 7 QC tools was done. Mann Whitney testing for implementation between SSI and large companies was also done to understand the production variability. Operator rotation and variable shift ideas were also suggested to improve the overall performance.

Womack and Jones (1994) developed a new plan for total elimination of waste and continuous improvement. A lean roadmap to visually promote production process was developed. The idea was to create an implementation model for the company that reduces the non value added work that was currently in practice. Evaluation and course correction of the model was also carried out to find the result. Wong *et al.* (2009) used many lean manufacturing tool to analysis the advantages of each process on a production line. Lean design pertaining to product design was first carried out. JIT, Poka Yoke, Six Sigma, Quality Function Deployment were also implemented for different processes. Value stream mapping and plant layout was designed to find the best adaptive lean technique to improve the performance. These papers were studied thoroughly to understand the principles and procedures involved in creating an effective lean manufacturing model to attain improvement in the production floor.

EXPERIMENTAL SETUP

DATA COLLECTION

The production floor was studied for three months to find the defects in various processes and also the current working model of the floor was identified.

Figure 1: Rejection Analysis for 3 Months

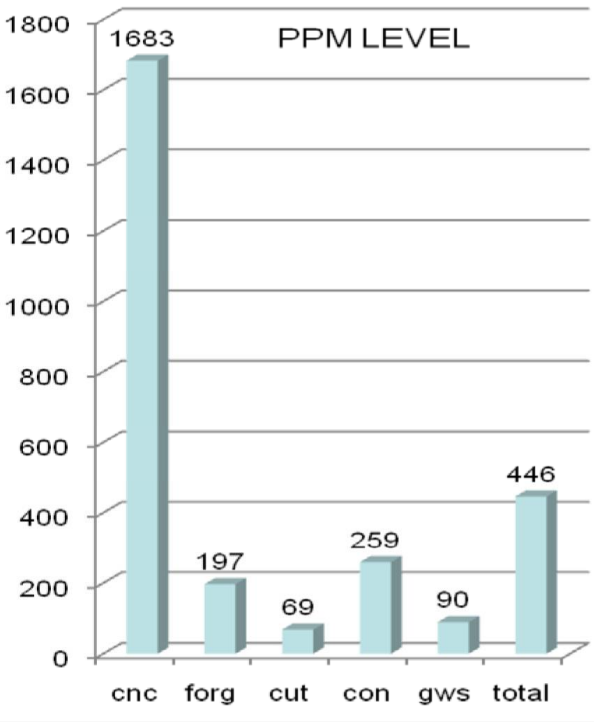


Table 1: Current State in Production Floor

No. of Components	Lead Time	Process Time
200 (per Batch)	26 Days	10 Days 2 mins

ANALYSIS OF THE PROBLEM

The above data were studied and the following lean concepts were stated and taken as input for FMEA and VSM.

- Rejection rate in CNC is higher.
- FMEA analysis for the failure of products in CNC machine is to be carried out.
- Non value added work must be identified and eliminated through VSM.

FAILURE MODE EFFECTIVE ANALYSIS

FMEA is a structured way to identify the ways in which a product or process can fail. Is it used to estimate the risk associated with specific causes. It priorities the actions that should be taken to reduce risk and evaluates design validation plan (product) or current control plan (process).

REASONS FOR FAILURE IN CNC

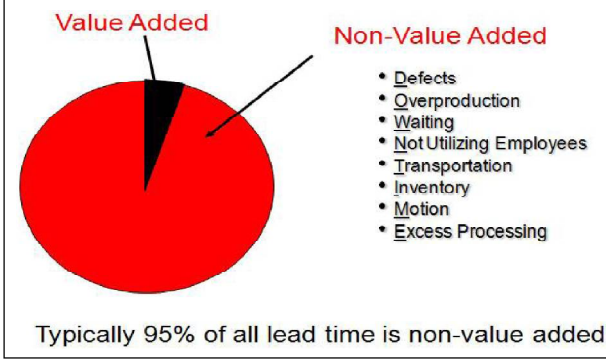
From the observation of the rejection analysis in the production floor, the causes for failure of products in the CNC machine was identified. The five frequently occurring reasons for failure are taken for FMEA analysis.

- Setting
- Material crack
- Drill shift
- Thread damage
- Dent

VALUE STREAM MAPPING

VSM is a lean concept that is used to identify the non value added services in the process. It is used to add value to every process and to reduce the overall lead time of production.

Figure 2: VSM Analysis



PRODUCTION PROCESS FLOW

Every product in the production floor followed a specific process flow and these steps were taken as input data for the VSM analysis.

- Order placement
- Receive raw materials
- Cutting
- Pre machining (optional)
- Machining
- De burring
- Quality inspection
- Packing and dispatch

LEAN IMPLEMENTATION – FMEA

Risk Priority Number (RPN) is calculated to prioritize the cause of failure. It forms the FMEA solution and the necessary action is framed based on the RPN data.

Severity x Occurrence x Detection = RPN

RATING SCALES

Severity: 1 = Not Severe, 10 = Very Severe

Occurrence: 1 = Not Likely, 10 = Very Likely

Detection: 1 = Likely to Detect, 10 = Not Likely to Detect

Severity, occurrence and detection is based on the importance of the product to the customer and how much a failure affects the quality of the product. The ratings are given with reference to the FMEA data book.

Table 2: RPN Calculation

Problems	Severity (1-10)	Occurrence (1-10)	Detection (1-10)	RPN
Setting	10	6	5	300
Material Crack	7	4	3	84
Drill Shift	8	6	6	288
Thread Damage	7	5	7	245
Dent	8	5	6	240

RPN RANKING AND REASONS

- Setting – Failure due to fixture problem or improper setting
- Drill shift – Failure due to sudden stoppage of drilling operation
- Dent – Failure due to clamping problem or inappropriate speed, feed or depth of cut
- Thread Damage – Failure due to burrs or improper grinding
- Material Crack – Failure due to misunderstanding of material properties

In FMEA, the failure with greater severity number is always given first preference as it influences the quality of a product more than the other reasons.

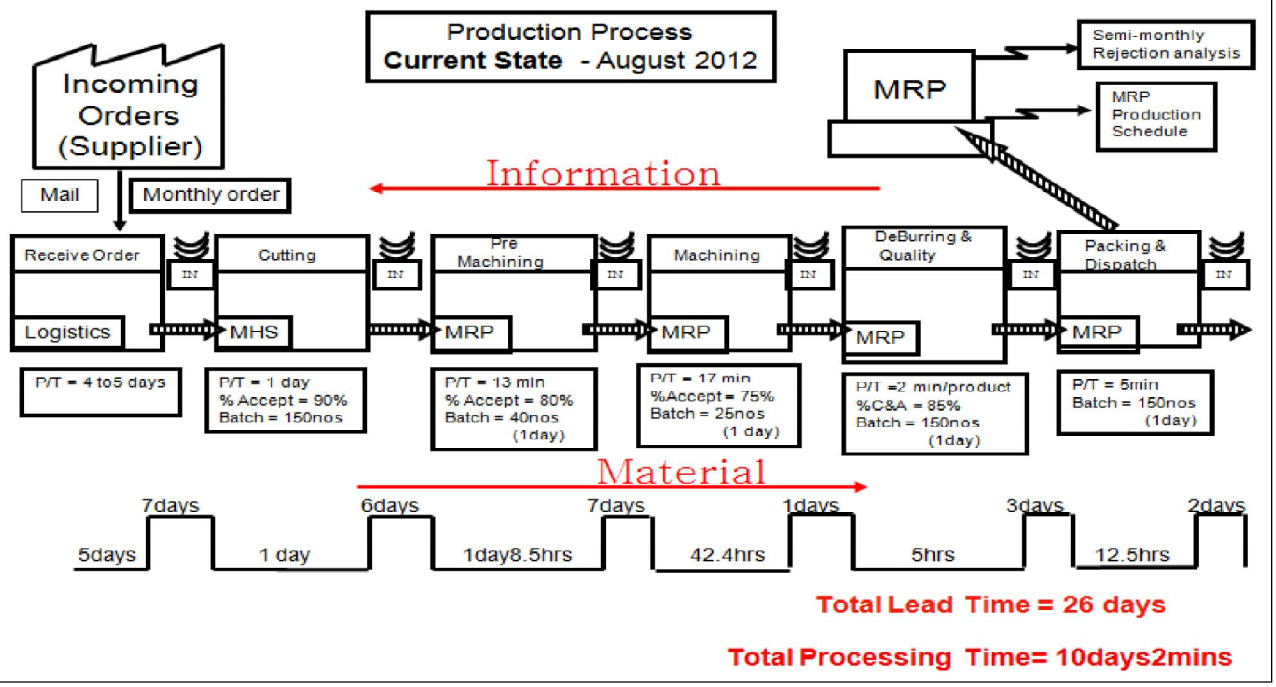
LEAN IMPLEMENTAION – VSM

The production floor layout and the current process flow were thoroughly studied to design the current state VSM model. An average of 5 components with a production rate of 200 per batch was considered for the VSM analysis.

From the current state VSM layout, the following non value added works were identified.

- Improper material handling system led to usage of high man power to load material into cutting machine.

Figure 3: VSM Current State



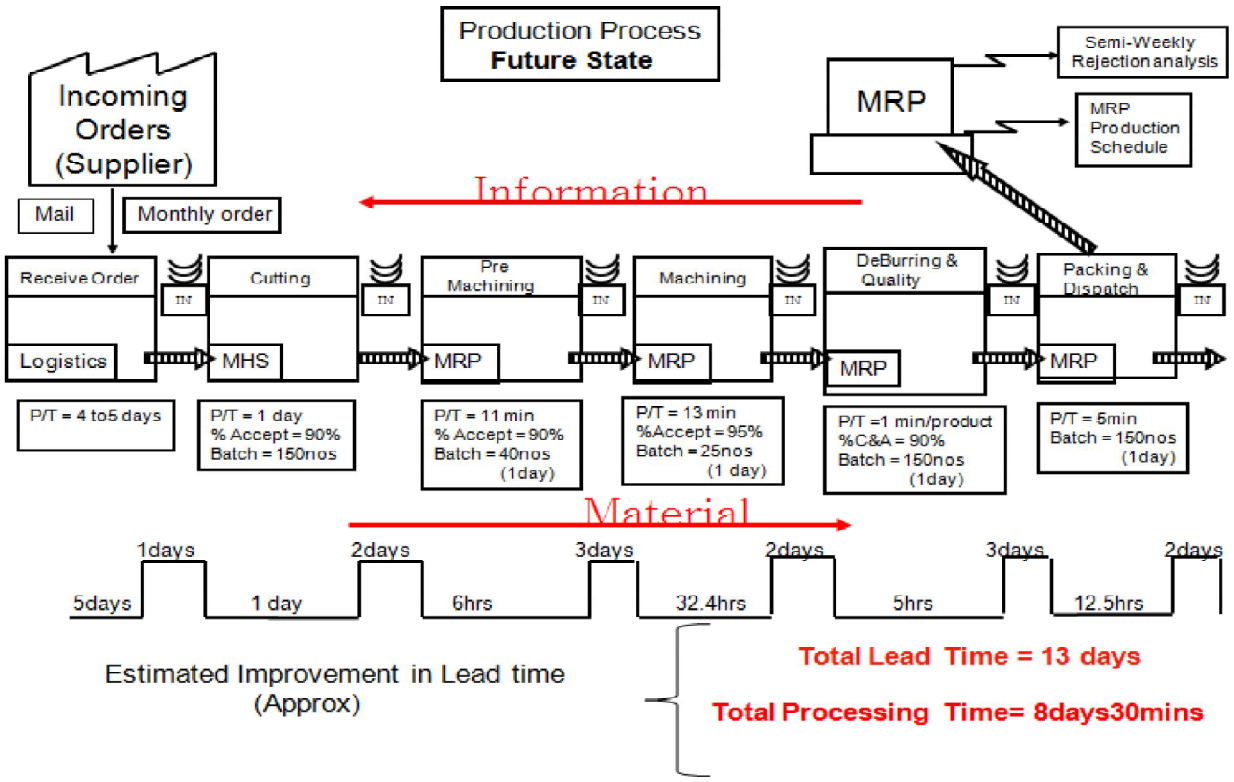
- Measurement equipment were provided only in the first M/c line which led to unwanted movement of workers to check the accuracy of machined components.
- Improper production leveling was practiced which led to unnecessary idle time for components in every machine.
- Fixture setup time was high since different components were machined due to improper leveling.
- Use of normal coolant shows an increase in the burr production during machining process. Improper coolant parameters such as velocity, viscosity and flow angle produced excessive burr thereby increasing the de-burring time.

To map the future state VSM model, the following method study was carried out to understand ways in which the non value added activity could be eliminated thereby increasing the quality of the product and also to reduce the overall lead time of the product.

- Understanding customer needs
- Flow with fewer interruptions
- Reducing overall lead time
- Removing non value added services
- Process improvement plan
- Production leveling
- Value addition and tracking

The Future state was mapped by understanding the complete production floor process. Although an improved lead time was attained, there was certain non value added work that could not be eliminated from the production floor. The final estimated improvement in lead time was achieved by implementing the necessary lean action plan.

Figure 4: VSM Future State



RESULTS AND DISCUSSION

Fmea Action Plan

Failure mode effective analysis works by considering the RPN number and ranking the defects based on it. Then the improvement plan is stated to improve the quality of the product. The occurrence of failure is decreased and every single failure mode is analysed for their cause and effect phenomenon. The following lean action plan was implemented in the production floor and the improvement in the failure mode was studied.

- Employ a BLACK BELT engineer familiar with all quality evaluation methods.
- Always follow procedure.
- Improved fixture designs.
- Informal inspection on fixation of material and usage of sensors.
- Proper removal of burrs and correct angle for coolant entry.
- Understand the material properties clearly.
- Grind tool bit properly and ensure tool position before operation.

Table 3: FMEA Results – Lean Implementation

Problems	RPN (Before Lean)	RPN (After Lean)
Setting	300	200
Material Crack	84	48
Drill Shift	288	150
Thread Damage	245	100
Dent	240	180

Vsm Action Plan

Value stream mapping is a visual lean implementation model which identifies the non value added service directly on the production floor. The current state and future state layouts are used to compare and significantly improve the performance on production floor. The following action plan was implemented on the production floor and the improvement on overall lead time was studied.

- Material handling system implementation.
- Pre cutting material based on requirements.
- Provide ease of material measurement and train all operators on handling measuring equipments accurately.
- Production leveling and dynamic shift of machine operators.
- Employ black belt engineers.
- Efficient coolant angle to reduce burr.

Table 4: VSM – Lean Implementation

VSM Model	Lead Time	Processing Time
Current State	26 Days	10 Days 2 mins
Future State	13 Days	8 Days 30 mins

CONCLUSION

The paper concludes that by the implementation of Lean Manufacturing Techniques like FMEA and VSM, the overall performance on the production floor is increased.

- Lean reduces operator fatigue and improves efficiency.
- Overall lead time is reduced by 40% on implementation of the lean concepts.
- Higher utilization of production floor space.
- Increase in production leveling and process performance.

Design improvement and higher process efficiency was also noted. Removal of non value added works and reduction in waste generation is also possible and lean management increases worker motivation. Hence it is noted that simple lean concept makes considerable improvement in the industry.

REFERENCES

1. Abdulmalek F A and Rajgopal J (2007), "Analyzing the Benefits of Lean Manufacturing and Value Stream Mapping via Simulation: A Process Sector Case Study", *International Journal of Production Economics*, Vol. 107, pp. 223-236.
2. Åhlström P (1998), "Sequences in the Implementation of Lean Production", *European Management Journal*, Vol. 16, pp. 327-334.
3. Doolen T L and Hacker M E (2005), "A Review of Lean Assessment in Organizations", *Journal of Manufacturing Systems*, Vol. 24, pp. 55-67.
4. Forza C (1996), "Work Organization in Lean Production and Traditional Plants, What are the Differences?", *International Journal of Operations Production Management*, Vol. 16, pp. 42-62.
5. Walder J, Karlin J and Kerk C (2007), "Integrated Lean Thinking & Ergonomics: Utilizing Material Handling Assist Device, Solutions for a Productive Workspace", MHIA White Paper, USA.

6. Womack J and Jones D T (1994), "From Lean Production to the Lean Enterprise", *Harvard Business Review*, Vol. 72, pp. 93-104.
7. Wong Y C, Wong K Y and Ali A (2009), "Key Practice Areas of Lean Manufacturing", pp. 267-271, IACSIT-SC 2009, Singapore.
8. Worley J M and Doolen T L (2006), "The Role of Communication and Management Support in a Lean Manufacturing Implementation", *Management Decision*, Vol. 44, pp. 228-245.
9. Wu Y C (2003), "Lean Manufacturing: A Perspective of Lean Suppliers", *International Journal of Operations & Production Management*, Vol. 23, pp. 1349-1376.