

Production Line Analysis via Value Stream Mapping: A Case Study in Pakistani Manufacturing Firm

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ABSTRACT: Improved Productivity, Reduced Lead Time and Reduced Wastes are some of the goals industries are trying to achieve to stay competitive in the market by adopting lean manufacturing techniques. For this purpose a number of lean tools and techniques are implemented in industries. The goal of this paper is to apply one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the assembly line in a manufacturing industry in Pakistan as a case study, as Value Stream Mapping (VSM) is a commonly assessed method employed for manufacturing process analysis. The methodology of the study is to firstly map the existing stage of manufacturing with the help of current Value stream map and to identify the waste areas in the assembly line, secondly to use the Kaizen activities to effectively support future state map for assembly line improvement. It consequently resulted in the improved productivity by 20%, reduced workforce by 47% and improved line balancing efficiency by 62 %.

KEYWORDS:Lean production, Value stream mapping, Lead times, Lean production, automotive industry.

I. INTRODUCTION

Efficiency and competitiveness are the two main goals for the firms in today's global market which forces them to adopt the new manufacturing method and strategies [1]. Delivering the goods and materials to the customers at low cost and high quality is the critical issue faced by most of the manufacturing firms. A number of methods and techniques are adopted to improve the productivity, efficiency and competitiveness of the firms such as Statistical analysis techniques, Six Sigma, Computer simulations and lean methodologies [2-4].

Lean manufacturing is one of the management approaches adopted by different manufacturing industries in different forms and names. Lean Production System (LPS) is the systematic approach of to identify and eliminate non-value added activities to increase the customer satisfaction [5]. It was originally invented by Toyota, Japanese automotive company, and known as Toyota Production System. The main goal of Toyota Production system was to improve the productivity by removing the non-value added activities [6]. Lean manufacturing is based on five principles stated as: specify value, identify the value stream, make the flow of value, construct a pull system by customer and seek perfection [6, 7].

A number of lean tools which efficiently help in removing non-value added waste activities include value stream mapping, 5S, Single Minute Exchange of Dies, Work standardization and Kaizen activities [8, 9]. Wastes are any kind of activities that use resources and incur costs but do not add value in terms of customer's perspective. Lean tools help in increasing productivity by focusing on details of manufacturing processes to remove the waste activities and processes. Value stream mapping is the tool which can be used as the start of the process of improvement through a systematic approach which consists of five basic steps i.e. Create a current state value stream map, Evaluate the current value stream map, identify problem areas, Create a future state value stream map, Implement the final plan [10]. This

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 12, May 2016

study is also based on the application of value stream map by doing a case study in an assembly line in one of the manufacturing industries in Pakistan.

II. CASE STUDY

A case study has been carried out in a leading manufacturing company which produces quality oriented Automotive and agricultural components in Pakistan. The company is currently manufacturing lot of automotive parts such as Silencers, Lever parking Brakes, Sheet Metal.

The company is ISO 9001:2008 certified company with reliable business partners in more than 15 countries which are further connected with the local partners in their respective area. The main processes that are handled in the company are, CNC Machining, CNC Wire Cuts, Press Section, Welding Section, Arc Welding, Argon Welding, Spot Welding, Seam Welding, Brazing and Assembly lines. In order to carry out this case study, a team was formed with the quality assurance and control staff in the said company. Being high in demand, Car's Hand brake assembly line was chosen as the candidate for the case study.

The data was collected according to the approach recommended by Rother and Shook [10] with the help of production planning and control department, and also by consulting the workers and operators at the assembly shop. The demand is forecasted on the monthly basis and the orders are received from the customers on weekly basis. The production control department orders raw material from suppliers on weekly basis and delivers the demand information to the line supervisor on daily basis.

Total demand per month = 30,000 pcs
No of working days in a month = 25 days
Demand per day = $30000/25 = 1200$ pcs

The No. of Processes + Inspections steps were 22 and no of employees involved were 21, Available Production Time per day was 8 hrs. And total Man Hours were 168 hrs. The initial layout of the assembly shop is shown in Figure-1.

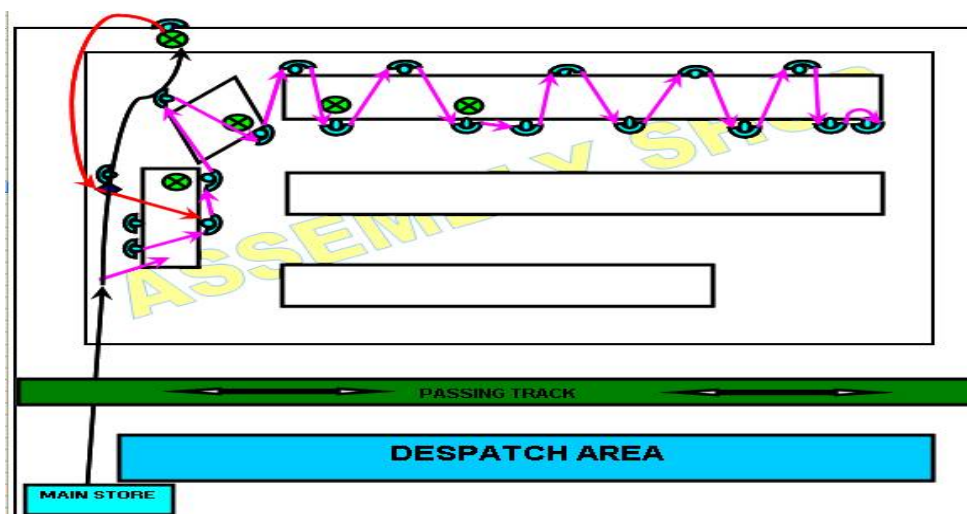


Figure-1: Layout of assembly line

The cycle time of each process is recorded and on the basis of the collected data, Takt time and line balancing efficiency was calculated to identify problems in the current state of a value Stream.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 12, May 2016

$$\begin{aligned} \text{Takt Time} &= \text{Available working time per shift} / \text{Customer demand per shift} \\ &= 8 \times 60 \times 60 / 1200 = 24 \text{ Sec} \end{aligned}$$

The analysis of cycle times of processes in shown in the Figure-2

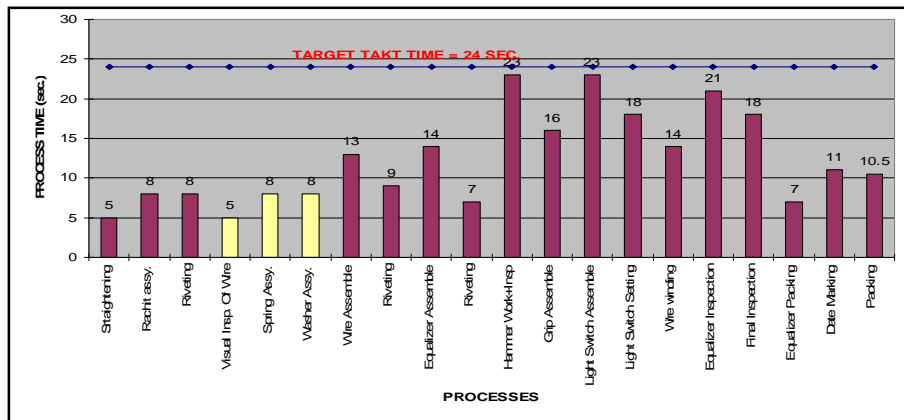


Figure-2: cycle times of processes

As the graph shows the Takt Time is 24 seconds but most of the time workers were not doing anything and there was a lot of free time for these workers.

$$\begin{aligned} \text{Line Balancing Efficiency} &= \text{Total Processing Time} / \text{No of Processes} \times \text{Longest processing Time} \\ &= 246.5 / 20 \times 23 = 54\% \end{aligned}$$

On the basis of the collected data, current value stream map was drawn using Microsoft Visio 2007 which is shown in Figure-3

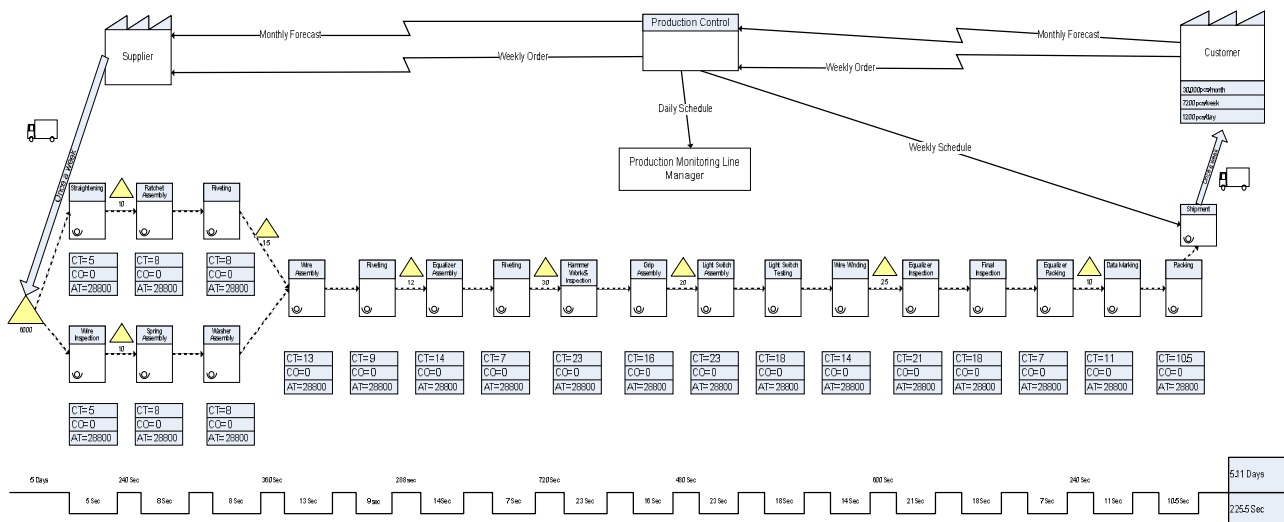


Figure-3: Current Value Stream map

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 12, May 2016

The current value stream map shows that, the total cycle time for hand brake assembly is 225.5 sec whereas lead time is 5.11 days. The hand brakes are being delivered to the customers on weekly basis. Further analysis shows that there are many wastes and non-value added activities in this process. First of all there are 7 work-in-process inventories on the way from raw materials to final products. These inventories cause the lead time to increase very much with respect to the total processing time. There are some non-value added activities such as inspection and rework at some stages (4 inspection activities out of 20 total activities). Another important point to notice is very low line balancing efficiency, which is 54 percent for the current situation. While the Takt time is 24 seconds, the cycle time for 17 of our sub processes are less than 20 seconds and only 3 of them perform with cycle times more than 20 seconds. This situation leads to lot of waste of labour force. 11 of workers have more free time than working time. The ergonomic situation of workers is also another problem at the production line. They face different discomforts during their work time that lower their performances.

III. PROPOSED CHANGES FOR THE FUTURE STATE MAP

After carefully examining the assembly process of hand brakes, it has been found out that there is line balancing inefficiency. A number of lean methodologies were adopted such as combining the processes having cycle times less than Takt time. Bottlenecks were identified and removed. In addition, 5S principles were implemented to eliminate waste that results from a poorly organized work area (e.g. wasting time looking for a tool). A number of proposed improvements were suggested and implemented in the assembly shop, to improve the line balancing inefficiency, which are:

- To save extra time and efforts for putting the Sub Parts on Table, “Proper Bins and Cartons are now placed on the table with arranged parts”.
- Table heights were lowered to facilitate the workers in getting and putting items from bins on the table.
- The Rib straightening process was being done by one worker in assembly shop. The ribs are now being rectified at the Paint shop.
- Three workers were involved in the processes of Rib Straightening, Equalizer Assembly and Riveting. Now one worker is doing all operations.
- Wire sub assembly was carried out by 3 workers. One worker is now doing these operations.
- Placement of Material at Wire & Nail assembly was disorganized. Bins are placed.
- For Nail & Wire Assembly adjustment or holding, worker faced problem. Fixture for Wire & Nail Assembly was developed to facilitate the worker and smooth operation with less time & efforts consumption.
- Wire Assembly & Nail Riveting was done by 2-Workers. One worker was facilitated to perform both operations.
- Equalizer Assembly & Riveting was done by 2-Workers. One worker is doing the same two operations.
- Riveting Machines Pedals were placed at height from the floor causing uncomforted to worker. Pedals were placed on the floor for easy pushing.
- There was too much work in process during Hand Brake Assembly. Work in Process was reduced from over 125 pieces to less than 20 pieces.
- Grip Insertion Machine was used to be rotated back manually after the process. Machine was modified for automatic operation.
- Equalizer was packed with carton strip and wire was winded by 2 workers. Processes combined.
- Date marking and final packing was done by 2 employees. Processes combined.

After implementing all these improvements, the new Assembly shop process layout is shown in Figure-4.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 12, May 2016

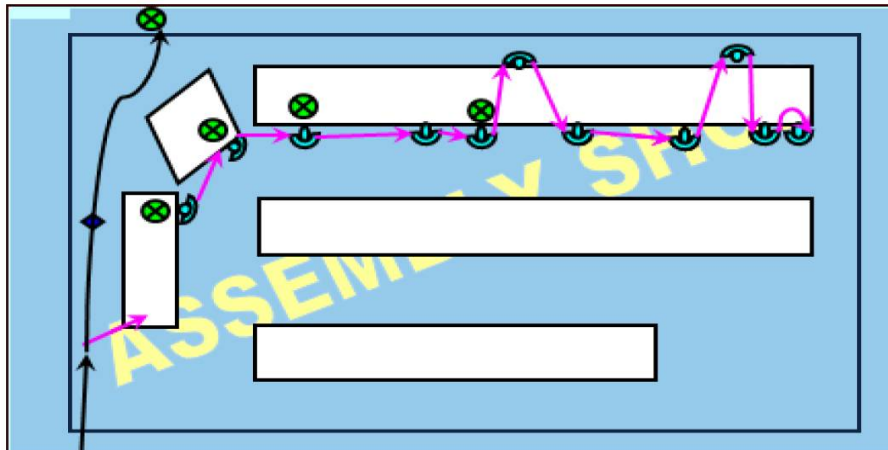


Figure-4: Future layout of the Assembly line

Based on the improvements the future value stream map was drawn and shown in the Figure-5.

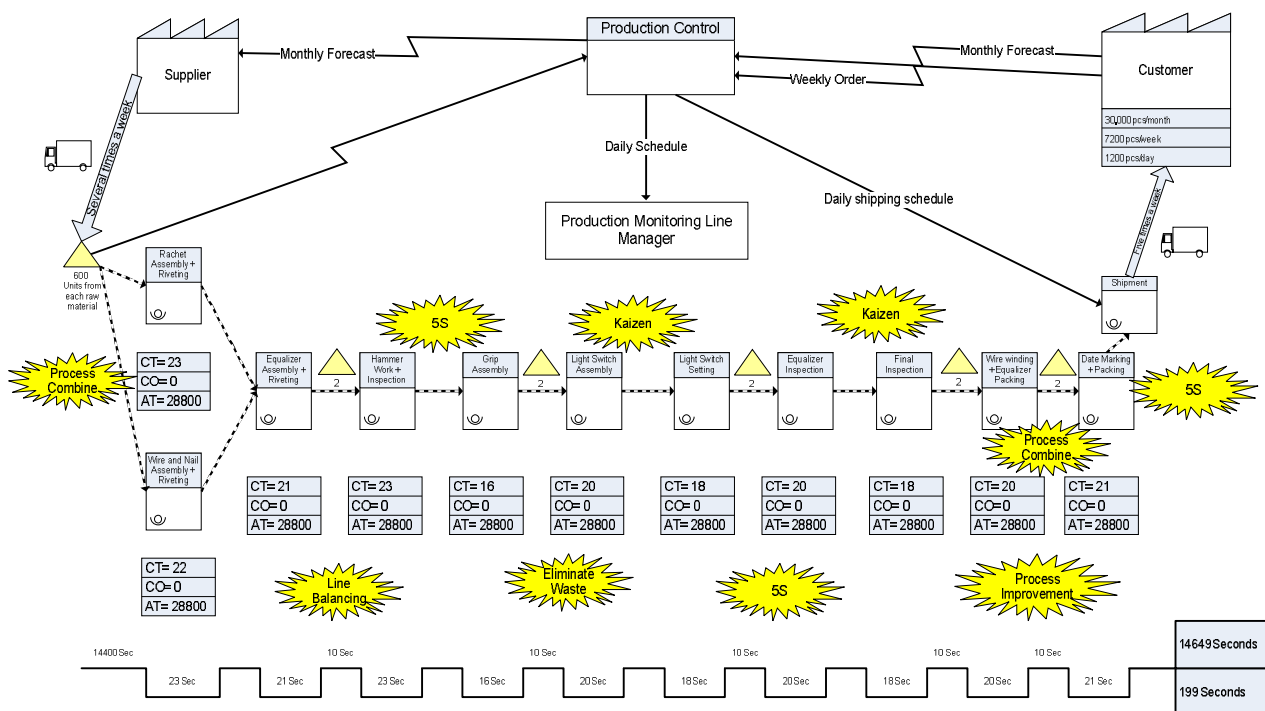


Figure-5: Future State Map

IV. RESULTS

After implementing all the suggested improvements, the line balancing efficiency has been improved from 54% to 88% and the Figure-6 shows the Takt time and cycle times of the processes.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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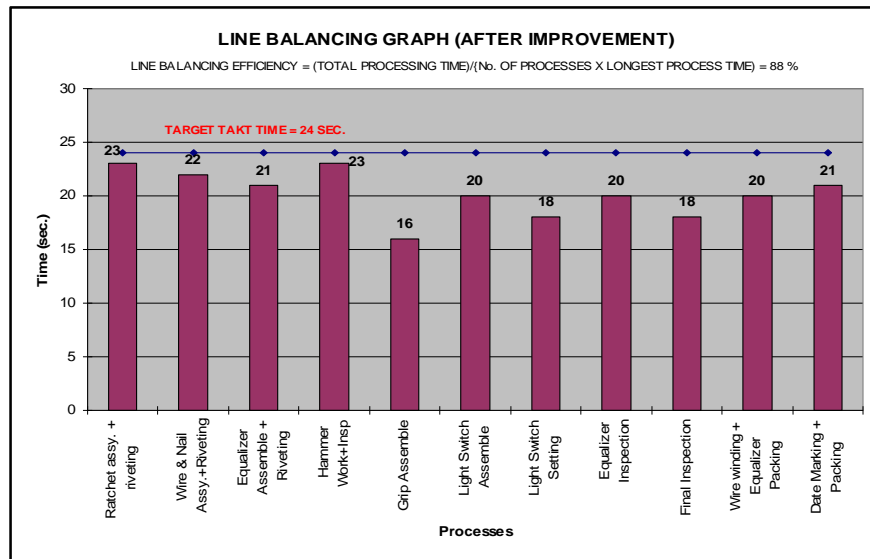


Figure-6: Cycle time after improvement

The no of workers has been reduced from 21 to 11 and line balancing efficiency has also been improved from 54% to 88%. Production per hour has been increased from 125 pieces to 150 pieces per hour. Man hours have been reduced from 168 to 88 hours (Figure-7).

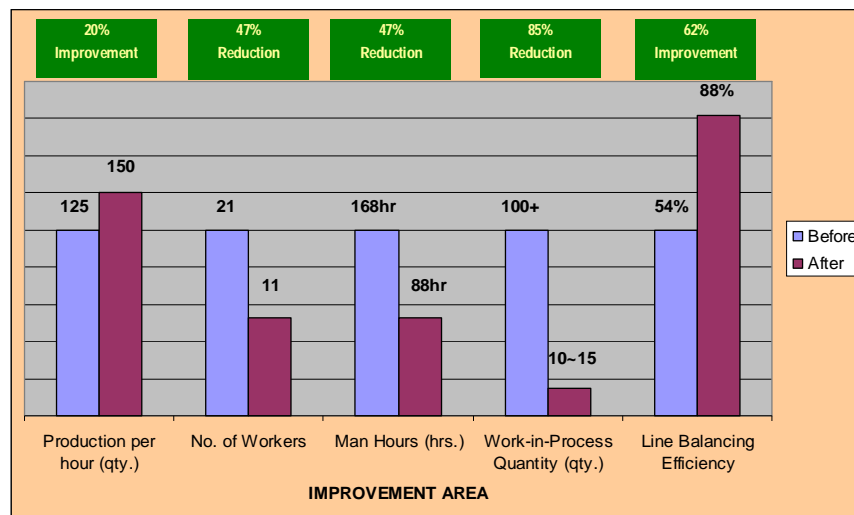


Figure-7: Results before and after

V. CONCLUSION

The goal of this paper was to do line balancing in the Assembly shop of a manufacturing industry in Pakistan for their Hand Brake Assembly shop using value stream mapping and other lean methodologies. Before implementing the improvements the Assembly line was balanced inefficiently with 28 seconds of Takt Time and 19 activities and 21 workers were involved in the process of assembly. Most of the time, workers were sitting idle because of line inefficiency. After improvement, the no of workers has been reduced from 21 to 11 and line balancing efficiency has

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also been improved from 54% to 88%. Production per hour has been increased from 125 pieces to 150 pieces per hour. Man hours have been reduced from 168 to 88 hours. The newly designed layout of the assembly shop with fewer workers involved and more efficient work process will defiantly effect the organization. There will be less cost of the assembly process, line will be more efficient, the free workers can be used for some other works, and there will be short lead times for the production and customer deliveries will be on-time.

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