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Keys to Succeed in Implementing Total Preventive Maintenance (TPM) and Lean Strategies

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ABSTRACT

Competition is global and it continues to get more intense, with changes in technology, introduction of new and differentiated products and techniques. These changes are faster than what can be implemented. Profits are no longer driven by prices but with costs.[1] Customers have access to just about anything at their finger tips. The expectation like quick response, lower prices, flexible orders and quality products, is increasing every day from the customers. Our OEM's (Original Equipment Manufacturers) are searching for new methods of doing business and they expect their suppliers, like us to do the same. The challenge in front of us is how we respond effectively to these changing trends in the industry for our survival & growth. Change is the only certainty and the above is very much applicable to any business to achieve and sustain competitive edge. It is evident that organizations, which are innovative and visionary, have successfully implemented the change, realizing its business strategies would lead to their long term survival

KEYWORDS: *TPM, Lean Manufacturing, SWOT Analysis, Value Stream, Map Techniques*

I. INTRODUCTION

Growth in productivity does not stem from improved allocation of resources. It deeply focuses on new technology, new products, cost effective products, which are faster then we can expect and implement it. Profits are driven by costs not prices. customers expect more from us like quick responsiveness, lower prices, better quality, and flexible orders. It is a challenge to survive in the present scenario.[2] Quick responsiveness to the customer needs and expectations, are key services required for our sustainability in the market. Lean manufacturing is one of the best suited practices for quick responsiveness through integrating various processes like, high machine utilization, best utilization of man power, elimination of waste, mistake proofing. The main objective of this process is to control cost through focus on Zero breakdown, Zero accident, Zero defect. This paper starts with identification of gap through SWOT analysis. Outcome of the SWOT analysis helps to arrive at primary objectives to meet current expectations of our customers. To meet the changing requirements & expectations from our customers, we need to be more agile, which leads to improved responsiveness, More Cost competitive to address cost reduction expectation. Both these objectives can be attained by identifying the waste in the total supply chain and eliminating wherever possible, or minimizing where it is not possible to eliminate. The Exercise of identifying the wastes starts with application of value stream map techniques throughout the scope of the supply chain .Further, application of various lean manufacturing concepts and tools like information sharing, educating and developing vendors to bring them to our level of expectation like supply of self certified parts, just in time (two bin system, VMI).

II. PROCEDURE FOR PAPER SUBMISSION

Lean manufacturing or lean production, which is often known as "Lean", 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.[3] 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. Basically, lean is centered on creating more value with less work. Lean Manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) and identified as "Lean" only in the 1990s. It is renowned for its focus on reduction of the original Toyota seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. Lean principles come from the Japanese manufacturing industry. The term was first coined by John Krafcik in a Fall 1988 article, "Triumph of the Lean Production System," published in the Sloan Management Review and based on his master's thesis at the MIT Sloan School of Management. To improve the lean production system, Management should be willing to make some strategic changes in their way of working in reality; it is difficult to change from current manufacturing system to a new method in a single step. People need to understand the significant success factors of implementation and should be familiar with the concepts to overcome the resistance of fear to change. This will enable the organization to get maximum benefit out of the lean implementation. While 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; it should be noted that for many Lean implementations this list shrinks to the last waste type only with corresponding benefits decrease. To illustrate the state of this thinking Shigeo Shingo observed that only the last turn of a bolt tightens it—the rest is just movement. This ever finer clarification of waste is key to establishing distinctions between value-adding activity, waste and non-value-adding work. Non-value adding work is waste that must be done under the present work conditions. One key is to measure, or estimate, the size of these wastes, in order to demonstrate the effect of the changes achieved and therefore the movement towards the goal [4].

A. Benefits of Lean

Decreased cycle time, Less inventory, Increased productivity, Increased capital equipment utilization, Continuous improvement, Reduce total cost, Low manufacturing lead time, Increase in equipment efficiency.

B. Tools to Achieve Lean

5s, TQM (Total Quality Management), TCM (Total Cost Management), JIT (Just in Time), TPM (Total Productive Maintenance), Six Sigma etc.

C. Lean Implementation Pre Requisite

Strategy, Commitment, Objective, Identifying champions for the program. Communication, Establishment frame Work, Activity plan, Cost and time management reviews / audits, Execution Measurement and Evaluation

III. SWOT Analysis

Drivers for lean manufacture: To understand this in detail, SWOT analysis of AAL process and list the drivers and barriers to identify the need for lean manufacture is listed below.

Table.1 Drivers for Lean manufacture

STRENGTH	**WEAKNESS**
Technology	Old and traditional manufacturing process
In house testing facility	Poor utilization of machine capacity
Excellent knowledge and skill base	Moderate utilization of man power skill
Sufficient and good machine power	Lagging in mistake proofing
State of the art manufacturing facility	High process cost
Excellent financial stability	Low morale
Strong promoters like BFL/ARM	Less flexible to change
OPPORTUNITIES	**THREATS**
To adopt generation-next manufacturing process	Resistance from root level while change in process
To extract manpower skills	Validation of process
To reduction in manufacturing cost	Process sustainability
To introduce mistake proofing system	To bring in a culture change in the work force
To raise O.E.E & O.L.E to 85%	

Based on the above analysis, it is evident that, there is an absolute need for an organizational structure which facilitates smooth flow of information, material & funds and Lean manufacturing system which converts threats into opportunities. The lean manufacturing process plays a vital role in addressing today's volatile

market which is hard to predict and ever increasing demands of OEM's in terms of responsiveness to flexible schedules and cost reduction. TPM is the sub set of the lean manufacturing system and in this dissertation; an attempt is made to make use of value stream mapping technique to identify the wastes in the various manufacturing process and application of lean manufacturing initiatives like TPM methodology to eliminate / minimize the waste in manufacturing process, setup time reduction, machine down time reduction, zero defect component, unnecessary process elimination to build agile manufacturing system to address the objectives of this exercise . Starts with study of existing manufacturing process through application of value stream mapping technique to identify the wastes in the manufacturing process & ends with proposal of revamped VSM in meeting prime objectives of this dissertation. An attempt is made to explain the above process through detail study of Gear manufacturing process.

IV. Analysis of Existing Process in Gear Manufacturing

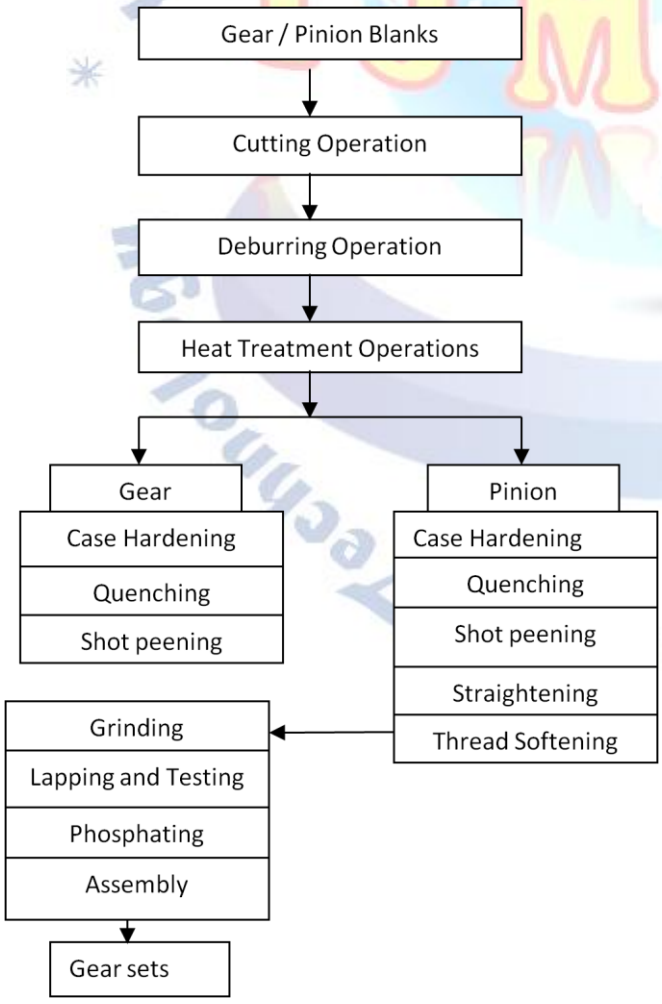

Fig:1 Gear manufacturing process

The objective of this project is to achieve the best manufacturing company with better utilization of man, machine and material with a minimum waste the focus on key areas are: Change in manufacturing process. Better cost control with minimum waste in the process. Scope of the project—the process starts from Receipt of material from stores processes in various departments like machine shop, gear and pinion soft cutting area, heat treatment process, lapping and testing process. The manufacturing process starts from machine shop to the gear set inspection area is the scope of this project.

V. Proposed Manufacturing Model

It concludes with all the improvement activities taken up at various manufacturing processes in various departments of the gear manufacturing and explains the proposed manufacturing model which will achieve the objectives of this dissertation and leads us to be the world class manufacturing company.

A. Defining the Production Rate

The first step in implementing lean system is to carry out initial calculations of critical parameters to define the production rate. These parameters are used to design new system based on the demand and effectiveness of the existing system. The parameters to be calculated are**:** customer takt time, [6]planned cycle time, overall equipment effectiveness. For the above calculations, the exact data of the demand for the type & quantity of the gear sets for axles (including OEM & spares).

B. Product Range

There are more than 9 series in which 50 different ratios are manufactured in automotive axle's ltd, where each ratio has a different specification. The steps involved in processing the different ratios are almost the same. The major series are:, R-149 series,R-149 forward series,Q-109 series,R-145 series,Rs-120 series,C-100 Series. The total demand for the gear sets on an average for the year 2007-08 is 12180 sets (in 5 cut method). This quantity will be considered for the future calculation.

C. Customer Takt Time (CTT)

The Takt time or customer Takt time is the rate at which customer required the product. Takt time defines the manufacturing line speed and the cycle time for all manufacturing operations of a product and becomes the heart beat of any lean system. The word "Takt" is derived from a German word

"takt", meaning rhythm or beat. Takt time determines the required production rate to meet customer's demand. *[Knowing how to identify 'fake flow' develops your eyes for recognizing continuous flow by Rick Haris].*Takt time is expressed as "second per piece", indicating that customers are buying a product once in so many seconds

Takt time is given by:

$$\text{Takt time} = \frac{\text{Net Available time per day}}{\text{Customer demand per day}}$$

The Takt time calculation is a critical calculation in lean line design, as it is the foundation for other calculations. The Takt time is determined based on the work load for each of the production cells in a day. The number of cells to be designed is five.

An 8hr shift, consists of planned breakdown of 30 min (includes breaks, Meetings, Planned maintenance, etc...). Hence, the standard operating time for a shift will be effectively 7.5 hrs. The calculation for the Takt time is as follows:

Demand for gear sets per month = 12180
Demand for a day = 12180/25 = 487
Number of cells = 5
Work load for each line in a day = 487/5 = 97
STD operating time for each shift = 450 mins
Num of shift in a day = 3
Planned operating time per day=450*3
=1350mins
Therefore Takt time = 1350 *60 /97
= 835.05 sec/set

The Takt time is approximated as 835 sec/set

D. *Overall Equipment Effectiveness (OEE)*

It is a hierarchy of metrics which focusses on how effectively a manufacturing operation is utilized. The results are stated in a generic form which allows comparison between manufacturing units in differing industries. Overall equipment effectiveness (OEE) offers a simple but powerful measurement tool to get inside information on what is actually happening in the system. The OEE concentrates on six major losses in the system as given below. Equipment failure, Setup and adjustments, Idling and minor stoppages, reduced speed operation, Scrap and rework, Setup loss. The calculation gives information on how effectively the machine or the line is functioning and which of six major losses needs to be improved. Overall equipment effectiveness is not the only indicator to assess a production system, but it is certainly very important if the goal is improvement.

$$\text{OEE} = \frac{\text{Net production time}}{\text{Planned operation time}} * 100$$

E. *Time Analysis for OEE Calculation*

In auto motive axle there are three shifts in a day for each having an 8 hrs (480 mins). For each shift there will be a planned down time is considered for 30 mins which includes Beaks, Meetings, PM, 5S etc. hence the scheduled up time for particular shift will be 7.5 hrs (450 mins). Other type of losses which usually occurs in up time is shown in below table.

Table.2 Time Losses

Time losses	Minutes
Setup time	38
Equipment failure	14
Defect cycle	15
R/W cycle/scrap	4
Lack of man/material	10
Changeover time	5
Total	86

The net production time =450-86 mins
= 364 mins

$$\text{OEE} = \frac{\text{Net production time}}{\text{Planned operation time}} * 100$$

OEE=(364/450)x100=80%
Therefore OEE loss will be about 20%

F. *Planned Cycle Time (PCT)*

The planned cycle time is the production rate required to meet the customer demand. If the work stations or operator are balanced or made to operate at Takt time, and then any variations like longer cycle time, scrap, rework, or different operators will cause not to produce the product at Takt time. Hence the takt time is adjusted for these factors by carrying inventory to buffer against these variations or by balancing the work at each station slightly faster then takt time to offset the variations. This is called planned cycle time (PCT).[7]

A good target for the planned cycle time is around 90 to 95 percent of the Takt time. The remaining time accounts for operator fatigue, minor interruptions in the cycle and variations in the processes between products. The above variations and other losses like down time, change over time and the breaks together come under O.E.E losses. Hence the actual PCT for a process is a product of actual Takt time and the OEE.

PLANED CYCLE TIME = Takt time * OEE
Customer Takt Time = 835 sec/set
Overall equipment Effectiveness = 80%
Planned cycle time = 835*0.80 = 668 sec/set

G. *Current Manufacturing Process*

In order to reach the target of the project, it is necessary to study the current manufacturing

processes in the gear manufacturing area in detail to identify the wastes in each process. This means each process in the gear manufacturing is studied for waste elimination, elimination of consequential operation and improvement in required operation. The value stream mapping is one such tool to achieve lean manufacturing.

H. Value Stream Mapping (VSM)

Value stream mapping is a technique used to depict relationships between critical processes in the value chain. Using VSM enables us to determine where barriers and inefficiencies occur and serves as a guide to reconfiguring processes to improve material flow. . VSM starts with materials received from stores to final book out of the gear sets down word stream gives[7] the clear picture of the gear manufacturing process and define specific action that will improve the material flow and decrease the lead time of the process. The process consists of four essential steps.

1. Mapping the current state of the value stream.
2. Mapping the future state of the value stream.
3. Collecting and documenting data on all systems of the value stream.
4. Creating a value stream, improvement plan, this includes key implementation factors, such as visual indicators, measurable goods, check points, and completion dates.

VSM is used to identify and plan improvements to the production system. VSM links three sets of processes or loops integral to the value chain-the customer loop, the internal loop and the supplier loop. Here we discuss only the internal loop to minimize the wastes in the gear manufacturing process chain

I. Major Concerns

1. More number of varieties: AAL supplies axle and gear sets to domestic and export market. The large number of varieties is due to huge geographical condition, Area of application, Customer taste and diversification of application area due to competition (As of now AAL is concentrate only on highway axles & now, we are also entering in to off - highway axles)
2. More number of setups: Even though our customers give a requirement for a month, it changes weekly which means more number of varieties results in more number of setup which pull the throughput time high.
3. Small batch quantity: Our customers order in smaller batch quantities in order to effectively manage their inventory, this leads to more setups in the production line.

To Maintain AAL as the leader in the Axle manufacturing, to compete with the global challenges and to fulfill the customer demand, requirement and cost. Implementing lean production through TPM (Total productivity maintenance) in the Gear manufacturing department to deal with the challenges, we need to

- Select one machine as model machine
- Study and implement how to increase the productivity by increasing the production time
- Study and implement how to get the best quality product
- Study and implement how to get the better safety
- Study and implement how to increase the machine uptime by correcting all abnormality in the machine
- Develop tools to study the validity of the above process
- Finally deploy all the activity of the model machine to all other machine

J. Post Kaizen Implementation

The planned & unplanned time losses after implementation.

Table.3 Planned & Unplanned Time Losses

Time losses	Minutes
Set up time	25
Equipment failure	25
Defect cycle	24
Rework/scrap	20
Lack of manpower/material	12
Changeover time	8
Tea time	4
Total	98

VI. Results and Discussion

After implementation of TPM the results are:

Table.4 TPM Implementation Results

Items	Before	After	Difference	%Of Improvement
Set Up Time	40 min	25min	15	37.50%
Overall Equipment Effectiveness	72.66%	78.22%	5.56%	7.65%
Planned Cycle Time	10.11min	10.88min	0.77min	7.61%

VII. Conclusion

From the above analysis, we can say that TPM is one of the best suited methods in Automotive Axles and a higher efficiency can be achieved with further implementation of [8] Total Productivity Maintenance which would lead to the achievement of Lean manufacturing. Result summary evidences the results of all the above actions in terms of P, Q, C, D, S, and M with comparison with the consecutive year's results.

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