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Optimizing Manufacturing Performance by Minimizing Waste using Lean Practices

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Abstract - This project aims to reduce the wastages and the overall lead time in the manufacturing process for one of the crankshaft industries using Value Stream Map VSM and some other lean tools. It also aims to reduce the non-value-added activities in the manufacturing line to make the line more effective and to keep the production aligned. Here we have used Value Stream Map. First, the manufacturing line data was collected from the industry. Then current state map was drawn. By analyzing the current state map, non-value-added activities were identified which also includes some types of wastages. The wastes which we identified were the unnecessary motion of the component as well as the worker, inventory pile up and excessive scrap generation, rework on the component. The leans tools were used to reduce these wastes. The tools which we used are Kaizen, Poka Yoke, and some other quality tools. A future state map was drawn with the new and improved processes. This ensures that the processes are more effective and efficient. The result of this project was excellent as we were able to increase the process ratio by 8.69%. Therefore, it is effective to use lean tools on the manufacturing processes in the industries.

Key Words: Value Stream Mapping VSM, Lean Tools, Value Added Time, Non-Value-Added Time, Productivity and Wastages.

1. INTRODUCTION

Lean manufacturing principles have been widely implemented in industries to improve production efficiency and reduce operational costs. The main objective of Lean manufacturing is to minimize waste and add value to existing processes, thereby improving overall system performance. Lean tools focus on eliminating different types of waste in manufacturing systems, which helps in reducing production lead time and improving product quality.

Lean Manufacturing plays an important role in helping Small and Medium Enterprises (SMEs) become more competitive by improving the utilization of available resources, reducing human effort, and ensuring on-time delivery with expected quality standards. However, the implementation of Lean practices in many SMEs progresses slowly due to factors such as limited working capital, dependence on traditional technologies, poor management practices, and lack of proper employee training.

In today's competitive industrial environment, companies are under continuous pressure to reduce costs, improve quality, and deliver products on time. Customers demand high-quality products at lower prices, which forces industries to continuously improve their production systems. Lean Manufacturing provides a systematic approach for identifying and eliminating non-value-added activities in production processes.

The concept of Lean gained global recognition through the success of the Toyota Production System. By eliminating waste such as excess inventory, waiting time, unnecessary transportation, and defects, organizations can significantly improve productivity and operational efficiency. In this project, the existing manufacturing process of the selected industry was studied and analyzed using Value Stream Mapping (VSM). TAKT time was also calculated to understand customer demand and production flow. Based on the analysis of the current state, a future state layout was proposed to reduce waste and improve overall production efficiency.

2. LITERATURE REVIEW

Alvarez R., Calvo R., et al. (2009) conducted a significant study titled Redesigning an Assembly Line through Lean Manufacturing Tools, published in the International Journal of Advanced Manufacturing Technology. The study focuses on improving manufacturing performance by redesigning an existing assembly line using lean manufacturing principles and tools. The authors identified that traditional assembly lines often suffer from multiple inefficiencies such as excessive work in progress inventory, long production lead times, poor workstation layout, unbalanced operations, and unnecessary operator movements.

Chiarini A. (2014) conducted an important study titled Sustainable Manufacturing Greening Processes Using Specific Lean Production Tools: An Empirical Observation from European Motorcycle Component Manufacturers, published in the Journal of Cleaner Production by Elsevier. The study explores the relationship between lean production practices and environmental sustainability, particularly in European motorcycle component manufacturing companies. The author begins by highlighting that modern industries are not only

expected to improve productivity and reduce costs, but also to minimize their environmental impact.

F. K. De-La-Cruz-Arcela, J. S. Martinez-Castillo et al. (2019) presented a study titled Application of Lean Manufacturing Tools to Reduce Downtime in a Small Metalworking Facility in the IEEE International Conference on Industrial Engineering and Engineering Management The research focuses on reducing production downtime in a small- scale metalworking company through the systematic implementation of lean manufacturing tools. The authors begin by explaining that small and medium sized enterprises in the metalworking sector often struggle with frequent machine breakdowns, unplanned stoppages, inefficient maintenance practices, and poor workflow organization

3. METHODOLOGY

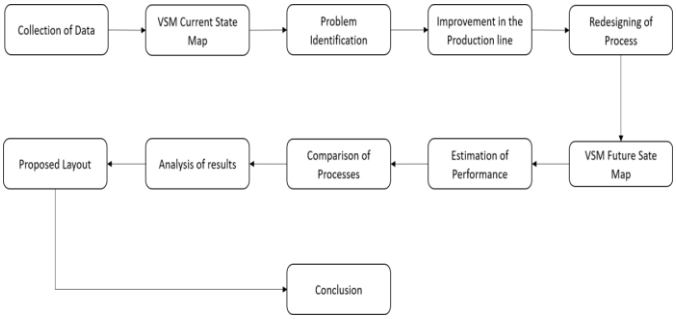

Fig -1: Methodology Block Diagram

3.1 DATA COLLECTION

Data was collected from the manufacturing line, as shown in Figure-1. This including process layout, process flow, cycle time, inventory levels, and distances between machines. Using this information, a Value Stream Map (VSM) was created to analyze the process. The VSM helped identify value-added time, non-value-added time, process ratio, distance travelled by the component, and inventory levels. From the analysis, several problems were identified such as unnecessary motion, scrap generation, rework processes, and inventory buildup due to rework. To overcome these issues, lean tools like Kaizen, Poka-Yoke, and Pareto analysis were implemented. After applying these tools, slight improvements were observed in the process. The process was then redesigned and a Future State Map was developed. Finally, the current and future state maps were compared, which showed an improvement in the process ratio and a significant reduction in non-value-added time, resulting in increased productivity.

3.2 VSM CURRENT STATE MAP

The given image represents a Current State Value Stream Map VSM for a crankshaft manufacturing process. This map visually explains the complete journey of the product starting from the raw material supplier and ending with the customer delivery. In simple terms, it shows how materials and information move through the factory, where delays occur, how much inventory is stored, and how much time is actually spent on productive work, as shown in Figure-2.

At the top left of the map, the process begins with the forging crankshaft supplier. Raw materials are received and stored before entering the production line. The map shows inventory triangles between processes, which indicate work in progress. These symbols clearly show that materials are waiting between operations, which increases lead time. The presence of high inventory levels suggests overproduction or poor flow balance. From the supplier, materials move into the initial machining operations such as cutting, facing, and rough machining. Each process box contains important data like cycle time CT, changeover time C/O, number of operators, and machine availability. This data helps us understand how long each operation takes and where bottlenecks may occur.

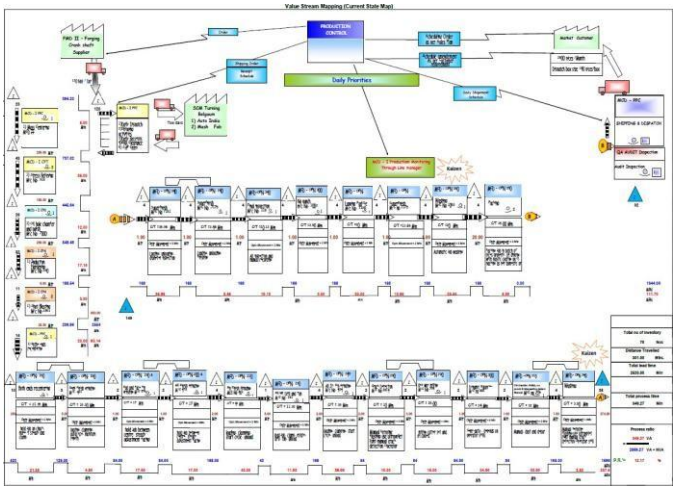

Fig -2: Current State VSM

4. RESULT AND DISCUSSION

After implementing Lean Manufacturing tools in the crankshaft production line, clear and measurable improvements were observed in the overall performance of the system. The comparison of the key performance parameters before and after the implementation is shown in Table-1. Initially, the production process had several inefficiencies such as excessive material movement, high non-value-added time, scrap generation, and rework. Once these problems were identified using Value Stream Mapping, appropriate corrective actions like layout modification, Poka-Yoke implementation, and Kaizen improvements were carried out. The system was then monitored again to evaluate the impact of these changes.

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One of the most significant improvements was the reduction in non-value-added (NVA) time. Before Lean implementation, the total NVA time was 2520 minutes. After eliminating unnecessary transportation, reducing rework, and improving process flow, the NVA time was reduced to 1260 minutes. This 50% reduction clearly shows that waste in the system was successfully minimized. The smoother material flow also reduced delays and waiting time between operations. The comparison of NVA time before and after the implementation is illustrated in Figure-3.

Material movement was another major area of improvement. By relocating the packaging section closer to the washing station and arranging machines according to process sequence, the total travel distance was reduced by 21 meters. This change reduced unnecessary operator movement, minimized fatigue, and improved efficiency. The improved layout also created a more organized and safer work environment. The comparison of the travel distance is presented in Figure-4.

Scrap rate was significantly reduced after introducing Poka-Yoke systems. The mechanical stopper prevented reverse loading of components, and the sensor-based interlock ensured that the dowel pin was properly positioned before machining. These simple but effective solutions eliminated major causes of defects and reduced rework. As a result, product quality improved and customer complaints were minimized. Another important outcome was the improvement in process ratio by 8.69%. The comparison of the process ratio before and after Lean implementation is shown in Figure-5.

This indicates that a greater portion of the total production time was spent on value-added activities rather than waste. Overall, the results confirm that Lean implementation made the production system more efficient, organized, and productive. The improvements were achieved through practical and low-cost solutions, proving that systematic waste reduction can significantly enhance manufacturing performance, especially in small and medium-scale industries.

Table -1: Comparison of Results

S.No	PARAMETERS	BEFORE	AFTER
1.	VALUE ADDED (VA)TIME	349.27 mins	332.12 mins
2.	NON-VALUE ADDED (NVA)TIME	2520 mins	1260 mins
3.	VA/VA+NVA RATIO	12.17%	20.86%
4.	DISTANCE TRAVELLED	301 m	280 m
5.	INVENTORY	66 Nos	33 Nos

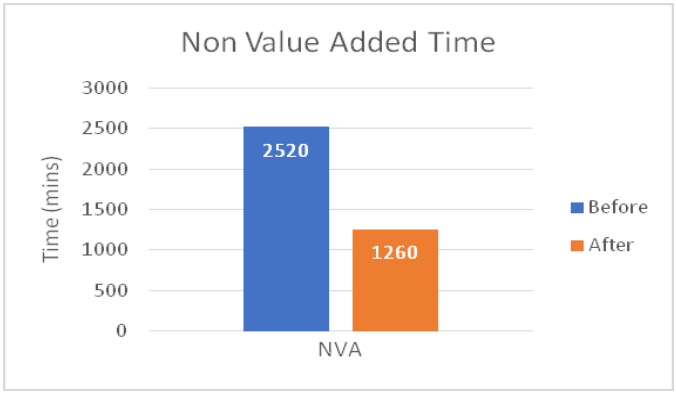

Fig -3: Comparison of NVA Time

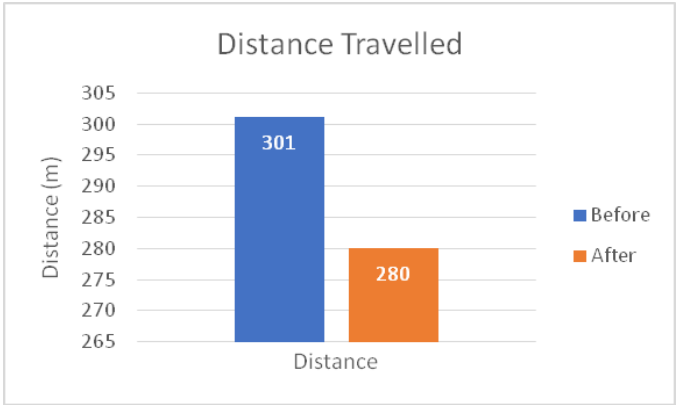

Fig -4: Comparison of the Distance Travelled by the Component

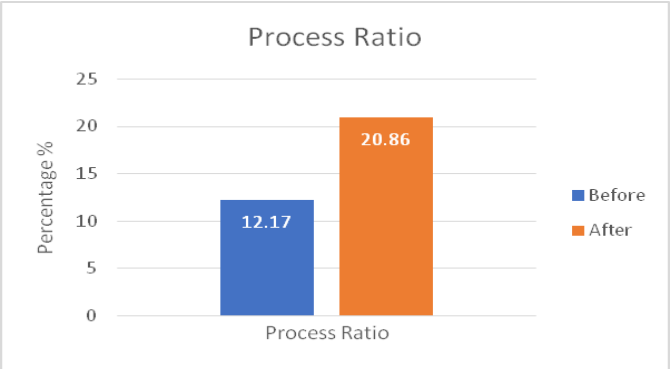

Fig -5: Comparison of the Process Ratio

5. CONCLUSIONS

The lean tools are the tools that are used for identifying and removing waste. This paper is intended to apply some of the lean tools to the crankshaft industry. The tools applied in this industry were Value Stream Map, Kaizen, Poka-yoke. The tool issued in the manufacturing line has shown excellent result. By implementing these lean tools in the manufacturing line, the non-value-added time was reduced which leads to customer satisfaction. The lead time, scrap generation percentage were also reduced and the process ratio of the manufacturing line was increased. Based on the data collected from the company, these techniques have helped a lot for manufacturing more components in lesser time. This also helps in fulfilling the customer demand before the deadline. By focusing on identifying and eliminating waste, whether it is unnecessary movement, overproduction, waiting time, or defects, the production process becomes smoother, faster, and more efficient. Tools like Value Stream Mapping, Kaizen, and Poka-yoke proved to be practical and impactful, helping to reduce lead times, minimize scrap, and increase overall productivity. Implementing these techniques not only allows a company to manufacture more products in less time but also ensures that customer demands are met reliably, leading to higher satisfaction. Moreover, the improvements in process efficiency and waste reduction directly contribute to cost savings and better resource utilization. Overall, this project highlights that lean manufacturing is not just a set of tools, but a strategic approach to creating a culture of continuous improvement.

So, these lean tools are very effective tools for the industries for reducing waste and improving the productivity of their manufacturing processes

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