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A Journey Through Lean Manufacturing

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ABSTRACT

The objective of this paper is to understand the meaning of Lean Manufacturing, its philosophy, its principles, Lean Manufacturing concepts, the various tools and techniques used while implementing Lean Manufacturing, benefits and advantages of Lean Manufacturing. The concept of lean manufacturing was introduced in Japan, and the Toyota production system was the first to use lean practices. Lean manufacturing by now is a widely discussed and used manufacturing philosophy, in different types of industries across the globe. Lean Manufacturing is different from traditional manufacturing. The traditional manufacturing concept focuses on the inventory of the system, whereas Lean Manufacturing opposes this concept. The 'Lean' concept considers inventory as a waste in the organization. Lean manufacturing helps in enhancing production processes and boosting up the employees job satisfaction. Most of the organizations today are going through a stage where there is a necessity to respond the rapidly changing customer needs. To sustain their place in the market, many organizations have started following the Lean Manufacturing concept.

Keywords: Lean Manufacturing; wastes; continuous improvement; manufacturing industry, Lean principles, Lean tools, TPS.

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I. INTRODUCTION

Product Design and development is the set of activities beginning with the perception of market opportunity and ending in manufacturing, sales and delivery of products. While manufacturing these products, lot of wastages are generated. These wastages are added to the product cost and make it unviable to sell the product in the market. Also because of huge competition, manufacturing the products at lowest cost , is the dream of each manufacturer.

For manufacturing the product at the reasonable price, as for as possible, one should minimise the wastages. Study and reduction of wastages continuously out of the manufacturing process is the basic theme of Lean Manufacturing.

As per the National Institute of Standards and Technology (NIST),Lean Manufacturing is defined as "A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of customer in persuit of perfection." Also the core idea behind Lean Manufacturing is maximizing customer value while minimizing waste, thereby achieving manufacturing excellence through the creation of more value with fewer resources.

Types of waste;

While defining the term Lean Manufacturing, everywhere we come across the word waste. The waste means anything which is non value adding activity and these should be removed. But identifying and elimination these wastes is a difficult task.

The concept of Lean Thinking is originated from Toyota Production System (TPS) that determined the value of any process by distinguishing value-added activities from non-value-added activities; and eliminating waste so that every step adds value to the process (Antony, 2011).

The elimination of waste is the goal of Lean Manufacturing and for this the Toyota Production System has defined three broad types of waste: namely,1) MUDA 2) MURI and 3)MURA and these are Japanese words.

MUDA; Waste generated within the manufacturing process which includes all the non-value adding works like the following 7 wastes.

Transport (moving products that are not actually required to perform the processing) Inventory (all components, work in process, and finished product not being

processed) Motion (people or equipment moving or walking more than is required to perform the processing) Waiting (waiting for the next production step, interruptions of production during shift change) Overproduction (production ahead of demand) Over Processing (resulting from poor tool or product design creating activity) Defects (the effort involved in inspecting for and fixing defects) Later an eighth waste was defined by Womack et al. (2003); it was described as manufacturing goods or services that do not meet customer demand or specifications. Many others have added the "waste of unused human talent" to the original seven wastes.

MURI; Waste created through over burden.
Muri is all the unreasonable work that management imposes on workers and machines because of poor organization, such as carrying heavy weights, moving things around, dangerous tasks, even working significantly faster than usual. It is pushing a person or a machine beyond its natural limits. This may simply be asking a greater level of performance from a process than it can handle without taking shortcuts and informally modifying decision criteria. Unreasonable work is almost always a cause of multiple variations.

MURA; Waste generated by irregularity, non-uniformity and unevenness in the workload.

1.2. Concept of Lean Manufacturing:

The concept of Lean Manufacturing arises when we desired to make the manufacturing process more efficient and productive, without any unwanted delays, with a minimum capital investment and able to produce the product at competent price. Lean Manufacturing concept eliminates the wasteful process steps out of production line and increases the production speed. This leads to reduction in the production cycle time and because of this we can manufacture the product as and when customer needs it.Thus there is no need to maintain the large inventory of finished products since we can produce faster. Today, the customer has become very knowledgeable and he is the driver. A survey conducted all over the world to understand the customers requirement globally, showed the following three top requirements.

a) On time delivery.
b) Good quality.
c) Low price, and to achieve these customer requirements, Lean Manufacturing philosophy is very suitable and beneficial.

II. NEED OF LEAN MANUFACTURING

Many Industries feel that there are many obstacles that prevent their organizations from satisfying the customers needs and making profit. But they do not understand how to identify and remove these obstacles. Hence they resort to short cuts like, firing the old employees and hiring new, going for cheap materials, compromising on quality matters, cheap advertisings etc. But these methods fail to overcome the obstacles and on contrary aggravates the problems. The most of manufacturing organizations are having the following common problems;

a) High cost of quality.
b) Delayed supply.
c) Reduced profit margin because of high production cost.
d)High inventory.
e) Higher product price compared to the competitors.
f) High customer complaints and product returns.
g)Failure to bring new products faster to the market and so on.

If any of the above problem persist with the manufacturing organizations, then they should promptly think over the implementation of Lean Manufacturing .

III. PRINCIPLES OF LEAN MANUFACTURING

Some Of Lean Manufacturing Principles Are As Follows:

Pull processing -- products are pulled from the consumer end (demand) not pushed from the production end (supply)

Perfect first time quality-- quest for zero defects revealing & solving problems at the source.

Waste minimization-- eliminating all activities that do not add value and maximize the use of scarce resources(capital, people and land).

Continuous improvement-- reducing costs, improving quality, increasing productivity and information sharing.

Flexibility--producing different mixes or greater diversity of products quickly, without sacrificing efficiency at lower volumes of production.

Building and maintaining a long term relationship with suppliers through collaborative risk sharing, cost sharing and information sharing arrangements.

IV. HISTORY OF LEAN MANUFACTURING

U.S. manufacturers have always tried for the efficient methods for reducing the cost, increasing the output, increase in market share even before world war2. But after world war2 the focus was shifted to the result oriented, output focused production systems. The term Lean Manufacturing was first coined by John Krafcik,who had been a quality engineer in the Toyota-GM joint venture.

After world war2 Japanese manufacturers were facing the declining in the resources like man power, materials and finance. Also the problems faced by them is entirely different from their Western and American counterparts. These circumstances led to the development of new and low cost manufacturing practices. The people like, Toyota motor companys Eiji Toyodo,Taichi Ohno and Shingeo Shingo developed a desciplined,process focused, production system called Lean Manufacturing System. The objective of this system was to minimize the consumption of resources that doesn't add any value to the product.

V. THE REVOLUTION OF LEAN MANUFACTURING

In manufacturing industries, the manufacturing facilities are the backbone and responsible for growth and development. When we intended to develop and to get more business opportunities, our focus should be on its manufacturing technologies .Lean Manufacturing is a very effective and powerful manufacturing philosophy, which is very effective to maximize business growth and development.

Lean Manufacturing has taken the manufacturing industries by storm and many companies around the world have adopted the Lean Manufacturing tools and principles. The huge industries like Toyota, Dell computers and Pratt and Whitney have achieved dramatic reductions in delivery time and lowered inventory levels, while increasing responsiveness to customer demand and improving the cash flow by implementing Lean tools.

VI. LEAN MANUFACTURING TOOLS

The following are the various Lean Manufacturing tools extensively used by the Lean Manufacturing practiceners.

1. 5 Why's. 2. 5S
3. A3 Report 4. Zero Quality Control
5. Bottleneck 6. Cellular Manufacturing
7. Cross-training 8. Dynamic Scheduling
9. Empowerment 10. ERP
11. External Setups 12. Fishbone Diagram
13. FMEA 14. Flexible Manufacturing System
15. Flow Chart 16. Future State Map
17. Heijunka 18. JIT/Inventory Reduction
19. Jikoda 20. Kaizen Events
21. Kanban/Small Batch Size 22. Lean Supermarket
23. Level Loading 24. Mass Customization
25. Metrics Based Process Mapping 26. Milk Ru
27. One Piece Flow 28. Process Mapping
29. Pareto Chart 30. Poke-a-Yoke/Error-proofing
31. SOP 32. Six Sigma
33. SMED 34. Spaghetti Diagram
35. Standardized Work 36. Statistical Process Control
37. Takt Time 38. Time Study
39. Total Productive Maintenance 40. Value Stream Mapping
41. Visual Indications 42. Visual Metrics
43. Visual Status Indicators 44. Gemba Walk

Today people have a different perspective on manufacturing processes. They understand that the value of a product is defined from the customer's point of view, not from an internal manufacturing point of view. Lean manufacturing focuses on the elimination of wastes from the manufacturing processes.

As said earlier, waste is anything that does not add value to the product. Lean tools when combined with SWOT (strength, weakness, opportunity, threats) analysis help in eliminating wastes within the organization (Upadhye,Deshmukh, & Garg, 2010). Lean manufacturing when implemented successfully results in an increase in production output per person and a reduction in the finished goods inventory and work in process (Seth & Gupta, 2005).The ultimate goal of a lean manufacturing system is to eliminate all wastes from the organization. A lean system is represented as two pillars: the first is 'jidoka ' and the second is 'just-in-time'. The main goal of a lean manufacturing system is to produce products of higher quality at the lowest possible cost and in the least time by eliminating wastes (Dennis, 2007).

VII. THE BENEFITS OF LEAN MANUFACTURING

There are many benefits the industries get by becoming the Lean Industries. The following are some of them.

Productivity improvement – in terms of costs, the overhead operating costs are reduced by almost 30% and hence the cost of product is also reduced drastically which is the requirement of today's world for getting competitive edge over the competitors.

Total manufacturing time saved – lead time is cut by 50% to 90%and hence the customer delivery dates can be achieved easily.

Less scrap – material cost is saved almost 29% contributes for reduction in the product cost.

Low inventory level – many a time process queues are reduced by 70% leads to reduction in the stock holding cost.

Quality improvement – leads to increase in sales and profit margin. Helps in winning the confidence of customer.

Plant space is saved.

Better labour utilization – reduce the labour cost and man power requirement.

Less equipment utilization – reduces the machine wear and tear and reduces the wastage of machine utilization hour.

VIII. STEPS OF LEAN MANUFACTURING IMPLEMENTATION

Identification of wastes in the system--Many organizations need to know that they have many hidden and unhidden wastes in their systems.

Wastes present in the organization can be of different types. There is a need to recognize the types of waste and their causes. Lean manufacturing believes in treating the causes and curing the problems permanently. There are various tools and techniques that are quite helpful in reducing or eliminating these types of waste.

The next step is to find the solution for the root causes. One must stick to basic lean concepts and identify the root causes. Looking at causes might not help properly, so there is a need to identify the effects of the solution on the entire system.

The final step in the Lean implementation process is to find the suitable solutions and test these solutions. After proper testing these are implimented. Training and following up are important in each and every step explained above. One needs to be patient because the implementation process might take a long time. (Figure 1) Industries in many developing countries are working on old and obsolete techniques of manufacturing. Mahapatra and Mohanty (2007) in their study

found that Indian companies were using workers only physically but not intellectually. There had been no suggestion system in the organizations. Singh, Garg, and Sharma (2010a) conducted a survey in the Indian automobile, machine tools and manufacturing industries. They created five groups as a parameter of evaluation. These groups were called organizational, supplier, customer, market focus and top management. They found that, for companies to implement lean, they have to focus on management and market issues. Sharma, Gupta, Kumar, and Singh (2011) found that supplier issues are crucial for the successful implementation of lean. Many big companies like Tata motors, HCL and Wipro have successfully implemented lean manufacturing principles. Thara Engineering and Gold Seal Engineering Products Ltd are some small scale industries that have improved their processes by the implementation of lean manufacturing. More companies, like Bharat Forge, Bajaj, L&T and Boyce, have become more globally competitive. Sundaram-Clayton Ltd cut down their costs by using lean manufacturing concepts.

As per ,
TPS – ThroughPut Solutions
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435-792-4380 ,www.tpslean.com who are Lean practioners from USA,they have implemented Lean Manufacturing principles in many of the industries and got a huge successes. The following tables gives the wonderful results of Lean Implementation.

TYPE OF INDUSTRIES	PROBLEM	LEAN SOLUTIONS	RESULTS
1.FOUNDRY	dozens of people would make a 4 to 8 block trip , several times a day to a building housing the NDT equipment. Parts were processed in buildings several blocks away, then transported via carts, trucks, or forklifts to NDT for further processing. Generally, parts would be tested at NDT, then returned to the original building for additional work. Certain parts would repeat this cycle several times.	Recognizing the importance of locating the NDT area near its internal feeders, we located a centrally located space that would sufficiently meet the needs of the NDT area. After considerable re-layout, equipment streamlining and workflow improvements, the new NDT location used only about one-third of the previous space. We then redesigned the x-ray processing booth to accommodate the improved workflow, and KanBans were established between NDT and their several "Internal Suppliers."	Dozens of lost production hours are recovered on a daily basis. Time spent transporting parts is now spent processing products. Communication and feedback between "Internal Suppliers" and "Internal Customers" significantly improved. Defects caused by packing and transporting parts are now almost completely eliminated.Very conservative estimates value this improvement at more than $2 million annually.
2. FLEXO LABEL PRINTING .	Long changeover and setup times between product runs created considerable downtime. Buying additional equipment was under consideration to prepare for a forecasted increase in demand. Quality defects and raw material waste issues considered "inevitable in this business" were also of great concern.	Using S.M.E.D. (Single Minute Exchange of Die) methods, we reinvented the entire operation and created a procedure that minimized downtime. Setups and changeovers became well orchestrated events. Due to the nature of the equipment, we also relied heavily on5S and ergonomic tools to properly stage needed items and reduce risk of injury and operator fatigue. Quality defects were also addressed. Raw material waste was also addressed through a "go, no go" procedure and a setup innovation.	Depending on the number of colors used on a job, setups and/or changeovers were consuming between 3 and 7 hours (5 hours on average) of production downtime per machine. After implementing the new procedures, all setups and changeovers were completed in under 30 minutes regardless of complexity. This improvement negated any need to purchase equipment to meet forecasted demand.
3. ANTENNA MANUFACTURING UNIT.	An awkward production process and workflow in the Transit Antenna build area created excessively long lead-times. This small factory used floor space too liberally, while the owner considered purchasing a new building to meet their needs.	We restructured the floor shop layout into a single work cell for the antenna build area. The primary "bread & butter" products became streamlined using work instructions and a balanced cell. Working closely with company engineers, we created several fixtures. Quality officers	Turning 26 workbenches into only 6 workbenches became almost overwhelming. Since floor space was a highly valued premium, this emerged as one of the great accomplishments of the effort. Since only a maximum of 6 people were now needed to operate the cell (including the newly integrated

		incorporated testing procedures into the process for immediate feedback and quality verification.	testing area), the remaining 5 people were relocated to other lagging areas.
4. CABLE MANUFACTURING UNIT;COAXIAL AND RIGID.	This global leader produces a wide variety of cables and assemblies. They needed to reduce setup times and WIP (work in process) inventory. They also struggled with quality consistency issues that warranted immediate attention. Long product runs were common, but did not allow sufficient flexibility to reduceLead time to market.	We first attended to the setup and changeover functions of essential equipment and found a number of ways to streamline the process. These methods were then applied to similar equipment. We then established KanBans between cable processing functions that required upstream processes to stop building product that could not be completed due to resources and equipment running at capacity. We then level-loaded these production areas via KanBans and then established new procedures. As always, 5S (Visual Workplace) methods were used to clean and organize the machines and areas for maximum efficiency and quick changes. Staging procedures and preparation checklists were instituted to maintain quality, process integrity and follow-through.	Immediate gains that, prior to the Blitz Event, were ranging from 3 to 12 hours (5 hours on average). At last check, setups averaged less than 35 minutes, with many below 17 minutes. This added approximately 5 hours of additional up-time per machine, per day. Quality checks for 1st articles that could take an hour or more were prioritized and all staff and equipment were subordinated to their rapid completion. "Known" products were given a "conditional green light" to continue production while the inspectors conducted the 1st article check. In the end, the company deemed current equipment sufficient to meet not only present demand but also forecasted sales expectations for quite some time. These improvements increased the capacity of this product line by approximately 35%, resulting in several million dollars of potential additional sales per year.
5. AUTOMOTIVE INDUSTRY.	Changing from one shift to another created long periods of low or stopped production. Since this was a three shift operation with shift changes averaging 30 minutes three times per day, this became a costly and destructive routine. Cell "purging" (consuming all WIP without leaving work "in cue" for the next shift) was also a common practice to meet or exceed each shift's specific production goals.	Working with the teams across all 3 shifts, we devised a changeover process that would minimize downtime . Procedures were agreed upon, posted, trained on, and adopted. The new procedure required all employees to spend the first 10 minutes of his or her shift cleaning the work area, All of these duties were performed while the operator from the previous shift continued to run the equipment or completed assigned work processes. Out-going operators would finish paperwork and minor cleaning only after their replacement was in position and working.	Adding one and a half hours of production up-time to a high velocity manufacturing plant yields incredible and powerful results. Streamlining the shift change process in this one cell increased much needed capacity, improving throughput by more than $1 million annually. It was commonly speculated among management that this one change in procedure was worth tens of millions of dollars to the company annually.
6. STEEL MILL.	This large division of a vertically integrated steel mill had been losing money for several years. The parent company was seriously considering closing it down. In addition to poor financial performance, the division had too much cash tied-up in inventory and had lead time and delivery	While there is a litany of standard objections, the number one is always "local optimization." This company's measurement and reward systems were typical, i.e. all geared to maximizing the efficiency of the individual operating units (tons per hour), … but not necessarily the	In Ten Months: Sixteen million dollars (U.S.) cash was generated via inventory reduction, Lead times were cut by 60%, Average lot size was cut by 65%, Average coil mass

	performance problems.	entire process.This inevitably results in a different set of operating rules at each unit. One unit wants to run by "grade," another "thick to thin," "wide to narrow," "light to dark," etc. The easiest way to accomplish these conflicting objectives is to keep a huge pile of inventory in front of every unit so that they can put together an optimal run schedule. Also note that these queues extend lead times, hide defects, increase handling damage, add difficulty to the scheduling process, tie up cash and space, cause excessive expediting, etc.Inventory reduction and on-time delivery goals were set, and commitment attained.	increased by 9% (yield improvement), On-time delivery soared, from 55% to 95%, the best in their industry, Customer complaints dropped by more than half, Cost of quality plummeted, Profitability improved by $5 million (U.S.) per MONTH

IX. CONCLUSION

Waste reduction is the one of the main goal of Lean Manufacturing and also today's need to the various industries ailing because of customer demand and stiff competition in terms of product cost. Lean Manufacturing helps to sort out these problems. This Review has focused on understanding the History of Lean Manufacturing, Lean Manufacturing concepts, principles, various types of wastes, Lean Manufacturing tools , and the various industries benefitted using Lean Manufacturing concepts.

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