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Lean Manufacturing: A Review of Opinion and Research within Environmental Constraints

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***Abstract*—Lean manufacturing is a proper technique to identifying and eliminating waste through continuous improvement. In lean manufacturing do more with less: time (production time, waiting time etc.), inventory, men, and money. At present time, Lean Manufacturing has become a worldwide technique. It is very successful in drawing the attention of companies of all sizes. Many organizations are following Lean technologies and experiencing drastically improvements in quality, production, customer service, and profitability. Process improvement is an iterative method of seeking the elimination or reduction of non-value adding work imbedded in a process. Non-value-adding work is described as elements of work that a customer is unwilling to pay for. The Lean manufacturing technique is meant convert non-value added activity into value added activity. Lean manufacturing has its effect on the manufacturer and the customers alike. A lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste. [2] This paper gives the literature survey on various type of industry to apply the lean manufacturing. And introducing about lean .what is lean manufacturing, why it is needed, and method of lean manufacturing that reduces waste. And also to introduces about different lean tools.**

***Index Terms*—Lean Manufacturing, Total Productive Maintenance (TPM), Kaizen**

I. INTRODUCTION

To understand what lean is it is helpful to understand why it developed Lean (and the Toyota Production System) have two main purposes; Provide customer satisfaction and do so profitably. Principles of lean manufacturing are widely used by industries to eliminate waste. After Second World War Japanese manufacturers were faced with big shortage of material, money, and human resources. These conditions resulted in the birth of the lean manufacturing concept (Womack et al., 1990). Early Japanese industrial leaders such as Toyoda, Shigeo Shingo, and Taiichiohno devising a new, disciplined, process oriented system, which is known today as the "Toyota Production System" or "Lean manufacturing".

Lean is a systematic method for the elimination of waste within a manufacturing system. Toyota has developed its production system around eliminating three enemies of Lean: Muda (waste), and Mura (unevenness), Muri (overburden) (Liker, 2004).

MUDA: Waste can be defined in eight types, 7 defined by TPS and non-utilized skills. This are defects: Overproduction, Waiting, Non-utilized talent, Transportation, Inventory, Motion, and Excess processing.

MURA: Any variation leading to unbalanced situations. In short: UNEVENNESS, inconsistent, irregular. Mura exists when workflow is out of balance and workload is inconsistent and not incompliance with the standard.

MURI: Any activity asking unreasonable stress or effort from personnel, material or equipment. In short: OVERBURDEN For people, Muri means: a too heavy mental- or physical burden. For machinery Muri means: expecting a machine to do more than it is capable of- or has been designed to do.

Figure 1 Illustration of muda, mura and muri.

II. TYPE OF WASTE

Following are the types of waste in lean manufacturing.

1. Downtime
2. Defects
3. Overproduction
4. Waiting
5. Non-utilized talent
6. Transportation
7. Inventory
8. Motion
9. Excess processing

III. LEAN MANUFACTURING TOOLS

The In lean manufacturing various types of tools and techniques are available like 5S, Value stream mapping, Andon, Bottleneck Analysis, Continuous Flow, Gemba (The Real Place), Heijunka (Level Scheduling), HoshinKanri (Policy Deployment), Jidoka (Autonomation), Just-In-Time (JIT), Kaizen (Continuous Improvement), Kanban (Pull System), Muda (Waste), Overall Equipment Effectiveness (OEE), PDCA (Plan, Do, Check, Act), Poka-Yoke (Error Proofing), Single Minute Exchange of Die (SMED), Total Productive Maintenance (TPM), Visual Factory, Takt Time, SMART Goals, Six Big Losses etc.

Some of the important lean tool are explained under in shortly.

5S

- The 5S's are from japanesse and are
- Seiri -Sort (eliminate that which is not needed)
- Seiton- Set in Order (organize remaining items)
- Seison- Shine (clean and inspect work area)
- Seiketsu- Standardize (write standards for above)
- Shitsuke- Sustain (regularly apply the standards)

5S helps to eliminate waste that results from a poorly organized work area

Just in time

Just in Time (JIT) Production means to make only "what is needed, when it is needed and in the amount needed". Just-in-Time is the Philosophy of complete elimination of waste. Just in Time Production strives to reduce overall business costs via eliminating in-process excess inventory and their associated costs. JIT uses Kanban (Japanese for sign or billboard) cards to communicate between processes. Toyota found that the just-in-time system reduced lead time on orders by one third and reduced production costs by 50 percent.

Kaizen (continuous improvement)

Kaizen is a Japanese word kai means change and zen means better so that kaizen means change for better continuously. Quality in Toyota's just in time manufacturing system was based on the kaizen continuous improvement concept. This approach is used to create trial and error experiences in eliminating waste and simplifying processes, and this approach is repeated over and over again to continuously look for problems and solutions (Russell and Taylor 2002). Kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizen requires no or little investment. The principle behind is that "a very large number of small improvements are more effective in an organizational environment than a few improvements of large value."

Poka-yoke (error proofing)

The Poka-yoke is a Japanese term that means "mistake-proofing". Poka Yoke or Mistake proofing is a simple technique that developed out of the Toyota Production system through Jidoka and Autonomation. It is normally a simple and often inexpensive device that prevents defects from being made or highlights a defect so that it is not passed to the next operation.

Total productive maintenance (tpm)

TPM (Total Productive Maintenance) is a holistic approach to equipment maintenance that strives to achieve perfect production: No Breakdowns, No Small Stops or Slow Running, No Defects.

In addition it values a safe working environment: No Accidents Text heads organize the topics on a relational, hierarchical basis.

PDCA (plan, do, check, act)

For example Iterative methodology for implementing improvements: Plan (establish plan and expected results) Do (implement plan) Check (verify expected results achieved) Act (review and assess; do it again).

Kanban

A pull method used in lean manufacturing is kanban, which ensures that material and products are pulled through the factory when they are demanded (Lai et. at 2003). Kanban is the Japanese word for card. In a simple form, kanban is a card or device used by a customer workstation to send a signal to the preceding supplier station that it needs more parts (Slack et al 2001). Kanban applied to lean manufacturing, is a stocking technique using containers, cards and electronic signals to make production systems respond to real needs and not predictions and forecasts. Kanban cards typically consist of relevant product information, such as inventory or parts. When a Pull system is used, other important term Supermarket and FIFO Lanes is used.

Value stream mapping (vsm)

The use of Value Stream Mapping (VSM) has been attributed to the cause of much of the success that Toyota of Japan has had since the 1980's1. Developed during the work conducted by TaiichiOhno at Toyota in the 1960's and 70's, at its basic level VSM is a systematic methodology to identify wasted time and actions in a manufacturing process. In more recent times VSM it has been used to re-engineer businesses because it identifies unnecessary effort and resources to permit simplification and streamlining of operations processes.

In TaiichiOhno's words - "All we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes." (Ohno, 1988).

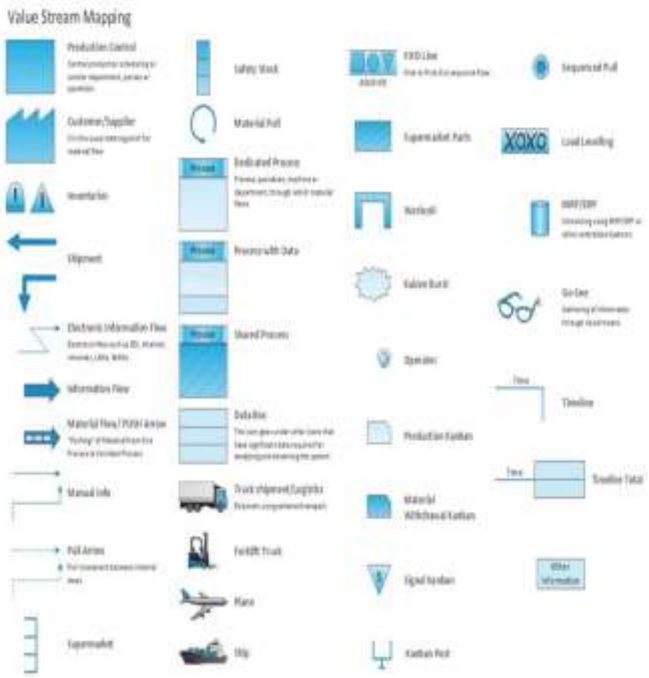

Figure 2 Value stream mapping symbols

Value stream mapping (vsm)

Tomas rohac, Martin Janushka drawn current state map for manufacturer producing plastic products dedicated to pharmacy and helth care industry. They told that implementation of VSM technique uncovers number of problems and bottlenecks in company logistic processes. They suggested 5 improvement after the application of this 5 improvement they noted that total lead time was reduced from 29,636 days to 9,600 days. [1]

Nor Azian et al. explain the kanban system and how kanban implement in the Malaysian small and medium enterprise. They also found the factors that hinder SME companies from implementating the kanban system are identifies as ineffective inventory management, lack of supplier participation, lack of quality improvement, lack of employee participation. After implementing kanban they reduce operational costs, wastes, scraps, and losses [2] Jafri MohdRahani et al. have goal to apply value stream mapping to improve the production line of a color industry. In this study they found that the big mixer and deplak mixer stations have the most cycle time so they applied continuous flow in production line. They draw a future state map with providing a 5s principles and Kanban method. After applying this tool.

The total lead time decreased from 8.5 days to 6 days and value added time decreased from 68 minutes to 37 minutes. [3]

Juthamas Choomlucksana et al .presented a case study in manufacturing sheet metal stamping process. They showed that the deburring and polishing processes create the most non value added activities and it should be addressed as quickly as possible. They used kaizen,5s,visual control, poka yoke tools and analysed that this tools helps in reducing processing time of a polishing stage from 6,582 seconds to 2,468 seconds or by 62.5% and also non value added activities from 1,086 activities to 261 activities or by 66.53%.[4].

Praveen Saraswat et al. gives the information about the value stream mapping. In this study they found that annealing and CNC machining processing have higher cycle time and work in process. They apply the VSM and 5s as lean tool and after successful implementation they showed that total lead time was reduced from 7.3 days to 3.8 days and production lead time was reduced from 409 seconds to 344 seconds [5].

S. Santosh Kumar et al. use the experiencing VSM and line balancing to reduce the cycle time in an automobile assembly plant. With the successfully implementation of lean tools and line balancing they reduce the cycle time of the total assembly and efficiency of the line[6] R. M. Belokar says that VSM has the reputation of uncovering waste in manufacturing and business processes by identifying and removing or streamlining non value adding steps. With the help of VSM they use a new fixture, a new robot welding machine and also improve the layout of weld shop. They found that there is about 44% improvement in value added activities [7].

A.Jayaganthandevelop the VSM techniques in pump industry. They also pointed that the company does not want to compromise with quality. They suggested the 7 proposal for future value stream map for company to reduce material handing time [8]. A Ramchandran et al. have discuss about the production improvement of automotive industry by lean manufacturing technique of VSM.

They improving the cycle time of welding process by introducing a new welding machine and by improving layout of weld shop. At the end they found that there is reduction in cycle time from 29 seconds to 15 seconds and 66% improvement in production by improvement in value adding activities [9].

Rahani AR et al. representing to find the sources of waste and these can be minimized or eliminated using lean tools from the front disc assembly in Malaysia. Number of parameters studies was stacking, work in process, process cycle time, work instruction. The VSM is applied to assess the expected impact of a change in the manufacturing process resulted in saving (lower rejection rates) [10].

K. Venkataraman et al. representing the use of VSM for reducing cycle time of crank shaft. VSM technique implemented in this paper is done in a crank shaft manufacturing cell to eliminate the 8 non value adding waste like over production, waiting, unnecessary transport movement, defects and unused employee creativity from the manufacturing system [11].

Tabe 1 Summary of literature review

Paper	Title	Journal	Product Analysed	Tool Implies	Benefits
1	Lean manufacturing case study with kanban implementation	ELSEVIER	Local Automotive Industry	KANBAN	Operation costs, wastes,scraps and losses were minimized.
2	Value stream mapping on real case study.	IJMVSC	Plastics products dedicated healthcare industry.	VSM	Reduce the lead time from 29000 to 9600 days
3	Production line analysis by value stream mapping: a lean manufacturing process of color industry.	ELSEVIER	Color Industry.	KAIZEN,5S., VISUAL CONTROL	Lead time reduce from 8 days to 6 days.
4	Lean Time reduction through value stream mapping.	IJMVSC	Pump	VSM, KAIZEN, LINE BALANCE	Reduced Material Handling time.
5	An Application of lean principle in automotive industry	ELSEVIER	Automotive Industry	VSM	Cycle time was reduced from 29 seconds to 18 seconds.
6	Application of stream mapping reduction of cycle time in a machining process	ELSEVIER	Crank shaft.	VSM, KAIZEN	Reduction of inventory between two machines and quick response to customer.
7	Cycle time reduction of a truck body assembly in an automobile industry by lean	IJMVSC	Truck Body	VSM, TREE DIAGRAM	Cycle time reduce from 90 minutes 40 minutes

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