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Introduction to Lean Waste and Lean Tools

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Abstract

In the turbulent and complex business environments, many Indian SMEs are facing stiff competition in the domestic as well as in the global market from their multinational counterpart. The concept of lean has gained prominence due to the fact that the resource based competitive advantages are no longer sufficient in this economy. Hence, lean is no longer merely an option but rather a core necessity for engineering industries situated in any part of the globe, if they have to compete successfully. Lean Manufacturing (LM) which provides new opportunities to create and retain greater value from the employee of the industry based on their core business competencies. The challenge of capturing, organizing, and disseminating throughout the aggregate business unit is a huge responsibility of the top management. The success of any industry depends on how well it can manage its resources and translate in to action. The adoption of lean manufacturing through effective lean practices depends on interpretations of past experiences and present information resides in the industry. Generally, in an industry, some tangible and intangible factors exist in the form of non-value adding activities which hinder the smooth lean implementation are known as lean manufacturing barriers (LMBs).

Keywords: Lean, waste, kaizen, manufacturing

1. Introduction

In the present worldwide situation, manufacturing industries are primarily handling difficulties from two directions. First, cutting edge manufacturing ways of thinking are arising, while the current techniques are getting outdated. Second, consumers demand is changing in very short of time. The clients have become more demanding for inventive product in short timeframe and at less cost. Basically, to adapt up to such difficulties, the idea behind manufacturing industries' these days is to capture the customer demand while limiting waste [1]. Subsequently, manufacturing firms working in such quick changing in customer demand in competitive market. In last thirty years, manufacturing industries are introducing lean thinking. The lean manufacturing word means to minimize the industrial waste or to eliminate the waste and improve the benefits of manufacturing industries by smooth production flow [2]. Without lean practices any industry cannot be successful in the present-day situation due to globalize competition in market with low cost, high quality, and shorter delivery time. It is very difficult for engineering industries to shift from traditional system to lean system. a troublesome undertaking to move from a conventional assembling framework to a lean assembling one. This change makes attention both employee and method.

Lean manufacturing is a management strategy that tries to make industries more competitive, minimize the manufacturing cost by eliminating the industrial waste and increase the productivity of an organization [3].

1.1 Research background of lean

Afterward World War II Japanese industries were confronted with the difficulty of immense deficiencies of skilled manpower, money, and material. These difficulties that industries of Japan were challenged with compared from those of their Western partners. This introduces “lean” thinking in manufacturing industries. Toyota Motor Company runs by Toyoda identified that American manufacturers were manufacturing better than Japanese manufacturing industries; during the 1940’s American industries were beating Japanese manufacturing industries. To take an action for progress timely Japanese pioneers like Shigeo Shingo, Toyoda Kiichiro, and Taiichi Ohno, they are receiving the challenge to improve the production system by eliminating the industrial waste, they have developed a new manufacturing strategy that is called “Toyota Production System,” or “Lean Manufacturing.” Taiichi Ohno, accept the responsibility to improve efficiency at Toyota is the primary force to develop Toyota production system. Ohno drew upon certain thoughts from the Western countries, and especially from Henry Ford’s book “Today and Tomorrow.” Ford’s stirring production lines for continuous material flow developed the basics for TPS. After research, the TPS was refined somewhere in 40’s and 70’s, is still emerging today all over the world. The crucial thought of this system is to maximize the resource utilization and minimize the inputs that cannot be enhanced any value to a product that is a waste.

To contend in the present furiously competitive market, United States manufacturing industries has understand that the mass production idea must be modified to the lean manufacturing. An assessment that was done by MIT of transformation from mass production toward lean manufacturing, as explained in the book “The Machine That Changed the World” [4] arise the US companies from their nap. The assessment highlighted the extraordinary achievement of Toyota and pulled out the enormous gap that developed between the Japanese and Western engineering firms. The thoughts came in the mind of US industrialists on the ground that the Japanese industries developed, manufactured, and delivered items within less manpower, less investment, less floor utilization, less time, instruments, raw material, and overall investment cost [5].

1.2 What is lean?

The fresh transformation in engineering products and service division has made extraordinary difficulties for US firms. The consumer focused and exceptionally aggressive market has delivered old-fashioned of management that was not enough to overcome these complexities. These factors present a key test to industries to seek for new methods to survive in competitive global market. While a few industries keep on developing based on financial steadiness, different firms fight because of their absence of understanding of the change in consumer mentalities and cost practices. To avoid the present situation and to turn out to be more valuable, many industries implemented lean principles in their organization and perform well in global market [6].

Waste exclusion, cost drop, and employee encouragement are the basic ideas behind the lean manufacturing system, which has been implemented in Japanese companies for many years. The Japanese thinking of making business is completely distinct from the thinking that has been dominant in United States for a long time.

The typical western belief was that the just way to get turn a profit to apply it to the cost of production to reach the preferred sales price. The Japanese method, on the contrary assumes that the generator of the sale price is client. The more consistency you build into the manufactured goods higher the cost that consumers pay. The distinction among the price of the goods and this price is what decides the profit [7, 8]. To minimize cost, raise investment, get in more revenues, and remain competitive in a rising international market, the lean manufacturing discipline is to function in all parts of the value stream by reducing waste. The value stream is explained as the specialized activities needed to plan, order and supply a specific product or value within a supply chain [9, 10]. As of Womack describe it the term “lean” indicates a system that utilizes less with respect to output, to produce the equivalent outputs as those generated be a conventional mass manufacturing system, which adding more varieties to the final consumer [11]. This theory of business goes by various names. Agile production, just-in-time-production, synchronous production, world-class production, and continuous flow are all concepts that are used in contrast with lean production. The resounding theory of lean manufacturing, therefore, is to minimize costs by continuous improvement, which would ultimately reduce the cost of services and goods, thereby increasing profits.

“Lean” focuses on the removal or reduction of waste (“muda”, the Japanese word for waste) [12, 13] and on optimizing or allowing maximum use of activities that add value from the perspective of the consumer. Quality is equal to something that the consumer is willing to pay for in a product or service that follows, from the viewpoint of the customer. The reduction of waste is also the central concept of lean manufacturing.

1.2.1 The 8 wastes of lean

The aim of lean is to abolish the waste from the production process. It is very important to identify the eight waste before digging it. Waste is in the least action or activity that will not enhance any cost to the product, or we can say, waste is any unwanted process that will reduce the value of the product and customer do not want to pay for that. Taiichi Ohno identified the initial seven types of waste that was called Muda in japan [12]. Transportation, inventory, movement, waiting, overproduction, overprocessing and defects are seven types of waste identified by Taiichi Ohno. The acronym ‘TIMWOOD’ also applies to them. The eighth waste was invented by western industries in 1990s, and that was unused of workers talent or ‘Skill’ of workers was later added. Therefore, ‘TIMWOODS’ [14] is generally referred to as the 8 wastes [15].

1. **Transport:** Unwanted movement of the product during manufacturing. It is caused due to unplanned layout and product are unnecessary move from one workstation to other. In addition, excessive movement causes fatigue, wear and tear of product and equipment’s [16–18].
2. **Inventory:** Over production or semi-finished product to convert into finished product. Sometime customer is not receiving the order or customer is canceled the order. So, this type of products is store and called waste. The advantage of inventory is that some time vendor will offer discount on large amount of purchasing. For maintain large inventory manpower and store cost is also involved and there is chance of product damage. Over procurement, work in progress (WIP) or the production of excessive goods than the customer demands may trigger surplus inventory. Certain inventory countermeasures take in procuring raw materials only when appropriate amount needed, reducing buffers between production stages, and establishing a queue system to avoid overproduction [15, 17, 18].

3. **Motion:** Workers are moving from one workstation to the other workstation without necessity and the manufacturing lead time is increase. This type of unwanted motion is considered as waste. Any excessive movement of workers, vehicles, or machinery requires waste in motion. Running, raising, reaching, bending, stretching, and shifting are part of this. To improve the working conditions for workers and improve health and safety standards, repetitive motion activities should be eliminated. Some motion countermeasures consist to make sure that the tools material is place near machinery in well organized manner [19].
4. **Waiting:** These are time delay and idle times during which value is not added to the product. If the machines, men, and material wait it is waste of these resources and it demoralizes the employees. The waste of waiting includes: 1) Operator is waiting for his turn and not receive material on time. 2) Machines are idle due to line unbalance [19, 20].
5. **Overproduction:** Excess of production over consumption. In market demand is less compare to the consumption, but industries are manufacture more to reduce the manufacturing cost. In this case inventory cost is increase and money is also block. So, it is considered as a waste. Overproduction means manufacturing additional goods via a 'push production mechanism'. Three countermeasures to develop overproduction. Firstly, by use of 'Takt Time' confirms that the production rate among workstations is continue. Secondly, reducing idle time like loading and unloading, setup times. Thirdly, reduce the WIP by using a pull or 'Kanban' system [19, 21, 22].
6. **Over-processing:** Over-processing will increase machining time, material handling time and add more process steps. Due to over processing the cost of the product is increased that will pay by the customer. For reducing over processing on products, consider standard job specifications for manufacturing. Prior to starting work, always think to the customer and produce product quantity as per the requirements of the customers and try to reduce the unnecessary operations and manufactured quantities where it is required [19, 22].
7. **Defects:** The product is not manufactured as per the specifications and tolerances given by the customer. Those products are rejected in quality inspection and consider as waste. Product/material will reject when the product/material is not suitable for use. Due to defective product/material it will loss of money and defective piece will not be reused [23–25].
8. **Skills - The 8th Waste:** This waste was not developed by Toyota, this 8th waste - the waste of human skills - is well known to many individuals. Also explain as no utilization of manpower skills, creativity, efforts consider in the 8th waste. This waste is developed when management not identify the skills of his workers in the organization. Employees is just following the boss order and do work as per the boss instructions. It is very difficult to optimize the process without taking help of frontline workers. This is because the worker who perform the job on shop floor is recognize the problems first and he has the solutions for that problem [14].

1.2.2 Identifying and eliminating the 8 wastes

Perceiving that they exist and giving a proficient system to characterizing them is the initial step to slashing waste. Value Stream Mapping (VSM) is a tool of Lean Management to assess the current state and to design a likely state. This outlines

the progression of information and substance as they emerge. VSM is an effective strategy to plan the process involved, outwardly show the connection manufacturing process and to recognize nonvalue added and value-added activities. Utilize the VSM to characterize waste and proceed in view of the end client. Work in reverse to the beginning of the production process from the end client. Record cases of the eight waste in the process and construct a methodology to eliminate or limit them. Keep on provoking the staff to discover more waste and reliably build up their strategies. Draw in with and bring out their thoughts for change from the forefront staff. They will grow more trust in their critical thinking abilities as the group keeps on limiting efficiencies and waste decrease turns out to be important for their regular everyday practice after some time.

1.3 The 9 principles of lean manufacturing

Assembly work is categorized by short development cycles and batch sizes continuously decrease, Although the number of categories of goods and the models are still growing. Constant pressure to cut manufacturing lead times precedes to these needs and really makes the mix difficult, also for the highly imaginative producers. The capability to react quickly needs evolving buyer requirements usage of production systems that it is possible to re-configure and extend the fly that can fit, and advances in methods for assembly without having any initial output obsolete investment [26].

Lean production, An Approach That depends heavily on versatility and flexibility. Organization of the office is an exceptional Starting point for businesses who want to take a new look at their present Methods for production. Lean approaches are also worthy of study, since big capital is removed by them dedicated equipment outlays until automation becomes completely, needed. The idea of lean manufacturing, indeed, represents a big departure from such a famous automated factory the past few years. The “less is better” Manufacturing policy leads to a widely condensed, strikingly uncluttered, environment which is carefully calibrated to the environment manufacturer’s specifications. Goods are generated in response, one at a time, to the specifications of the customer rather than of the batch produced for inventory. The target is to only generate the amount used and no more [27].

The number of parts is produced, it can change procedures, it is appropriate to handle various components and allow full utilization of workers, services, and floor area. The intrinsic versatility in manual assembly therefore, cells are superior to automated ones. This maximum requirement flexibility makes distinctive requirement on the lean work cell and the elements compose a lean work cell. Admittedly, the lean solution is not the only the solution to all production issues. But it does deliver a versatility that is special solution for more complex assembly commodities. This guide explains 9 essential descriptions Lean principles of development that should be assist you in evaluating lean manufacturing solutions for your own.

1. Continuous Flow:

The lean work cell’s chosen to form U-shaped workcell. In order of method, each subprocess is linked to the next. And an employee within the U, minimum movement to move is needed the workpiece or one-piece assembly toward the next workstation. Ultimately, one of the targets of the slim workcell is to remove all movement with non-value-added; hence its U-shape. Where, when the procedure has been completed by the employee, he it just turns around and is back on the move. The workpiece may be carried from one piece to another. Operation with value applied to the next one. There are times, however when the workpiece or the fixture which holds the workpiece is too heavy and between workstations must be

manually moved [28]. While it is possible to transport very heavy components on belt conveyors, manual push conveyors of gravity or gravity are suitable for moving the components between workstations. Theirs' The minimal complexity makes it easy for them to support and reduces time. Moreover, they are easy to attach to end-to-end, making it quick to switch inside a workcell workstations. The bent U-shaped "corners" a working cell can pose a problem. As they may serve as a possible dead space, they may act as a mini storage room, thereby facilitating a storage area going back to batch manufacturing. Alternatively, the use of a ball roller transfer should encourage the movement of parts through the corners and the U-shape [29, 30].

2. Lean Machines/Simplicity:

One-at-a-time from continuous-flow another aim of lean manufacturing is it is necessary to produce each one, the workstation is designed to match a nominal covering. The Minimum the envelope guarantees the removal of excess of flat space at the workstation or workstation that machine [28]. This is done to prevent the risk of components or subassemblies being stored from the computer. Components stock increases "work in method and outcomes in " batch processing, which then defeats the goal of lean. In addition, smaller workplaces and devices of minimal size remove unnecessary steps taken by the worker between Via subprocesses [31].

Ultimately, valuable floor space can be saved by sizing workstations correctly machines and the implementation of uniform machine bases or workstations for all processes should be avoided, while tempting for the sake of conformity and standardization. Every base machine to optimize assembly subprocesses, which in most cases may differ from workstation to workstation, the workstation or workstation should be built. For virtually every structural material, this customisation can be accomplished. However, to save on costs and to minimize the environmental issues associated with the disposal of inflexible welded steel structures, material that is reconfigurable and reusable should be given priority. The modular characteristics of extruded aluminum and bolt-together systems make them suitable for lean manufacturing principles to be applied. In addition, constant enhancement as a method, all workstations and work cells need to be simple to alter [32].

3. Workplace Organization:

The desired outcome of a smooth, uninterrupted flow of finished workpieces is a lean workcell, correctly planned. Nothing here this flow can be slowed or stopped quicker than the tool failure or misplacement. Thus, all, applications used on a workplace must have a holder on their own. Exactly, there are as many tool holders as there are tools, so that the deficiency of a tool is quick observed [33]. Using an integrated tool holder device for each instrument with a particular holder that is ideal. If it is possible to add holders quickly, to a workstation or taken away from it, this it adds to the workstation's versatility and enhances its usefulness in a lean production technique. Backup tools, to reduce downtime, at any automated workstations, they should also be available. These instruments should be equipped to being out of the way of the worker before a failure this happens at an automated workstation. In the maximum advantage is tool holding frameworks that allow instruments to swing or slide [30].

4. Parts Presentation:

Naturally, the workcell will require additional components during the average work shift. In a lean workcell, traditional techniques of resupplying workstations

are not useful. With the minimum number of interruptions, each worker can go about his job. Each part should also be delivered from outside the work cell to each workstation. The use of gravity feed conveyers or bins suits the lean work-cell's streamlined nature. Parts bins should be filled from at the back (outside the work area of the work cell) so that production can be continued without interruption by the worker. Gravity transports the components to the area of reach of the worker. Bins can be reconfigurable as well. The containers using a key stud in the picture to secure them in place [30]. When reconfiguring the workspace, bins are conveniently stackable and provide the ultimate in flexibility.

While bins are suitable for small parts, larger parts are needed for many assemblies. In bins or boxes, these can be shipped. Again, without entering the workspace, the components should be sent to the workcell. This function is served well by gravity feed conveyors. An additional gravity feed conveyor can be placed in the reverse direction if scrap, or containers must be removed from the cell. Lift assist devices are recommended in instances where pieces are very large. With mechanical, pneumatic, or hydraulic control, heavy parts or boxes of parts can be loaded onto a case lifter and lifted to the correct working height.

5. Reconfigurability:

A lean workcell that is properly built must be easy to reconfigure. In fact, it is a must to be able to adjust the process and go from good piece to good piece as fast as possible. Faster the changeover, less time is lost in production. Switching can be done in a matter of seconds with a strong quick-change fixture. As the situation requires, a variety of different fixtures may be kept at the workstation and swapped. At times, a lean cell must be rapidly attributed to process shifts or other variables to accommodate assembly of a new product, reconfigured or even relocated. In the ability to transfer each part of the work cell rapidly becomes extremely essential if a computer or workstation needs to be changed. The versatility required for rapid and efficient changeover is given by lockable casters on machines or workstations [28, 34].

6. Quality:

A reduction in quality concerns is one of the consequences of one-at-a-time production. Visual inspection by the worker will check that it is correctly assembled when each component is made. They should be installed on the computer or workstation if verification is necessary via gages. And they can be replaced quickly. Fast release of fixtures is a must using star knobs or locking levers. There will be a time when it is not easy to address a quality issue. A defective method or a malfunctioning computer could be the root of the problems with consistency. In the case of a defective process, the structural framing scheme allows for improvements in a minimum amount of time, no matter how big. Once again, in limited time, bolt-together construction addresses a big issue [34]. A malfunctioning machine can also be easily replaced, particularly if it is fast. When the lean cell is constructed, disconnections for all pneumatic or electric lines are given. Furthermore, in the lean cell, there should be no pneumatic or electrical contacts between machines. These would slow the machines inside the cell from changing. If the system has been removed from all power sources, if installed on lockable casters, it can be transported easily. Ease of reconfiguration and swapping eliminate any inability on the part of the employee or management to attempt to "Make do" with "almost" accurate devices or processes. This adjustment in Attitude can contribute greatly to the development of true quality [35].

7. Maintainability:

A further requirement of a lean cell is ease of operation. In a pull-through system, long down periods cannot be tolerated. The product must be generated while consumer demand exists. The ultimate in keepability is given by a modular structural framework. Components may be removed in a matter of seconds [34]. The design of bolt together ensures that computer stands, part presentation equipment or workplaces can be repaired in seconds. In a limited amount of time, even whole computer bases can be restored. Also, the systemic framing scheme provides for all machine bases, guards, a source for common components, workstations and with standardized elements, maintaining a structure requires a minimum number of resources. Three or four basic hand tools are necessary to construct or restore any structure with a structural framing system [36].

8. Ease of Access:

All required work elements can be installed in easily available locations using an aluminum mounting system as the basis for a lean cell, since each side is a possible mounting side. For productive work, parts bins, instruments, shelves, and fixtures may all be placed in the ideal spot. The T-slot on the surface of the framing device often enables if clearance space is critical, swift repositioning of pneumatic or hydraulic parts. Components can be rapidly attached to any workstation and quickly repositioned to ensure each worker's usability [34]. Additionally, with simple hand tools, whole guards or individual panels can be removed easily, allowing service technicians to conduct maintenance in a matter of minutes [37].

9. Ergonomics:

The worker must, eventually, be shielded from ergonomic issues. Each lean work cell properly designed must be ergonomically designed. It is always necessary to maintain work at the ergonomically correct height in the work cell. While it is sometimes not considered, a design for the average height of the worker is also a requirement. Since average heights vary from country to country, it is important to easily change the height of a computer or workstation if there is a risk of a it is possible to ship workstations from country to country [34, 38].

1.4 Lean tools and techniques

Several industries introduce Lean by seeing Lean as a series of 'tool'. For a while, this could be helpful, but in the long run, it will not be enough. Behavior is developed by defining values like as dragging the Andon chord when a difficulty arises, but it continuously does this, always expects it, and always supports it [39]. Lean techniques are the base of lean thinking and the most common applied techniques are listed below:

1. 5S

It is the most common methods used in lean management. Starting the Lean journey with 5S, however, might not be a good idea. Although 5S is simple to incorporate, it has improve the efficiency and quality, it can also be a distraction from real goals or simply clean-up [39]. A 5S program's real goals should be:

- To lower waste
- To enhance variant
- To increase productivity

It is necessary for senior management to be supportive before introducing the 5S Lean technique.

Since 5S may be ideal model for many organizations, even if they understand the concept of it. Using the model methodology is one way of helping workers grasp 5S. It targets small section of the shop floor and implements 5S there. Before any consideration is given to moving to another location, the 5S should be identify every detail. The primary reason for doing this is to inspire employees to look and assess the outcomes of 5S with their previous way of working. Since 5S would be the better option compare to the older ways, the workers would be ready and able to proceed to other regions and eventually the whole business with it.

- i. **Sort:** Everything sorted in the work area. First, they categorized what is required for manufacturing and what are not required. Those that are not needed in the work area or serve no purpose must be discarded immediately. The company can choose to red tag products when in doubt. Red tag is a sticker indicate the date of object and then it is discarded if the object is not used up to the date [17].

The products are sorted accordance with the use. High use equipment's are kept close (perhaps daily) as possible to staff so that they do not waste time reaching them. Those that are used less often are positioned slightly further (perhaps once a week) so it is easily reachable to the workers, but not very near as to compete with the use of regularly used objects. Lastly, those that are seldom used are kept furthest away (per-haps once a month).

The sorting should be carried out regularly, maybe single time in a month but it is habit [18, 40].

- ii. **Set in order:** The set deals with each item's location. Each item should be place in the manner that it can be easily available for everyone and everyone knows that where it is placed. Two methods used to identify the product for all employees where color coding and labeling on the product. Whenever there are some products, parts or instruments shift, this stage should be repeated [17, 18, 40].

- iii. **Shine:** Everyday, the work area should be kept physically clean, workers also checked the working area that everything is placed in proper manner and if it is outplaced then it can be fix instantly. One technique is used to clean shop floor in every five-minute routine basis on each day (this process should be standardized for getting best results). The cleaning and tidying equipment's are properly arranged and regularly maintained. 'Cleaning is testing' implies the incorporation of both. You are not just washing up, you are looking for any abnormality's and their root causes [17, 18, 40].

- iv. **Standardized:** For the first 3Ss, expectations must be established to confirm that the employees do what the business requires from them. "Standard work aims to create repeatable, reliable and capable processes and procedures". The greatest norm is one that employees consider to be so strong and consistent that the workers are followed the given process plan and they do not divert in some other way (or do the process in some other way) [17, 18, 40]. For the introduction of the 5S to be a success, these standards need to be well managed.

- v. **Sustain:** All staff should make a habit of the first four Ss and must also continually strive to use and improve them. Audits are supported and enhance the values of 5S to uplift [17, 18, 40].

2. Just-in-Time (JIT)

JIT is a lean technique based on waste reduction and productivity growth. Waste can be defined as any action which does not add any value to the manufactured goods. Excess lead times, overproduction, and scrap are common examples of waste [17]. Instead of moving goods based on expected demand, JIT can be considered as a 'pull' operation based on client demand [40]. JIT's primary aim is to "produce and transport what is needed, when it is needed, amount needed, in the shortest possible lead time" [41]. "In summary, JIT is based on the concept of supplying raw materials just when required and producing products just when required".

3. Kaizen

The most well-known Lean approach is Kaizen. The combination of kai and zen, meaning "change" and "good" is Kaizen. This is what we have simply translated as "continuous improvement". For Kaizen implementation no initial cost is required or with in very less money it can be give big profits. Neither it cannot change the floor layout, nor it is need any advanced technology [17, 18, 40, 42].

4. Kanban

Kanban the Japanese word means "sign" or "card" This is the main technique used for continuous work flow between the work stations. It is used to identify the condition of product and what operations are carried out on the products and who is the operator. Kanban will maintain the flow of product from start to the end [40, 43].

5. Poka-yoke

"Poka-Yoke is fool-proofing technique for error prevention and elimination". This approach is not restricted to being used only in production but can also be used in office activities (such as post office, clinics etc.). Poka-yoke helps an industry to avoid the occurrence of a problem or flaw, or to interrupt a procedure immediately when a probation occurs. The clutch in a car is a normal and daily instance. The vehicle will not start until the clutch is pressed [44].

6.5 whys

Sakichi Toyoda would have designed the Lean system of the "five whys". It is one of the significant approaches that Toyota uses to solve problems. The theory is to evaluate the problem before the root cause or causes are found, not to stop at the first cause of a problem (the first why). In fact, it is more of a theory than a cause analysis tool since it is not sufficiently organized nor 'accurate' (why 5 and not 4, 6? In the 2nd, the root cause can be quite well discovered) [44].

7. Andon:

The Japanese origin term is the mixture of the two symbols 行 (go) and 灯 (light) that can be translated as "going where the light is". The andon is a luminous show activated in its technical application when a problem is found on a workstation to fix it as quickly as possible [45]. It can be caused by an operator or by the equipment where the problem happens automatically. To perform suitable activities, color codes may specify the form or degree of urgency of the anomaly. Initially, it was planned for large production workshops that are very important for visibility. It does, however, refer to other cases, such as call centres, and in its computerized form, in which warning lights can be displayed on the PCs (or mobile devices) of the persons concerned [46].

8. Autonomation or Jidoka:

Jidoka (働化) is an automated shutdown of a machine in the event of detection of a defect. It is a word coined by Sakichi Toyoda in 1896 when he invented the first weaving machine that stops automatically when the yarn breaks; it means “automation with human touch” and has been translated by autonomy (contraction of automation and autonomous) into English; it eliminates the human interference from the machine because if it stops itself, it not required to watch continuously [46].

It has two important concepts in the original TPS:

- One operator can handle many machines at same time, it will improve the human efficiency and save manpower cost.
- To fix them efficiently, the “built-in Quality” identifies quality issues as soon as possible; the full definition also consists of determining the root causes to definitively correct them.

9. Continuous flow:

Unlike batch processing, which consists of producing many products at a time, continuous flow production consists of producing only one product at a time at every stage of the process. It minimizes inventory levels of work in progress and decreases production cycle time, because before going on to the next production stage, each product does not have to wait for others [46].

10. Gemba:

This is undoubtedly one of Lean’s most iconic strategies. Gemba, is a Japanese term that means “crime scene” literally. Toyota, which originally used this term, replaced it with the term “Genchi genbutsu” which has a more positive connotation and means “going where the problem is encountered” In fact, the word most widely used today in the industry is the “Gemba walk” usually explained using the Genchi genbutsu translation.

There is a more substantial distinction in theory behind the discrepancies in terms. Whatever the word is, it is a manager’s visit to the office. Gemba, however, stresses the inspection and checking of evidence in its original version to make the right decisions. While the “Genchi genbutsu” version, which is like the “management by wandering around” American version, insists more on the casual side and listening to the visited employees [47].

11. Heijunka (Level Scheduling):

Leveling, which means smoothing the preparation or workload in the industrial, is the Heijunka translation. This approach is important to the success of the development of “continuous flow” in practice. It compensates for the fact that orders seldom arrive at a regular pace, in practice [46].

There are two forms of grading:

Volume leveling: the smoothed output produces the average of the orders over a given time, as the orders are of different amounts per day,

leveling by product type: Smoothing is a little more complex, it is a matter of mixing the various items every day according to their processing period to achieve an equal (or nearly identical) average time every day.

The two strategies are merged in practice. The Heijunka box has been developed as a visual medium: it consists of boxes, each representing the type of product (in columns) and the day of the week (in rows), the number of sheets per box being the number of products of the type considered to be manufactured on that day, the sum of the products in the same column being the date of manufacture.

12. Hoshin Kanri:

Hoshin Kanri's literal translation is 'management of the direction'. It means that implementing organizational policy or strategy, or of implementing major improvements, such as restructuring projects, in a wider context. It is the contrary, or rather a supplement to continuing change.

There are three pillars to this method [48]:

A cascaded implementation based on the vision definition: management sets the key directions that are implemented across the organization ("top down" process).

An iterative and participatory process at each hierarchical level: it helps the teams at each level to learn, adjust to reality and appropriate; this process is also called "catchball".

Short and long PDCA cycles: enabling the deployment to be corrected and improved over many time horizons.

13. Plan-Do-Check-Act (PDCA):

The PDCA emerged from a seminar sponsored by the Japanese Union of Scientists and Engineers (JUSE), where W. Edwards Deming updated Shewhart Cycle. It is a method of designing and developing a product according to specifications; it has been introduced by JUSE, and by Kaoru Ishikawa, to be used as a more general method called PDCA. It has become a central component of the Lean theory of quality improvement. It is called the Deming Wheel as well. It is composed of four steps [49]:

Plan: After determining what you want to implement and the targets, plan the actions,

Do: Execute the acts,

Check: Monitor the achievement of acts and goals, understand the outcomes,

Act: Act, apply corrective or enhancement measures [50].

14. Single Minute Exchange of Die (SMED):

It is developed at Toyota by Shigeo Shingo. Its mission is to decrease as much as possible tool changeover times in production [51].

The procedure consists of five stages.

Identify the activities performed: it is important to identify and quantify all activities performed, with waiting times,

Determine inner and outward behaviors:

- Inner activities are relevant to the process of modification that involve the cessation of output.
- Outward activities are performed during the manufacturing or before the manufacturing: component or tool preparation, presetting, etc.

Group external tasks together: Grouping can be eliminating the downtime of output by removing the downtime of processes.

Reduce internal operations time: Detailed analyze can be done for every operation and removed or updated the unwanted things.

Reduce external running time: It has not affect directly but it will increase performance or reduce costs.

15. Standardized Work:

Operation standardization was invented by Henry Ford, and it is backbone of the TPS. It includes the standardization of systems, tools, operating procedures, and even the extension of parts and components [40, 44].

16. Takt time:

Takt originates in German and means rhythm.

It is not a technique strictly talking; it is the basic measurement component of the method of non-stop flow output. This is the manufacturing amount of all item, which in principle essential be equal to the sales price. If all development phases are perfectly balanced at a period equal to Takt time [44] (according to the Heijunka method).

17. Total Productive Maintenance (TPM):

This technique is based on two main concepts which are included in its name [40, 44].

- Productive: To perform the maintenance without disturbing the production flow.
- Total: Contains very variables that influence the correct working of the machines and involves one and all.

JIPM has established eight TPM pillars [52]:

- i. Independent maintenance: Basic processes carried out by production managers (cleaning, lubrication, inspection, etc.) and the avoidance of breakdowns or the detection of irregularities as early as possible.
- ii. Kobetsu-Kaizen: In the TPS system, it is the equivalent of Kaizen.
- iii. Scheduled maintenance: By preventive work it avoids breakdowns.
- iv. Training and of knowledge management: Trained the technicians and machine operators to improved maintenance.
- v. Maintenance at design stage: In the design of machines or goods, maintenance is considered to promote maintenance processes.
- vi. Quality maintenance: Quality is improved by proper maintenance by removing defects.
- vii. Health, Safety and Environment: This pillar provides workers with a healthy working conditions and support to build a community that attracts equipment consideration.

- viii. Office maintenance: Ensuring that the support functions recognize the maintenance issues and, in addition to developing a sense of change of their own processes, can provide support.

18. Value Stream Mapping (VSM):

VSM is the analysis technique that allows all the knowledge flows of a process to be defined and visualized in a synthetic way.

A unreal and visual feature is likely to use of standardized symbols and a definition which, without being exhaustive, must remain at a macroscopic stage [53, 54].

In flow mapping, many pieces of understanding are characteristic:

- The mutual representation of basic and information flows.
- In addition to the other pure development phases, the representation of the journeys and stock phases.
- The identification of key figures for volume for each phase.
- By specifying the processing times and the times between operations, the cumulative time line.
- Identifying the challenges.

19. Waste reduction.

To elimination of waste, which is often more of a Lean concept than a Lean process, is one of Lean core principles. Three forms of waste exist, according to Taichi Ohno [13, 18]:

Muda: Activities with no added value to the finished product; some of its activities, such as quality controls or modifications, are still important [13].

Muri: Tasks that are unnecessary or too difficult [13].

Mura: Variability undergone [13].

1.5 Conclusion

In this study, an overview of the research background has been provided. Eight types of lean waste, nine types of lean manufacturing principles, and nineteen types of lean tools and techniques were identified to eliminate the industrial waste. It concludes that kaizen and 5S are mostly implemented in industries due to no cost or very less cost is required for implementation.

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