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Lean Manufacturing Technique used for Industrial Improvement

Raktate Omesh Uttamrrao[1]*, Dr. Vinay Chandra Jha[2], Dr. Mohan B. Vanarotti[3]

[1] PhD Student, Kalinga University, Raipur, CG

[2] Professor & Research Guide, Kalinga University, Raipur, CG

[3] Professor & Research Co-Guide, Kalinga University, Raipur, CG

Abstract - After finding success with the Toyota Production System in Japan, lean manufacturing quickly spread across sectors throughout the globe. As a systematic approach, lean manufacturing is a component of the idea of continuous improvement that a firm employ. In this article, we put the Lean Manufacturing System to the test. Increasing one's capacity to satisfy needs is the goal of continuous improvement, which may be defined as an ongoing process. Lean management, sometimes known as "lightened management," is a method for cutting down on manufacturing waste. This method aims to eradicate several forms of waste, including transportation, unnecessary movement and processes, and overproduction. The core principle of lean management is to design and produce environmentally friendly goods more efficiently and with less impact on the environment. Along with physical installations and financial resources, the emphasis is on the enthusiasm and competence of partners. The constraints of a system are less considered and more attention is paid to how the system functions. In this article, we cover lean manufacturing and its numerous tools. The significance of Lean tools for industrial improvement is further shown by the research. The foundation of lean manufacturing, 5S aids in increasing output.

Keywords - Lean manufacturing, waste, mainstay, improvement, productivity.

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INTRODUCTION

The origins of LM may be traced to the mid-century, when it was first used as the Toyota Production System (TPS) to characterize the production of automobiles at the Nayoga, Japan, plant of the Toyota Motor Company (Ohno, 1988). But in their groundbreaking book "The machine that changed the world" (Womack, Jones and Roos, 1990), Wommack, Jones, and Roos presented and described the contemporary framework of Lean Manufacturing, which has been extensively used by numerous sectors in the previous several decades. What started as a program to upgrade processes with the goal of helping Toyota Motor Company increase revenue and productivity has now become a popular production system in many industries that want to reap the benefits of LM, which include better delivered quality, less inventory, no waste, and constant process optimization (Art of Lean, n.d.; Ohno, 1988; Womack and Jones, 2003).

Follow the product only when the customer wants it, dubbed "pull," in pursuit of excellence; this is the Lean Manufacturing System's guiding principle. It aims to discover and eliminate waste and non-value added processes via continuous improvement. In the 1990s, the Toyota Production System was the first to use it, and since then, every other company has followed suit. Productivity is always driven by quality. Revenue growth, job creation, and innovation in technology are all outcomes of increased productivity. Quality must no longer be seen as an inspection tool, but as an organizational trend. Quality is everyone's responsibility, as we all know. Eventually, we went from percentages to parts per million, and now we're even talking about zero parts per million. Quality has to be a commodity driven by demand instead of supply.

Lean manufacturing is a method of managing production with the end goal of satisfying consumers by consistently meeting their needs in terms of quality, quantity, location, method of production, price, and variety. Less waste means greater quality, more efficiency, and more profits with Lean Manufacturing. The end goal of Lean Manufacturing is to make better goods at less costs while eliminating all waste in the manufacturing process.

LITERATURE REVIEW

Caiza, G., Salazar-Moya, A., Garcia, C. A., & Garcia, M. V. (2022), Knowing, analyzing, and projecting one's processes into a reality of conceptual innovation and technological applications that enable one to dig into prolonged control over one's resources is essential for every industry or business that aspires to be competitive. A way to raise productivity and generate profits from manufacturing processes is to eliminate Productive Waste, which refers to everything that does not contribute value to the operations. The Japanese philosophy of Lean Manufacturing proposes this approach. Various industrial techniques and topics are covered in this article's proposed literature study, which aims to demonstrate the success of Lean Manufacturing within the context of Continuous Improvement in a productive industrial setting.

Adam Wysoczański, Piotr Motyka, Renata Gnitecka, Krzysztof Kolbusz, Magdalena Dąbrowska, Anna Burduk, Zdzisław Pawelec, and José Machado are all members of the group headed by Medyński. the year (2023), When it comes to using lean manufacturing processes and technologies to achieve process sustainability, standardization is crucial. Together, they ensure that workers are making use of the most effective equipment and aren't squandering time on pointless tasks, which in turn helps the organization cut down on waste and boost productivity. In line with the idea of Industry 4.0, digital technologies may further enhance these tasks. As a result, the writers have created the e-Lean system, which mission is to digitalize chosen lean manufacturing resources. This study aims to examine the usefulness and efficiency of the e-Lean system's central application, which is a piece of specialist TPM (Total Productive Maintenance) software. Lean manufacturing and maintenance experts tested the TPM application throughout its installation in a building production firm. Examining how well procedures worked in comparison to more traditional TPM solutions was the focus of the study. The e-Lean system has additional confirmed functionalities, such as the systemic approval of machinery inspection, which takes all the required steps at individual inspection points; direct access to photographic documentation of machines added during inspection, both in terms of optimization of working time and its course (e.g., the optimal number of steps taken by the employee during the inspection); and an efficient system of motivating employees, which includes collecting points. We measured the control timings for three control points (polymerization furnace, packing area, and defibering equipment) to find out how much process effectiveness was improved. A decrease from 16,200 to 13,923 s was seen in the average control time. The results showed that the TPM tool was about 15% more efficient after utilizing the program as compared to the non-digital methods that had been utilized before.

Guha, B., Moore, S. & Huyghe, J.M. (2023), We provide a methodology that uses closed-loop analytics, big data, and cyber physical system principles to replace the labor-intensive manual manufacture of complicated biomedical equipment with a more streamlined and efficient production process. In addition to providing real-time quality control, the concept model can handle large quantities and varieties of products, as well as self-adapt and correct under different operating situations. The method takes into account the difficulty of these sectors' highly regulated environments and the need for improved quality control by proposing a closed-loop system that adheres to regulatory standards and existing Industry 4.0 best practices. The suggested model demonstrates that, even in highly controlled manufacturing settings, contemporary manufacturing processes and ideas can be successfully implemented, and it also shows that the model can be applied to many production situations.

In the year 2020, Krzysztof Ejsmont, Bartlomiej Gladysz, Donatella Corti, Fernando Castaño, Wael M. Mohammed, and Jose L. Martinez Lastra were authors of the article published in Pantea Foroudi. Companies that want to stay in the game are always trying to find new ways to improve their efficiency, quality, and service level. Manufacturers have become increasingly optimistic about the potential benefits of automation and system integration as the idea of Industry 4.0 has progressed. A tried-and-true method of management, "lean management" has stood the test of time. It seems that the next logical step in improving operational excellence (the use of money, effort, materials, and machines/devices) is to combine Lean with Industry 4.0 principles. As is well-known from Lean Management, a growing number of companies are turning to Industry 4.0 solutions in an effort to cut down on waste. Hence, conveying the outcomes of a literature study on the idea of "Lean Industry 4.0" is the primary goal of this piece. It made use of a dynamic technique known as "Systematic Literature Network Analysis (SLNA)". It finds new subjects and how they're changing over time by combining the systematic literature review method with quantitative analysis of bibliographic networks. This study presents a thorough organization and rationalization of existing information about the integration of LM and I4.0 principles. It also highlights key research trends and outlines potential avenues for future research in this area. This article provides a framework that summarizes what is currently known about Lean Industry 4.0.

In 2014, Das, B., Venkatadri, U., and Pandey, P. published, The primary goal of this study was to find out how Blue Star Limited might increase the efficiency with which they produced air conditioning coils by using a lean manufacturing system (LMS). A 77% increase in productivity, or a jump from 121 to 214 coils per shift, was achieved by the use of LMS in the coil production process. The setup time of the coil expander machine was reduced from 60 to 20 minutes, an improvement of 67%, by using LMS technologies such as value stream mapping, single minute swap of die, and kaizen. The coil shop's percentage value addition (%VA) went raised from 5% to 12%, which is a 140% boost. Changes in design and work methods were the focus of the kaizen (continuous improvement) process, which led to improvements, notably in the coil expander machine. In order to cut down on setup time, the expander machine underwent several unique design adjustments. These included the following: (1) a gear rack and gear pinion mechanism; (2) a spring, cam, and lever mechanism; and (3) a one touch mechanism throughout the machine. There were a lot of suggestions for kaizen methods that would streamline the setup process by removing unnecessary steps (muda). Reducing work-in-process inventory has other positive effects, such as easing congestion on the factory floor, preventing coil damage from excessive handling, and making the workplace safer.

LEAN TOOLS or TECHNIQUES

5S

The lean manufacturing system is built upon it. Sorting, methodical order, cleanliness, uniformity, and self-discipline are the main points discussed. The 5S method consists of the following steps: 1S seiri, 2S seiton, 3S seiso, 4S seiketsu, and 5S shitsuke, which stand for sorting, systematic organization, cleaning, and self-discipline, respectively. These terms are all from Japanese [12]. The PEEP principle—"a place for everything and everything in its place"—is used. Finding certain cutting tools, inserts, spanners, dies, etc., takes less time using this tool. 5S improves workplace conditions, which in turn boosts efficiency and output. As a result, industrial output and quality are both enhanced.

Overall Equipment Effectiveness (OEE)

The manufacturing industries' overall equipment effectiveness is a measure of their performance. Machine availability, machine productivity (performance), and product quality are all factors that go into overall equipment effectiveness (OEE) calculations [9]. Here is the formula for OEE:-

OEE = Availability x Quality x Productivity

OEE % = OEE x 100

$$\text{Availability} = \frac{\text{Net Available time}}{\text{Planned min.}}$$

$$\text{Quality} = \frac{\text{(Ok Quantity + Casting Rejection Quantity)}}{\text{(Ok Quantity + Casting Rejection + m/c Rejection Quantity)}}$$

$$\text{Productivity} = \frac{\text{O/P Time}}{\text{Net Available Time}}$$

If a machine's OEE is lower than the world-class average of 85%, then there is room for improvement within the company [12]. OEE provides a means of measuring equipment performance and provides data for enhancing productivity.

Kaizen

It is the vital instrument for lean production. Continuous improvement and lasting transformation are the essence of kaizen. Low productivity, high rejection, and rework rates, as well as excessive manufacturing costs, may be permanently resolved by kaizen. Every single person in the company is involved in kaizen. Everybody is urged to provide suggestions consistently, often, and routinely in this tool.

The term "kaizen" refers to a continual process of change for the betterment of all individuals in the sector, as "kai" implies change and "zen" means better. The physical phenomenon of breakdown quality faults is known as kaizen thinking. Reduced cycle time, improved quality, decreased tooling cost, elimination of rejection, and reduction in casting flaws are all results of kaizen.

3M (Muda, Mura and Muri)

This is a method that is part of the lean manufacturing approach. "Muda" means "waste" in Japanese. Waste may be categorized into seven main areas: transportation, movement, waiting, processing, defects, inventory, and overproduction. Improving production quality and lowering manufacturing costs are both made possible by reducing or eliminating these seven forms of waste.

In the context of material flow, mura refers to any kind of unevenness, lack of homogeneity, irregularity, or inconsistency. When there is a disparity in client demand, manufacturing speed, excellent component quality, or workload, it leads to mura. Employees, or Muri, are the ones who bear the brunt of the workload. Muri places an emphasis on the worker. Obviously, a worker's efficiency will diminish if he is under tremendous stress and is required to do heavy lifting. In order to eradicate muri, it is necessary to create an ideal working atmosphere where employees experience little stress. Putting excessive strain on machinery and tools, which increases noise and wear and tear and lowers morale. When employees feel valued and appreciated by their employer, they are more likely to give their all on the job, resulting in higher output quality. The system's performance will improve when these 3M are removed.

Layout Modification

Layout modification increases the production rate. It reduces the production time. By reducing the Ton-meter distance we reduce the production time.

Ton-meter = Distance X Weight X Quantity

Saving Ton-meter = (Old Ton-meter – New Ton-meter)

Using the aforementioned method, we were able to determine the ton-meter and saving ton-meter flows from a process and operation perspective. The organization's production rate is directly proportional to the amount of money saved per metric ton. Time spent processing is decreased.

Suggestion Scheme

Participation in the organization's productive forces and the possibility for those with creative bents to make their ideas a reality are the goals of the suggestion plan. Improvements in work process, job efficiency, cost-effectiveness, scrap utilization, and worker safety are the focus of the ideas. Anyone is welcome to drop a recommendation in the box located at the front entrance of the firm. An award of a certificate and monetary compensation will be presented to the best proposal. The organization's management will decide on that award amount. Reward amounts typically range from 5% to 10% of monthly expense savings. These instruments not only enhance product quality but also help companies save money.

Single Minute Exchange of Die (SMED)

The primary objective of this method is to drastically cut down the machine setup time to less than one minute. Disentangle the internal and external setups in SMED. While the machine is not running, internal implies this. During operation, using external methods. Make the change from the internal to the external arrangement. Do away with the need for adjusting. Uses a consistent design and the same component for different goods to save down on setup time. Employees should put in the time and effort to become good at the routine. Employ fasteners that are easy to use. Cutting down on setup time boosts output rate. Hence, it is a crucial component in lean production.

Seven Quality Control Tools (7QCT)

In lean manufacturing, it is one of the tools that is primarily concerned with product quality. Simplifying the process of data collecting is its purpose. Both the recording mistake and the difficulty of analysis are reduced. We use seven quality control tools to enhance company outcomes. Graphs and charts, a histogram, a scatter plot, a classification system, a classification system, a check sheet, and a pareto diagram are the seven quality control tools provided. The purpose of this utility is to remove faulty components. This tool allows us to comprehend the process and its relationship to the input and output. The data is analyzed and conclusions are drawn. The problem's actual source is revealed. Therefore, these lean manufacturing technologies are crucial for the expansion of the industrial sector.

Total Productive Maintenance (TPM)

The goal of TPM is to restore and keep machinery in top working order. Improve the operator's maintenance skills and stop the forced degradation in its tracks. Five sorts of pillars make up TPM: 5S, kaizen, scheduled maintenance, overall equipment effectiveness (OEE), autonomous maintenance (Jishu Hozen), and training [12]. Error prevention, enhanced maintainability and repair quality, enhanced safety, and increased dependability are all achieved via corrective maintenance. By cleaning and replacing the lubrication oil, forced degradation may be eliminated. Areas that are difficult to clean or cause difficulties might be identified with the assistance of maintenance. Perform duties related to fluid analysis and vibration. The primary responsibility is to establish maintenance standards and work on the design of new equipment [3]. Training for all operators is included in TPM to improve maintenance quality. An essential component of TPM is kaizen. It boosts output, shortens cycle time, and enhances product quality. The total efficacy of the equipment rises once TPM is implemented. Optimizing equipment usage at decreased production costs and improving overall equipment effectiveness (OEE) by decreasing or eliminating losses are the goals of total product management (TPM) [12].

Value Stream Mapping (VSM)

Any time an end user receives any kind of service or product, a value stream is created. The term "value stream" refers to the set of interconnected processes that work together to meet the demands of consumers [1]. The end result of implementing Value Stream is a customer-valued offering. Throughput, efficiency, cycle time, and customer satisfaction are all improved by VSM. Value stream management entails cutting down on waste, improving quality, lowering costs, and shortening lead times. "Value" is defined as "what the customer wants so much that he is willing to pay for it" [2]. Using a step-by-step approach, Value Stream Mapping may identify processes that create value (related to customer value) and those that do not. Using VSM, the process may be improved. Using VSM, one may get insight into the present state of affairs, see the ratio of non-value added to value added time, identify the origins of waste rather than simply the waste itself, and see the connections between the three forms of flow: process, material, and information.

Human Error Prevention (HEP)

In order to enhance the operation of work, including materials, equipment, and techniques, human error avoidance is essential. Remove tasks from the process that are prone to human mistake. Cost, productivity, and performance are all areas where elimination solutions might negatively impact. A complete overhaul of the process or piece of equipment is often required. Substituting more dependable machinery or equipment for human operators may decrease HEP. To have a machine do the work of a person entirely, automation is the way to go. Assist operators in reducing the likelihood of human mistake by providing them with resources like as checklists, reminders, and samples. As a result, fewer mistakes in subassembly component installation due to misunderstandings of work order sheets are likely to occur. The established detection method incurs substantial corrective costs due to late detection. The function of hardware is critical. Avoid hardware malfunction. Apply the remedy for preventing the occurrence of errors if they cannot be stopped.

Statistical Process Control (SPC)

Quality control may be achieved via statistical process control. The process of organization is monitored and controlled by it. Make a more targeted product with less waste by using SPC to guarantee process efficiency. The design of experiments, continuous improvement, run charts, and control charts are essential tools in statistical process control (SPC). Attribute data and variable data are the two main categories of information used in statistical process control. Simply identifying the issue is not enough for SPC.

Inventory Management

The business's strategy and management are included by inventory management. Excess raw material, work in progress, finished items, consumable tools, and supplies are all considered inventory. Improving customer service and having things readily accessible are the motivations for keeping inventory. In addition to hedging against price fluctuations, it promotes production, purchasing, and transportation efficiencies. Preventing demand uncertainty is its main function. Stocks for safety, lot size, decoupling, pipeline, transportation, and anticipation are among the inventory functions [2]. To keep up with fluctuating market circumstances, meet demand during replenishment periods, minimize stock outs by maintaining reserve supplies, stabilize or level out production, reduce sales losses, and meet other business limitations, inventory is necessary. There are three distinct types of inventory: active, inactive, and outdated. Using the EOQ model and ABC analysis, inventory management may be discovered. Improving industrial processes relies on effective inventory management.

Material Requirement Planning (MRP)

Using MRP, you can plan the manufacturing schedule for all of your materials. The foundation of material demand planning is the flow of materials in accordance with the production schedule. Considering the existing inventory levels, it shows what kinds of materials need to be obtained from outside sources and how much of each. Knowing what kinds of supplies are required and in what quantities, considering stock levels, is essential. Be sure to allow enough time to place these orders, whether you're buying outside or making them inside. Production schedule master, material bill, and inventory status file are the MRP components. One of the products of material requirements planning (MRP) is a timetable for production, which details when and what will be produced. Another product is a list of purchasing requirements, which details what needs to be bought and when. The final inventory of MRP parts, components, and subassemblies after the completion of the master schedule [1]. After MRP finishes the master schedule, the closure capacity becomes available. It details the expected production deficiencies, which could be caused by components or capacity limitations. Because MRP helps businesses make more money, it's a big deal in the sector.

Kanban

Lean manufacturing's potent tool is Kanban. A standard amount of production is indicated by this card. This method had its start with a two-bin inventory. Kanban helps keep pull production disciplined. The manufacturing and transportation of products are authorized [3]. Kanban types include The approval of products manufacture is granted by production kanban. The movement of products is facilitated by withdrawal kanban. A Kanban square is a predetermined location for storing products. The signal kanban is a triangle-shaped kanban that indicates that the preceding workstation is ready to produce. One usage of material kanban is to pre-order materials for a procedure. Using supplier kanban, the system is constantly moving from one supplier to another [2]. The following is the formula for finding the kanban number:-

$$N = \frac{dL+S}{C}$$

Where,

N = no. of kanban

D = average demand

L = lead time

S = safety stock

C = no. of products

Kanban system is basically generated for replacement of push system with pull system. Kanban play very important role in making a better product flow.

Factors that inhibit Lean

Although LM has many positive effects for businesses, there are obstacles to effective lean deployment (Melton, 2005). Lean adoption's perceived lack of visible advantages and people's natural inclination to resist change are the two main issues. Both managers and employees often refuse to accept the results of adjustments made within the framework of LM and refuse to implement any more changes to the process.

As a result of human error, Figure 6 shows a few problems that develop when lean theory and lean practice diverge.

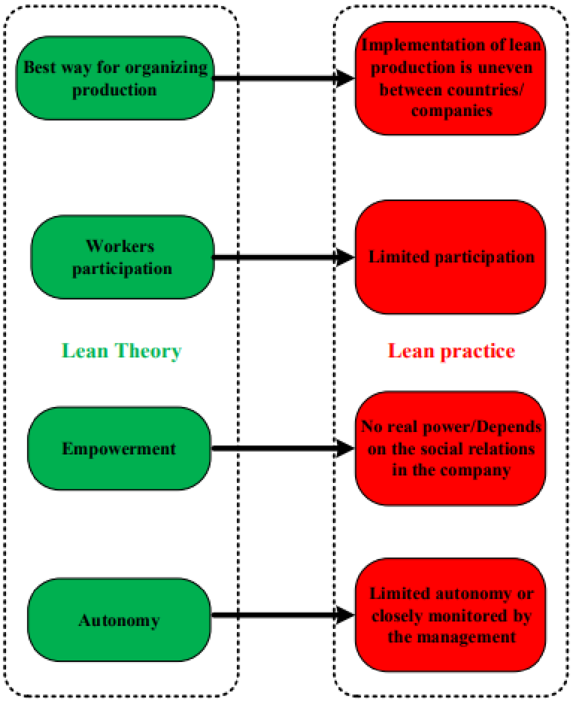

Figure 1: Discrepancies between Lean theory and practice

In addition, LM implementation is ongoing and requires ongoing assistance (Drew, McCullum and Roggenhofer, 2004). (Mwacharo, 2013). Companies should be well-prepared before adopting LM and should commit to accomplishing all the hard work required for a seamless transition into lean thinking. To preserve the efficiency attained via lean adoption, they should reassess their strategy on a regular basis. Otherwise, LM might have some short-term success before completely bombing (Bicheno and Holweg, 2009). Although it may seem like the answer to immediately reduce inventory as suggested by LM, this is not the correct approach to apply lean. Recognizing trash and eliminating it one step at a time should be the goal. As a result, it is also quite difficult to identify the true Muda in each department. Thus, one of the main challenges to lean adoption is maintaining enthusiasm for regularly evaluating already-implemented LM technologies.

Process industry characteristics and prospects of LM implementation

The manufacturing of products can be divided into two main categories (King et al., 2008):

- Products that are put together from smaller, pre-made components into larger ones; examples include computers, cars, cell phones, and electronics.
- Products that go through certain refining processes during production, like blending, baking, and chemical reactions, and when finished, cannot be separated into their original components. Products like these include things like food, chemicals, medications, and building supplies.

According to Abdulmalek, Rajgopal, and Needy (2006) and King et al. (2008), the first kind is called discrete industry, while the second is called process industry. One common, albeit oversimplified, way to compare the two kinds of businesses is based on whether their processing is discrete or continuous. When comparing discrete manufacturing and process manufacturing, the difference is best illustrated by looking at the end result of the production operation. Discrete manufacturing involves reducing the number of parts in the manufacturing industry's assembly line, while process manufacturing uses limited raw materials to create a wide variety of products.

The following table compares the process industry with the manufacturing-discreet industry, going into more detail:

Table 2. Discrete versus Process industry characteristics

Discrete Industry	Process Industry
Items	Materials
Variable volume	High volume
Extended variety	Low variety
Flexible equipment	Dedicated equipment
Reduced setup times	Lengthy setup times
Cellular/ product layouts	Fixed layouts
Parallel machines	Fixed routing

Additionally, a segmentation of the process industry based on the type of product they produce can be conducted into the following categories:

1. Lighting goods, flat glass, fiber optics glass, glass containers, concrete, gypsum, cement, pavement and plaster, abrasives, and asbestos are all examples of usual items in the area of glass, ceramics, stone, and clay.
2. Metals and steel: This group includes main smelt refining products, nonferrous metals, and various shapes and sizes of steel, stainless steel, structural steel, slabs, bars, and sheet metal.
3. Chemicals: Medications, cleaning supplies, paints, cosmetics, plastics, inorganic and organic chemicals, and agricultural

chemicals are all part of this sector's extensive product catalog.

4. Food and drink: including a wide range of items including meat and dairy, canned goods, baked goods, sugar products, oils, alcoholic drinks, and snacks.

5. Clothes and apparel, carpets, towels, rope and twine, upholstery for automobiles, reinforcing materials, bulletproof vests, ornamental braids, and ribbons are all part of the textile group.

6. Lumber and wood: Items such as common lumber, wood storage containers, mobile houses, and other wood items and panels.

CONCLUSION

The significance of lean manufacturing for the expansion of industrial sectors has been covered in this study. To drive their manufacturing system towards success, industries should concentrate on a few features of lean tools including 5S, Kaizen, OEE, TPM, SMED, 3M, VSM, and MRP. The correct sequencing of lean tool implementation is essential for a lean system. In order to increase efficiency and revenue, lean tools are inexpensive. The elimination of waste is the primary goal of lean tools. By adopting TPM, businesses create a setting that actively seeks to improve production system efficiency. With fewer machine breakdowns, fewer faults, and a higher production rate, the overall efficacy of the equipment increased. Operator Effectiveness (OEE) measures how well a machine works in relation to its operator. Due to the decrease in setup time, there is undeniably a rise in OEE with SMED implementation. Alterations to the layout may indirectly boost production rate by reducing the amount of material that must go from raw to finished goods. Both the operator's productivity and the environment benefit from the 5S and 3M initiatives. Hence, Lean Manufacturing is a crucial tool for enhancing the industrial sector.

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Corresponding Author

Raktate Omesh Uttamrrao*

PhD Student, Kalinga University, Raipur, CG