International Journal of Innovative Research in Science and Engineering
Vol. No.2, Issue 01, January 2016
www.ijirse.com
ISSN: 2454-9665

LEAN MANUFACTURING PROCESS – A REVIEW

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ABSTRACT

In Mechanical Engineering, Lean Manufacturing has one of the most important word for last few years. It is an important process for Product and Process Development. Lean manufacturing has made a significant impact on both academic and industrial areas. The given paper describes lean manufacturing tools like 5 S, 5 Why's, Visual Factory, Focus Group, Quality Tools, 6 Sigma, Poka Yoke, Kanban, Total Productive Management with manufacturing waste produced during production process along with their remedies as well as advantages and limitations of lean manufacturing.

The objective of this paper is to provide a framework for understanding evolution of lean not only as a concept but also understanding its implementation due to which improvement in quality, reduction in waste, time and cost takes place.

Keywords: 5 S, Lean manufacturing, Manufacturing waste, Product and process development, Quality tools, Quality.

I. INTRODUCTION

Lean Manufacturing (LM) or Lean Production (LP) or Lean is simply a method of elimination of waste within a manufacturing process. It's a manufacturing strategy that aimed to achieve smooth production flow by eliminating waste and by increasing the activities value. Also, it is a new organizational change and improvement method particularly as a cost reduction mechanism [1].

II. HISTORY

LM is a management philosophy derived from the Toyota Production System (TPS) in 1990's. Lean principles are derived from the Japanese manufacturing industry. During 1980's there was an intense interest on LM implementation among the western manufacturers because of growing Japanese imports. It became a serious concern to the western producers. The primary goal of TPS were to reduce the cost and to improve productivity by eliminating wastes or non-value added activities [2].

It was with Taiichi Ohno at Toyota that these themes came together. He built on the already existing internal schools of thought and spread their breadth as well as use into what has now become the Toyota Production System. It is principally from the TPS, but now including many other sources, that lean production is developing [3].

Still, the interest taken in lean by the western manufacturing community was limited until the performance gaps between Toyota and other carmakers were highlighted by the book "The Machine that Changed the World" which also coined the term 'lean production' [4].

III. LEAN PRODUCTION

3.1 Toyota Production System (TPS)

The basic idea in TPS is to produce the kind of units needed, at the time needed and in the quantities needed such that unnecessary intermediate and finished product inventories can be eliminated. Three sub-goals to achieve the primary goal of cost reduction (waste elimination) are quantity control, quality assurance and respect for humanity. These are achieved through four main concepts: JIT, autonomation, flexible workforce, and capitalizing on worker suggestion and 8 additional systems (Monden, 1983).

The basis of TPS is the absolute elimination of waste. The two pillars needed to support the TPS are JIT and autonomation. TPS can be described as an effort to make goods as much as possible in a continuous flow (Ohno, 1988).

TPS includes standardization of work, uninterrupted work flows, direct links between suppliers and customers, and continuous improvement based on the scientific method (Spear and Bowen, 1999). Lean production is an integrated system that accomplishes production of goods/services with minimal buffering costs (Hopp and Spearman, 2004).

3.1.1 Just In Time (JIT)

Just in time production system as ''only the necessary products, at the necessary time, in the necessary quantity'' (Sugimori et al., 1977). Kanban system, production smoothing and setup time reduction are critical components of any JIT system (Monden, 1981b). JIT philosophy is associated with three constructs: total quality, people involvement, and JIT manufacturing techniques (Hall, 1987). Programs associated with JIT include ''elimination of waste, and full utilization of people, equipment, materials, and parts''. (Davy et al., 1992). JIT is a comprehensive approach to continuous manufacturing improvement based on the notion of eliminating all waste in the manufacturing process (Sakakibara et al., 1993). JIT is based on the notion of eliminating waste through simplification of manufacturing processes such as elimination of excess inventories and overly large lot sizes, which cause unnecessarily long customer cycle times (Flynn et al., 1995a,b). JIT is composed of three overall components namely, flow, quality and employee involvement (McLachlin, 1997) [5].

3.2.2 Autonomation

Actually, the word "autonomation" is made by two different words "autonomous" and "automation". Autonomation is a key element in LM implementation. In TPS, it is written by using 3 kanji characters: "self", "work" and "-ization". It represents a feature of machine design to effect the principle of "Jidoka" used in the TPS and LM [6]. Jidoka is a decision to stop the fix problems as they occur rather than pushing them down the line which are to be resolved later [7]. The Autonomation targets the attention towards understanding the problems with their solutions, elimination of waste and prevention of production of defective parts [8].

JIT and Autonomation are the two main pillars on which TPS is built [9]. The scientists Jeffrey Liker and David Meier shown that Jidoka is a large part of the difference between the effectiveness of Toyota and other companies who have tried to implement LM. JIT and LM are always in search of continuous improvement in its quest for quality improvements, searching and eliminating the causes of problems, so they do not occur again.

Jidoka find defects automatically during production earlier. The halting time of production forces immediate attention to the problem when defect is detected. But, halting leads to slow production [7].

3.2 Lean Production (LP)

Lean Production is an integrated socio-technical system whose main objective is to eliminate waste by minimizing customer, supplier and internal variability. It is most frequently associated with elimination of waste commonly held by firms as excess inventory or excess capacity (machine and human capacity) to ameliorate the effects of variability in supply, processing time or demand which in turn require firms to effectively manage their social and technical systems simultaneously [5].

3.3 Differentiation between TPS and LP

LM was coined by “James Womac” and “Daniel Jones” in their book “The Machine That Change The World” to describe the phenomenal success that Japanese manufacturers were having in global markets. Since the Toyota Motor Company was the most successful of these Japanese manufacturing philosophy with their supply base and strategic partners, the term “Toyota Production System” was born. Regardless of what it is called, the global is always to eliminate waste from processes in order to reduce lead time.

3.4 Takt Time

Takt Time is nothing but a ratio of “Available production Time in a day” to the “Customer’s Demand”. For example, demand of customer is 420 units per day and the production time is 3 shifts except 3 hours of lunch i.e. 24 – 3 = 21 hours, then takt time will be 420 units/21 hours = 420 units/21 hours = 20 units per hour [10].

IV. MANUFACTURING WASTE

Identifying and classifying manufacturing problems is of significant value to a manufacturing organization. True advances, however, come from exposing manufacturing wastes. Shingo and Ohno (Shingo 1992) identified seven different types of manufacturing wastes: overproduction, waiting time, transport, inventory, motion, defects and processing. Within the context of lean manufacturing, many researchers have extended the list of manufacturing wastes to encompass many other wastes mentioned previously (Womack et al. 1990, Liker 1998). Imai (1986) lists nine wastes in production: of rejects, in design, in WIP, in the first phase of production, in motion, in management, in manpower, in facilities and in expenses. Lists of wastes abound; classifications of wastes by where, when, how and why they occur do not yet exist. While exposing and classifying manufacturing, wastes can be the first step in improving a manufacturing organization. Identification is useless if the waste cannot be eliminated. It is therefore important to apply the correct tools, lean manufacturing tools, to eliminate manufacturing waste [11].

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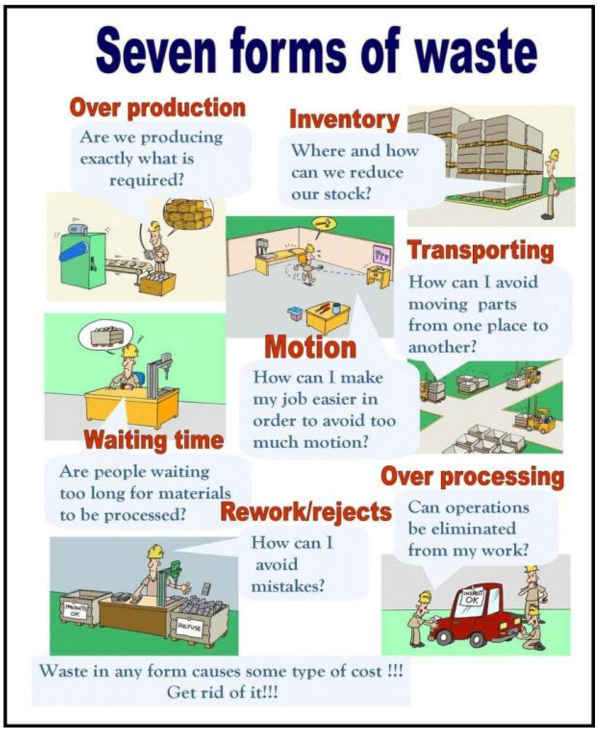

Fig.1: Seven types of Waste [12].

4.1.1 Overproduction

Overproduction means to make products in huge quantity or before it is actually needed leading to excessive inventory. It is the worst among the seven wastes. Companies produce large production because of long setups on some of the machines, so they try to maximize throughput of these machines and use "economical batch quantities" to dictate how much material has been processed rather than what customer wants. Companies also distrust suppliers' ability to supply what they need, so they order more than they need.

4.1.2 Inventory

Inventory means stock of raw materials and finished goods hold far more than is required. It can be observed in many areas as for production, raw materials are ordered in excess of customer requirements due to mistrust of suppliers or to take advantage of bulk discounts to the large amounts.

The wastes Inventory and Overproduction are interrelated to each other. Because, the main cause of inventory is to make more than customers' demand.

4.1.3 Transporting

The stock produced in factories transport in different places many times. This transporting may be from one country to another or from in factory itself from one shop to another. Transportation does not add any value to the product and customer also would not make the payment for it.

The main cause for transporting that contributes waste of overproduction also in turn leads to the waste of inventory which has to be transport between factories and even continents. Also, the areas for specific functions like pressing, welding, molding are different. This leads to the need to transport of product to each area.

4.1.4 Motion

Moving does not add any value to the product. Moving product does not transform it anyway therefore, it is a waste.

This also refers to identifying a place for everything and storing everything in its place. When items are not arranged in correct flow, then such an efficient work flow is impossible. Due to this, workers have to search for equipments and tools during the process.

4.1.5 Waiting Time

It is an act of doing nothing or working slowly or waiting for a previous step in the process. Operators have to wait for the previous operation, a delivery of products to arrive or just slowly working so as not to highlight that they have run out of materials. It means material required for manufacturing of a product does not reach to the worker on correct timing. So, that he cannot start his work on correct time.

4.1.6 Over Processing

Sometimes, many operations are carried out during manufacturing of any product. But, are all operations necessary for it? It may be like that some of the operations that are not needed for a particular product.

Over-processing means to add more value to a product than the customer requirements. Over-processing results in more money, more cycle time, more human efforts and more material also. It also reduce efficiencies as the operators that are over-processing could be performing other value adding tasks that the customer is willing to pay it for.

4.1.7 Rework/Reject

Rework or rejection takes place when there are some defects in a component. Whatever work is done while manufacturing, it is not compared with the final goal which is pre-defined and so rework and rejections takes place.

Defects can be caused by many different problems. Many defects are caused by incorrect method due to non-standard operations, differences in the way that processes are undertaken by different operators in different shifts. The parts a product damage due to excessive handling sometimes.

If defects are small and can be overcome easily, then the components are subjected to rework and if they are non-avoidable, then rejection of component take place [13].

V. LEAN MANUFACTURING TOOLS

Over the years, many lean manufacturing tools and techniques have been developed and every day new ones are proposed (Schonberger 1982, Dillon et al. 1985, Womack et al. 1990, Barker 1994, Liker et al. 1995, Cusumano and Nobeoka 1998, Liker 1998, Feld 2000, Taylor and Brunt 2001). With such a plethora of tools and techniques it is important and helpful to organize them into a systematic and logical manner. A systematic organization of these tools will help in their effective implementation of tools or for getting lean. For example, an organization or listing of tools according to the resource they are applied to will ease the process of tool selection for improvement. Taylor and Brunt (2001) developed a simple correlation matrix that relates seven different value stream mapping tools —process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis, and physical structure volume and value—to the seven basic types of wastes identified by Ohno and Shingo. The correlation matrix is used to select the appropriate value stream mapping tools to eliminate a particular waste. Taylor and Brunt also identified a range of frequently encountered key processes in an organization; 12 value stream wastes within a component and assembly production, seven work environments, and wastes in warehousing. While understanding and classifying lean manufacturing tools is important, there is a need to consider the relationship of these tools and techniques to the manufacturing organization components, the problems they attempt to solve, the type of waste they address and the resources to which they are applied. The purpose of this paper is to propose a classification scheme that will enable matching lean manufacturing tools to the wastes they eliminate and to the manufacturing problems they solve. We believe this to be useful to both application and research. The lean manufacturing tools' classification scheme proposed by us would classify lean manufacturing tools and techniques by their relationship to the component of manufacturing organization where they are applied, the type of waste they identify, measure and eliminate, the resource they are applied to, and the characteristic of the resource they improve. This type of classification is useful to recommend the use and application of lean manufacturing tools for an organization trying to become lean.

The lean manufacturing tools are described below:

5.1 5 S

Various housekeeping activities are often used first in adopting the continuous improvement way of life and are:

5.1.1 Sort

Sort out what is unneeded.

5.1.2 Set in order

Straighten what must be kept.

5.1.3 Shine

Just the workplace must be clean.

5.1.4 Standardize

Establish a cleaning schedule. This requires self-discipline.

5.1.5 Sustain

It spreads the clean routine and provide employees with training as well as time to improve their work areas.

This tools is applicable to the wastes like over-processing, motion etc.

5.2 5 Why's

When a problem is found ask "why" five times. Repeating why five times helps find the root cause of the problem rather than merely responding to symptoms.

5.3 Visual Factory

Information is made available and understandable at a glance for each operator to see and use in achieving continuous improvements (Grief 1991).

5.4 Focus Group

Process improvement teams are trained and responsible for detecting waste. Departmental barriers are eliminated and replaced with cross-functional teams that study a process and then immediately implement improvements.

5.5 Quality Tools

Any scientific decision for improving quality of a product or a process requires collection, analysis and presentation of a lot of data. Data may be generated by actual measurement or as a result of counts of defects or defectives. So, these tools can be used for documentation, analysis and organization of data needed for quality control.

These seven typical quality tools are Check sheets, Flow charts, Histograms, Pareto charts, Cause and effect diagram (Fish bone diagram), Scatter diagram and Control charts etc. These quality tools are only applicable for the waste of waiting time [14].

5.6 Six Sigma (6σ)

In 1987, Motorola developed the six-sigma metric in response to sub-standard product quality traced in many cases to decisions made by engineers when designing component parts. They developed it with a goal to reduce the number of defects to 3.4 parts per million.

Design engineers used the "±3**σ**" rule when evaluating whether or not an acceptable proportion of manufactured components would be expected to meet tolerances. When a component's tolerances were consistent with a spread of six standard deviation units of process variation, about 99.7 percent of the components for a centered process would be expected to conform to tolerances. That is only 0.3 percent of parts would be non-conforming to tolerances which translates to about 3.4 rejects per million [15].

5.7 Poka Yoke

Poka Yoke means simple, low cost devices that prevent defective parts from being made or passed on in the process. Poka Yoke eliminates defects by eliminating mistakes (Shingo 1986).

Here, poka denotes 'inadvertent errors' and yoke denotes 'to avoid' i.e. Poka Yoke means "avoiding inadvertent errors"

5.8 Kanban

A Kanban system is pull type of signalling system that controls the required parts in the required quantities at required time.

Here, kan means 'card' and ban means 'signal' i.e. Kanban stands for "a signal in the form of a card". It is applicable to the waste of inventory.

5.9 Total Productive Maintenance (TPM)

TPM is a quality management program related to maintenance of plants and equipment. This aims at significantly increasing production volumes at the same time providing an environment for improving employee morale and job satisfaction.

The purpose of TPM is to avoid wastage, reduce cost, supply defect free products to customer, producing short batches in minimum time, producing goods without loss of quality. TPM is applicable for waiting time waste [16].

5.10 Value Stream Mapping (VSM)

A Value Stream is a collection of all actions value added and non value added. They are required to bring a product that use the same resources through main flow, from raw material to the arms of customers. These actions are those in the overall supply chain including both operational flow and information which are the core of any successful lean operation.

VSM is one of the improvement tools which assist in visualization of the whole production process including information flow and material. It is only the tool by applying transport and overproduction wastes will be eliminated [17].

VI. ADVANTAGES OF LM

6.1 Elimination of Waste

Waste consumes time, resources, or space in any type of activity, but does not add any value to the product or service. So, preservation of time, resources and space takes place by eliminating waste from the process.

6.2 Quality Improvement

Once, the customer is identified by the company, their needs are required to be discovered. Their needs should be converted into our requirements. To stay competitive in today's marketplace, this is necessary.

6.3 Time Reduction

If the whole process completes in less time i.e. there is saving of a time. Every LMP takes place in a less time as compared to other conventional manufacturing processes due to elimination of waste and lower cost. Hence, there is an advantage of reduction of time in this process.

6.4 Total Cost Reduction

If there is no waste and no unnecessary operations in the process, then it may lead towards the cost reduction of whole process definitely. A company must produce as per customer’s demand to reduce overall cost. Also, overproduction increases the company’s inventory cost because of storage needs [18].

VII. LIMITATIONS OF LM

7.1 Every tool of LM is not applicable to every type of waste. Because, some of the tools are not applicable to some of the wastes like Kanban is not applicable to the wastes like motion, waiting time, reject/rework etc.

7.2 Quality tools can be use to vanish the waste like Waiting time only. It cannot applicable to any other waste elimination.

VIII. CONCLUSION

Lean Manufacturing is a versatile process due to which the wastes like Overproduction, Inventory, Transport, Motion, Waiting Time, Over-processing, Rework/Reject can be eliminated by applying some tools like 5 S, VSM, JIT, Kanban, TPM, Quality Tools, Jidoka etc.

Due to implementation of tool 5 S, factory or company where manufacturing is going on, it remains as a clean place. Value Stream Mapping is a tool by which wastes such as Overproduction and Transport can be eliminated. Takt time is a concept which due to which workers can aware of the production rate per hour. So, it is necessary to calculate takt time everytime.

Lean Manufacturing is receiving more and more attention to reduce the various wastes, cycle time, cost, human efforts etc. in the view of manufacturers and it does not affect the environment, so it is an environment friendly method.

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