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Application of Lean Manufacturing Tools and Techniques: A Case Study in a Manufacturing Industry

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Abstract: Industries of this generation are spending a considerable amount of money in Research and Development sector to invent and discover new technologies that would help them increase their profits. Lean Manufacturing is a manufacturing philosophy that is now being adopted by many of the big industrial giants across the world to improve the current process. This study applies lean manufacturing tools and techniques to an automotive parts industry located in the Gujarat state of India. The current state of the assembly line is plotted using Value Stream Mapping, a tool of Lean Manufacturing. The processes performed in the current state which were not adding any value to the finished product were then selected as opportunities for improvement. Various lean manufacturing tools were then applied to these processes to either eliminate them or reduce their impact on the total production time. After the implementation of these improvements, a Future State Value Stream Map was plotted. It was possible to reduce the total production lead time from 16.39 days to 6.67 days. Also, 160.3% improvement was done in the total production capacity of the company.
Keywords: Lean Manufacturing, Manufacturing Industry, Automotive Industry, Value Stream Map, VSM, Cellular Manufacturing, Time Study, Single piece flow, One piece flow, Line Balancing, Kanban, 4M, Fishbone Diagram, 5WHY

I. INTRODUCTION

In this fast pacing world, the demand for cars has been increasing substantially because the standard of living of people is also rising. They now prefer using private cars for their daily requirements and therefore, the number of people using the public mode of transport is decreasing gradually. Due to this increased demand, the industries or companies relating to the manufacturing of automotive products or vehicles have seen a surge in the total product requirements. However, the traditional way of manufacturing sometimes looks incapable of efficiently meeting these requirements.

Lean manufacturing is a relatively new concept invented by Toyota Production System (TPS) from Japan. After World War II, Japan struggled to meet the high demand for vehicles and limited capital. Therefore, Toyota Production System came up with a new way or new perspective towards manufacturing called “Lean Manufacturing”. Lean Manufacturing focused on the elimination of waste occurring in the process. This methodology broke down all the activities of the process to properly analyse each one of the activities and thereby categorized these activities as value adding, non-value adding and necessary non-value adding activities. Therefore, it becomes easy to reduce the process times of the activities that did not contribute well enough to increase the value of the final product. This is possible by eliminating such processes or changing the standard operating procedures of these processes. Lean Manufacturing uses various diagrams and flowcharts like 4M and 5WHY to perform root cause analysis of the entire process and helps in finding the problems which can be eliminated. Other tools of lean manufacturing include Cellular Manufacturing, 5S and Visual Management which keeps workplace organized, clean, and makes the workplace easy for employees to interpret.

Lean Manufacturing is not just limited to these processes. Another tool of lean manufacturing called KAIZEN meaning “continuous improvement” ensures that the process continuously evolves by taking into consideration the opportunities of improvement suggested by the employees working on it. Therefore, according to Lean Manufacturing, there is always an opportunity for improvement. Most of the organizations around the world have already started implementing these Lean Manufacturing tools and techniques into their daily routines in production or manufacturing. However, there are still many industries that are yet to implement this manufacturing philosophy.

The case study was conducted in an XYZ company situated in the Gujarat state of India. After the application of lean tools and techniques, improvement of 160.3% was possible in the total production capacity and total production lead time is reduced from 16.39 days to 6.67 days.

II. LITERATURE REVIEW

Lean Manufacturing is defined as a comprehensive set of techniques that, when combined and matured, will allow you to reduce and then eliminate the seven wastes. This system not only will make your company Leaner, but subsequently more flexible and more responsive by reducing waste [1]. Lean manufacturing has the term 'Lean' because it makes the current process run [1]:

- Utilizing less material
- Investing less
- Accumulating less inventory
- Consuming less space and
- Using the minimum required manpower.

Lean Manufacturing can be defined from three different statements given by Taiichi Ohno as "the TPS is a production system which is a quantity control system, based on a foundation of quality, whose goal is cost reductions, and the means to reduce cost is the absolute elimination of waste [1]."

According to Lonnie Wilson, there are various aspects that make the Normal Mass Production Model different from the new Lean Manufacturing Model. These manufacturing aspects include [1]:

- The makeup of the typical production cell/line and how quality is handled
- Handling multiple models of a product
- The use of "pull" versus "push" technology
- The issue of changeover times
- How parts and subassemblies are transported in the plant
- How finished product demand and supply variations are handled
- How quality is managed
- How cycle time variations are managed
- How line availability is managed

Therefore, Lean Manufacturing focuses on designing the current process such that it includes the following aspects [1]:

- Production cells flowing using pull production systems
- Balanced, so synchronized flow is achieved
- Producing at takt rate
- Using kanban to reduce inventory
- Rate and product mix leveled to minimize inventory
- Using cycle/buffer/safety stocks to handle internal and external rate fluctuations (while keeping cell production stable)

A. Value Stream Mapping

The term 'Value Stream' was coined by James Womack, Daniel Jones, and Daniel Roos in the book that launched the manufacturing transformation, 'The Machine that Changed the World' [2]. A Value Stream is the sequence of activities required to design, produce, and deliver a product or service to the customer, and it includes both material and information flow [2].

The use of Value Stream Mapping can be first traced back to a similar visual mapping technique used at Toyota Motor Corporation called "Material and Information Flow Mapping" [2]. Toyota Production System had achieved positive results after mapping such information and material flows and therefore it performed consistently throughout, even during the financial crisis in Japan [2]. Since then, Value Stream Mapping is used by most of the organizations that adopt or implement Lean Manufacturing philosophy.

The primary purpose of creating a current state and future state value stream map is to find out where the process can be improved by categorizing the entire process into value-adding and non-value adding activities [3]. According to Lean, value is defined as everything that the customer would pay for [3]. The value stream map also includes some necessary non value-adding activities that do not fall under Lean's definition of 'value'. However, these activities cannot be eliminated because they are essential within the process (quality inspections, etc.). Therefore, Value Stream Mapping helps to filter the activities and reduces the cycle times and production lead time by eliminating process times of these non-value adding activities. In other words, Value Stream Mapping is a lean manufacturing tool for achieving continuous improvement in the current state of the process [3].

B. Cellular Manufacturing

1) *Cell:* A cell is a combination of people, equipment, and workstations organized in the order of process flow, to manufacture all or part of a production unit [1]. A cell often uses one-piece flow, houses equipment specific for the cell, has a layout of ‘C’ or ‘U’ shaped for the purpose of easy monitoring, and employees cross-trained people [1].

In Cellular Manufacturing, the grouping of various machines or equipments specific to a particular cell helps in minimizing inventory because one-piece flow is achieved in this manufacturing strategy [1]. It also helps in reducing the wastes of transportation because both workers and machines are in close proximity to each other [1]. Therefore, workers get cross-trained and problem-solving is done by the involvement of the whole team.

Cellular Manufacturing employs workers who are flexible and cross-trained. As a result of this, it becomes easy for the organization to optimally use its workers and machines during times when there is a fluctuation in customer demand. This is an advantage of implementing Cellular Manufacturing because otherwise in Traditional Manufacturing, the organization operates at full capacity even when demand falls. Therefore, when the month’s demand has been met, it has to shut down its operations and then restart it when the demand again rises [1].

C. Line Balancing

Line Balancing helps to balance or synchronize the workload among all the workstations or processes [4]. Whenever there are variations in the process times of different processes, the slowest process defines the overall process time. The other workstations face some idle time and so, an unbalanced line contributes to the ‘Waste of Waiting’ and faster processes create inventory if the next process is slower. This also contributes to the ‘Waste of Inventory’. The purpose of Line Balancing is to balance the cycle times, bring all of them below theoretical takt time, and find the optimum number of workstations for the manufacturing line.

D. 5S

5S system is adopted by organizations so that the activities can be performed efficiently and effectively. This system focuses on putting the components to where they belong and keeps the workplace clean and sorted making it simpler for employees to work and also ensures their safety [5].

The term 5S comes from five Japanese words which when translated to English are: Sort, Set in Order, Shine, Standardize, and Sustain [5]. The benefits of implementing 5S methodology are improved quality, higher productivity, better employee experience, and a safer work environment [5].

III. METHODOLOGY

The case study was performed in a manufacturing industry of India to implement the tools and techniques of lean manufacturing. To achieve this, the contact information of many manufacturing industries in India was collected in the first step. They were approached either by e-mail or phone for approval to conduct a case study in the industry. Their responses were recorded in a formal document. In the second step, the companies which gave positive responses were visited. During the plant visits, interviews were held by the management departments and process improvement engineers of the respective organizations. After being interviewed by the companies, the case study to be conducted was finalized in a manufacturing industry located in the Gujarat state of India. The objectives assigned by the industry were to improve their current processes and improve their production capacity.

IV. CASE STUDY

The company manufactures and assembles automotive parts and supplies them to various automotive industries in Gujarat. The working hours of this industry are 8 hours (1 shift) in a day and 5 days a week. The average daily demand for these parts is 300. The processes of manufacturing these parts include Molding, Drilling and Assembly/ Fitting of Sub-Components, Final Assembly, and Quality Inspection and Packing. To convert the raw material obtained from the supplier to finished product, first of all, the Molding Process is carried out and then inventory is allowed to build for the entire shift. Once the components for the daily demand are molded, these molded components are then transported to a new facility within the plant to carry out further operations. The transportation activity takes around 20 minutes. After arrival at the new facility, drilling operation on these molded components is carried out with the help of a conventional hand drill. At the same workstation, other sub-components are fitted in the drilled-molded parts. These components are then transferred to the final assembly station which is carried out on an automatic machine. These final products pass through a quality inspection and when their quality is checked and approved by an operator, they are finally packed and transferred to the supermarket for shipping.

The industry can just produce 126 parts per day and therefore currently, it is unable to meet the customer demands. However, it is fulfilling these demands through the aid of safety stocks kept within the plant. To identify the root cause of this inability to meet the daily demands, firstly, Time study was carried out by measuring the times of all the operations involved. This study included noting cycle times, times of breakdowns, and change-over times. After conducting the Time Study, the understanding of the entire process was developed. The data on the flow of materials and information throughout the manufacturing process was collected. After gathering all the above information, a current state Value Stream Map was plotted.

The current state was plotted as shown below in Fig.1 with all of the inventory, safety stocks, supermarkets and receiving/ shipping information included. In the current state, shipments are sent to the customer on a daily basis and the raw materials are received by the industry's warehouse every week. The manufacturing philosophy followed by the industry is conventional i.e., the industry follows the Push System which means the individual processes process the product and then pushes it to the next workstation. This often results in building of inventory between the workstations. As shown in the current state VSM, the Molding operation takes place at one location and therefore it accumulates inventory throughout the shift. Both of the above-mentioned points lead to the "Waste of Inventory". Therefore, a separate space is required in the plant to accommodate this molded inventory which requires an extra amount of money for its handling. These components are transported to the next location (near the workstation two) 20 minutes before the shift ends. This transportation activity does not add any value to the required product and therefore it is marked as non-value adding activity leading to "Waste of Transportation". As mentioned above, the current capacity of the industry to produce automotive parts per day is just 126. Therefore, to meet the customer demands which is 300 parts per day, the industry has to keep and handle some safety stock within the plant which also requires some inventory handling costs. Also, as the Molding operation and other subsequent operations are carried out at two different locations, it is not possible to implement one-piece flow. Furthermore, the Production Control Department daily co-ordinates with all the different workstations by sending them daily production schedules to each of the process departments making the entire manufacturing process management tough to handle and control.

As currently, the industry is unable to meet the customer's demand. Therefore, calculations of takt time were done. Takt time is the minimum time at which we should produce the products to meet the customer demand [6]. If the cycle time of the process is above takt time, the process might not be able to meet market demand.

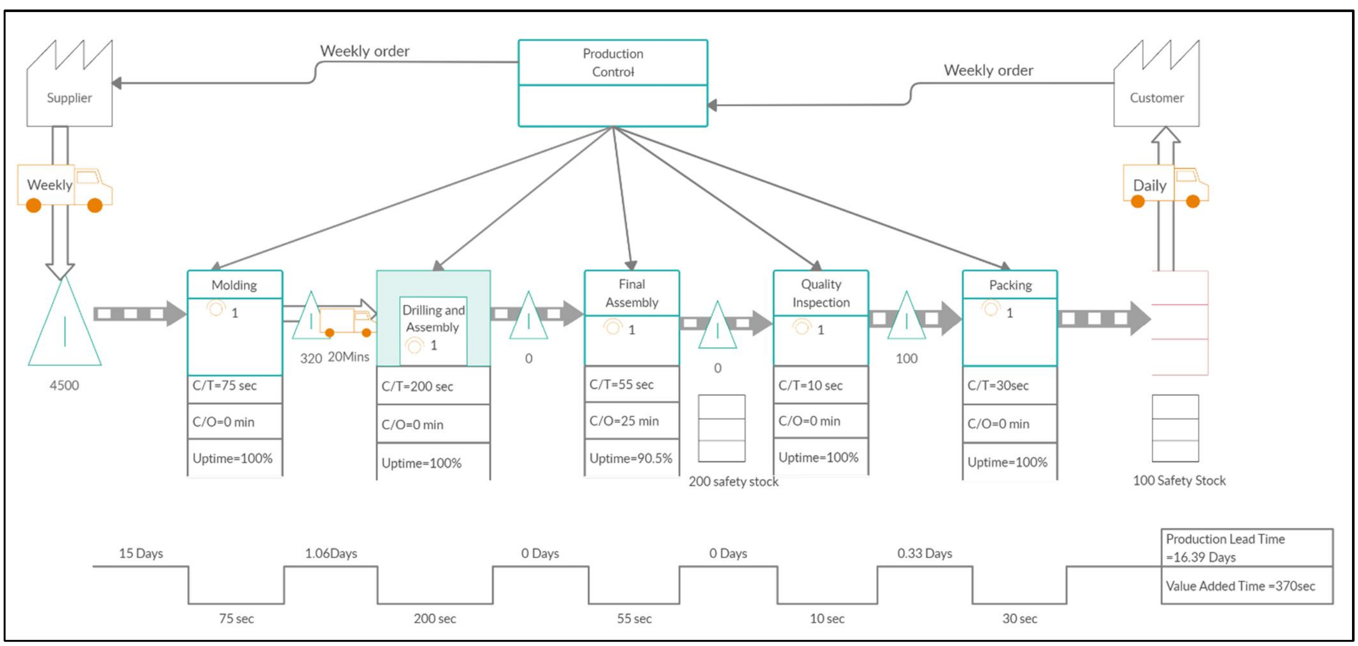

Fig. 1, Current State Value Stream Map

The industry works for 8 hours (1 Shift) in a day. The total break time for the employees is 60 minutes. Change-over time and Equipment Breakdown times are 25 minutes and 15 minutes, respectively. Therefore, Available time becomes (480 – 60 -25 -15) minutes = 380 minutes in a day. Also, Daily Customer Demand is 300 parts.

$$\text{Takt time} = (\text{Available time}/ \text{Daily Customer Demand})$$

$$\text{Takt time} = (380*60) / 300 = 76 \text{ seconds}$$

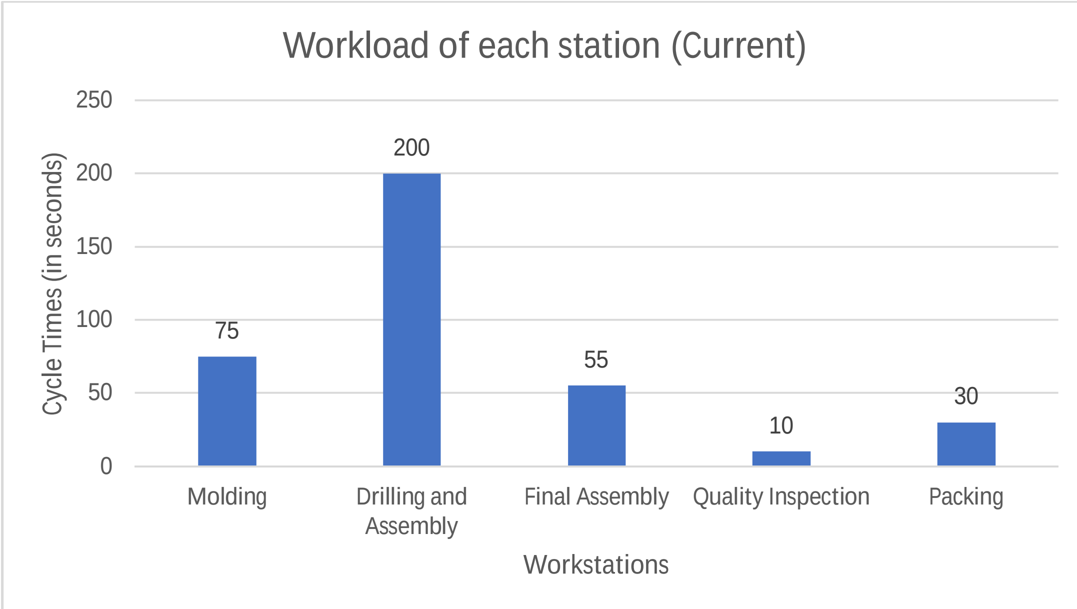

Fig. 2, Bar Graph representing workload (current state).

As seen from the above bar chart, it can be seen that the manufacturing line is not properly balanced. Some of the operators have too much workload due to which downstream operations have to wait for the parts to come and therefore, there is “Waste of Waiting”. The cycle time of Drilling and Assembly workstation is 200 seconds which is above the takt time (76 seconds). Therefore, the line needs to be balanced to distribute this workload among other operators.

After interpreting all the data plotted on the Current State Value Stream Map, a Fishbone (Ishikawa) diagram was constructed to further analyze all the major and minor causes for the industry’s inability to meet customer demands. This Fishbone diagram is shown in the below Figure 3.

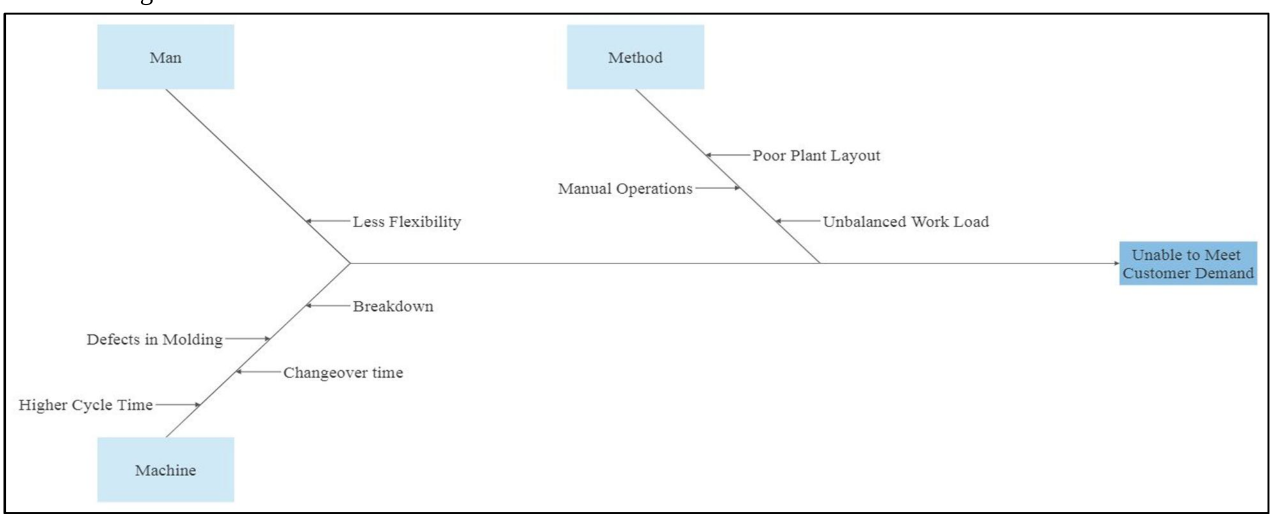

Fig. 3, Fishbone (Ishikawa) Diagram

From the Fishbone Diagram, the above causes were determined which contributed towards non-value adding activities, thereby increasing the cycle times of the operations within the manufacturing cycle. After constructing this diagram, Lean Manufacturing tools like 5WHY and 5W1H were implemented to identify the root cause of the problem. As mentioned above, in the current state, the Molding process is done at one location and other processes are done at another location. Therefore, there is transportation causing a delay of 20 minutes within the manufacturing cycle. Also, drilling operation is performed with the help of a manual hand drill which takes more time than required to complete the operation. Furthermore, the workers are not currently flexible to work in different departments. For example, the workers having less workload cannot assist another workstation during their waiting time. There is approximately 15 minutes of breakdown on an average per shift occurring in the final assembly machine.

Considering these causes delaying the operations, improvements were found using different lean manufacturing tools and techniques and the Future State was plotted on a Value Stream Map.

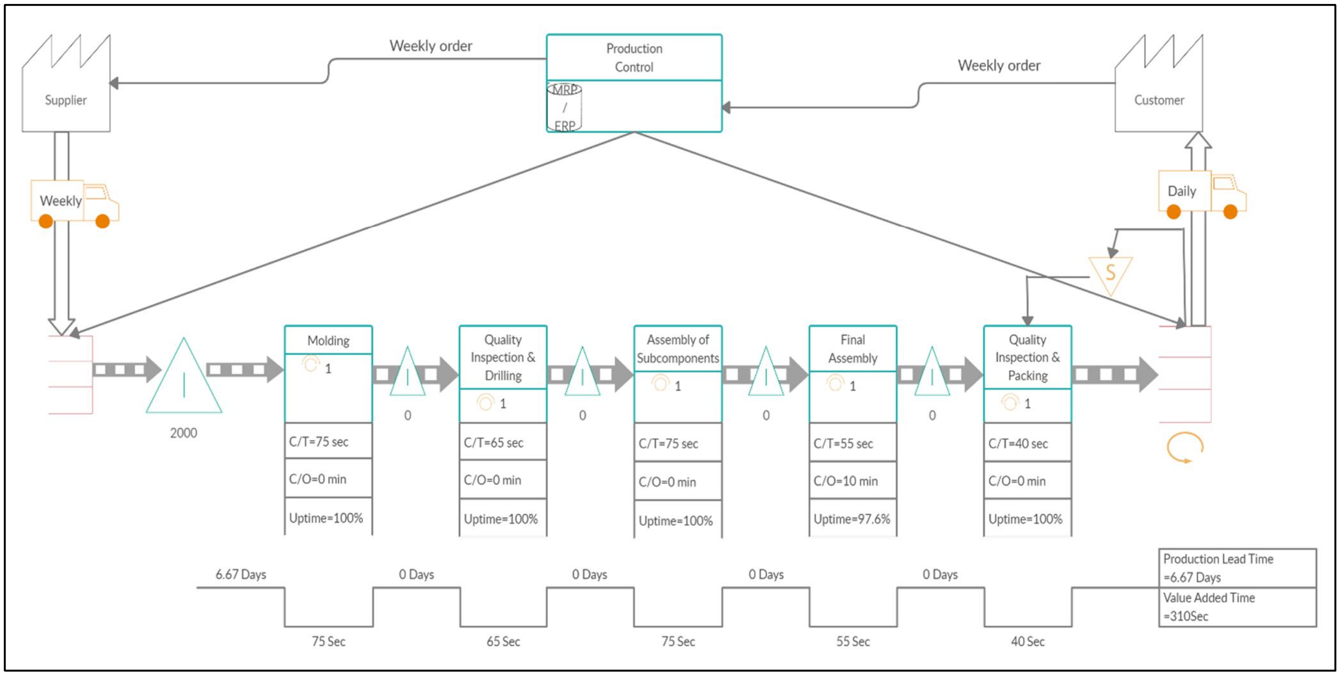

Fig. 4, Future State Value Stream Map

As discussed in the current state, the location of the molding operation was different from other operations. Therefore, in the future state, the entire process is combined into a single work cell where all the operations are being performed at a single location to facilitate the one-piece flow. This implementation eliminated the transportation of 20 minutes which occurred in the current state. Also, it eliminated the piling of inventory after the molding operation thereby reducing the "Waste of Inventory".

As it can be seen from the Future State Value Stream Map, breakdown occurring in the final assembly station is eliminated using the 5WHY technique of lean manufacturing. 5WHY technique led us to the root cause of the breakdown problem that was defective parts being produced in the molding operation. These parts caused a breakdown of 15 minutes (on an average) per shift in the final assembly machine. To eliminate this, quality inspection activity is introduced after the molding operation. Also, Single Minute Exchange of Dies (SMED) is used to reduce the change-over time from 25 minutes to 10 minutes. Therefore, the uptime improved in the future state. As mentioned before, in the current state, the drilling operation was performed using a conventional hand drill which took too much time to complete the operation. Sometimes, this manual operation led to rework which increased the cycle time. Therefore, the use of an automatic hand drill is suggested which has more precision than the conventional hand drill. This improvement not only reduced the rework but also improved the cycle time.

According to the concept of one-piece flow, the longest cycle time within the process defines the cycle time of the process. In other words, the operation taking the longest time to complete one cycle defines the cycle time of the entire process.

The minimum number of workstations required is calculated below for the current state,

Minimum number of workstations (current) = (Σt) / (takt time) = 370/ 76 = 4.86

(Here Σt = summation of individual cycle times of process = 75 + 200 + 55+ 10 + 30 = 370 seconds)

Therefore, minimum workstations required are 5. The current state also has five workstations that match with this theoretical calculation. Although the current state has five workstations, the industry is not efficiently meeting the customer demands because the line is not properly balanced. This improper balancing of the line is described in the subsequent paragraph.

In the current state, the longest operation was "Drilling and Assembly of Sub-components" that took 200 seconds to complete one cycle. Therefore, a finished will be produced every 200 seconds. However, the cycle times of other stations are less than 75 seconds. This huge difference in cycle times creates a difference in the workload of the operators. Therefore, proper and equal utilization of the workers was not done in the current state. Therefore, the line needs to be balanced to properly distribute the workload among workers.

In the future state, to balance the workload, "drilling and assembly of sub-components" which previously 200 seconds for one cycle (in the current state) is separated and a new workstation of "quality inspection and drilling" is made after the molding operation (in the future state). "Assembly of sub-components" itself was a long cycle-time process, therefore it is now kept at an individual process workstation, i.e., Workstation-3. Also, "Quality and Packing" is now a combined operation performed at Workstation-5.

To further reduce the cycle time, use of the 5S strategy is suggested in the future state. Successful Implementation of 5S can save time for searching the parts, avoid unnecessary movements, etc. The workplace is also now kept organized so that everything that the worker needs is within his reach. After making the above changes, the workload of operators (in seconds) against workstations is plotted on a bar graph as shown below.

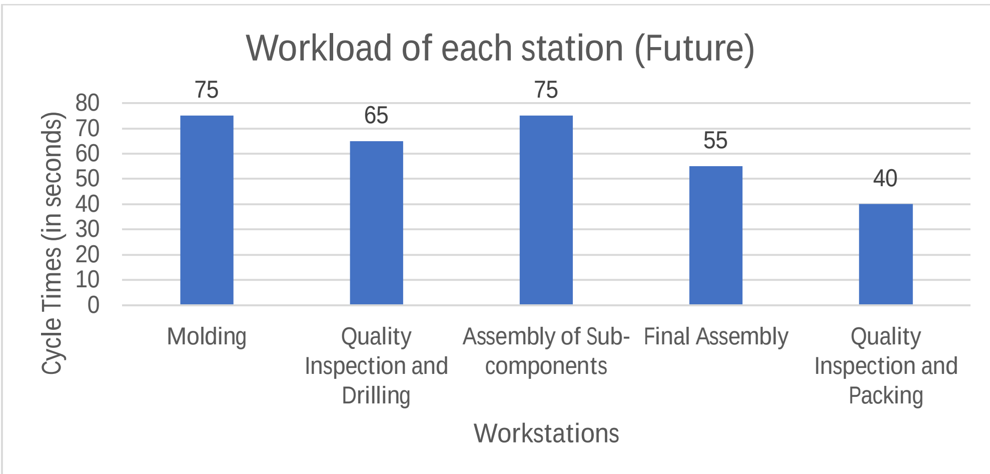

Fig. 5, Bar Graph representing workload (future state).

As it can be seen from the above bar graph, the workload is smoothened throughout the process and so, better utilization of workers is now possible. Also, the longest cycle time is reduced from 200 seconds to 75 seconds through line balancing. Therefore, every finished part now takes just 75 seconds to be produced. So, the capacity of production of the industry is improved and so, they can now efficiently meet customer demands without the need for "Safety-Stock".

Previously, in the current state, the push-type production strategy was being performed. But now, Signal Kanbans are used in the future state to promote pull-type production strategy. Therefore, now, only the required amount of parts gets produced. This eliminates the "Waste of Inventory".

V. CONCLUSION

To conclude, after the use of lean manufacturing tools and techniques, the breakdown time of 15 minutes is totally eliminated by introducing a quality inspection unit before the final assembly is done. Also, the change-over time is reduced by 15 minutes through the Single Minute Exchange of Dies (SMED). Therefore, the uptime was improved from 90.5% to 97.6%. Moreover, the production lead time was improved from 16.39 days to 6.67 days. The production capacity of the industry to produce automotive parts was increased from 126 to 328 in the future state. Therefore, the capacity of production is increased by 160.3 percent. The summary of improvements done throughout the study is shown below:

TABLE I

Summary Of Improvements

Sr. No.	Category(↓/→)	Current State	Future State
1	Breakdown Time	15 minutes	0 minutes
2	Change-Over Time	25 minutes	10 minutes
3	Production Lead Time	16.39 days	6.67 days
4	Production Capacity	126 parts per shift	328 parts per shift

The above improvements prove the importance of lean manufacturing tools and techniques in today's competitive world. This case study performed in an automotive industry implemented various lean manufacturing strategies to improve the state of the industry with little or no additional resource requirements. This study used tools like Value Stream Mapping, Cellular Manufacturing, Line Balancing, etc. to achieve the lean goals of the industry. After its implementation, the industry can now produce enough parts to meet customer demands on a regular basis.

REFERENCES

[1] L. Wilson, How to Implement Lean Manufacturing: McGraw-Hill Education, 2009.
[2] K. Martin and M. Osterling, Value Stream Mapping: How to Visualize Work and Align Leadership for Organizational Transformation: McGraw-Hill Education, 2013.
[3] What is Value Stream Mapping? Accessed on: March 5, 2020. [Online]. Available: https://kanbanize.com/lean-management/value-waste/value-stream-mapping
[4] Line Balancing. Accessed on: March 1, 2020. [Online]. Available: https://www.six-sigma-material.com/Line-Balancing.html
[5] What is 5S? 5S System is Explained Including Tips on Getting a 5S Program Started. Accessed on: March 6, 2020. [Online]. Available: https://www.5stoday.com/what-is-5s/
[6] What is Takt Time and How to Define it? Accessed on: March 6,2020. [Online]. Available: https://kanbanize.com/continuous-flow/takt-time