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IMPLEMENTATION AND ANALYSIS OF LEAN MANUFACTURINGTECHNIQUES IN A LARGE SCALE AUTOMOTIVE ENTERPRISE

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Abstract: *This study incorporates the implementation of the technical aspects of the most important lean manufacturing processes in an automotive industry. With the increased and intensifying competition amongst the industries, they are adapting to various practices to achieve success in the market. The lean systems are seen as the basis to achieve the above goal. The principles of lean manufacturing include continuous improvement by eliminating waste at a primary level and mistake proofing at a secondary level. This case project shows the means and ways of improvement adopted by an automotive industry and the effect of the same on its productivity and efficiency qualitatively. Most of the present research focuses on local premises in an Indian industry, the present means that are adopted by it to implement the lean techniques and apposite changes, implementation of which will bring desired results in the industry to increase its competency in the market.*

Keywords: *Continuous Improvement, Mistake Proofing, Lean Enterprises, Implementation.*

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1. INTRODUCTION

The market today has immense competition and survival in such a market is extremely difficult unless there are state of the art factories, advance machinery and customer satisfaction through promising fulfilling of their needs. Currently, there are six challenges in the automotive market that are: (1)scarcity and elevated cost of qualified operators; (2)unpredictable demand of product mix and production volume;(3) pronounced emphasis on safety at workplace;(4)energy-efficient production; (5)drop in cost of production;(6)product accessibility[1,2]. To improvise and overcome the aforementioned challenges, any manufacturing facility has to keep its focus on improving quality and productivity which forms the basis for any industrial leader. The concept of lean enterprises is on the rise since it provides the aforementioned target achievement plan. The results of an international survey showed, that 80 % of the participants claim to use the principles of Lean Production Systems (LPS). More than half finished the implementation and improve their LPS continuously [3].The whole concept of lean deals with eliminating the wastes being produced by the facility to the maximum possible extent. By continually focusing on waste reduction, a company can react better to the needs of their customers and will also be able to operate at more efficient performance levels [4]. There are various tools present under lean most of which are generic and can be applied to any industry. These tools can be categorized as the certain most important ones i.e. the primary tools and certain tools i.e. which become industry and facility specific.

Womack, Roos, and Jones (1990) studied the implementation of lean manufacturing practices in the automotive industry on a global scale. Other research efforts, such as the Lean Aerospace Initiative (2002), have looked at the unique challenges of implementing lean manufacturing practices in a specific type of industry [5]. Today, the automotive companies are facing a tough fight in a far more unstable world which emphasizes on creating a business with high impact and effectiveness. But this objective has to be accomplished using minimal costs without the compromise in the quality. The enterprise taken into consideration for the analysis and improvisation of lean techniques is one of the largest automotive original equipment manufacturers across the world. The company‘s ability to offer complete lifecycle solutions backed by a global support system, technological superiority and customer orientation, make it a force to reckon with in its areas of expertise.

The paper mainly focuses on the spot welding operation on the child parts and the die punching of the chassis of innumerable cars produced. Many different parts such as panel dash, right mounting hub and fender aprons etc. are fabricated. These two facets make use of the lean manufacturing techniques which are analyzed in this paper. The methodology adopted in this research was deductive and started with literature review of the manufacturing systems in automotive industry. The variables of primary focus are the dependent variables in this research and reflect the performance of a manufacturing enterprise. These dependent variables are the six major competitive dimensions of manufacturing in the automotive sector, which are quality, delivery reliability, response time, low cost, customization, and product life cycle, in addition to the revenue [6].

2. TECHNICAL ATTRIBUTES OF LEAN MANUFACTURING IMPLEMENTATION

Lean manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for [7].It is a theme of increasing proficiency, decreasing the hidden wastes, and using pragmatic methods to decide what influences the industry. In the following section, the pillars and strengths of the lean techniques are elaborated.

There are various kinds of wastes existing in an enterprise. These include primarily seven types which are waiting, movement, transportation, process, exceeding the production, inventory and faulty parts and components. Lean manufacturing principally focuses on reduction of the seven wastes. Thus as a lean leader, the focus is on getting the things right, getting the right things, to the appropriate place, at the right time and in the right quantity. This is done in order to achieve unhindered work flow and flexibility. Historically, Taiichi Ohno and Shigeo Shingo [8] developed the Toyota Production System from which the Lean Manufacturing principles were derived over a period of 20–30 years. In 1980, Shigeo Shingo documented the Toyota Production System and added to it the concepts of Single Minute Exchange Die (SMED), mistake-proofing, and Zero Quality Control (ZQC) [9]. There are four pillars of lean manufacturing that are waste reduction, just-in-time manufacturing, error-proofing, and smart automation. This papers deals with these pillars and their individual and interdependent role in lean manufacturing in the automotive sector.

2.1 Waste Elimination

Waste reduction is one of the primary objectives of lean enterprises. It is through the elimination of wastes that any enterprise reduces the capital involved and increases the efficiency and productivity of the manufacturing facility. In a die pressing manufacturing process, a considerably large amount of waste is generated in the form of scrap metal. This has to be eliminated by reusing the rejected metal pieces again. The process is illustrated through the following photographs which are tracked by a vivid description.Five main operations are performed on the sheet metal to obtain the automotive chassis. The gemba or shop floor area mainly comprises of five heavy hydraulic die pressing machines to perform each of those operations. These machines use the hydraulic pressure to cause deformation of the sheets. The unit also has a die storage area where all the dies, both male and female, required to produce the various parts of the vehicles are stored. The various parts along with their stage requirement can be seen in the table 1.

Table1: Various parts, their stages and force of dies.

PART	STAGES	PROG NO.	800 TON	400 TON	400 TON	400 TON
PANEL DASH	4	4	1	2	3	4
QUARTER INNER LOWER- RH	4	3	1	2	3	4
REAR WHEEL HOUSING LH	4	12	1	2	3	4
FEDRON APRON - RH/LH	3	30	1	2	3	
PANEL DASH	4	29	1	2	3	4
DASH SIDE LH/RH	3	31	1	2	3	
REAR QUARTER INNER-RH	4	22	1	2	3	4
REAR QUARTER INNER-LH	4	23	1	2	3	4
FWHO RH/LH	3	13	1	2	3	
PANEL DASH	4	6	1	2	3	4
QUARTER INNER UPPER -RH	4	7	1	2	3	4
QUARTER INNER UPPER -LH	4	8	1	2	3	4
HOOD INNER	4	32	1	2	3	4
REAR SKIRT	3	1	1	2	3	
FENDOR APRON - RH/LH	4	5	1	2	3	4
RWHO R/L	4	2	1	2	3	4
PANEL DASH	4	83	1	2	3	4
TUNNEL	4	14	1	2	3	4
DOOR HINGH RH	4	39	1	2	3	4
DOOR HINGH LH	4	35	1	2	3	4
PANEL BACK	4	37	1	2	3	4
PANEL DASH	4	26	1	2	3	4

Source: Unpublished, Compiled: By the researchers

We would first elaborate on the five major operations being performed followed by the analysis to carry out the improvement.

DRAWING: Drawing generally refers to the forming of sheet metal into convex or concave shapes. In this process the sheet metal is given the basic shape of the part using a hydraulic press. The basic shape is given for the first time using a force of 800 ton. Workers help in unraveling the sheets from the pile one by one. Suction cups are used to keep sheets at the right position on the female die for the drawing operation and is semi -automated. However at the end of the process wrinkling occurs which is removed using trimming operations.

Fig.1: The drawing operation of rear lower housing.

PUNCHING: Punching process which is very similar to blanking except the fact that the cut piece is called a slug or scrap. Various holes are punched into the drawn part wherever necessary to provide the space for fitting of the fasteners and other child parts. Here again a die is used to carry out the process. A force of 400 ton is applied by the male die on the female die to punch the holes wherever necessary and as per the part requirement.

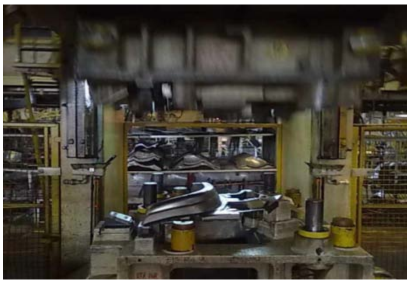

Fig2: The punching of rear lower housing.

CUTTING: In this operation shearing between two sharp cutting edges take place. The punch pushes into the work and causes plastic deformation. It then compresses and penetrates into the work resulting in a smooth cut surface. The fracture initiated at the two opposing cutting edges causes the separation of the sheets.Here it is carried out for symmetrical parts of the chassis where a mirror image of one part attached to it is cut off from it resulting in two parts at a time.

Fig.3: The waste collection of trimmed parts

TRIMMING: In this process the extra pieces of metal coming out from the part are trimmed away by using a male die. A high force is used to remove the pieces. The waste metal produced as a result of trimming and cutting is removed and reused.

RE-STRIKING: This process is important to obtain the final shape of the chassis using a male die as in the operations like drawing, punching and cutting the part would have been subjected to large forces due which it might bend.

Fig.4: The re-striking operation of rear lower housing.

The major waste in the press shop occurs in the form of scrap metal. When operations like punching and trimming take place then the pieces of metal are discarded from the workplace and loaded into a trolley. They are then loaded into the truck and sent back for melting and forming the sheets again. Thisprocess is followed in order to eliminate the existence of waste which is in the form of scrap materials and reducing a considerable amount of investment in raw materials as the scrap materials are melted and beaten to obtain sheets for further processing. This technique is a utopian example of lean implementation. It eliminates the waste generated to a large extent and has proved to be highly efficient for the industry. This pillar of lean manufacturing has fortified the industry's foothold.

2.2 Just in time manufacturing

The American Production and Inventory Control Society (APICS)define Just in Time as *"A philosophy of manufacturing based on planned elimination of waste and continuous* *improvement of productivity."*It involves timely arrivals at the workstation, reduced buffer stock, complete eradication of waste in the production system and a pull system throughout the plant. Thus, it exposes the problems and the bottlenecks, streamlines the production line making the operations completely smooth and strengthens the factory and warehouse networks. The primary elements of Just in Time include the inventory when required, improve quality to attain zero defects, reduce the lead times by reducing the setup time, queue length and size of the lots, keep revising the operations themselves and cost reduction as well.

In the current sequence of operations, just in time is effectively implemented. The dies are brought from the die storage areas via an electronic control unit when the production of a new part has to begin. This is necessary as the dies are each more than one ton themselves. The ECU places the female die at the designated position from where it is trolleyed beneath the male die attached to the hydraulic press. This ensures that the machinery stays in place and replacements of dies as per the requirements of parts is carried out, the final parts move through the operations mentioned before and are inspected manually and loaded onto the trolleys which are carried by the forklift to the assembly line.This state of the art technique and process clearly delineates the use of Just in Time Manufacturing principles.

The requirement of each part is clearly reciprocated to the managers so that the operations can be timed as per those requirements. Whenever there is a need for more parts due to higher production rates, the number of parts for that particular model is adjusted and the time for carrying out the operation is also varied. This prevents bottlenecks in the industry.

Fig.1: The loaded trolley to be carried by the forklift.

2.3 Mistake Proofing

Mistake proofing forms another pillar and a secondary objective of the lean manufacturing technique. In this automotive industry the major implementation of mistake proofing can be seen in the welding shop, where the child parts are welded together using spot welding. The operation is semi-automatic with the placement of these parts at the appropriate place and in an appropriate orientation done manually, but the welding operation carried out by robotic arms. The entire sequencing of operations is controlled manually as the delivery time of different parts varies according to the requirements and delivery at the right time. The initial step is to place the two child parts to be welded at the right spot. This is followed by the locking of the clamps to hold the parts together. If a worker makes a mistake in placing the wrong parts or improperly oriented parts the clamps would not fit in and the operation will stop. This is one way of implementing Poka Yoke. Once this step is cleared, and clamping is ensured, the operation is started manually. The robotic arm moves and performs welding as per the programming based on the type of parts being welded. Further, to ensure safety, infrared light is used to demarcate the premise of the operational area from the rest. This ensures that if any person steps in while the operation is in progress, the process will stop immediately and the light signals will turn from green to red. This is a major tool for ensuring safety and Poka Yoke in the industry.

2.4 Lean Leadership

There is a lot of emphasis going on the implementation of lean manufacturing techniques for the various benefits it offers. But only a very few of the many industries succeed in getting the true benefit and creating continuous improvement. This is because the focus in many such industries is mainly on the techniques and not on the involvement of the employees, who play a major role in governing the implementation of these techniques. This discrepancy can be eliminated by lean leadership. Shop floor workers might have a crystal clear idea of the weaknesses and glitches of the processes, but they cannot fix them alone. They need support from the management to carry out the desired improvement process.

Lean leadership is not a short term plan. It involves working on daily basis on the shop floor itself. There are new challenges and learning that an employee faces every day. Thus, coaching methods are used by the industries and so is the case with this automotive industry. It uses the Toyota Kata method of coaching which helps to make the continuous improvement process maintainable [10]. Lean leaders follow a certain set of rules to govern the implementation process. They are:

1. Reach the Gemba

Whenever a problem arises, the lean leaders should go to the place where it started.

2. Inspect

Brainstorm and analyze to see what could be the possible cause of the problem. Define all possibilities. The cause might be a process or people or product.

3. Take temporary actions

Some temporary steps have to be taken to alleviate the problem before it reaches to a stage causing a detrimental effect. This step might lead to some expensive measures being implemented, but they are unavoidable.

4. Find the root cause

It is the most necessary step. It is essential to find the root cause. Otherwise, the implemented solution would collapse soon. This is the penultimate step in the process.

5. Normalize

Once the root cause is found, the permanent solutions can be implemented. Revision of the current process and its standardization will have to be implemented.

3. CASE ANALYSIS IN THE IMPROVEMENT OF PROFITABILITY

The operations though comprising of an enormous number of parts in general for the purpose of making the frames of the multi-dimensional cars, have one particular thing in common: The use of the Mild Steel Sheet ordered from the common source. In order to maintain the uniformity in costing, transporting and delivery, sheets of one particular size are ordered: 1000 X 980 mm. But manufacturing of varied parts makes use of different volumes of sheets, wasting the rest. With the objective of the paper to minimize the wastage, we propose a hypothetical study of how much material is saved per unit per part of a manufactured automobile. The maximum usage of the Mild Steel Sheet volume occurs while the manufacturing of the hood of any car. About 92% of the sheet is utilized which means wastage of 8% equivalent to 0.0784 m^2 out of 0.98 m^2. Therefore: Input= 100, waste= 8; used = 92, for every 11.5 units of production, we have waste raw material of 92, which could be recycled to produce one additional unit. The recycling cost is about 25% of the original cost. If original cost = X, total cost for 11 units is 11X and for the next 0.5 units, it is 0.5 of 0.25X.It is also evident that with the decrease in mild steel usage, there will be reduction in the cost incurred by the industry. Though the processing of the waste steel into sheets will require processing costs, there is a net saving by the reuse. Thus, there is an overall decrement in cost, increasing the profitability. Though, one important consideration is that lean techniques could be done only in mass production and this cost reduction might prove to be a big factor of improving company's overall economic health.

4. DISCUSSION

This paper gives an overview of how broad the implementation of lean practices is in the Indian automotive industry. The level of lean manufacturing varies quite a lot depending on the operations to be carried, the requirements and the demand of the product and the type of technique that is best suited. Though the techniques that are implemented and mentioned in this paper have been there for quite some time, there is always the scope for continuous improvement. New concepts with the change in product, the change in operation and the change in requirements can be implemented to make the industry leaner and more efficient. This will enhance the productivity of the industry by building the principles and pillars of the lean manufacturing techniques. In order to improve further, the degree of continuous improvements in everyday business should also be discussed. How well are whereabouts related to the work with continuous improvements performed? Continuous improvements are important to keep up a good standard in everyday business. Unless and until we do not emphasize on the good standards, we cannot know the shortcomings. The four major aspects of lean are: philosophy, procedure, individuals and companions as well as problem solving. Most organization shave focused on the procedure and have eliminated waste by using one piece flow, error proofing, standardized work and many more. But they have neglected the other three aspects of lean. Finally, we discussed the importance of human resources through encouragement, training and coaching and how lean leaders can make a drastic change in the efficiency and productivity of the industry. All the pillars of lean enterprises bear the weight of continuous improvement of the industry. The automotive industry taken here for the case study is no different. The specifics of the industry were focused upon and the lean concepts were described using those specifics. The processes involved were elaborated and how lean techniques are implemented was analyzed. Moreover, a case study on the hood of a particular car model was demonstrated to show the quantitative effect of recycling waste material on the efficiency and profitability.

5. CONCLUSION

Lean is business strategy that will continue to be part of organizations. The right kind of techniques and their implementation depends upon the nature of the industry. Leaner the industry the better it is. Thus this change is appreciatively welcomed by the industries. It is only a lean enterprise which continues to promote and establish real continuous improvements. The focus of this paper is to illustrate the implementation of lean practices in an automotive industry in India and elucidate the benefits of the same. The pillars and principles of lean manufacturing: waste elimination, just in time, mistake proofing were elaborated and their qualitative effect on improvement of efficiency and productivity was analyzed. Another very important aspect of lean principles is lean leadership. In order to accomplish a better improvement culture, the lean leader needs to be a role model for his employees. The lean leader has to conduct a substantial gemba management. The importance of gemba seems to be widely known but enterprises might need new methods for the specific application [10].This paper gives an insight in the state of the art in lean techniques. It defines positive effects of using lean along with the prerequisites being able to effectively implement lean in the organization.

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