

Implementation of Lean Manufacturing in a Plastic Grain Manufacturing Company in India: A Case Study

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Abstract—Lean manufacturing is a worldwide accepted technique for the optimization of the industry and for the elimination of the waste within the system. Following the after effects of the World War II, the Toyota production system evolved a technique which was termed as Lean thinking or Lean manufacturing. Lean means less of many things — less waste, shorter cycle times, fewer suppliers, less bureaucracy and also means more — more employee knowledge and empowerment, more organizational agility and capability, more productivity, more satisfied customers, and more long-term success. Usually this has been implemented in large scale and small scale industries. In this research paper lean manufacturing is implied in a micro scale industry in NCT of Delhi, India manufacturing plastic grains. The man power and floor space is not utilized efficiently despite being limited in amount. The research starts with the study of existing system in industry and the problems faced by it. After the industry analysis, two tools of lean manufacturing viz. value stream mapping and KAIZEN are thoroughly studied to check their applicability in the system. The detailed study and developed value stream map reflects the successful implementation of these tools in the selected industry. The technique improved the space utilization, manpower utilization and increased the graph of production of plastic grains at minimum investment and in minimum time. The paper concludes by elimination of various types of waste and proper and efficient utilization of resources available at the industry. It results that lean concept and its tools can be effectively implemented in small and micro scale industries easily.

Keywords: Lean manufacturing, Value stream mapping, KAIZEN, micro-scale industry, plastic grain production.

1. INTRODUCTION

The lean manufacturing (LM) or Toyota Production System (TPS), pioneered by a Japanese automotive company, Toyota, has been implemented by nearly all countries across the world due to its global superiority in cost, quality, flexibility and quick respond [1]. Lean is a production practice that aims to minimize waste with entire value streams creating more value for customers [2]. It is purely a customer based strategy which focuses on the value stream and its optimization. According to

lean principles, use of resources that does not deliver consumer value is a target for change or elimination. It is practiced across nations in order to improve firm's efficiency and production [3]. In 1989, the term LM was coined by the researchers at the Massachusetts Institute of Technology (MIT). James P. Womack and Daniel T. Jones described it as doing "more and more with less and less—less human effort, less equipment, less time and less space—while coming closer and closer to providing customers with exactly what they desire [4]. The lean practice explains seven types of wastes namely as overproduction, waiting, over processing, transportation, unnecessary part movement, excess inventory and defects. The waste is eliminated using strategies such as One piece workflow, Takt time and Pull system.

There are various tools and techniques which are used by different firms to implement lean concepts. The core lean methods frequently used are Kaizen Rapid Improvement Process; 5S; Total Productive Maintenance (TPM); Six Sigma; Cellular Manufacturing / One-piece Flow Production Systems; Just-in-time Production / Kanban; Pre-Production Planning (3P) and Lean Enterprise Supplier Networks [5]. The use of such tools leads to greater productivity, shorter delivery times, low cost, improved quality, and increased customer satisfaction. In this case study a firm, XYZ Plastics Pvt. Ltd., was chosen located in East Delhi, India. It is a micro scale industry which manufactures plastic grains and till now has not implemented lean concepts in it.

2. LITERATURE REVIEW

Rahman et al. [1] tried to determine how the Kanban system works effectively in multinational organization and identified problem prone factors like ineffective inventory management, lack of supplier participation, lack of quality improvements in application of Kanban in SMEs. N. Nordin et al. [6] conducted questionnaire survey querying background information of organization, barriers in implementation and respondent

information. The study was implied in the Malaysian automotive industries. R. Bednar [7] tried to imply concepts of LM including Kaizen, teamwork, bottleneck management, Kanban, VSM, 5S, production cells, TPM, SMED and EPE to mass production industries. R. Muslimen et al. [8] studied a case study of LM implementation in Malaysian automotive industry. A semi-structured questionnaire was created and a series of open-ended interviews with the management of the industries were carried out. N. A. Kumar [9] investigated LM barriers like lack of planning, lack of top management commitment and methodology. This questionnaire-based survey was to facilitate Indian industry experts in developing a relationship towards an ISM-based model. B. V. Ramnath et al. [10] elucidated on execution of lean concept in an industry where engine valve machining cell manufacturing is done with the aid of tools like VSM to map current state, Kanban system for reduction of waste in pre-machining and single piece flow in machining process. G. Singh et al. [11] deduced reasons for industry's low productivity by identifying the bottlenecks in assembly shop of tractor manufacturing company. The problem was identified in terms of high cycle time at different machines. Once bottleneck station was detected, initial process flow map was generated followed by analysis and actions taken to eliminate root cause with KAIZEN tool. R.K. Chakraborty et al. [12] implemented LM concept in a garment manufacturing company of Bangladesh including clusters for different buyers, process flow diagram and layouts. The lean practices used were process focus, pull production, quality programs, increase in equipment efficiency, form of lean organization and continuous improvement. P.S. Gill et al. [13] implemented VSM to eliminate waste in an emergency room of a hospital in US. The continuous improvement plan-do-check-act (PDCA) cycle was also implemented. Based on the methods, a list of suggestions was made and conclusion drawn from this study was that Lean and VSM can be successfully applied to healthcare system if top management reads lean as continuous approach. W. M. Goriwondo et al. [14] tried to apply VSM technique in a Zimbabwean bread manufacturing industry. A series of interviews with managers were conducted followed by generation of a VSM. It is also shown that VSM tool is not limited to manufacturing organizations but can also be applied to service industries like banks, hospitals, and transport sectors with necessary adjustments. N Sharma et al. [15] conducted survey in those industries which already have embraced LM concepts and also other operations management tools. It was concluded, major manufacturing industries have been trying to adopt manufacturing initiatives in order to stay alive in the new competitive market place, and found LM as the most efficient initiatives. T. L. Doolen et al. [16] conducted a survey to complete an exploratory study which included cross-section of electronic manufacturers in the Pacific Northwest. In this study it was found that electronic manufacturers used lean practices up to some extent and challenges limited LM implementation. P Hines et al. [17] presented reviews on the concepts that have sought to address some of the earlier gaps

in lean thinking. It focuses on the evolution of the concept of lean thinking from its beginning and the different stages it went through over the course of years, also points out the area of future research.

3. EXPERIMENTATION AND METHODOLOGY

3.1 Data Acquisition

The XYZ Pvt. Ltd. is a micro scale (number of workers= 6) plastic grain manufacturing company situated in National Capital Territory of Delhi. The industry manufactures plastic grains by recycling the waste plastic products. The plastic grains have wide applications throughout various manufacturing industries and they can be used to produce any type of plastic products. The main drawbacks encountered were zero variation in the product manufactured and no record of the demand or supply from or to customers. The industry has a fixed production irrespective of market demand. The data collected has been tabulated in Table 1 below.

Table 1: Profile of Production Line

Company name	XYZ Plastics Pvt. Ltd.
Age of the company	12 years
Number of workers	6
Number of processes	9
Total production time	480 minutes per day
Available production time	480 minutes per day (production continues in lunch and breaks)
Lead time	10 days
Total cycle time	407 minutes 35 seconds
Loading/Unloading	Manual
Unloading time	1 day
Loading time	2.75 days
Production batch size	150 kg
Bottleneck and its capacity	Extruder (50 kg)
Feedback and Forecast	No

3.2 Methodology

An open-ended questionnaire based approach was followed for data acquisition inside the firm along with series of interviews. The questions in the questionnaire and interviews were based on knowledge of lean manufacturing, production time per unit, bottleneck activity, steps to distribute load at bottleneck, automation level, quality control measure in the firm, industry layout etc.

Follow up questions were asked further which were strictly based upon the responses of the participants. Based on these responses conclusions were drawn through current state value stream map. By analyzing the current state value stream map the state of the firm was determined and then studies were conducted for the implementation of the LM concept and its selected tool KAIZEN. The implementation of tool was followed by the development of the future state value stream map which displayed the state of the firm after the elimination of various types of wastes.

3.3 Problems Identified

Based on the methodology used in the firm the problems which led to various types of wastes were identified as:

1. Too much excess inventory, raw material, work-in-process, finished goods.
2. Zero level of automation.
3. Delay in the shipment of the order.
4. Unbalanced production line.
5. No proper motion of the workers and goods.
6. Improper utilization of floor space.
7. Machinery is outdated and outfitted for product (consumes too much energy, huge and bulky).
8. Bottleneck machine (extruder) has low input.
9. Loading and unloading of raw material and finished goods is a slow process due to space constraint.
10. Outdated machinery increases the level of pollution in the firm's environment.
11. Weighing and packing though done on a digital scale but due to lack of worker's commitment errors creep in, especially in packing process where a certain type of product get mixed with another.
12. Safety measures are inadequate as working temperature is of the order 200-250°C.

These problems in the firm let to numerous wastes in terms of raw material, floor space, time, production cost etc. The root cause of these hurdles in the working environment of the firm occurs due to the following reasons:

1. Lack of commitment from top management.
2. Work Attitude of middle management that is the supervisors etc.
3. Lack of dedication of workers.
4. No expansion in terms of investment.
5. No expansion of the firm itself.
6. No record of market supply or demand.
7. Assumption based production of product (no actual market studies).
8. Industry works on push system.
9. Outdated techniques and machinery.
10. Improper management of inventory and tools.

4. ANALYSIS OF DATA AND IDENTIFIED SOLUTIONS

4.1 Selection of lean manufacturing tool

There are vast numbers of tools and techniques in the lean manufacturing which are used for the optimization of the system and removal of the waste within the system. A thorough study of lean manufacturing tools led to the selection of KAIZEN tool which is suitable for a plant with mass production and does not overlooks work force.

4.1.1 KAIZEN as Remedial Tool

KAIZEN was selected due to the following reasons for this micro scale firm.

1. The firm being a mass producing industry of plastic grains, KAIZEN is an excellent tool for such mass production industries.
2. Like other lean tools KAIZEN does not shut down the plant during its implementation. It does not incur any loss of production time and potential profit.
3. In KAIZEN the changes made are slow, steady and permanent putting no immediate pressure on the budget of the plant owner unlike other tools such as poke-yoke or 5S.
4. KAIZEN itself means continuous improvement, hence a scope always exist for the upgradation from the last improvements achieved.
5. Only KAIZEN tool works on the eighth type of waste i.e. the underutilization of the workers, hence only this tool can resolve this waste of human resources.

In totality, KAIZEN reduces the loss of production time, loss of potential profit and the expenditure of the sudden implementation of the changes made in the industry, along with the prevention of plant shut down. It is a tool which is slow to implement but is steady in nature and open for upgradation at any level of the firm.

4.1.2 Value Stream Mapping

Value Stream Mapping is a lean-management method for analyzing the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer. A value stream map is an advanced form of process map that focuses particularly on the lean principles of value and flow within the process. Value Stream Mapping was selected for the research work because of the following reasons:

1. VSM follows customer's perspective and is focused on delivering to customer's needs.
2. VSM, in a single view, provides a complete, fact-based; time-series representation of stream of activities—from beginning to end—required to deliver a product or service to the customer.
3. VSM provides a common language and common view to analyze the value stream and shows how the information flows to trigger and support those activities.
4. VSM shows where activities add value and where it don't, enabling how to satisfy the customer.

5. RESULTS AND DISCUSSION

5.1 Analysis of Results

Considering all the problems and the constraint parameters in the firm a future state value stream map was proposed. Its analysis led to the following inference:

1. Lead Time Reduction by 50%
 - a. Loading and unloading of the material was automated which reduced unloading time of raw materials by 0.75 day and loading time for finished goods by 2 days.
 - b. Loading and unloading dock area was increased in terms of space for fast and quick process.
 - c. Installation of new machines reduced the cycle times of various processes and merged two processes (heating and cutting) which could now be carried out on a single machine.
2. Working on Pull System (Market Demand)
 - a. Change to pull system made the firm to start its production starts when demand is placed by customer, thereby reducing the inventory and fatigue to workers.
 - b. This change led to proper space utilization which previously was wasted in inventory.
3. Elimination of Work-in-process inventory
 - a. Identification of the bottleneck of the plant i.e. the extruder helped in identifying the critical point in production line and further rest of the plant was laid down according to that.
 - b. Batch of raw material was now considered by the account of the extruder capacity.
 - c. The upgradation of machines was carried out which was a new environment friendly mixer and automated grinder. This increased the limit of bottleneck, reduced cycle time and decreased changeover time resulting in reduced work-in-process inventory.
4. Increase in Level of Workers' Satisfaction
 - a. Efficient working of plant and growth in profit earned bonuses and wage hike to workers by the top management making them more happy and satisfied.
 - b. New advanced machinery improved the working conditions leading to a less hazardous and pollution free environment for the workers.
 - c. New and automated machines run on the safety standards ensuring the safety of the workers.
 - d. Lunch and break timings have been increased to 60 minutes and 45 minutes respectively. This reduced the fatigue in workers, hence delivering better commitments and better productivity.
 - e. Total production time per day has been reduced from 480 minutes to the 420 minutes. Therefore shift reduced from 8 hours to 7 hours leading to less fatigue and higher satisfaction in workers.
5. Increase in Safety and Environmental Standards
 - a. New machines are eco-friendly and produce no air pollution.
 - b. These machines are safe for the workers.
6. Enhanced Working Environment
 - a. Plant layout was redesigned and transformed to "U-shaped" layout on availability of free floor space.
 - b. Elimination of work-in-process inventory made the plant more clean and hygienic.
7. Dip in Production Time (High Product Quality)
 - a. Total production time drastically decreased resulting in decrease in the production efficiency from 84.79% (407/480) to 74.76% (314/420) i.e. a decrease of 10.03%.
 - b. As per a famous saying "*An industry where everyone is working every time is very inefficient*" [18], therefore reduction in efficiency leads to better quality product manufacturing earning better profits.
 - c. Despite the decrease in efficiency, the increased productivity of the industry can be judged by halving the lead time and the fulfillment of the demands of the customer on time.
8. Quality of Product
 - a. Automated machines follow a standard set of instructions, hence producing all products of same quality and nearly identical to each other.
 - b. Elimination of product variations occurring due to manual operations led to enhanced uniformity in product quality.
9. Customer Satisfaction (goods on-time delivery)
 - a. Reduced lead time and increased productivity resulted in timely delivery of finished goods to customer.
 - b. No complaints from customers as the quality of product is increased with newly installed machinery.
 - c. Due to the above two points the trust of the customer on the company increases and they place large orders, hence more profit is incurred to the company.
10. Reduction in Motion of Workers and Material
 - a. Machines in the plant are placed such that worker movement is minimum and floor space is not wasted.
 - b. Movement of material (raw, semi-finished and finished) between the machines has been automated, hence reducing the changeover time.
11. Balanced Production Line
 - a. Lean aims at balancing of production line so that there are minimal changes and variations in the production thereby saving variation of time in the fulfillment of orders and the product as well.
 - b. Redesigned production line to "U-shaped" fixes the intake and exit of raw material and finished good respectively, eliminating the wastage in terms of time and floor space.
12. Time Management on Production Line
 - a. Automation decreased loading and unloading time drastically along with floor space used for these.
 - b. Unloading time of raw material decreased by 0.75 day (earlier it was 1 day, now it is 0.25 day) and loading time of finished goods decreased by 2 days (earlier it was 2.75 days, now it is 0.75 day).
 - c. Automated weighing and packaging decreased weight variability in the packets hence saving time.

5.2 Value Stream Maps

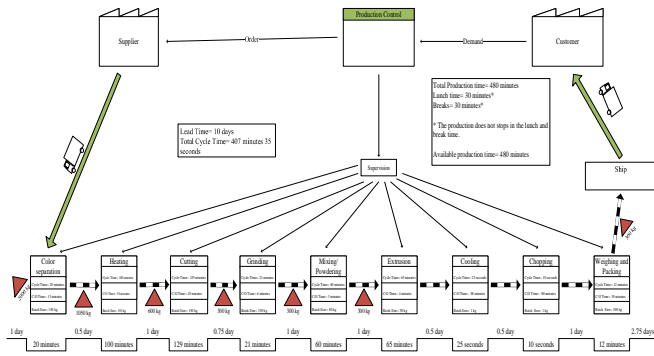


Fig. 1: Current State Value Stream Map

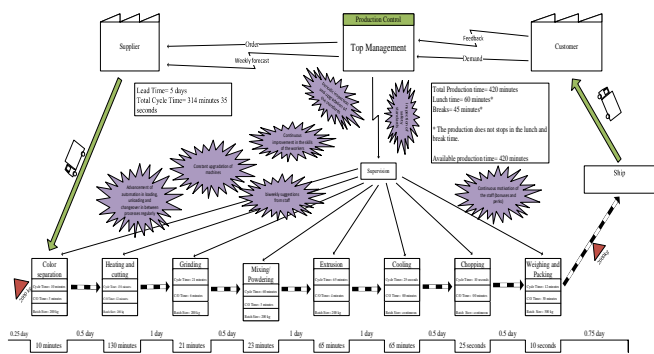


Fig. 2: Future State Value Stream Map

5.3 Juxtaposition of current state and proposed future state (after implementation of LM)

Table 2: Comparative Analysis of two States of Firm

Parameters	Current state	Proposed future state
Company name	XYZ Plastics Pvt. Ltd.	XYZ Plastics Pvt. Ltd.
Age of the company	12 years	12 years
Number of workers	6	14
Number of processes	9	8
Total production time	480 minutes per day	420 minutes per day
Available production time	480 minutes per day (production continues in lunch and breaks)	420 minutes per day (production continues in lunch and breaks)
Lead time	10 days	5 days
Total cycle time	407 minutes 35 seconds	314 minutes 35 seconds
Loading/Unloading	Manual	Automated
Unloading time	1 day	0.25 day
Loading time	2.75 days	0.75 days
Production batch size	150 kg	200 kg
Bottleneck and its capacity	Extruder (50 kg)	Extruder (200 kg)
Feedback and Forecast	No	Yes (electronic)

5.4 KAIZEN Bursts

KAIZEN bursts are the small improvement points which are carried out in the firm regardless of the situations present in the firm or anywhere else which might affect the firm’s production. KAIZEN bursts used in current situation for the firm were:

1. Advancement of automation in loading, unloading and changeover between the processes regularly.
2. Constant upgradation of the machines.
3. Formation of quality circles in each department (since it’s a micro scale industry quality circle will include everyone in each department).
4. Continuous improvement of skills of workers.
5. Periodic inspection and standards upgradation.
6. Inspection of the safety standards.
7. Continuous motivation of the staff (by giving them bonuses and the perks).

6. CONCLUSION

Lean manufacturing can be applied to any kind of system and any type of industry, plant or company irrespective of small scale, medium scale or large scale. In this research work a plastic grain manufacturing company was selected as plane of study and further experimented the different tools of the lean philosophy and eventually combined VALUE STREAM MAPPING and KAIZEN tool to solve the problems which were encountered in the industry. The selected micro scale industry was automated and redesigned to efficiently utilize the raw material, floor space, human resources, machine tools along with the maintenance of quality standards of product and satisfaction of workers and customers. Lean approach made the industry more eco-friendly and free from various types of wastages.

Today’s ever-growing market demands various organizations to have a plethora of choices when considering approaches to both their tactical and strategic pressures and challenges. Among all the approaches the “Lean” approach is increasingly becoming popular as it offers the firms a sensible, proven, and accessible path to long-term success. The concept of lean manufacturing and the continuous improvement methodologies have been developed for enhancing the resource utilization along with elimination of waste. Lean manufacturing is a worldwide approach which is being implemented in the countless industries.

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