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A Review of Lean Manufacturing Tools in Automobile Industries

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Abstract :*Lean manufacturing is a concept which is developed for the purpose of reducing the waste generated with increase in the utilization of resources. The term lean was formulated and designed in order to respond to the fluctuations and to challenge business environmental competition. In today's scenario, business environments are rapidly changing. Thus, forcing organizations to face the challenges along with the complexities. Many of the organizations, such as manufacturing or service oriented related to survive are dependent ultimately to the systematic and continuous respond for the changes which are enhanced with the product values. In order to achieve this perfection, value adding process plays a major role. Thus, for many type of organizations, implementation of a lean manufacturing system becomes a core competency in order to sustain. From analyzing the studies based on lean management major part of study describes only a single part of the lean element, only very few studies focus on a greater number of aspects of lean element. In order for successful lean manufacturing implementation, the organization have to focus on many aspects such as Cellular Manufacturing (CM), Line Balancing, 5S Techniques, Value Stream Mapping (VSM), Inventory Control, U-Line system, Kanban, Pull system, Just-In-Time (JIT), Single Minute Exchange of Dies (SMED), Production levelling, Bottleneck effect etc.… From this paper, we have analyzed and developed lean route map which can able to implement lean manufacturing system in organizations.*

Keywords: *Lean Manufacturing, Automobile Industries, Manufacturing tools, Continuous Improvement*

1. INTRODUCTION:

Lean manufacturing plays an important role in any industry. The method of Lean Manufacturing has emerged due to defects in products either semi-finished or finished with relation to the increase in cost. From the literature review and expert's opinion, various variables of lean manufacturing have been observed. Since early 1990s, the concept of lean manufacturing has been approved as a conceptual framework. According to the theory of Womak and Jones in 1996, lean manufacturing can be classified as an elimination of wastes in the process of production. Either process or tangible product or intangible product which cannot be used as a value to an end product is considered as a waste. Based upon the theory of Womak and Jones in 1994, the process of producing a product according to the customer satisfaction, with the elimination of non-value activities for an end product is considered as a lean management, the study concept of Henderson and Larco which has been defined in 2003 justifies that the need of an organization that can make aware of people and converts people into groups. When we study under the concept of Csokasyand parent who has been stated in 2007 classifies, the method of lean transition into organization culture plays a major role in management of change processes rather than management of lean tools as well as techniques.

Lean is defined as a continuous improvement philosophy which is related with Kaizen or Toyota Production System. This history of lean management or lean manufacturing has been traced back from early years of Toyota and its development in Production System after the collapse of Japan in World War II. While, the company was looking for a means to compete with US car industry through implementation and development of range of low-cost improvements within their business terms. Also, lean management seeks for implementing business process which achieve high quality, safety and worker morale, whilst reducing cost and shortening lead times. This in itself is not unique to Japan. What sets lean management apart, and makes it particularly

effective, is that it has at its core a laser-sharp focus on the elimination of all waste from all processes.

2.CONCEPT OF LEAN MANUFACTURING:

Lean principles are derived from the Japanese manufacturing industry. The term was first coined by John Krafcik in his 1988 article, "Triumph of the Lean Production System", based on his master's thesis at the MIT Sloan School of Management. Krafcik had been a quality engineer in the Toyota-GM NUMMI joint venture in California before joining MIT for MBA studies. Krafcik's research was continued by the International Motor Vehicle Program (IMVP) at MIT, which produced the international best-selling book co-authored by James P. Womack, Daniel Jones, and Daniel Roos called The Machine That Changed the World. A complete historical account of the IMVP and how the term "lean" was coined is given by Holweg (2007) For many, lean is the set of "tools" that assist in the identification and steady elimination of waste. As waste is eliminated quality improves while production time and cost are reduced. A non-exhaustive list of such tools would include: SMED, value stream mapping, Five S, Kanban (pull systems), poka-yoke (error-proofing), total productive maintenance, elimination of time batching, mixed model processing, rank order clustering, single point scheduling, redesigning working cells, multi-process handling and control charts (for checking mura).

There is a second approach to lean manufacturing, which is promoted by Toyota, called The Toyota Way, in which the focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating mura ("unevenness") through the system and not upon 'waste reduction' per se. Techniques to improve flow include production leveling, "pull" production (by means of Kanban) and the Heijunka box. This is a fundamentally different approach from most improvement methodologies, and requires considerably more persistence than basic application of the tools, which may partially account for its lack of popularity. [3]

The difference between these two approaches is not the goal itself, but rather the prime approach to achieving it. The implementation of smooth flow exposes quality problems that already existed, and thus waste reduction naturally happens as a consequence. The advantage claimed for this approach is that it naturally takes a system-wide perspective, whereas a waste focus sometimes wrongly assumes this perspective.

Both lean and TPS can be seen as a loosely connected set of potentially competing principles whose goal is cost reduction by the elimination of waste. These principles include: pull processing, perfect first-time quality, waste minimization, continuous improvement, flexibility, building and maintaining a long-term relationship with suppliers, autonomation, load leveling and production flow and visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems it saw within its own production facilities. Thus, what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework. [4]

Toyota's view is that the main method of lean is not the tools, but the reduction of three types of waste: Muda (non-value-adding work), muri (overburden), and mura (unevenness), to expose problems systematically and to use the tools where the ideal cannot be achieved. From this perspective, the tools are workarounds adapted to different situations, which explains any apparent incoherence of the principles above.

Lean implementation emphasizes the importance of optimizing work flow through strategic operational procedures while minimizing waste and being adaptable. Flexibility is required to allow production leveling (Heijunka) using tools such as SMED, but have their analogues in other processes such as research and development (R&D). However, adaptability is often constrained, and therefore may not require significant investment. More importantly, all of these concepts have to be acknowledged by employees who develop the products and initiate processes that deliver value. The cultural and managerial aspects of lean are arguably more important than the actual tools or methodologies of production itself. There are many examples of lean tool implementation without sustained benefit, and these are often blamed on weak understanding of lean throughout the whole organization.

Lean aims to enhance productivity by simplifying the operational structure enough to understand, perform and manage the work environment. To achieve these three goals simultaneously, one of Toyota's mentoring methodologies (loosely called Senpai and Kohai which is Japanese for senior and junior), can be used to foster lean thinking throughout the organizational structure from the ground up. The closest equivalent to Toyota's mentoring process is the concept of "Lean Sensei," which encourages companies, organizations, and teams to seek third-party experts that can provide advice and coaching.

In 1999, Spear and Bowen identified four rules which characterize the "Toyota DNA":

- All work shall be highly specified as to content, sequence, timing, and outcome.
- Every customer-supplier connection must be direct, and there must be an unambiguous yes or no way to send requests and receive responses.
- The pathway for every product and service must be simple and direct.
- Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization.

3.PRINCIPLES OF LEAN MANUFACURING:

Lean manufacturing is defined as a performance-based process which is used in manufacturing organizations in order to increase its productions along with competitive advantages. Its basic is to employ continuous improvement processes in order to focus on waste elimination or non-value-added steps within organization. The challenge for the organizations is to utilize lean manufacturing for the purpose of creating a culture that will create and sustain long-term commitment from top management through the entire workforce. [1]
The application of five principles to guide action of management toward success is

a. Value: The foundation for the value stream that defines what the customer is willing to pay for.

b. The Value Stream: The mapping and identifying of all the specific actions required to eliminate the nonvalue activities from design concept to customer usage.

c. Flow: The elimination of all process stoppages to make the value stream “flow” without interruptions.

d. Pull: The ability to streamline products and processes from concept through customer usage.

e. Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.

The lean manufacturing is a set of principles is now fairly rooted in the literature. The principles that are behind the lean manufacturing are not in themselves new; many of them can be traced back with work of pioneers commonly as (Deming, 1986; Taylor, 1911; Skinner, 1969). Though the concept of lean as now understood could have modeled from this literature, it was not until the Japanese auto industry was studied, that the total concept became clear. Instead lean manufacture has been extended to encompass whole spectrum of activities in business such as world-class companies, in particular, automotive and electronic sectors are seeking in order to become lean enterprises. There are also some voices of discontent such as (Gordon, 1995; Berggren, 1992) to the adoption and ultimate effectiveness of lean production, nonetheless many case examples exist to demonstrate how companies are changing their production methods and management practices to become leaner. Therefore, to analyze the implementation in lean approach; it is essential to study about the inner working of companies along with following the fundamental principles of TPS identified by various researchers over a period of time. In this study, we have analyzed and examined the lean principles implementation techniques and inner workings of about more than 50 companies in automotive sectors in countries such as USA, UK and India. [2] We also have analyzed the production system, product development processes, supply chain management, and management style in order to see how these companies are following lean principles as documented by various researchers and also analyzed and examined engineers, senior managers, workers involved in attending their review and problem-solving meetings to understand thecoordination mechanisms. In the process of interaction and cooperation between supplier and customer.

4. GOALS OF LEAN MANUFACTURING:

The espoused goals of lean manufacturing systems differ between various authors. While some maintain an internal focus, e.g. to increase profit for the organization, others claim that improvements should be done for the sake of the customer. [5]

Some commonly mentioned goals are:

• Improve quality: To stay competitive in today's marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.

• Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.

• Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.

• Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company’s inventory costs because of storage needs.

The strategic elements of lean can be quite complex, and comprise multiple elements. [6] Four different notions of lean have been identified:

• Lean as a fixed state or goal (being lean)

• Lean as a continuous change process (becoming lean)

• Lean as a set of tools or methods (doing lean/toolbox lean)

• Lean as a philosophy (lean thinking)

5. STRATEGY:

Lean production has been adopted into other industries to promote productivity and efficiency in an ever-changing market. In global supply chain and outsource scale, Information Technology is necessary and can deal with most of hard lean practices to synchronize pull system in supply chains and value system [7]. The manufacturing industry can renew and change strategy of production just in time.

The supply chains take changes in deploying second factory or warehouse near their major markets in order to react consumers' need promptly instead of investing manufacturing factories on the lost-cost countries. For instance, Dell sells computers directly from their website, cutting franchised dealers out of their supply chains. Then, the firm use outsourced partners to produce its components, deliver components to their assembly plants on these main markets around the world, like America and China. [8]

The other way to avoid market risk and control the supply efficiently is to cut down in stock. P&G has done the goal to co-operate with Walmart and other wholesales companies by building the response system of stocks directly to the supplier's companies.

With the improvement of global scale supply chains, firms apply lean practices (JIT, supplier partnership, and customer involvement) built between global firms and suppliers intensively to connect with consumers markets efficiently.

6. STEPS TO ACHIEVE LEAN SYSTEMS:

The following steps should be implemented to create the ideal lean manufacturing system:

• Design a simple manufacturing system

• Recognize that there is always room for improvement

• Continuously improve the lean manufacturing system design

6.1. DESIGN A SIMPLE MANUFACTURING SYSTEM:

A fundamental principle of lean manufacturing is demand-based flow manufacturing. In this type of production setting, inventory is only pulled through each production center when it is needed to meet a customer's order [9]. The benefits of this goal include:

• Decreased cycle time

• Less inventory

• Increased productivity

• Increased capital equipment utilization

6.2. CONTINUOUS IMPROVEMENT:

A continuous improvement mindset is essential to reach the company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance [10]. Lean is founded on the concept of continuous and incremental improvements on product and process while eliminating redundant activities. "The value of adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated" (Rizzardo, 2003). Improving the flow of material through new ideal system layouts at the customer's required rate would reduce waste in material movement and inventory.

6.3. MEASURE AND CRITICISM:

Overall equipment effectiveness (OEE) is a set of performance metrics that fit well in a lean environment. Also, PMTS, methods-time measurement, cost analysis and perhaps time study can be used to evaluate the wastes and IT effectiveness in the operational processes. For example, Jun-Ing Ker and Yichuan Wang analyze two prescribing technologies, namely no carbon required (NCR) and digital scanning technologies to quantify the advantages of the medication ordering, transcribing, and dispensing process in a multi-hospital health system. With comparison between these two technologies, the statistical analysis results show a significant reduction on process times by adopting digital scanning technology. The results indicated a reduction of 54.5% in queue time, 32.4% in order entry time, 76.9% in outgoing delay time, and 67.7% in outgoing transit time with the use of digital scanning technology. [11]

One criticism of lean is that its practitioners may focus on tools and methodologies rather than on the philosophy and culture of lean. Consequently, adequate management is needed in order to avoid failed implementation of lean methodologies. Another pitfall is that management decides what solution to use without understanding the true

problem and without consulting shop floor personnel. As a result, lean implementations often look good to the manager but fail to improve the situation.

In addition, many of the popular lean initiatives, coming from the TPS, are solutions to specific problems that Toyota was facing. Toyota, having an undesired current condition, determined what the end state would look like. Through much study, the gap was closed, which resulted in many of the tools in place today. Often, when a tool is implemented outside of TPS, a company believes that the solution lay specifically within one of the popular lean initiatives. The tools which were the solution to a specific problem for a specific company may not be able to be applied in exactly the same manner as designed. Thus, the solution does not fit the problem and a temporary solution is created vs. the actual root cause.

The lean philosophy aims to reduce costs while optimizing and improving performance. Value stream mapping (VSM) and 5S are the most common approaches companies take on their first steps towards making their organization leaner. Lean actions can be focused on the specific logistics processes, or cover the entire supply chain. For example, you might start from analysis of SKUs (stock keeping units), using several days to identify and draw each SKUs path, evaluating all the participants from material suppliers to the consumer. Conducting a gap analysis determines the company's 'must take' steps to improve the value stream and achieve the objective. Based on that evaluation, the improvement group conducts the failure mode effects analysis (FMEA), in order to identify and prevent risk factors. It is crucial for front-line workers to be involved in VSM activities since they understood the process and can directly increase the efficiency. Although the impact may be small and limited for each lean activity, implementing series small improvements incrementally along the supply chain can bring forth enhanced productivity.

After adopting the lean approach, both managers and employees experience change. Therefore, decisive leaders are needed when starting on a lean journey. There are several requirements to control the lean journey. First and most importantly, experts recommend that the organization have its own lean plan, developed by the lean Leadership. In other words, the lean team provides suggestions for the leader who then makes the actual decisions about what to implement. Second, coaching is recommended when the organization starts off on its lean journey. They will impart their knowledge and skills to shop floor staff and the lean implementation will be much more efficient. Third, the metrics or measurements used for measuring lean and improvements are extremely important. It will enable collection of the data required for informed decision-making by a leader. One cannot successfully implement lean without sufficient aptitude at measuring the process and outputs. To control and improve results going forward, one must see and measure, i.e. map, what is happening now.

7. TOOLS IN LEAN MANUFACTURING:

7.1 KAIZAN

In Japanese, Kaizen means "continual improvement". This lean manufacturing tool dictates that processes be continually improved in order to eliminate waste and boost efficiency. In the automotive industry, Kaizen is often implemented in order to address problems and provide solutions in the assembly line process.

Fig 1: Kaizen Event Process

7.2. POKA YOKE

The goal of Poka-Yoke is to prevent mistakes from becoming defects, which is a crucial aspect of efficient, quality manufacturing. In the automotive industry, one example of Poka-Yoke being implemented is a conveyor belt that will reject a part if it is underweight and therefore prevent a mistake from becoming a defect that makes it through the assembly line.

7.3. HEIJUNKA

The Japanese word for "leveling" Heijunka is used to level out the production process to reduce batching and ensure that a consistent number of components are produced each day. This enables companies in the automotive industry to optimize their manufacturing process for a specific number of items manufactured rather than having that number vary on a day-to-do basis.

Fig 2: HEIJUNKA

7.4. A3 PROBLEM SOLVING

A3 Problem Solving is a method of problem solving used to find flaws, explore solutions, and implement those solutions in order to achieve a desired goal. A3 Problem Solving was first implemented by Toyota and offers a lot of value to companies in the automotive industry.

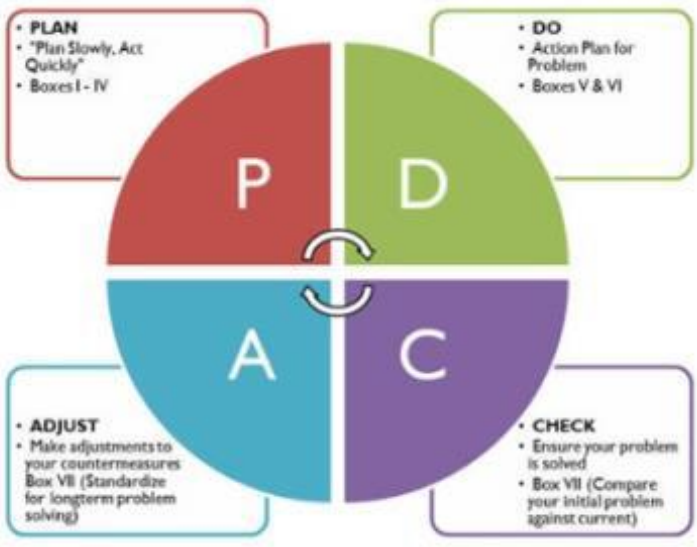

Fig 3: PDCA

7.5. JUST IN TIME

Just in Time manufacturing dictates that products be produced when the customer wants them in the amount the customer needs. This process enables companies to reduce their inventory and eliminate waste by ensuring their products are sold as soon as they roll off the assembly line.

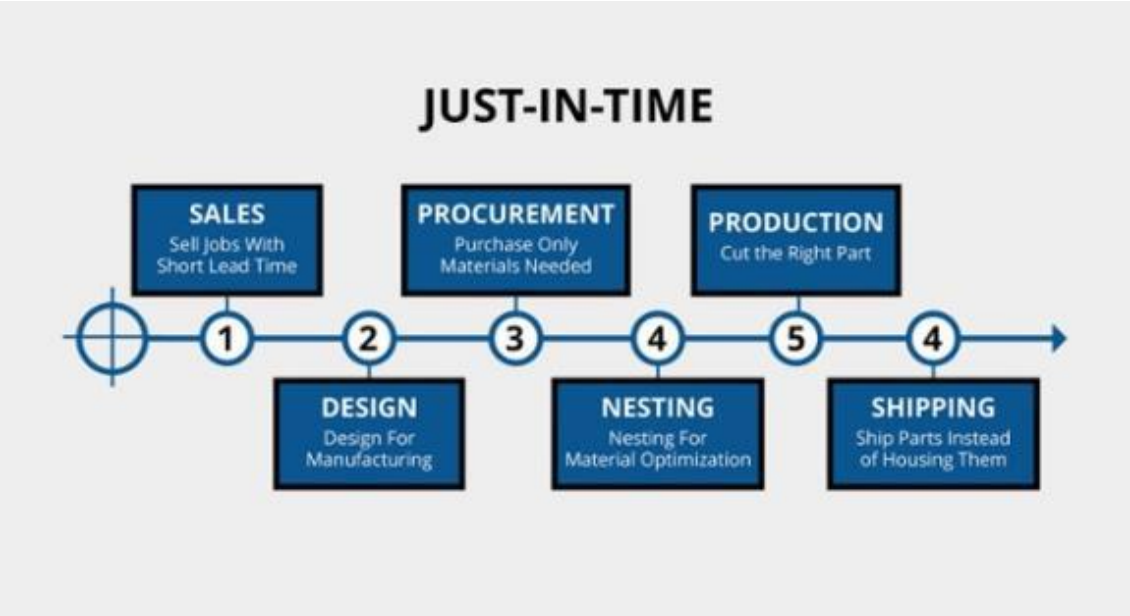

Fig 4: JIT

7.6. SIX BIG LOSSES

Six Big Losses highlights the six most common causes of inefficiencies in production and provides companies with the steps they need to use in order to address these causes.

Fig 5: TPM six Big Losses

7.7. ROOT CAUSE ANALYSIS

RCA dictates that it's much better to get to the root cause of the problem rather than treating its obvious symptoms. In automotive manufacturing, which can be quite complex, it can often be difficult to find the root cause of a problem. By using the RCA tool, companies can make spotting and fixing the root cause of problems much easier.

7.8. 5 WHYS

Like RCA, the 5 Whys tool is designed to help companies find the root cause of a problem rather

than treating its symptoms. In the automotive industry, companies can use the 5 Whys tool in order to ask the questions that need to be asked about their manufacturing process and find the correct answer to those questions.

Fig 7: RCA

7.9. TYPES OF WASTES

The 7 Wastes lean manufacturing tool is implemented by Toyota and is perfect for companies in the automotive industry. This tool helps companies analyze the seven areas where waste commonly occurs and provides steps for them to eliminate that waste.

Fig 8: 7 Wastes

Although the elimination of waste may seem like a simple and clear subject, it is noticeable that waste is often very conservatively identified. This then hugely reduces the potential of such an aim. The elimination of waste is the goal of lean, and Toyota defined three broad types of waste: muda, muri and mura; for many lean implementations this list shrinks to the first waste type only with reduced corresponding benefits.

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. To link these three concepts is simple in TPS and thus lean. Firstly, muri focus on the preparation and planning of the process, or what work can be avoided proactively by design. Next, murathen focuses on how the work design is implemented and the elimination of fluctuation at the scheduling or operations level, such as quality and volume. Muda is then discovered after the process is in place and is dealt with reactively. It is seen through variation in output. It is the role of management to examine the Muda, in the processes and eliminate the deeper causes by considering the connections to the muri and mura of the system. The Muda and mura inconsistencies must be fed back to the muri, or planning, stage for the next project.

A typical example of the interplay of these wastes is the corporate behavior of "making the numbers" as the end of a reporting period approaches. Demand is raised to 'make plan,' increasing (mura), when the "numbers" are low, which causes production to try to squeeze extra capacity from the process, which causes routines and standards to be modified or stretched. This stretch and improvisation leads to muri-style waste, which leads to downtime, mistakes and back flows, and waiting, thus the Muda of waiting, correction and movement. [4]

Eventually, an eighth "Muda" 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. For example, Six Sigma includes the waste of Skills, referred to as "under-utilizing capabilities and delegating tasks with inadequate training". Other additional wastes added were for example "space". These wastes were not originally a part of the seven deadly wastes defined by Taiichi Ohno in TPS, but were found to be useful additions in practice. In 1999 Geoffrey Mika in his book, "Kaizen Event Implementation Manual" added three more forms of waste that are now universally accepted; The waste associated with working to the wrong metrics or no metrics, the waste associated with not utilizing a complete worker by not allowing them to contribute ideas and suggestions and be part of Participative Management, and lastly the waste attributable to improper use of computers; not having the proper software, training on use and time spent surfing, playing games or just wasting time. For a complete listing of the "old" and "new" wastes see Bicheno and Holweg (2009)

The identification of non-value-adding work, as distinct from wasted work, is critical to identifying the assumptions behind the current work process and to challenging them in due course. [8] Breakthroughs in SMED and other process changing techniques rely upon clear identification of where untapped opportunities may lie if the processing assumptions are challenged.

8. LITERATURE REVIEW OF JIT AND BATCH PRODUCTION:

8.1 BATCH PRODUCTION:

Batch production is a technique used in manufacturing, in which the object in question is created stage by stage over a series of workstations, and different batches of products are made. Together with job production (one-off production) and mass production (flow production or continuous production) it is one of the three main production methods.

Batch production is most common in bakeries and in the manufacture of sports shoes, pharmaceutical ingredients (APIs), purifying water, inks, paints and adhesives.

In the manufacture of inks and paints, a technique called a color-run is used. A color-run is where one manufactures the lightest color first, such as light yellow followed by the next increasingly darker color such as orange, then red and so on until reaching black and then starts over again. There are several advantages of batch production; it can reduce initial capital outlay (the cost of setting up the machines) because a single production line can be used to produce several products. As shown in the example, batch production can be useful for small businesses that cannot afford to run continuous production lines. If a retailer buys a batch of a product that does not sell, then the producer can cease production without having to sustain huge losses. Batch production is also useful for a factory that makes seasonal items, products for which it is difficult to forecast demand, a trial run for production, or products that have a high profit margin. it also has some drawbacks. There are inefficiencies associated with batch production as equipment must be stopped, re-configured, and its output tested before the next batch can be produced. Idle time between batches is known as downtime. The time between consecutive batches is known as cycle time. Cycle time variation is a Lean Manufacturing metric. Continuous production is used for products that are made in a similar manner. For example, a certain car model has the same body shape and therefore, many of the same model cars can be made at the same time without stopping, decreasing manufacturing cost.

8.2. JUST IN TIME:

Just-in-time (JIT) manufacturing, also known as just-in-time production or the Toyota Production System (TPS), is a methodology aimed primarily at

reducing flow times within production system as well as response times from suppliers and to customers. Its origin and development were in Japan, largely in the 1960s and 1970s and particularly at Toyota.

Alternative terms for JIT manufacturing have been used. Motorola's choice was short-cycle manufacturing (SCM). IBM's was continuous-flow manufacturing (CFM), and demand-flow manufacturing (DFM), a term handed down from consultant John Constanza at his Institute of Technology in Colorado. Still another alternative was mentioned by Goddard, who said that "Toyota Production System is often mistakenly referred to as the 'Kanban System'", and pointed out that Kanban is but one element of TPS, as well as JIT production. But the wide use of the term JIT manufacturing throughout the 1980s faded fast in the 1990s, as the new term lean manufacturing became established, as "a more recent name for JIT". As just one testament to the commonality of the two terms, Toyota production system (TPS) has been and is widely used as a synonym for both JIT and lean manufacturing.

Sepheri provides a list of methodologies of JIT manufacturing that "are important but not exhaustive":

- Housekeeping – physical organization and discipline.
- Make it right the first time – elimination of defects.
- Setup reduction – flexible changeover approaches.
- Lot sizes of one – the ultimate lot size and flexibility.
- Uniform plant load – leveling as a control mechanism.
- Balanced flow – organizing flow scheduling throughput.
- Skill diversification – multi-functional workers.
- Control by visibility – communication media for activity.
- Preventive maintenance – flawless running, no defects.
- Fitness for use – producibility, design for process.
- Compact plant layout – product-oriented design.
- Streamlining movements – smoothing materials handling.
- Supplier networks – extensions of the factory.
- Worker involvement – small group improvement activities.
- Cellular manufacturing – production methods for flow.
- Pull system – signal [Kanban] replenishment/resupply systems.

Objectives and benefits of JIT manufacturing may be stated in two primary ways: first, in specific and quantitative terms, via published case studies; second, general listings and discussion.

A case-study summary from Daman Products in 1999 lists the following benefits: reduced cycle times 97%, setup times 50%, lead times from 4 to 8 weeks to 5 to 10 days, flow distance 90% – achieved via four focused (cellular) factories, pull scheduling, Kanban, visual management, and employee empowerment. Another study from NCR (Dundee Scotland) in 1998, a producer of make-to-order automated teller machines, includes some of the same benefits while also focusing on JIT purchasing: In switching to JIT over a weekend in 1998, eliminated buffer inventories, reducing inventory from 47 days to 5 days, flow time from 15 days to 2 days, with 60% of purchased parts arriving JIT and 77% going dock to line, and suppliers reduced from 480 to 165.

Hewlett-Packard, one of western industry's earliest JIT implementers, provides a set of four case studies from four H-P divisions during the mid-1980s. [43] The four divisions, Greeley, Fort Collins, Computer Systems, and Vancouver, employed some but not all of the same measures. At the time about half of H-P's 52 divisions had adopted JIT.

"Just-in-Time" means making "only what is needed, when it is needed, and in the amount needed." For example, to efficiently produce a large number of automobiles, which can consist of around 30,000 parts, it is necessary to create a detailed production plan that includes parts procurement. Supplying "what is needed, when it is needed, and in the amount needed" according to this production plan can eliminate waste, inconsistencies, and unreasonable requirements, resulting in improved productivity.

9.THRUSTS IN LEAN MANUFACTURING DESIGNS:

9.1. SOLID LEADERSHIP

The term solid leadership improves communication of the vision. Thus, facilitates and models the behaviors of lean manufacturing. It also sets the standards for the organization allowing to assist the workforce in adapting to the change. It also builds trust and inspires commitment by coaches and develops the workforce and constantly challenges the system.

9.2. TEAM-BASED CULTURES

It uses project-oriented, team-based structures which focus on empowerment concepts. It helps to leverage knowledge by using highly skilled workers. It also promotes employee accountability and responsibility for work. Advocating the continual development of the workforce by value diversity. Believe that employee ownership of the final product is shared throughout the process.

9.3. COMMUNICATION SYSTEMS

Advocating and developing processes to identify critical design issues within early processes. Encouraging "on-the-spot" decision-making processes that use the fewest resources in order to resolve critical design issues. It also promotes knowledge sharing among hourly workers, management, as well as design personnel. Drives the behaviors of internal operations, as well as focus on the behaviors of suppliers and customers. Accept formal and informal communication behaviors

9.4. SIMULTANEOUS DEVELOPMENT AND CONTINUOUS IMPROVEMENT PROCESSES

It encourages designing the product right the first time. Using continuous improvement processes in order to identify the non-value-added problems. Drive commitment for the purpose of eliminating problems (controlling them is not enough). Advocating just-in-time material control systems and promoting constant improvement throughout the supply chain. Leverage the knowledge of the organization with the knowledge bases of suppliers and customers. Continually training and developing highly skilled workers. Usage of scoreboards or measurement systems to monitor progress.

10. RESULT AND DISCUSSIONS:

In this paper, we have analyzed and studied about the principles of lean manufacturing, its basic is to employ continuous improvement processes in order to focus on waste elimination or non-value-added steps within organization. The challenge for the organizations is to utilize lean manufacturing for the purpose of creating a culture that will create and sustain long-term commitment from top management through the entire workforce. majorly discussed principles are value, value-stream, flow, pull, perfection. This paper also describes about various thrust methods that are involved in lean techniques. Some of the thrust methods that are included are solid leadership, team-based cultures, communication system, simultaneous development and continuous improvement process.

We also have studied and analyzed, Companies like to use JIT because it can be a more cost-efficient method of keeping merchandise in stock. JIT minimizes the amount of time that you need to keep merchandise in your warehouse. Requires less warehouse space: With a faster turnaround of stock, you don't need as much warehouse or storage space to store goods. This reduces the amount of storage your small business needs to rent or buy, freeing up funds for other parts of the business. It can help in eliminating wasted by faster turnaround of stock prevents goods becoming damaged or obsolete while sitting in storage, reducing waste. This again saves money by preventing investment in unnecessary merchandise and reducing the need to replace old stock. and requires a smaller investment: JIT inventory management is ideal for smaller companies that don't have the money available to purchase huge amounts of stock at once. Ordering merchandise as and when it's needed helps to maintain a healthy cash flow. Entrepreneur Depot adds that JIT has the added benefits of allowing you to maintain a flexible workforce. Having workers who are trained in other areas of the manufacturing process – and not just in maintaining the logistics of a warehouse bulging with inventory – allows you to move workers where they are needed most. JIT also allows you to synchronize production schedules with demand.

But JIT systems are not all rosy and easily managed. Entrepreneur Depot notes that JIT can leave you vulnerable to supply stocks. JIT leaves manufacturers vulnerable to supply stocks.

On analyzing Batch Production, Products can be produced in mass quantities, reducing the overall cost per unit Companies only focus on a small group of products, leading to greater quality control and product expertise Cost of labor is reduced, as workers only focus on a particular task or set of tasks Cost of machinery is reduced, as one machine can handle several different product configurations Lends itself to repeat orders, meaning a smoother, more consistent production flow over time Machinery isn't always on, saving on energy costs
On other hand, each batch must be tested for quality and uniformity before future batches can be produced, causing idle downtime Machinery must be stopped and recalibrated between batches, also causing downtime Storage costs are high for large batches of the same product. Fewer varieties of jobs can demotivate employees.

We conclude saying that, the above-mentioned principles of lean manufacturing along with the techniques can be implemented in automobile industries in order to achieve increased production. The lean tools should be implemented one at a time. Trying to implement multiple tools at a time will lead to loss of time, materials and human power and money. Lean Manufacturing is a

concept which yields excellent results in an industry in the long run. Hence, it is very necessary to implement, standardize and sustain the lean principles on a day-to-day basis and wait for the best output. The results should also be regularly monitored every day. Small changes always make a big difference while implementing lean principles. Hence, we can choose the tools to be implemented in an industry based on the nature of industry. Requirements of industries vary from one to another. Hence that should also be considered while choosing lean concepts. It is always advisable to choose the most important one or two tools based on the industry's requirement and implement them to get best results. One can improve efficiency, productivity, Overall Equipment Efficiency (OEE), Employee satisfaction, better industrial relationships and so on in an industry.

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