

Areas of Lean Manufacturing for Productivity Improvement in a Manufacturing Unit

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Abstract—Many organisations are nowadays interested to adopt lean manufacturing strategy that would enable them to compete in this competitive globalisation market. In this respect, it is necessary to assess the implementation of lean manufacturing in different organisations so that the important best practices can be identified. This paper describes the development of key areas which will be used to assess the adoption and implementation of lean manufacturing practices. There are some key areas developed to evaluate and reduce the most optimal projects so as to enhance their production efficiency and increase the purpose of the economic benefits of the manufacturing unit.

Lean manufacturing is becoming lean enterprise by treating its customers and suppliers as partners. This gives the extra edge in today's cost and time competitive markets. The organisation is becoming strong in all the conventional competition points. They are Price, Quality and Delivery. Lean enterprise owners can deliver high quality products quickly, with low price.

Keywords—Competitive points, implementation, Lean manufacturing, tools and techniques

I. INTRODUCTION

IN the 1950's Toyota Motor Corporation created Toyota Production System, then it formatted a new kind of Management concept 'Lean thinking' [1]. The applications of lean thinking on manufacturing i.e. 'Lean production' reduce manufacturing cost, shorten development and manufacturing cycle time and enhance enterprise competitiveness. Besides auto industry, Lean production also extends to machinery manufacturing, electronics, consumer goods, aerospace and shipbuilding and becomes another milestone of modern production methods after mass production methods. In 21st century the application of lean thinking obtains advancements and has turned into a new generation guidance thinking of management revolution. Lean manufacturing means eliminating wastes by identifying non value added activities thorough out the supply chain. The five fundamental Lean principles are to specify value from the point of view of customer, identify the value stream, make the identified value flow, set the pull system which means only make as needed and finally perfection in producing what the customer wants and by when it is required in the right quantity with minimum waste.

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Lean manufacturing or lean production has attracted vast interest from both academicians and practitioners. Technical aspects of lean manufacturing have been widely discussed. It has become a universal production method and numerous plants around the world such as Toyota and other companies have successfully implemented it. Though Lean manufacturing started in the automotive industry, it has been applied successfully in other disciplines as well. Due to heightened challenges from global competitors, lean manufacturing has become a production method for many organisations to pursue. However, there is a lack of studies which are focused on consolidating the various key practices of lean manufacturing and investigating their level of adoption in real life. This paper reviews the practice areas of lean manufacturing. A set of areas is used to explore the adoption of lean manufacturing practices.

II. LITERATURE SURVEY AND REVIEW

Toyota Production System (TPS) which is known as Lean manufacturing by in their book "The Machine That Changed the World" has influenced the manufacturing practices around the world [2]. The fundamental of TPS is to eliminate wastes and produce only the items needed at the required time and in the required quantities. Principles of lean are universal as they are broadly accepted by many manufacturing operations and have been applied successfully across many disciplines. It has become an integrated system composed of highly inter-related elements and a wide variety of management practices including Just-in-time, quality system, work teams, cellular manufacturing, etc [3].

The main purpose of implementing lean manufacturing is to increase productivity, reduce lead time and cost and improve quality thus providing the up most value to customers. There are many descriptions regarding lean manufacturing. It is most frequently associated with the elimination of the seven important wastes to make the effects of variability in supply, processing time or demand. The seven wastes mentioned are: overproduction, waiting, unnecessary transport or conveyance, over processing or incorrect processing, excess inventory, unnecessary movement and defects. According to J. P. Womack, lean manufacturing uses less of everything compared to mass production - half the human effort in the factory, half the manufacturing space, half the investment in tools and half the engineering hours to develop a new product [1]. In addition, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and

produces a greater and ever-growing variety of products. In short, it is called lean because it uses less, or the minimum, of everything required to produce a product or perform a service.

III. WHAT IS LEAN MANUFACTURING

Lean Manufacturing can be defined as: Lean manufacturing or lean production, which is often known simply as "Lean", is the optimal way of producing goods through the removal of waste [4]. OR

"Lean manufacturing is the system which aims in elimination of the waste from the system with a systematic and continuous approach" OR

Lean Manufacturing is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste. Lean manufacturing techniques are based on the application of five principles to guide management's action toward success [5].

A. Value

In lean production, the value of a product is defined solely by the customer. Identifying the value in lean production means to understand all the activities required to produce a specific product, and then to optimise the whole process from the view of the customer.

B. Continuous improvement

The transition to a lean environment does not occur overnight. A continuous improvement mentality is necessary to reach your company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance.

C. Customer focus

A lean manufacturing enterprise thinks more about its customers than it does about running machines fast to absorb labour and overhead. Ensuring customer input and feedback assures quality and customer satisfaction, all of which support sales.

D. Perfection

The concept of perfection in lean production means that there are endless opportunities for improving the utilisation of all types of assets. The systematic elimination of waste will reduce the costs of operating of an enterprise and it fulfill customer's desire for maximum value at the lowest price.

E. Focus on waste

The aim of Lean Manufacturing is the elimination of waste in every area of production including customer relations, product design, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible.

IV. WASTES IN THE ORGANISATION

The key to lean manufacturing is to compress time by eliminating waste and this continually improving the process. Ohno defines waste as all elements of production that only increase cost without adding value that customer is willing to produce. The wastes in the organisation are: [4]

Overproduction: Producing more than needed.

Waiting: Idle operator or machine time.

Motion: Movement of people or machine that does not add value.

Inventory: Any supply in excess of required to produce product.

Transportation: Any material movement that does not directly support value added operations.

Defects: Making defective parts.

Extra processing: Any process that does not add value to the product.

Underutilising people: Not taking advantage of people's abilities.

V. LEAN MANUFACTURING TOOLS

The foundation of lean manufacturing includes the following tools: [4]

Standardised work: Operations are organised in the safest, best known sequence using the most effective combination of resources. Jobs are broken down into elements and examined to determine best and safest method for each. The standard is then established, taught and sustained by repetition.

Workplace Organisation/5S: Various housekeeping activities are often used for continuous improvement. The workplace organisation activities are:

Sort-out - what is required and not required;

Set in order - a place for everything and everything in its place;

Shine / cleanliness - cleaning all the work places with an eye of preventive maintenance;

Standardise - the system throughout the organisation;

Sustain - the efforts with self-discipline.

Visual factory (VF): Information is made available and understandable for each operator to see and to use in achieving continuous improvement.

Point of use storage: Locate all parts raw material, tools and fixtures as close as possible to where they are being used.

Kanban: A Kanban system is an information system that controls the required parts at the required time.

Kaizen: Kaizen is a Japanese word for continuous improvement. Kaizen is the process of identifying and eliminating wastes as quickly as possible at the lowest possible cost [6].

Quick changeover / Single minute exchange of dies (SMED): SMED is a system that allows the mixing of production without slowing output or creating higher costs from waste of setup.

One piece flow: To minimise work in process operator should focus on completing one part through the process before starting on the next part.

TAKT time: TAKT time is the maximum time per unit allowed to produce a product in order to meet demand.

Total productive maintenance (TPM): TPM consist of companywide equipment maintenance program that covers entire equipment life cycle and requires participation by every employee [7].

Value stream mapping (VSM): VSM serves as a starting point to help management, engineers, suppliers and customers recognise waste and identify its waste. VSM is a method of visually mapping a product's production path including material and information flow. It takes a look at the activity required (both value added and non-value added) to move a product from raw material to customer.

The Areas responsible for improving the productivity of any unit needs to satisfy this;

These areas are work processes, scheduling, inventory, equipment, layout, material handling, employees, quality, product design, suppliers, tools and techniques, customers, ergonomics and safety and management and culture [8].

Employees who are motivated and empowered are essential since people are the key element in lean manufacturing. Unexpected machine downtime would result in line stoppage and decrease productivity. Equipment is a vital area where preventive maintenance and reduction of setup time play an important role to ensure the success of lean manufacturing.

Appropriate scheduling methods such as pull system could reduce inventories and avoid overproduction. Quality is critical in lean manufacturing because poor quality management would result in many wastes such as scraps and rejects. Suppliers encourage developing capabilities of JIT production as well as JIT delivery in order to enhance long-term competitiveness. Material handling is identified as important in lean manufacturing because material movement and waiting time are wastes that need to be minimised. Layout determines the travelling distance and processing sequence. An inappropriate layout would result in unnecessary transport or conveyance which is a major waste. It is also crucial to standardise work processes and eliminates non-value added activities in order to achieve lean. Other than that, there is a need to maintain the inventory at the minimum level because excess inventory would require more valuable space and result in higher carrying cost. Product design is also important as the choices of product structures and materials would affect the production methods and cost. Concurrent engineering techniques play a vital role in a "lean" product development process. Setting up good relationships with customers would enable an organisation to meet customers' needs and predict their demands accurately. Safety is the foundation of all activities. Ergonomics is also important as it helps humans to improve productivity, reduce injuries and fatigues. By using ergonomic features, unnecessary motions (one of the major wastes) are reduced. This helps to reduce mistakes caused by human errors thus enhancing the quality of products

VI. CASE STUDY

This is a practical case study of an assembly line set up whose production line target is to manufacture 3200 pump sets/ month on two shift basis. In the existing set up, the

assembly line having a production capacity of 3200 pump sets/ month was conveyed on a closed loop conveyor with total 12 stations having a tact time of 6.2 minutes for each station. There were three test beds for testing the engines and manually handling the tested engines from the testing area towards the pump set assembly area. During testing of the engines total cycle time for testing is 40 minutes for each test bed excluding the fitment of sensors (exhaust, inlet, lube oil temp.) which are to be fitted before the testing and remove after the testing cycle is completed. Many of the activities were manually done which was unsafe ergonomically. The demand for the pump set was increasing so as per the market research carried out by the marketing department of the company, the customers demand (as per sales forecasting) is more than the required production rate i.e. 8000 pump sets/ month.

The system under study is a semi automatic pump set production line whose target is to manufacture 8000 pump sets/ month on two shift basis having a tact time of 2.80 minutes for each station for assembly and three shift basis for testing, pump assembly, pump set assembly, pump set painting, pump set packaging. The pump set production line consists of eight main stations washing, sub-assembly, assembly, testing, pump assembly, pump set assembly, pump set painting, pump set packaging and two different types of conveyors [9].

During the setting up of the assembly line different tools, techniques and areas of lean manufacturing were being introduced for improving the productivity and removing the wastes during the installation and work in process. Different points were being discussed, out of this discussion study of the layout, material handling, equipments, employees, suppliers, inventory, takt time, line balancing, kaizen, single minute exchange of dies, ergonomics, safety and employee's intake had a major role.

1. Based upon the area available six different layout were taken into consideration and from these six layout one layout was finalised, where it was possible to set up the assembly, testing, pump assembly, pump set assembly, pump set painting, pump set packaging without disturbing the initial set up of chimney, fuel – water – air pipe line and sludge tank area.

2. For travelling of material from the initial stage to the final stage different material handling applications were being introduced; slat conveyor for assembling the product from the raw component stage to the finished assembled stage having total 24 assembly stations, EMS for handling the engines before and after testing, monorail, cranes and buffer conveyors for conveying assembled engines from assembly to testing area, testing to pump set area. Forklift are used for lifting packed engines from pump set packaging area to finished goods area, stackers and trolleys for handling 2 – bin material, raw components from the storage towards the desired area.

3. The takt time was reduced from 6.4 minutes to 2.80 minutes based upon the work distribution and increase in the

work stations.

4. As the production capacity was increased from 3200 pump sets/ month to 8000 pump sets/ month, the intake of the employees was also more.

5. Different new equipments were introduced for improving the productivity; washing machines for washing the oily and dusty parts, the engine is to be checked for any leakage which is checked by an engine leakage testing machine, filling of one litre lube oil in the assembled engine by the means of a hand pump for testing purpose, the cylinder head is to be checked for any leakage which is checked by an engine head leak test machine.

A. Benefits

- i. The layout selected for the new assembly line has a better floor space utilisation.
- ii. The distance traveled is less as compared to the old assembly line.
- iii. Buffer stock can be maintained before & after engine testing.
- iv. There is no disturbance to existing set up (the other series engine can work continuously).
- v. More space for Finished Goods is available.
- vi. Existing chimney foundation can be used.

B. Drawbacks

- i. Investment is high.
- ii. Requirement of the more and highly skilled labors for working on the line.
- iii. No back tracking or rework of engine possible is some activities are left behind during working on assembly line.
- iv. As the production is for 8000 pump sets there is a high requirement of components from the sub vendors within the allocated time, if not available: causing stoppage of the line.

VII. CONCLUSION

Lean production method is an effective way to improve management, enhance the international competitiveness of manufacturing enterprises. The key areas proposed are more comprehensive to assess the current state of adoption and implementation of lean manufacturing. The proposed set of key areas will be validated and improved using a pilot study that involves experts from the academia and industry. From the case study it can be concluded that the production of the pump set has increased from 3200 to 8000. This increase in production can yield significant financial benefits and savings to the company

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