PRODUCTIVITY IMPROVEMENT IN THE MANUFACTURING INDUSTRY THROUGH THE IMPLEMENTATION OF LM TOOLS

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Abstract.
Lean manufacturing is a set of principles and practices that may improve a company's efficiency and competitiveness in the marketplace. Lean manufacturing aims to maximize efficiency and productivity without compromising on product quality. Quality improvement is crucial since it reduces expenses by eliminating defective products. When production times are lowered, associated labor and infrastructure costs per unit are lowered, too. The elimination of unnecessary steps and processes is fundamental to the lean manufacturing philosophy. This might streamline, speed up, and enhance the process as a whole. Many companies have found success with lean manufacturing because it allows them to achieve their productivity targets and more by using straightforward, repeatable processes. Therefore, quality improves, production increases, and costs decrease. Participants were asked to rate the effectiveness of the implementation of these initiatives. After averaging the means across all scales, statistical analyses may be performed.

Keywords:
Lean manufacturing, LM philosophy, Quality Improvements, Productivity

INTRODUCTION

Lean manufacturing (LM) or the Toyota Production System (TPS) was established by a Japanese car company, Toyota, and has since been adopted by almost every country in the world due to its cost, quality, flexibility, and reaction time benefits [1]. Lean manufacturing is a strategy for maximizing customer value while decreasing costs. The focus of value stream optimization is always on the end user [3,7]. According to the tenets of lean management, every activity that fails to directly benefit the customer should be minimized or eliminated [1]. Lean manufacturing aims to improve value for customers by reducing production costs, increasing output per unit of time, and improving product quality [2,5]. There are many different ways to describe "lean manufacturing."

The manufacturing business is constantly changing, driven by the need for enhanced efficiency and cost- efficiency. Lean Manufacturing (LM) has become a crucial method for improving efficiency and optimizing operations in the ever-changing business environment [9]. The employment of LM tools has the potential to enhance resource allocation, eliminate inefficiencies, and ultimately enhance operational efficiency [3]. This research focuses on the investigation and implementation of Language Model tools in the manufacturing industry, with the goal of providing valuable insights that may lead to measurable enhancements in productivity and cost reduction. In light of increasing global competition, manufacturers are driven to pursue creative tactics in order to maintain a competitive edge. Lean Manufacturing, based on the ideas of waste reduction and continuous improvement, has become well- known as a technique that may bring about considerable improvements in operational operations [7,12]. This research aims to explore the actual use of Lean Manufacturing (LM) methods, including 5S, Kanban, and Value Stream Mapping, in the manufacturing sector. By doing this, the goal is to analyze the possible influence of these technologies on operational efficiency, cost savings, and overall productivity. When it comes to dealing with the challenges of contemporary manufacturing, using LM tools is a very promising approach for firms that want to succeed in a time of intense competition and changing customer needs.

Lean Manufacturing Procedures

- The system's waste is first detected; this requires many different types of organizations to become conscious of the wastes—both visible and invisible—that exist inside their own processes.
- A company may collect a wide range of trash, as it is important to know how to categorize trash and where it comes from. Lean manufacturing seeks to identify root causes and implement lasting solutions. Several efficient tools and strategies have the potential to significantly cut down on the production of such rubbish.
- The third step is to use common lean techniques and concepts to isolate the issue's origin. It is vital to identify how the suggested change will influence the larger picture since cause-and-effect analyses may be deceptive.
- The last step in implementing lean is identifying problems and conducting preliminary tests of potential solutions. The next stage is to implement the tested strategies. Each of the procedures relies heavily on training and subsequent monitoring to be effective. Since the real implementation might take some time, patience is essential [3,7].

LITERATURE REVIEW

Alalawin, et al (2022)[1] Understanding where the system fails and where the processes are flawed—both of which have a domino effect on performance and efficiency—is a major issue for lean adoption in the service sector. This research presents a new approach that might help service providers improve lean implementation and better align appropriate Key Performance Indicators (KPIs) with overall company goals. This article draws on a global best practice to examine the many forms of waste that reduce service delivery efficiency. To overcome the limitations of more traditional tools, this method aims to use and integrate the KPIs with Lean Management Tools. The first step in reducing or doing away with waste of any kind is to design a new KPI lean method. Improved procedures, higher performance, increased time and effort efficiency, and improved precision are all expected outcomes of this approach. With low-performance tasks in mind, a new model was created. The proposed framework is also used to create quantifiable key performance indicators (KPIs) that may be used to identify issues and guide future improvements. Consistent use of the method is likely to result in a significant cutback in waiting time and non- value-adding activities for service providers. Monitoring and controlling processes and activities inside an organization may be improved as well. Lean management may also help the telecom sector since it allows for a more rapid response to the ever-evolving telecom technology, which might lead to greater customer satisfaction.

Joseph, et al (2021)[6] This report outlines the research and testing conducted by a Chennai-based firm that supplies timing belt to original equipment manufacturers. The major emphasis of this study is on how to use lean manufacturing concepts to increase output from the production floor. Using Overall Equipment Efficiency (OEE) in manufacturing allows for more precise troubleshooting of complex issues that affect output. Analyzing cycle times helps businesses assess how well their different productivity-enhancing factors are working. A new set of processes was implemented after carefully examining cycle times, and the outcomes were compared to those of the past to see whether they were an improvement. The previous range of slabs produced per hour was 7.32–7.97, although current rates are closer to 7.32. Following the first day of applying measures to reduce the variation in cycle time, output increased from 8.9 to 9.1 slabs per hour, a 19.1 percent increase.

Mishra, Sushil&Terker, Ravi (2022)[2] The research presented here aims to educate readers about lean manufacturing, from the idea behind it to the wide variety of tools and techniques used in the process, as well as the benefits gained and challenges faced along the way. By making more effective use of resources and wasting less of them, lean techniques increase productivity. Most marketplaces are becoming more competitive, thus efficient manufacturing is essential. Because of how quickly

business and its environment are changing, companies may anticipate facing challenges and complexities. It's an efficient strategy for cutting down on pointless waiting around. The goal of this study is to assess the relevant literature and extract the most significant and applicable findings. Lean manufacturing is an umbrella term for several methods of streamlining production. A company's culture must be changed in addition to using most of the lean technologies for lean to be successful. Manufacturers that use lean manufacturing are better prepared to respond to changes in the market.
Rahmanasari, D &Sutopo, Wahyudi & Rohani, J. (2021)[3] Due to inefficient practices, the industrial sector is often criticized for producing vast quantities of trash. The production of electronic components, for instance, is still dealing with significant waste issues. They squandered resources, which hurt their competitive position. Using a lean manufacturing strategy, this research will show how waste may be reduced. The goal of this study is to identify inefficient processes in lean production and suggest ways to improve them. Value stream mapping (VSM) and waste relationship matrix (WRM) techniques were utilized to identify and analyze the industrial waste stream. The next step is to utilize a waste assessment questionnaire (WAQ) to determine how often trash needs to be picked up. Value Chain Mapping (VALSAT) is a program that uses Value Chain Mapping to create a complete map. Three different approaches are examined: the net present value, the internal rate of return, and the profitability index. We made a list of all the garbage in the system and decided the third biggest one was the one we should clean up first. Based on the data analysis, it was determined that increasing the amount of production equipment, carrying out the appropriate maintenance procedures, giving additional training and supervision, and building more workstations would improve the production process. In general, the suggested rules help the company lessen the seven waste and raise the unit production. It is envisaged that this would lead to a more streamlined production procedure.
Susilawati, Anita (2021)[4] It may be challenging for the organization to create an effective performance evaluation system that can drive continuous development because of its mission and its many different aspects. The study's overarching goal is to develop performance measurement systems (PMS) that may boost the effectiveness of a very lean firm or organization. The PMS uses the Multiple Incremental Decision Making and the Fuzzy Analytical Hierarchy Process to get its decisions. Using the hierarchical levels as decision makers, fuzzy human judgment was converted into clear scores based on pair-wise comparisons. Hierarchical systems and various performance criteria may connect tactical operational operations to strategic levels. It might assist a company keep tabs on its progress toward its goals, giving its management more data with which to work when making strategic and operational decisions. The flexibility of the PMS architecture allows the system to be optimized for the company's specific needs. In order to determine the viability and potential effectiveness of the lean PMS model, a case study was conducted.

PURPOSE OF THE STUDY

The objective of a research on productivity enhancement in the manufacturing sector via the use of Lean Manufacturing technologies is to bolster operational efficiency, diminish expenses, and optimize resource allocation. This entails the discovery, execution, and assessment of Lean technologies such as 5S, Kanban, and Value Stream Mapping to optimize processes and eradicate inefficiencies within the industrial setting.

METHODOLOGY

Setting explicit goals aids in determining and choosing the research methodologies for this present investigation. During the manufacturing process of the product, a thorough study has been carried out on all activities done at workstations, including component assembly, to identify the most efficient flow sequence. The investigation starts with the observation carried out on the shop floor. Here is the sequential graphic illustrating the recommended technique. The 5 Whys methodology [1,9] has been used to ascertain the root cause behind the failure to meet the delivery aim. The Five Whys, sometimes referred to as 5 Whys [1,9], is an iterative interrogative method used to ascertain the main causal relationship that underlies a problem. The main goal of this strategy is to determine the fundamental source of a flaw or issue by asking "Why" repeatedly. Every response acts as the basis for the next investigation.

RESULTS AND ANALYSIS

Application of the Integrated Model for the Case Study of Auto Component Manufacturer

In this research, we'll analyze just one of the many thriving corporations out there. The authors demonstrate the provided methodology by integrating VSM, plant layout, FFMEA, FAHP, and FQFD using a case study from the discrete manufacturing industry. The characteristic of the discrete manufacturing industry is the production of individual, easily identifiable products. Automobiles, electronics, toys, and household appliances are just some of the many products that are produced by discrete producers. The suggested concept is tested with a car components maker.

Industry Profile of Auto Component Manufacturer

The selected industry is a forerunner in the manufacture of car components in southern India. Location: Tirupur district, Tamilnadu state, India. In 1983, it debuted on its expansive 120-acre plot. The cutting-edge framework is the home to all the amenities. Its two main divisions are casting and machining. The industry is one of the few in the nation with its own machining area, where components created by casting are finished. Outsourcing the machining of just 5% of the components is more than manageable. The firm manufactures many important car safety parts, such as rotors, brake drums, and brake discs, as well as steering knuckle joints. We have chosen to focus on the following companies: Maruti Suzuki, Honda Siel cars, Hyundai, Fiat, Ford, General Motors, Toyota, Renault, Volkswagen, Tafe, Mahindra & Mahindra, Volvo, and Haldex.

Selection of Production Line for Illustration

Because it is illustrative of the industry as a whole, the steering knuckle production line will be examined. An example of a modern vehicle's steering knuckle is shown in Figure1.

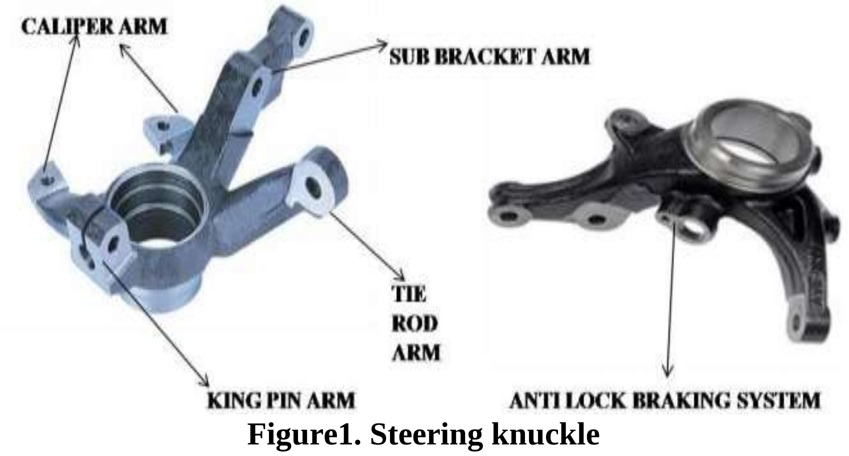

Figure1. Steering knuckle

Figure 2. shows the process of making a steering knuckle. Here are the stages of this development:

Casting: The steering knuckle is made by sand casting. The item has been sent to the machining facility.

Turning: Turning is the first machining technique used on the knuckle to get the main component for assembly. The knuckle is machined on both the left and right sides using LH and RH side turning, respectively.

Milling & Drilling: To get the parts of the steering knuckle, milling and drilling are used. Faces of components are made using a series of operations including milling (Sub Bracket Arm, Tie Rod Arm, Caliper Arm, King Pin Arm, Anti-Lock Braking System) and drilling.

Inspection: All finished parts, including machined surfaces and profiles, are measured, and inspected when machining is complete. If a part has a significant enough variation from the standard, it will fail the inspection and be thrown away. No diagnostic checks are made to make sure these mistakes aren't made again.

Hardness test: The reliability of the component is next examined by testing its surface hardness and other mechanical properties.

Ultrasonic test: Ultrasonic testing is a nondestructive technique for locating defects inside an item. Furthermore, any defect caused by stress during milling may be uncovered by ultrasonic testing. If the right machining conditions were created throughout production, and the quality of the casting was confirmed by testing after it was made, then it is possible that these defects may be completely avoided.

Packing: The last step is to package the component and store it in the finished goods warehouse until it is time to ship.

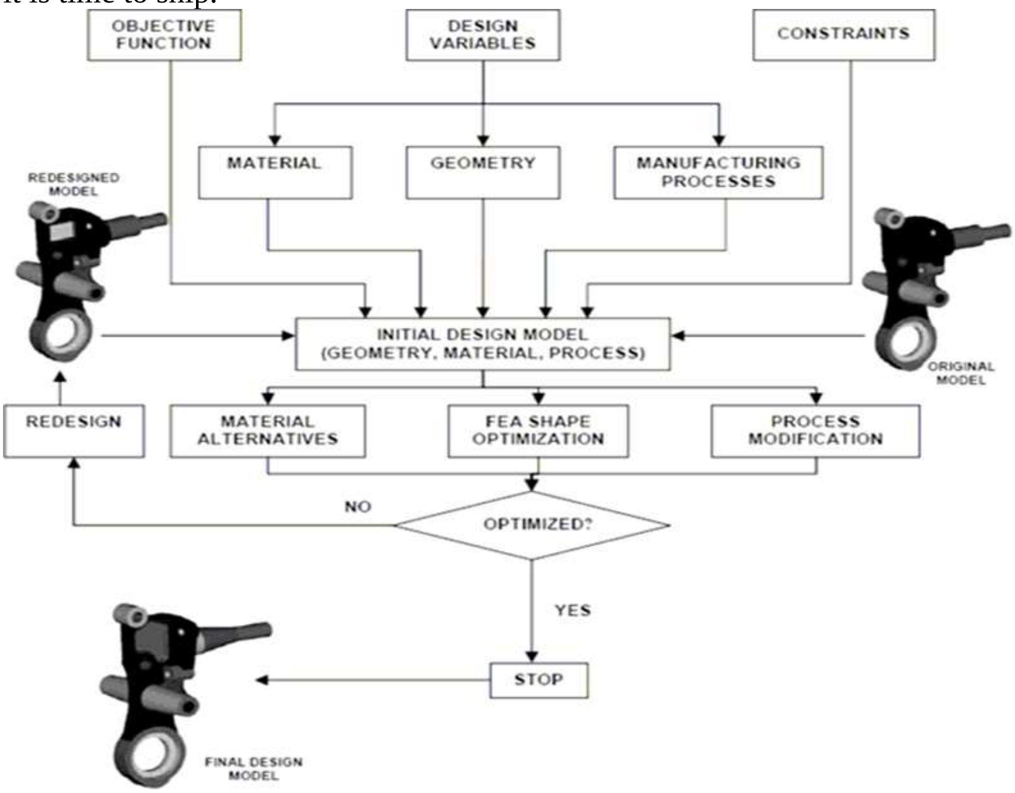

Figure2. Process of steering knuckle manufacturing Routing sheet of Foundry shop

A route sheet is a detailed plan or diagram of a manufacturing process at a production facility that outlines the precise route or sequence to be adhered to throughout the process. A pre-existing route sheet in the foundry shop may be regarded as a precedence map for the operations. This diagram shows the necessary stages to accomplish a certain job in the manufacturing or production process. The task time of the product is recorded and shown in Table

1. after each activity.

Table 1 Task time before implementation of LMT

Task Name	Predecessors	Task Time (Min)
Core Sand Preparation	–	5
Facing Sand preparation	–	7
Core making	A	36
Drag Making	B	20
Core Collection	C	15
Mold painting	D	10
Cope making	B	25

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Core insertion	E,F	75
Final checking and box marking	H	3
Cope and Drag assembly	I,G	12

Study On Task Time

A stopwatch time study was done at foundry shops to ascertain the duration required to execute each activity specified in Table 1. Five observations were conducted for each activity to get the average observed time, which was then compared to the standard time. The research outcome is shown in Table 2.

Table 2 Time study for mold making process in foundry shop

Task Name	Average observed time including wastes during working (Min)	Standard time (Min)	Ratio of standard time to average observed time
Core Sand Preparation	5	5	1
Facing Sand preparation	7	7	1
Core making	36	36	1
Drag Making	20	15	0.75
Core Collection	25	18	0.72
Mold painting	15	5	0.33
Cope making	10	10	1
Core insertion	75	50	0.67
Final checking and box marking	3	3	1
Cope and Drag assembly	12	8	0.67

Table 3 TAKT time determination

Available data for activities	Frequency
Customer Order/month	75 Nos. finished good
Raw material procurement	Monthly
Total shift/day	One shift/day
Working day/month	25 days
Available time for working	480 minutes/day (12000 min/month)
Demand per day	(75/25) = 3 Nos. finished good
Major components per finished good	1 bolster and 2 side frames
Daily requirements for mold for 3 Nos. finished good	9 (3 for bolsters and 6 for side frames
TAKT time- (Total available time per day/ demand per day)	(480/9) = 53.33 min.

Table 4 Task time after implementing LMT

Activity	Task Name	Predecessors	Task Time (Min)
A	Core Sand Preparation	–	5
B	Facing Sand preparation	–	7
C	Core making	A	36
D	Drag Making	B	15
E	Core Collection	C	5
F	Mold painting	D	10
G	Cope making	B	18

H	Core insertion	E,F	50
I	Final checking and box marking	H	3
J	Cope and Drag assembly	I,G	8

This study mainly focuses on waste elimination via the implementation of lean manufacturing methods such as Value Stream Mapping (VSM), line balancing, and layout optimization. The objective is to identify bottlenecks and eliminate non-value-added (NVA) operations from the system, therefore reducing lead time and enhancing productivity. Post-study, the use of lean technologies has resulted in the following observable outcomes:

(i) Line balancing decreases the cycle time of the operations that are shorter than the TAKT time and minimizes the idle time of the workstation. Following the introduction of lean principles, including line balancing, the cycle time per workstation has been reduced to 50 minutes, aligning with the TAKT time of 53.33 minutes.

(ii) The suggested arrangement has been designed to minimize the time it takes to go between two workstations and to minimize the movement of cranes compared to previous practices.

(iii) The line balancing calculation indicates that the line's efficiency has improved to 78.5% from 69.33%, and the balance delay has decreased to 21.5% from 30.66%.

(iv) The use of VSM results in a reduction in the lead time in foundry shops from 208 minutes to 157 minutes, enabling them to meet customer demand within the required time frame.

CONCLUSION

The effect of Lean Manufacturing (LM) techniques on increasing industrial productivity is investigated in depth in this study. In this research, we found that LM tools can significantly improve efficiency, cut down on waste, and streamline operations. Overproduction, surplus inventory, and needless motion are just a few examples of the types of waste that have been significantly reduced using LM techniques like 5S, Kanban, and Value Stream Mapping. Streamlining production processes and optimizing resource utilization are both achieved by methodically removing these inefficiencies. Based on the findings, LM tools help reduce mistakes and faults, which in turn improves product quality. In addition, producers can stay ahead of the competition in today's ever-changing business environment because to the flexibility that LM brings to the table. Significant cost savings may be achieved with the deployment of LM tools. These tools help reduce waste, optimize resource utilization, and increase overall operational performance. Manufacturing enterprises become more competitive in the global market as a result.

The research focuses on enhancing efficiency in a medium-sized manufacturing sector by using lean and industrial methodologies, without incurring additional expenses, resources, or labor. The VSM and time study methods are used to distinguish between value-added (VA) and non-value-added (NVA) activities. The present Value Stream Map (VSM) has eliminated the bottleneck Non-Value-Added (NVA) operations to achieve the delivery objectives. This research has focused only on the implementation of value stream mapping, layout optimization, and line balancing within a specific industry. Notably, various improvements have been seen without the need to modify existing procedures or provide more staff at an additional expense. Other lean technologies, such as 5S, TPM, Single minute exchange of Die (SMED), and others, may be used in the organization's activities to further enhance productivity to its maximum potential.

Limitations

1. **Generalizability:** The conclusions of this research may only apply to the sectors, organizations, or environments that were examined. Generalizing the findings to other industries or varied organizational frameworks may not be suitable.

2. **Timeframe:** The study's duration may be restricted, providing a brief overview of the influence of LM tools throughout a certain time frame. The long-term consequences and durability of these enhancements may not be fully understood.
3. **External Factors:** External variables, like as economic circumstances, regulatory changes, or technology upheavals, may impact productivity irrespective of the installed LM techniques. The research may not have accounted for these exogenous factors in their entirety.
4. **Human Factors:** The research may not thoroughly examine the influence of human variables, such as staff training, motivation, and resistance to change. These factors are essential for the effective application of LM tools.

Further Directions of Research

Subsequent investigations in the domain of enhancing productivity in manufacturing using Lean Manufacturing (LM) technologies may include longitudinal studies to evaluate the enduring effects over an extended period. Conducting comparative assessments across different sectors and organizational sizes would improve the capacity to apply the findings to a wider range of situations. An investigation of the incorporation of LM tools with Industry 4.0 technology, together with an examination of the human variables related to their adoption, such as employee involvement and organizational culture, would provide detailed and nuanced understandings. Qualitative research has the potential to provide subjective experiences that occur with the adoption of LM.

Furthermore, benchmarking studies may help identify optimal methods, while research on the environmental sustainability effect of LM tools and their function in developing robust manufacturing systems would provide significant insights. Further research might explore the ways in which firms adapt and tailor LM tools to meet their unique requirements and circumstances. Additionally, it could investigate the collaborative impacts of implementing LM on supply chain operations.

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