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Bottleneck Analysis and Standardized Lean Tool to Improve Productivity in Automotive Industry

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Abstract— Industries in 21st century has been the customers and have become very competitive to satisfy the consumers demand. This project presents an experimental study made on improving overall efficiency and increase in productivity in assembly line. This article addresses on implementation of lean manufacturing tool (value stream mapping) by analyzing the operations status, bottlenecks, and the interdependence of the manufacturing activities between machines. The concept of project is to make parts single piece flow at a time from raw materials to finished goods and to move them one by one to the next workstation with no waiting time in between. Perfection achieved by continuous improvement process of eliminating waste and reducing mistakes while offering what the customer wants becomes possible [1]. Methodology adopted includes reduction of takt time results in the removal of bottlenecks by reducing cycle time. Apply the lean tool by method time measurement and line balance efficiency and reduce the cycle time in assembly line and improve efficiency in that product line. Also says that lean manufacturing is a business philosophy that continuously improves the process involve in manufacturing [2]. Hence, we could reduce the manpower as our goal is to provide employee satisfaction by implementation of lean techniques and thereby increase in productivity to meet customer demand which resulted in a cost saving benefit to company.

Index Terms— Bottleneck, Cycle time, Just in time, Lean tool, Productivity improvement, Takt time, VSM.

1 INTRODUCTION

Now a day's manufacturing industries are trying to develop their current production system and situation and continuously looking for lean tools and techniques in order to keep swiftness with the rapid changes of trend in consumers demand products. The present study focuses on assembly line as production system has many problems and Bottleneck is one of them. Time study is a work measurement technique for recording the cycle time of current process and analyzing the data to obtain time necessary for an operator to carry out at a defined rate of performance. Based on the time study the bottleneck identified and balanced the operation in assembly line [3]. In assembly line, allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the Takt time thus increasing the productivity. value stream mapping is an enterprise improvement tool to help in visualizing the entire production process, representing both material and information flow. Defined value stream as collection of all activities value added as well as non-value added bring a product or a group of products that use the same resources through the main flows, from raw material to the end customer by implementing lean manufacturing in recent year for reducing and eliminate waste as application of VSM for reduction of cycle time in a machining process. Various type of tools is applied to create a current state map of the assembly line and creates a future state map for improving process of assembly. As customers' requirements rise and the competition grows stronger, manufacturers forced to continue the improvement of their manufacturing processes[4]. Its aim is to maintain the required level of manufacturing quality and to enhance the efficiency while, at the same time reducing the manufacturing costs by increasing productivity. Bottleneck analysis is an approach to bussiness profitability improvement that enhances a company to use time as a stratergic weapon to win intensely in competitive global markets. added that are required to bring a product or a group of products that use the same resources through the main flows, from raw material to the end customer by implementing lean manufacturing in recent year for reducing and eliminate waste as application of VSM for reduction of cycle time in a machining process. Various type of tools is applied to create a current state map of the assembly line and creates a future state map for improving process of assembly. As customers' requirements rise and the competition grows stronger, manufacturers are forced to continue the improvement of their manufacturing processes[4]. Its aim is to maintain the required level of manufacturing quality and to enhance the efficiency while, at the same time reducing the manufacturing costs by increasing productivity. Bottleneck analysis is an approach to business profitability improvement that enhances a company to use time as a statergic weapon to win intensely in competitive global markets.

2. LITERATURE REVIEW.

For rejection of bottleneck in a manufacturing industry, to contain the takt time analysis for balancing bottleneck problem. Detailed survey of literature has the researchers. The contributions and directions of selective research works reported in the literature presented below.

Rahami AR, Muhammad al-Ashraf described a case where Lean Production (LP) principles adapted for the process sector of an automotive part manufacturing plant. Value Stream Mapping (VSM) is one of the key lean tools used to identify the opportunities for various lean techniques. Current State Map has been drawn to document how things operated on the production floor. Then, a Future State Map developed to design a lean process flow for LP initiative on a product through the elimination of the root causes of waste and through process improvements. The use of the VSM improved the approach in LP initiatives as it reveals obvious and hidden waste that affected the productivity of production. The VSM applied to assess the expected impact of a change in the production process resulted in savings (lower rejection rates) and to a certain extent, a positive view was due to the fact that there were substantial gaps between standardized work and real work ,this gap meant that workers did not follow strictly assembly standards and in continuous improvement sustainability on the production floor as operators are fully aware on the long-term commitment to practice Lean [5].Santhosh Kumar, Pradeep Kumar stated that assembly line balancing is the process of assigning operations to workstations along an assembly line, in such a way that the assignment is optimal in some sense. This paper deals with studying the existing operation time for assembling, line balancing to avoid station delay, and the implementation of lean tools resulting in a shortening of the cycle time in an assembly line. based on the studies, the main operations and strategy of the company and the time taken for the assembly line are calculated. Initially the cycle time of the total assembly was 90min., After the line balancing the cycle time has been reduced to 37.5min [6].Chitturi RM suggested Practical issues like how to calculate Takt time, where can we use continuous flow processing, what process improvements can be done, and how to handle different product families while mapping job shop operations using a standard. VSM were being explored and it was also explained that while drawing by pen and paper technique by a standard VSM in job shop operation where information is collected from the first to the last operation [7]. V. Ramesh, K.V. Srinivasan Prasad, T.R. Srinivas analyzed how Value stream mapping helps an organization to identify the non-value-adding elements in a targeted process and brings a product or a group of products that use the same resources through the main flows, from raw material to the arms of customers. In this study, a practical study carried out in a manufacturing industry for the manufacture of Machining Centre are being discussed. The main aim was to draw the current state value stream mapping for the main components like Base, Column, Cross Slide, Milling Head and Table. It discusses the reduction in the set-up time and cycle time that contained through the implementation. This paper also discusses the plan of action for improving the Future State Value Stream Mapping (FVSM). A FVSM for the manufacture of Base is drawn [8]

3 PRESENT WORK

The present study have been carried out in production industry, which manufactures automotive axles located in Karnataka (India). Present study proceeds with the mapping of the current state of assembly line. VSM process symbols being used to discuss the lean implementation process in the production industry. This mapping can be done by using various process symbols of VSM to visualize the material flow and information flow as the product flows in manufacturing line hence target of company is to increase productivity.

4. METHODOLOGY

4.1 Observation of current study assembly process

In present case study material moves from raw material store to finished items store through number of processes like washing, name plate engraving, pinion preload, oil seal & c/f press, lock nut torque test, air leak test, shim selection. Note down the cycle time required in each process and number of workers required. The data collected in the form of time study conducted on the whole operations of assembly section. The time study table is as follows.

Table 1. Time study table of current process.

Sl. no	process	Machine type	Cycle time in sec	No of workers required
1	washing	Pinion washing m/c	60	1
2	Name plate engraving	Pneumatic machine	62	1
3	Pinion preload	Pinion cage assembly m/c	180	4
4	Oil seal & C/f press	Mico Oil seal & bearing press m/c	73	2
5	Lock nut torque	Torque testing m/c	43	2
6	Air leak test	Test with gas (helium) under pressure	72	1

4.2 Problem identified in pinion assembly

Process involved in pinion preloading is more complex and testing of torque is time-consuming method. The manufacturing process usually tracks down times or waiting times for machines. when there is bottleneck, the machine after bottleneck is holding up production and machine processing its output doesn't get through material to work continuously. Hence there is waiting time for movement of pinion carriage in conveyor is bottleneck problem as non-value-Added steps like transportation, over processing, defects, waiting etc. have been eliminated.

FIG 1: pinion cage assembly bearing press with torque test

FIG 2: carriage waiting time hence Bottleneck problem

4.3 Defining the specific objective and scope of the project.

Bottleneck identification in pinion cage assembly which add performance in terms of time – Takt time, Cycle Time, processing time. Improvement in existing methods by Work measurement data which helps by eliminating unnecessary non-value-added steps like transportation, over processing, defects, waiting etc. In a takt diagram, the process cycle times displayed and compared to each other with the takt time. The highest bar exceeding the takt time is the (current) bottleneck. To keep the cycle time of operation under the takt time, some improvements are being suggested in order to product to be completed within required time. By comparing the cycle time of current process shown in section figure 3.
Scope-Shifting activities from the bottleneck to other resources, reducing non-value-added work from bottlenecks

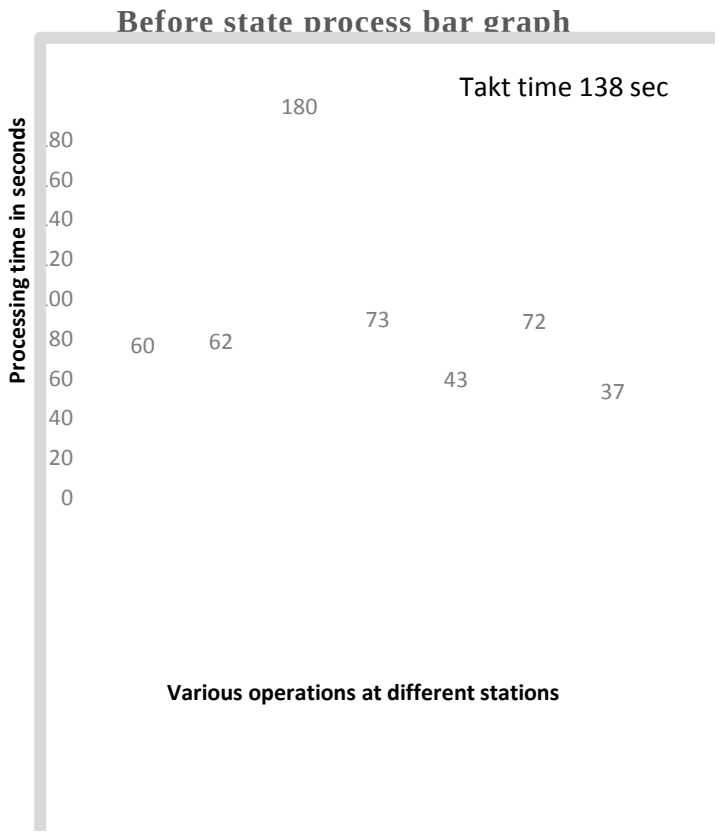


FIG 3: Before state process bar graph

The one operation having cycle time above the takt time. The operation with cycle time above takt time is pinion preloading. Rests of operations were well covered within the takt time. The total workforce involved was 12.

4.4 Calculate the Takt time

Mathematically, Takt time is the ratio of number of work minutes per day to the number of orders per day. Here, I took number of work minutes per shift and number of orders per shift. The shift was of eight hours from which lunchtime and two breaks time were omitted. Section 4 describes the calculation of takt time

TAKT time calculation
Demand = 180 pieces per shift
Available working time = 480 - 60= 420 min's per shift
(Excluding 30min's of lunch time, two fifteen min's break time from 8hrs of shift).
Effective number of days = 25 days
Number of shifts per day = 3
TAKT TIME= 420/180=2.3 MIN=138SEC

4.5 Elimination of bottleneck

The solution is to focus on improving overall efficiency of pinion assembly line. By reducing cycle time and takt time and distribution of workload at each workstation by line balancing. this technique is implemented by rearrange the existing machine by splitting the process of pinion assembly into two.

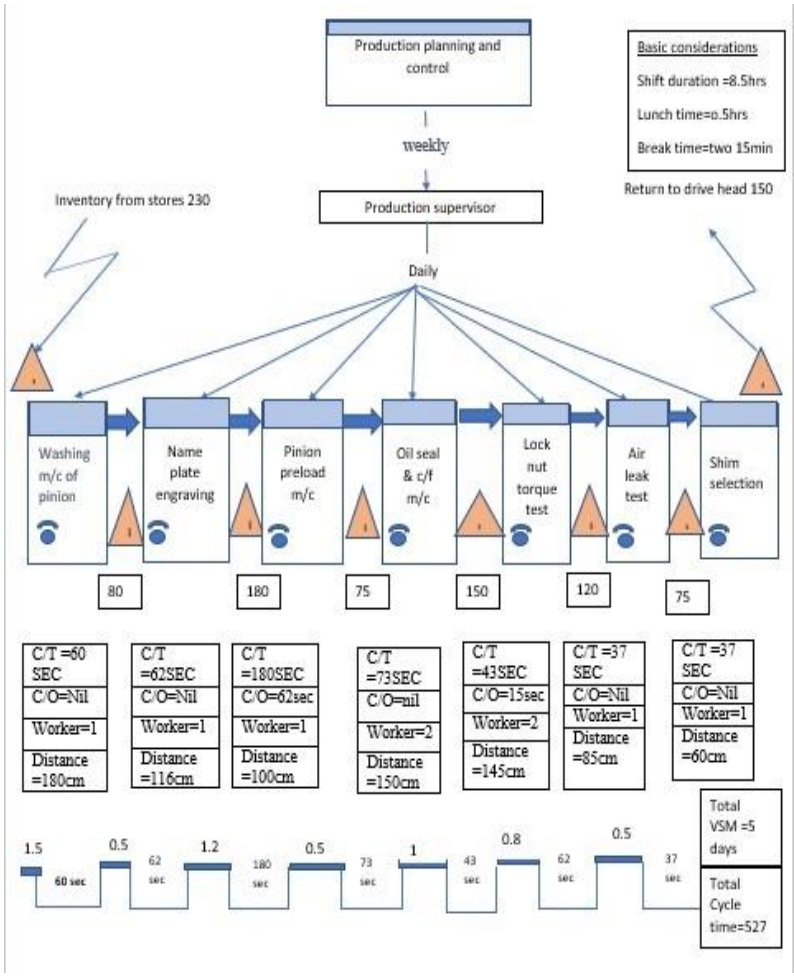
Present Pinion preloading operation

Current pinion assembly productivity/ shift= 150/ shift
Pinion preloading operation involved 180sec of cycle time having
Loading time =10 sec/single pinion
Value added time =80sec. Waiting time= 75sec
Unloading time =15sec.
As waiting time is very much high, so efforts were applied to reduce the queue time as much as possible. Before inner bearing and outer bearing is pressed inside the pinion by hand and torque testing leads to more time hence 4 workers were operating pinion preload operation. By incorporating '40T Press' hence non-value-added activity can be reduced. Hence 1 worker were required for 40 T Press and 1 worker for pinion preloading after the implementation. The concept requires automatically collected data of individual products (i.e. process cycle times). These cycle times are then accumulated per batch and integrated over time to receive the cumulative probability function for each product variant at each production step along the current value stream mapping tool and comparing the result from future value stream mapping.

I. Current state value stream mapping

Daily demand of pinion cage assembly is 180, effective number of working days are 25 per month, number of shifts per day is 3 and the working hours per shift is 420 min Excluding 30min's of lunch time, two fifteen min's break time from 8hrs of shift.
In order to draw value stream map following strategies applied:
1. Obtained information from company
2. Conducted time studies
3. Collect process data from shop floor observation.
4. Pen and paper method for mapping
5. Add data and time lines to the map
6. Identify 7 wastes of lean
7. Create the ideal value stream map.

FIG 4: Current Value stream mapping



4.6 Proposed change

Pinion preloading section of the industry is facing on time delivery problem of the product which leads to the customer dissatisfaction. VSM tool can localize the bottlenecks of a product. Takt time tool is implemented to overcome this problem. Some improvements were suggested in order to product to be completed within required time. The manufacturing process usually tracks down times or waiting times for machines. when there is bottleneck, the machine after bottleneck is holding up production and machine processing its output doesn't get through material to work continuously. Hence assembly operation activity is split-up by two machines. 40Tt press had been introduced were bearing with spacers are pressed and pinion preloading is used to check the torque. Hence eliminate wasteful activities by linking and balancing equal amounts of work steps together, enabling products has been consumed directly into the next step by single piece flow.

FIG 5: Introduction of 40 Ton press

4.7 Increase in Productivity

Shifting activities from the bottleneck to other resources, reducing non-value-added work from bottlenecks. Hence Pinion assembly productivity increased from 150/ shift to target of company 180/shift represented in graph

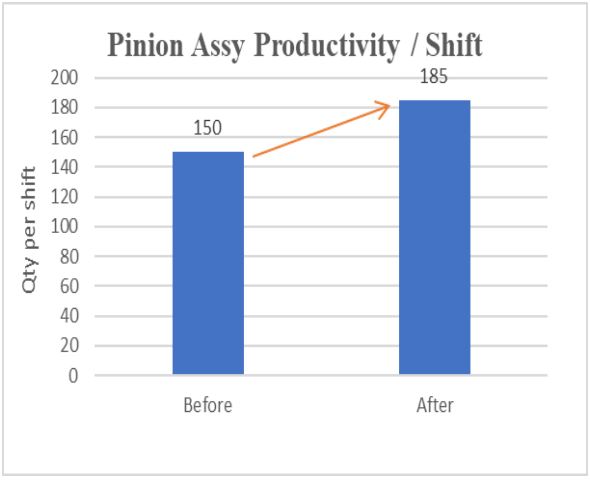


FIG 6: Productivity improvement

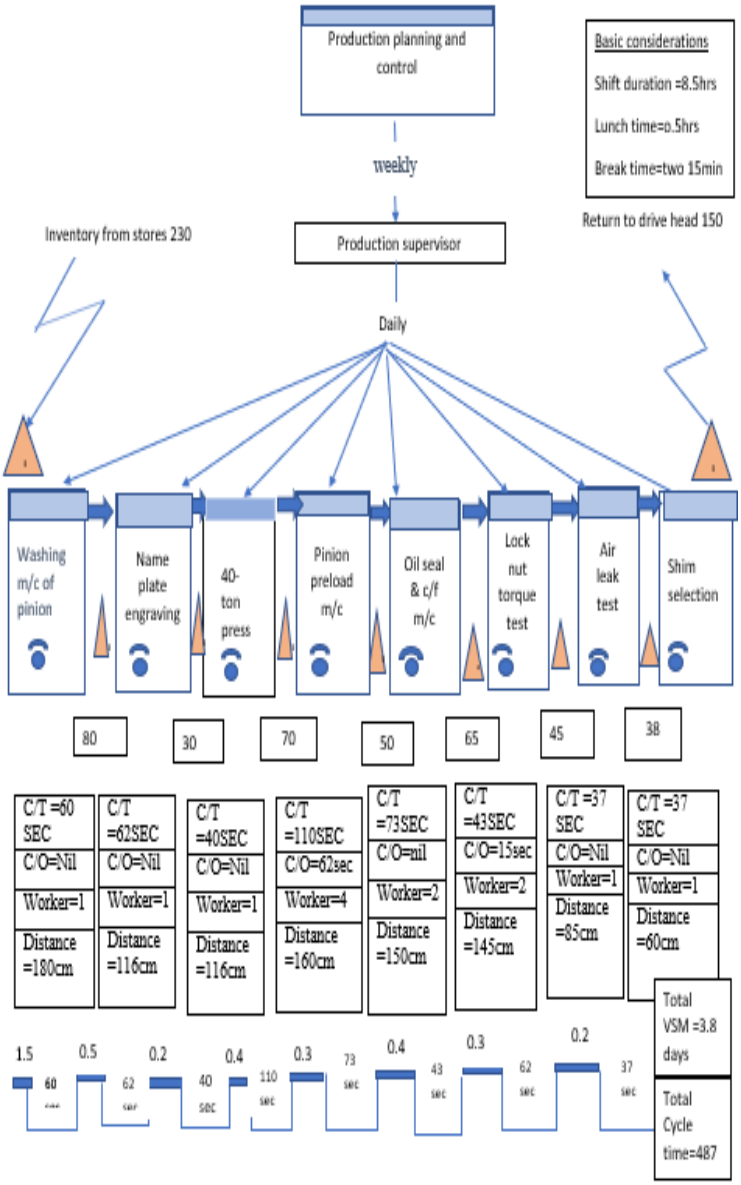
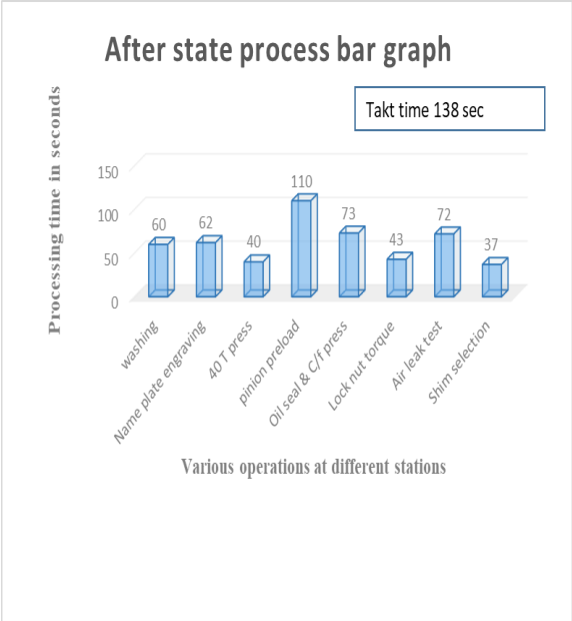


Fig 7 Proposed change implemented in future state value stream mapping

5. RESULTS AND DISCUSSION

After state process bar graph

The following graph shows the future state process's at different operation having all the operations of pinion assembly line was well covered under the takt time. Hence elimination of bottleneck problem. The analysis of the future state map shows the improvement by applying lean principles and techniques in order to achieve the objectives. Evaluation and comparison of results as shown in the below table.



6. CONCLUSION

Table 2: Comparison of results of pinion preloading operation.

PINION PRELOADING OPERATION			
ELEMENTS	**BEFORE STATE**	**AFTER STATE**	**PERCENTAGE REDUCTION**
VALUE ADDING TIME (SEC)	80	40	50%
LOADING TIME (SEC)	10	10	0%
WAITING TIME(SEC)	75	15	80%
UNLOADING TIME(SEC)	15	15	0%

SL. NO.	PARAMETERS	BEFORE	AFTER	PERCENTAGE REDUCTION.
1	Total lead time (days)	5	3.8	24%
2	workforce	12	10	17%

Table 3 Comparison of parameters.

In this research, we observe that the total lead in the current state map which is 5 days has been reduced in the inventory levels of the process with the help of implementation of 40 Ton press, which almost reduces the inventory level and waiting time by 3.8 days. All the above factors are great contributors to the reduction in the total lead time that is of great value to meet the customer demand. Total number of workforces reduced from 12 to 10 or 17% reduction. VSM is a powerful tool for lean manufacturing and allows firms to understand and continuously improve its understanding towards lean. VSM done in the same way for practically any business activity. Thus, identifying the importance of VSM from the above review this research proves the utility of value stream mapping as an effective tool for lean implementation which is very useful in contributing both to research field and for organizational benefits.

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