LEAD MANUFACTURING: ELEMENTS AND ITS BENEFITS FOR MANUFACTURING INDUSTRY

Rakesh Kumar¹, Vikas Kumar²
Research Scholar, YMCA University of Science and Technology, Faridabad-121006 (Haryana)
Associate Professor, Mechanical Engineering Department, YMCA University of Science and Technology, Faridabad-121006 (Haryana)
e-mail: rakesh_siwach@yahoo.com

Abstract
In today’s competitive environment organizations needs to leverage the strength it has and must work to improve upon its weakness. Lean manufacturing has been recognized the key to improve competitiveness for manufacturing organizations over the globe. Lean manufacturing offers a basket full of tools and techniques which can help in waste identification, reduction or elimination to enables manufacture product with superior quality, lower cost and on time with lesser efforts. Considering its potential of improving operational performance lean manufacturing is gaining popularity among manufacturing industries. Purpose of this paper is to present Lean Manufacturing elements, benefits, implementation strategy and obstacles in implementation for manufacturing industry.

Keywords: Lean Manufacturing, Theory of Lean Manufacturing, Elements of Lean Manufacturing, Benefits and Lean Manufacturing implementation strategy.

1. Introduction:
Offering high quality product with competitive cost has always been a challenge for all manufacturing companies (2). This can be achieved by removing waste from the system by following certain practices called best practices. Many of the best practices in manufacturing have been originated by Toyota (10). Toyota got popularity in 1980’s for efficient operations in all over the world by effectively implementation of JIT (just in Time) system. Brox and Fader, 2002 defined just-in-time (JIT) production as a manufacturing philosophy that identifies and eliminates all forms of waste from the system and calls for continual improvement. In this philosophy non value adding activities are identified and either reduced or eliminated resulting in reduction of cost, productivity improvement, improved quality and delivery.

In 1990 a book written by Womack, Jones and Ross “The machine that changed the word” introduced a new concept called Lean Production or Lean Manufacturing (2, 14, and 17). In Past two decades Toyota Production System has been studied by many of researchers namely Adler,1993;Womack and Jones,1994;Liker,1998;Sobek et al. 1998;Spear and Bowen,1999;Mike Rother,2009. Although all of the lean Manufacturing principles studied by these researchers were not new to manufacturing system but it was observed that Toyota was able to sustain the better outcome of these principle s with input of lesser resources (17). The acceptability of these principles increased because Japanese companies who adopted these principles were able to develop, manufacture and supply the product to customers with the lesser resources like material, machines, tools, human effort, capital investment, floor space, time and total expenses (Womack et al., 1990). Ohno, 1988; Shingo, 1989; Womack et al.; 1990, Monden 1997; Mike Rother, 2009 and other researcher made Lean Manufacturing approach popular among the industry.

2. Theory of Lean Manufacturing:
Lean Manufacturing is a philosophy that aims to maintain smooth production flow by continuously identifying and eliminating waste resulting in increasing value of activities in the production process (18). Lean manufacturing approach makes an organization able to sustain market competition by improving its competence for better quality; on time delivery with lower cost Lean Manufacturing aims for Identification and elimination of waste (any activity that does not add value to customer).

Lean Manufacturing aims for the accomplishment of unidirectional and continuous material movement known as production flow (2, 9). Processes should be free from bottlenecks, waiting, disruption, and backflow. Lean manufacturing aims to produce only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation. Lean
Manufacturing focuses on defect free production lines (11). It aims for defects to be eliminated at the source and for quality inspection to be performed by the workers as part of the in-line production process. Lean Manufacturing requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continual improvement process.

3. Elements of Lean Manufacturing:
To convert a conventional organization into a lean organization numerous and continual efforts are essential. Certain elements are discussed by researchers and are adopted by the manufacturing organizations to improve competitiveness in the market by reducing product manufacturing cost, reducing response time to customers and improving quality and productivity.

Followings are the key elements which have been recognized in different research papers.

<table>
<thead>
<tr>
<th>Table 1. Lean manufacturing elements</th>
<th>Attributed in reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMED/setup time Reduction</td>
<td>(5,10,11,15,16,18,24,26,27)</td>
</tr>
<tr>
<td>Kanban</td>
<td>(5,10,11,14,15,18,24,27)</td>
</tr>
<tr>
<td>TPM</td>
<td>(5,10,16,18,24,26,27)</td>
</tr>
<tr>
<td>Batch Size Reduction /Single piece flow</td>
<td>(5,10,16,18,24,26,27)</td>
</tr>
<tr>
<td>Cellular Layout /Layout improvement</td>
<td>(10,16,18,24,25,26,27)</td>
</tr>
<tr>
<td>Poka yoke</td>
<td>(5,11,16,18,24,26,27)</td>
</tr>
<tr>
<td>Quality Circles/Quality at the Source</td>
<td>(10,11,11,16,25,26)</td>
</tr>
<tr>
<td>Kaizen</td>
<td>(11,16,17,24,26,27)</td>
</tr>
<tr>
<td>5 S’s</td>
<td>(10,18,24,26,27)</td>
</tr>
<tr>
<td>Employee involvement/development</td>
<td>(10,16,17,18,25)</td>
</tr>
<tr>
<td>Continuous improvements/PDCA</td>
<td>(15,17,24,27)</td>
</tr>
<tr>
<td>Standard Work</td>
<td>(5,17,24,27)</td>
</tr>
<tr>
<td>Visual Management</td>
<td>(10,11,18)</td>
</tr>
<tr>
<td>Value Stream Mapping</td>
<td>(11,24,27)</td>
</tr>
<tr>
<td>Production Leveling (Heijunka)</td>
<td>(10,24,27)</td>
</tr>
<tr>
<td>Group technology</td>
<td>(16,27)</td>
</tr>
<tr>
<td>Jidoka</td>
<td>(24,27)</td>
</tr>
<tr>
<td>Andon</td>
<td>(24,27)</td>
</tr>
<tr>
<td>Milk run</td>
<td>(24)</td>
</tr>
<tr>
<td>FIFO</td>
<td>(24)</td>
</tr>
</tbody>
</table>

3.1 SMED/setup time Reduction-Lean Manufacturing targets reduction of setup time and changeover time because it consumes critical working time and reduces proper utilization of machine and operator time. This can be achieved by sequenced and structured work instructions to perform the job. The operator will follow the instruction and should be able to finish the job within minimum possible time. The work instruction is based on time and motion study during changeover, analysis of the waste and modification with the aim to eliminate the waste.

3.2 Kanban -Kanban is a shop floor tool which communicates customer requirement from downstream to upstream worker. Once product is withdrawn from finished goods against customer demands to replenish the moved quantity it is replaced with colored card (or electronically). This becomes a production order for the internal supplier in the upstream value chain.
3.3 Total Productive Maintenance - Total Productive Maintenance (TPM) promotes basic preventative maintenance job to operator itself so that break down time of machines is reduced. It also enhances operational efficiency of machine as worker does cleaning, lubricating, inspection, tightening activity of his machine.

3.4 Batch Size Reduction - Lean Manufacturing calls for smaller batch size production. The word single piece flow means it tends to one part at a time to be produced when operating for various types of product. In practical case it is not possible in some cases so minimum possible batch size should be selected. It helps in reducing waiting inventory of part. Lesser idle inventory means lesser working capital requirement and better financial efficiency.

3.5 Cellular Layout - In cellular production layouts, equipment and workstations are arranged into a large number of small tightly connected cells so that many stages or all stages of a production process can occur within a single cell or a series of cells. Cellular layout helps to achieve many of the objectives of Lean Manufacturing due to its ability to help eliminate many non value-added activities from the production process such as waiting times, bottlenecks, transport and works-in-progress. Another benefit of cellular manufacturing is that responsibility for quality is clearly assigned to the worker in a particular cell and he/she therefore cannot blame workers at upstream stages for quality problems.

3.6 Poka Yoke - Poka Yoke means mistake proofing. This involves bringing a system which eliminate human mistakes in term of quality, safety and other process parameters to ensure quality and safety in the manufacturing lines.

3.7 The Five S’s - The 5S is a lean tool which consists of five steps Seiri, Seiton, Seiso, Seiketsu, Shitsuke and taken from Japanese language which aims to improve work place efficiency.

  Seiri: It refers to the action of sorting out wanted and unwanted material in and around workplace. Unwanted material should throw away and material which needs with lesser frequency should be place near to workplace and material which is required more frequently must be kept at a defined place very near to point of use. Seiri ensures in reduction of material searching time waste.

  Seiton: Seiton or set in order means every object (material, tool or instrument) must have a designated place to keep and every place have is the same object. The correct place, position, or holder for every tool, item, or material must be chosen carefully in relation to how the work will be performed and who will use them

  Seiso: Seiso, is the third step in "5S", speaks about clean and shine. Everybody is caretaker of its workstation and should see to clean all the commodities in and around workplace and make it shine.

  Seiketsu: The forth S of "5S", is seiketsu, it means standardization. It consists of defining the standards by which personnel must measure and maintain 'cleanliness'. Color coding can be used for standardization which can enable to visualize between current level and desired level.

  Shitsuke: The S of "5S" is Shitsuke, which means 'Self Discipline.' It stands for promise to maintain the first 4 S as a way of life. The importance of shitsuke is taking away of bad habits of disorderliness and regular practice of good ones.

3.8 Quality at the Source - Quality at the Source means that quality should be built into the production process in such a way that defects are identified and eliminated at the source. The main responsibility for quality inspection is done in-line by workers, not by separate quality inspectors who inspect sample lots. In lean manufacturing primary job of a quality control team is to troubleshoot the root cause of defects, implement preventive measures and provide training to workers to make sure that the defects are not produced.

3.9 Worker Involvement - In Lean Manufacturing, workers are assigned clear responsibility to identify sources of non value-added activities and to propose solutions to those. Lean Manufacturers typically believe that the majority of useful ideas for eliminating non value-added activities typically originate with workers involved in those processes. In order to ensure that ideas for eliminating non value-added activities are acted upon, the power to decide on changes to the production processes are pushed down to the lowest level possible (i.e. normal workers) but any
such changes are required to meet certain requirements. For example, at Toyota workers are encouraged to implement improvements to the production processes but the improvement must have a clear logic which is in accordance with the scientific method, the improvement must be implemented under the supervision of an authorized manager and the new process must be documented in a high level of detail covering content, sequence, timing and improvement is effective, Toyota will implement the change across its manufacturing operations.

3.10 Continual Improvement - A company can never be perfectly efficient. Lean Manufacturing requires a commitment to continual improvement, and preferably a systematic process for ensuring continuous improvement, whereby the company constantly searches for non value-added activities and ways to eliminate those. The focus of continual improvement should be on identifying the root causes of non value-added activities and eliminating those by improving the production process.

3.11 Kaizen - Kaizen means small improvement. To maintain continuous improvement activities throughout the organization Kaizen culture should be created and maintained. Kaizen is done by the individuals mainly by operators for improvement in working condition, safety, quality, productivity, set up time reduction or any other small change for betterment.

3.12 Standard Work - Standardized work means defining work and process instructions are well defined with full details of operation or process and parameters. It will reduce variation in repeated work cycles. All the work instructions should contain standard worker movement, actions, checkpoints for quality, safety along with machine time, standard inventory.

3.13 Visual Management - Visual Management facilitate everyone to be known about manufacturing targets, current status, deviations etc. It makes information available for all regarding status of production lines, down time and also controls the process by defining limits of tolerance. Good and not good parts are also defined with different colors. Location of not good parts are generally defined by red color.

3.14 Value Stream Mapping - Value stream mapping is a set of methods to visually display the flow of materials and information through the production process. The objective of value stream mapping is to identify value-added activities and non value-added activities. Value stream maps should reflect what actually happens rather than what is supposed to happen so that opportunities for improvement can be identified. Value Stream Mapping is often used in process cycle-time improvement projects since it demonstrates exactly how a process operates with detailed timing of step-by-step activities. It is also used for process analysis and improvement by identifying and eliminating time spent on non value-added activities.

3.15 Production Leveling (Heijunka) - Production leveling, also called production smoothing, aims to distribute production volumes and product mix evenly over time so as to minimize peaks and valleys in the workload. Any changes to volumes should be smoothed so that they occur gradually and therefore in the most non-disruptive way possible. This will also allow the company to operate at higher average capacity utilization while also minimizing changeovers. A key element of production leveling is that the person(s) responsible for placing orders to the factory floor should have a system for automatically smoothing out the orders so that any increases or decreases are gradual and not disruptive. This makes it easier to correctly allocate the necessary equipment and people.

4. Benefits of Lean manufacturing implementation:
Lean manufacturing focus on waste reduction, lowering cycle time, reducing defects and reduction of response time and work in progress inventory. These all positively impacts the performance of the organization. Some of the benefits are observed during study.
4.1 Reduced cost: By implementation of Lean Manufacturing organizations can achieve reduced cycle times, increased labor productivity and elimination of bottlenecks and reduced machine downtime can be achieved, and companies can generally significantly increased output with reduced cost from their existing facilities.

4.2 Reduced lead time: With the effect of reduced cycle time and work in progress inventory lead time to manufacture and deliver the product is drastically reduces.

4.3 Waste reduction: Waste identification and reduction is one of the main functions of Lean Manufacturing implementation plan. All the form of waste i.e. overproduction, defect, transportation, work in progress inventory, over processing, waiting and motion are reduced with Lean manufacturing implementation.

4.4 Improved productivity - Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessarily tasks or unnecessary motions).

4.5 Reduced work in progress (WIP) Inventory - Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also mean lower working capital requirements.

4.6 Lower Cycle Times - Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times.

4.7 Improved Flexibility - Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time.

4.8 Multi skill worker – Involvement of worker in various Lean tools i.e. quality circles, kaizen circle, layout improvement; value stream mapping, set up time reduction etc. creates better understanding of processes, machines, material flow among the team and improves core competencies of worker.

4.9 Better Utilization of equipment and space - Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime

4.10 Reduced Defects - Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers.

5. Lean Manufacturing Implementation strategies:

Lean manufacturing is a philosophy which cannot be implemented instantly so it requires tolerantly developing understanding within the organization about lean, starting with smaller projects of lean at tool level, taking guidelines of an expert, making and following the strategy with due course correction in strategy while implementing lean throughout the organization. Some of the steps are as follows:

5.1 Senior Management Involvement-For any major change, support and commitment from top management is vital. It is very much possible that problems will arise when lean implementation will progress and these issues must be understood and solved by top management without effecting lean implementation process.

5.2 Initiate with smaller projects - Initial project must be small so that more resources are utilized and more chances are for better results with lesser risk moreover people working on project and around will learn while doing
project. The results will motivate other to follow the same and people will start having faith in lean techniques. So recommendation is to start with smaller project at tool level.

5.3 Start with limited execution – Lean implementation should be within limited area during start so that it can be monitored, corrected and directed for further implementation starting lean all-around the organization will reduce control and mentoring of people involved in lean implementation. Once movement is gained it should be spread in other areas.

5.4 Employ a professional – Services of a professional mentor should be taken at least at the start. During conversion of a conventional organization to a lean organization lots of issue will arise and should be handled professionally they can be taken care with the use of expert.

6. Obstacles in Lean Manufacturing implementation:
The following may be some obstacles in Lean manufacturing implementation:

6.1 Lack of management support: the reason can be pressure from customer side; competitor is following lean practices or others. In this case management just starts and does not propel further this results only superficial lean and neither lean is implemented nor does it get benefit.

6.2 Lack of training: Another reason is lack of clear understanding about lean throughout the organization. The organization where knowledge of lean lacks it cannot be implemented.

6.3 Communication – Lack of communication is one of the prime obstacles in lean manufacturing implementation.

6.4 Resistance to Change – Resistance to change is very common phenomena as it increases fear of failure, initial cost so many of routine liking people doesn’t want to change and hence it stops the progress of lean implementation.

6.5 No direct financial advantage – Lean does not produces any direct financial benefits but it helps in identification and elimination of waste hence reduction of cost. Lean does not have any financial measure in terms of input and output so sometimes lean idea is superseded by other organizational priorities.

6.6 Past failures – In case of poor launching of Lean is itself big obstacle. Lack of implementation strategy may lead to lack of faith in whole philosophy.

5. Conclusions:
Lean Manufacturing has been broadly accepted over the globe by manufacturing sector and in some areas it has deep penetration resulting in improvement in operational performance of the organization. Many researchers has studied and documented their view on lean manufacturing so it is observed that there is no short and snappy definition for lean manufacturing. Common understanding about lean manufacturing is mainly waste reduction, continual improvement, process improvement and improving supplier customer relationship by reducing lead time. Lean manufacturing offers an extensive list of tools to improve manufacturing and generate the desired advantage to survive in today’s competitive scenario. Selection of tools depends upon understanding about lean manufacturing, focus area for improvement, current condition etc. Smaller lot size results in lesser work in process inventory and reduces blockage of cash finally making organization able to release that capital for working asset. Improved flexibility by reduction of changeover time results in reduced inventory and reduced response time to customer. Implementation strategy of lean manufacturing is very important aspect. It should be carefully prepared and followed otherwise investment of resource for lean manufacturing implementation will go waste it may result into cost impact and demoralized employees. For effective implementation obstacles must be taken care of before initiation and should be backed with action plan to overcome them. Finally lean Manufacturing is not one time activity which can bring all the benefits right away but it should be taken as a way of life for improving manufacturing to make the organization more productive, profitable, and customer oriented which is the call for of the day.

References


