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LEAN MANUFACTURING: PRINCIPLES, TOOLS, TECHNIQUES AND BENEFITS

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ABSTRACT

In manufacturing to profitability improvement applying lean concept can really good. Broad fields of lean manufacturing are simple to get to deal with a broad range of matters found by altered production process. It helps to lessen expenses of the producing products. The elementary Non-Value added Activities were apparent and chances needed for enhancement has been supposed. Value Stream Mapping (VSM) has the position of finding waste during manufacturing and business measure which encourage finding and eradicating or stream the worth added steps. Initiative of lean manufacturing aims on reduction of cost and turnover increases by methodically eradicating non-value-added actions on continuous basis. In current cut-throat setting, lean can be considered as "the solution" to producing firms across the globe for sustained survival.

Keywords: Lean Manufacturing Tools, Productivity Enhancement, Gear Box, Lead Time, Line Balancing, VSM, Work Standardization

INTRODUCTION

Lean manufacturing is a is a systematic technique intended to minimize waste in a production system. Lean manufacturing was started in Toyota Production System (TPS), at Japan endeavors to decrease waste in a production function, with the idea being obviously depict what is adding value by eradicating and what does no adding value. For any firm to go for lean manufacturing it's very important to think about the process of putting into practice lean takes time. Numerous lean tools are proposed, permitting each firm to fit lean manufacturing techniques into it's diverse production process. Eight types of waste lean manufacturing look for eliminating are there. There are five general lean principals, tools and techniques which producers around the globe have implemented into their production processes.

LITERATURE REVIEW

Big challenges are faced by Indian production sector in the current circumstances regarding low costs, enhanced quality and changing items with major execution, Dhruv Shah et al. 2018 [1] .As per the Lean thinking, any movement which gets through assets but not make an inducement for the end user is ineffectual, and along this way ought to be wiped out [2, 3]. At working level lean production is helped out through numerous lean actions and steps. By appying these steps and procedures lean production mainly focuses to be familiar with and dispose of various wastes exist inside the production line or along the store network Sohal [4, 5]. Further it was said that lean production is a trade theory that incessantly enhances the procedure include in production. [6]. According to As stated by Vinodh et al. how lean is applied as a producing worldview depending on the very important purposes of Toyota Production System, which is concentrated on continuously limiting waste to expand stream [7,8]. As confronted by Upadhye et al. [9], how the Application of Value Stream M aping in a roll producing plant has put influence on the results by finding that employ of lean production brought about augmentation in quality, turn down in inventory, increase in appropriate conveyances, improved usage of tool and supplies and lessen in lead time.

Gupta et al. [10] explains with the employing of lean producing in a spiral tire fabricating firm and found that authoritative culture and human asset the board assume a crucial job to deal with the transform. Creators similarly found that important reasons for high production cost were over-handling and needless defects. It was revealed by Singh et al., Garza-Reyes et al. and Ghosh [11,12, 13] how the Indian manufacturing business runs with regard to lean implementation issues although there is negligible investigative research associated and

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concentrated on the process necessary to get better in the production sector of manufacturing firms in India. In the study, Biodiesel from Lemon and Lemon grass oil and its impact on Engine execution and fumes emanations by S. Sundararaj and R. Dhivagar[14,15] , examined about motor exhibitions. This paper was important to divide the different regions where lean can be executed [16, 17]. Certainly, even in papers managing composite materials by Kaviyarasan et al, Dr. P. Prathap and T. Pridhar it is believable to carry out lean for expanding the effectiveness and time [18, 19] .Paper on Productivity enhancement in engine assembly employing lean tools and techniques by P. Sivaraman et al discusses in detail about DMAIC approach [20].

8 TYPES OF WASTE IN LEAN MANUFACTURING

Implementing lean starts with eradicating waste to concentrate on adding value to the process, that goes for adding value for customers. It is very important to be acquainted with the range of waste and their effect on business. 8 types of waste can be explained as:

- Defects
- Overproduction
- Waiting
- Non-utilized talent
- Transportation
- Inventory
- Motion
- Extra Processing

- **Defects:** It is the most obvious type of waste. They can produce to waste of several types. Delivery delays and logistics problems can be caused by defects which most liable lead to a reducing in client satisfaction. To rework imperfect products is an expensive issue. Removing defects results the firm to spend additional time correcting defects and filing official procedure.
- **Overproduction:** Surplus inventory is caused by overproduction that leads to increased coast of storage.
- **Waiting:** It is a by product of very many types of waste and it causes chaos on client satisfaction. For example a full waiting room in a hospital. For example in an industry downtime of machinery causing packaging delays.
- **Non-utilized talent:** Often ignored as a form of waste, not using your employees to their full capacity can have a large effect on company's bottom line. Imperfect teamwork, very less training, deprived communication and unnecessary office are common instances of non-utilized talent.
- **Transportation:** Producing product parts in one country and transporting them to another country to assemble is an example. This is a non value added activity, end result is same but it puts an additional cost. In Toyota's manufacturing setup, most of their vendors are in vicinity to the production setups.
- **Inventory: If the** product is piled up waiting to be sold it is an inventory waste. A physical cost associated with inventory. Inventory waste is often caused by making in excess to the customer's requirement.
- **Motion:** The unneeded motion of man, machines or goods don't add value and is the waste of motion or wasting time. This form of waste is due to not following the 5s' lean manufacturing tools. Examples of it, employees wandering here and there for searching materials or equipment due to poorly design of workplaces.
- **Extra Processing:** It means adding work that is unnecessary. Extra processing costs the waste of time of the staff, materials used and equipment wear, and they add up over time. It turns process inefficient since employees performing the extra processing tasks could be doing value-adding tasks instead.

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SEVEN PRINCIPLES, TOOLS AND TECHNIQUES FOR LEAN MANUFACTURING

1. **Kaizen:** "change for the better." It stresses on continuous improvement. It assures teams work together proactively and take accountability for their work areas within the firm. People do gradual improvements in the process of production. With the help of kaizen, always there is a space for upgrading, and workers have to continually look to get better the workplace. This methodology also stresses that each individual's ideas are significant and that each employees have to be engrossed in the act to get better the firm. A Kaizen firm never disapproves suggestions and accepts suggestions for betterment at any level. It creates an atmosphere of open communication and mutual respect.

Benefits of Kaizen
Implementing Kaizen improves your productivity, effectiveness, safety and lessens waste

Benefit	Explanation
Reduce waste	Inventory and employee's skills are used more efficiently
Workers satisfaction & commitment	Workforce have a direct impact on how things are done which gives them more of a participation in the firm, which leads to a commitment to do a good job
Better retention	Happy and engaged employees are more likely to stay for a long time.
Client satisfaction	More satisfied customers.

2. **5s System:** It is a Japanese method given by 5 Japanese words: seiri, seiton, seiso, seiketsu and shitsuke. Which means organize, tidiness, clean, standardize and sustain. They stand for a five-step process meant to reduce waste and increase productivity and efficiency.

Benefits of the 5s System
The 5s' help out in minimizing several areas of waste

Benefit	Explanation
Lessening cost via less storage area	Freeing up of space can be done by removing unused materials, tools and equipment, and organizing. This type of cost savings is on storage rental costs and heating and cooling, cleaning and the maintening the workspace
Tidiness	Cleanliness translates into improved maintenance and less downtime. If a machine is clean, you'll be able to spot defects and issues like oil leaks.This lets you perform preventative maintenance to prevent downtime
Safety	Cleanliness directly relates to improved safety. It removes clutter which can reveal electrical, chemical or mechanical hazards. Organizing tools and equipment in areas close to where they're needed minimizes movement, reducing injury

- **Seiri** (organize): It, involves eliminating disorder and unnecessary items from the workplace.

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- **Seiton**(tidiness or orderliness): There is a place for everything, and everything is in its place.
- **Seiso** (clean): Cleaning the workplace and always keeping it in a clean state.
- **Seiketsu** (standardize): All work processes must be standardized and keeping them consistent, so any other person can perform a job if necessary..
- **Shitsuke** (sustain) Maintaining and strengthen the previous four steps.

3. **Kanban:** By applying a method for regulating the flow of material inside and outside the factory it helps removing inventory and overproduction waste. It represents "billboard" or "visual signal" and depends on visual signals to be of assistance for employees to control inventory. In a visible area a Kanban card is kept to signal when inventory needs to be restocked. By this process, products are produced only when there is demand from the consumer, allowing firma to lessen inventory and waste. The Kanban method is very responsive to clients since products can be made by responding to customer needs rather than of trying to predict their future needs.
   A basic form of Kanban is having three columns: "To Do," "Doing," "Done." Once you've started a project or the primary step in a process, move a colored sticky note with your name on it to the "Doing" column, so everyone knows where you're at in the process. Columns can be labeled to match your particular project and there can be as many columns as you need.

Benefits of Kanban

Benefit	**Details**
Flexibility	Priorities are ever being reassessed by the Kanban technique depending on the most recent information
Continuous delivery	To deliver precisely what the customers require by continually delivering smaller batches of product Kanban helps. This lets the team continually update processes depending on new business needs
Waste reduction	Productivity and efficiency is enhanced by Kanabn by reducing over-production, defects, unnecessary motion, and waiting.

4. **Heijunka:** It implies "levelling." Level scheduling is a sort of production that intentionally produces goods in smaller batches by arranging dissimilar products in the same process.

If we take an example, let's say you produce watches and you get an order for 500 of the same style of watches each week. The orders come in as 200 orders on Monday, 50 on Tuesday, 100 on Wednesday, 100 on Thursday and 50 on Friday. Rather than trying to meet that order in sequential order, you could use Heijunka and level the demand by making an inventory of 100 watches close to shipping for Monday's order. Make sure 100 watches are in inventory every Monday and the rest of the week, produce 100 watches each day (a level amount).
Putting into practice Heijunka requires to set the speed of your manufacturing according to what's known as Takt time. Takt time is the rate at which your customer makes a purchase or the time it takes to finish a product to meet customer demands. It means, you're matching your production rates to meet your customer's demands, creating a level process.

Benefits of Heijunka
Three major benefits are brought by Heijunka to manufacturing facility

Benefit	**Details**
Predictability	Predictability enables leveling production schedule when it goods are produced.
Flexibility	Reduction in changeover time by leveling production schedule
Stability	Balancing of the use of labor and machines and predict demand lets you level your production schedule

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5. **Just in Time (JIT):** It is a management philosophy having only producing a product when the customer wants it, in the amount the customer asked for it and delivered to the place where they want it without putting it up in inventory. It means, you make what customers order when they order it instead of making and storing products in anticipation of customers need. Reduced inventory costs, reduced space, lead time reduction, productivity increase can be achieved by JIT .

Requirements of Just in Time
Just in Time lean production plays off of numerous other lean tools and techniques. To Implement JIT following are required.

1. For JIT perfect equipment is essential to work suitably. Frequently break down in machinery or making low-quality products may hinder JIT
2. Well designed workspaces is key for the JIT flow is. Use the 5s system is required to improve workspace layout and flow to minimize inadequacies
3. Improving the quality of the workforce by setting up Kaizen teams, so workers take ownership of their own work areas.
4. For how each operation has to be performed standards must be set.
5. It endeavours to produce merely as per client's demand hence JIT lean manufacturing doesn't pile up inventory, Using the Kanban technique signals improvement is obvious.
6. **SMED (**Single-minute exchange of dies): To very much reduce the time required to complete equipment changeovers this process is applied. The SMED process led to a general reduction in changeover times of 94 percent across numerous industries. When it comes to going lean and minimizing waste putting into practice a SMED process has manifold benefits. These benefits comprise:

The SMED process engross a sequence of steps or "elements", which are classified in two types: internal and external. While the equipment is stopped internal elements require to be changed, external elements can be completed while the equipment is running. The aim of SMED is to have a lot of external elements while streamlining and simplifying all other elements.

Implementing SMED :

a. Decrease in manufacturing costs;
b. The ability to produce smaller lot sizes;
c. Improved schedule flexibility and responsiveness to customer demand;
d. Lower inventory levels;
e. Improved machine startups;
f. Identifying a pilot area;
g. Identifying elements;
h. Separate external elements;
i. Convert internal elements to external elements;
j. Streamline the remaining elements.

7. **Poka-Yoke:** It implies "mistake proofing". It is a technique used to ensure lean process produces quality products. It's function is to minimize or eradicate defects by preventing, correcting, or bringing to light any human errors that are occurring. An instance of poka-yoke is "A car with a manual gearbox requires the driver to step on the clutch pedal before the vehicle will start".

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In production, poka-yoke can be put into practice at any step where human error can cause something to go incorrect. For instance, a device holding pieces for processing might be improved to only let pieces to be held in the right orientation needed for input. One more instance would be a digital counter that counts the number of spot welds on each manufactured piece to make sure the welder does the right number of welds.

Three types of poka-yoke for finding errors in a manufacturing setting:

1. The **contact method** identifies defects by testing the product's shape, size, color and physical makeup.
2. The **fixed-value method** (constant number) sends out an alert to the operator if a predetermined number of movements are not executed.
3. The **motion-step method** (sequence) makes sure the predetermined number of steps for a particular process have been followed.

Normally, the operator is warned when a mistake is looming (known as a warning poka-yoke) or the poka-yoke device prevents the mistake from being made itself (known as a control poka-yoke). Advantages of implementing poka-yoke comprise less expense by training operators; eradication of definite quality control functions; reducing the number of recurring operations; a decrease in the number of rejected products; integral quality control; stopping defected products from delivering to customers and more.

BENEFITS OF LEAN MANUFACTURING

It lessens waste and hence enhances efficiency and productivity. Following are the benefits.

- **Increased quality of product E**mployees and resources are freed up for innovation and quality control that would have previously been wasted: by improved efficiency.
    - **Lead times improvement**:, Businesses can better respond to fluctuations in demand and other market variables, resulting in fewer delays and better lead times as manufacturing processes are streamlined.
    - **Sustainability**: Less waste and better adaptability makes for a business that’s better equipped to thrive well into the future.
    - **Employee satisfaction**: Workers know when their daily routine is bloated or packed with unnecessary work, and it negatively affects morale. Lean manufacturing boosts not only productivity, but employee satisfaction.
    - **Increased profits**: And, of course, more productivity with less waste and better quality ultimately makes for a more profitable firm.

STEPS IN THE LEAN MANUFACTURING CYCLE

Nearly 60 percent of production activities are waste in manufacturing operations around the world, according to Vorne Lean Production. When it comes to minimizing waste, making high-quality products and lowering their overall production cost almost every firm has space for improvement. If someone wants to apply lean, it should be kept in mind it takes time to put into practice the right methods, tools and philosophies. People has to learn lean techniques, so that they will be capable to reduce one or more of the eight types of waste just by performing their work. it's imperative to keep the lean manufacturing cycle in mind.

The five steps in the lean manufacturing cycle are:

1. Identify value. Think about the end user and what they believe valuable.
2. Value stream mapping. Put all the steps within the process and remove, those that don't add value.
3. Flow Creation. Find out ways to create the important steps more streamlined in a tight sequence to offer the end user with most value, rapidly.
4. Establishing pull. Generate more demand from your end customers, so they're seeking for the product rather than you having to push it on them.

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5. Endeavour for perfection. In lean manufacturing Continuous improvement is main. The objective is to ever be thinking of methods to eliminate waste and document and standardize the processes that generate success.

It is significant to always value the human elements when talking about going lean and putting into practice lean principles. It means go-getting to keep workforce happy and engaged with their work by putting this goal a core principle. Devoid of a respect for employees and the people inside your organization, people are inclined to disengage and not perform at a consistently elevated level. It's a comparatively easy principle to implement as there are only some elements to consider, but each element tends to be difficult to manage as you're dealing with humans and not machines.

Key elements include:

- Don't overload employees.
- Show employees their purpose by outlining what their work is achieving and align their purpose with their own goals.
- Uphold a greater level of accountability for successes and failures.
- For all time get to the root of any issue by communicating directly with employees.
- Provide stability and less variety in their work.

CONCLUSIONS

Lean to be applied more and more because of the alters in the business environment in current years. It is clear that the taking on the Lean Production principles will get better the whole process of production, the point of this strategy being that of dropping costs by eradicating waste and by growing customer satisfaction, thus increasing the performance of the firm.

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