Lean Manufacturing Improvement Using ECRS and TRIZ Methods: Literature Review

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Abstract

Lean manufacturing is a method used by Toyota to eliminate or reduce waste to reduce production time and decrease production costs. Eliminate, Combine, Rearrange, Simplify (ECRS) are used to eliminate, combine, rework and simplify the non-value-added activity. This paper proposes lean manufacturing, ECRS, and TRIZ to reduce waste and increase production efficiency. The results of implementing lean manufacturing with ECRS and TRIZ in this study will contribute to the literature on ways and solutions for more effective and efficient improvements so that it can be helpful in industry and academics in the future. Meanwhile, the Theory of Inventive Problem Solving (Theory of Resheniya Izobreatatelskikh Zadatch, TRIZ) is helpful for systematically solving or reducing waste based on data and contradictions.

Keywords
ECRS, Lean Manufacturing, TRIZ, Waste.

1. Introduction
Industry demands for improvement or innovation are increasing along with the development of global information and technology. Companies must be able to adapt and improve themselves with more effective and efficient improvement methods. Improvement methods such as lean manufacturing also need to carry out continuous development to be even more effective over time. The company makes continuous improvements in the production process to increase consumer desire and satisfaction (Palange and Dhatrak 2021). One of the methods often used to eliminate or reduce wastes, namely Lean Manufacturing. Lean manufacturing focuses on value-added activities in processes that generate value for customers and eliminates non-value added activities (Sojka and Lepsik 2020). Lean manufacturing methods identify and reduce waste but need continuous development to provide more effective and efficient improvement analysis results. This paper carried out a resume of the recent development of lean manufacturing and its development using other methods such as Six Sigma, ECRS, 5S, and TRIZ to minimize waste, increase efficiency in achieving organizational productivity. However, this paper will only focus on finding gaps or opportunities for developing Lean Manufacturing methods with other methods such as ECRS and TRIZ in repairing problems such as defects, motion, and time which are still difficult to overcome. Resume of lean manufacturing recent development can be providing input and insights into the current development of lean manufacturing. Moreover, this latest journal resume intends to find new ideas to be recommended for future research to contribute to the development of lean manufacturing in the future.

2. Literature Review
Around 1950, Taiichi Ohno began developing the Toyota Production System to find continuous wastes for perfection (Pavlović and Božanić 2010). Lean manufacturing is a method for reducing waste and methodically changing processes. Lean is a technique for getting less input and creating more output to fulfill organizational goals. Input refers to the physical number of resources consumed, while output relates to the quality and quantity of items sold, as well as customer service (Wahab et al. 2013). Lean manufacturing divides three types of activities, i.e., Value Added (VA) Activity, Necessary but Non-Value Added (NNVA) Activity, and Non-Value

Adding (NVA) Activity. The five main principles of lean manufacturing are widely accepted, as is the lean roadmap known as VVFPP, as explained below (Mousa 2013):

- ✓ They recognize the worth of customers (V). Only what clients consider valuable is essential, and meaningful value and criteria are essential.
- ✓ Analyze the value stream (V). Following a thorough understanding of customer value, the next stage is to examine business procedures to see which ones genuinely contribute value. If an action brings no value to the process, it must be changed or deleted. In each process, the VSM phase is critical for determining value-added, non-value-added, and business value-added.
- ✓ It is flowing (F). Rather than transporting commodities in huge batches, focus on establishing a sustainable flow through production or the supply chain. In this phase, a transformation the operation into a single flow to avoid wastage.
- ✓ Pull (P) Demand chain management prevents the production of commodities into stock, attracting customer demands for finished products through the system. Employees will complete the previous process if the next process requires.
- ✓ Perfection (P) The removal of non-value-adding parts (waste) is a continuous improvement process (CIP).

3. Methodology

This paper reviews journals about lean manufacturing methods. The journal used is the latest journal from 2017-2021, which discusses lean manufacturing and its combination with other methods. Papers that can be used are only papers that use the lean manufacturing method with the ECRS or TRIZ method in solving manufacturing company problems. After collecting several suitable journals, then they are analyzed, draw conclusions and recommendations for future research. The authors did this study to make it more descriptive. This research is based on several previous studies to understand better how lean manufacturing processes have evolved.

4. Result and discussion

4.1 Recent Development on Lean Manufacturing

Nallusamy (2020) According to the author, in today's global industrial environment, every company strives to match the expectations of its clients to maintain its market position. In the worldwide competitive market, waiting time plays a significant role in their improvement. The difficulty for businesses is to figure out how to produce huge volumes with less time, inventory, and capital while using fewer resources. In Chennai, India, research is being conducted in the pump sector to reduce overall product waiting times by identifying and eliminating bottlenecks. The research focuses on reducing lead time by minimizing waste, such as NVA activity, using VSM to find areas for improvement, such as line balance, layout optimization, Pareto diagrams, and cause and effect diagrams. The research found that balancing the assembly line increased the line's efficiency and lowered the overall pump waiting time.

Alifiya and Singgih (2019) highlighted that enhancing quality, productivity, and efficiency while lowering production costs are problems that all manufacturing industries must tackle to be more competitive. Executing simple adjustments to the previous process for the next step can implement lean manufacturing (LM). Traditionally, implementation of cost-cutting techniques via enhancing operational efficiency through the use of LM. This study aims to provide an overview of the workflow simplification and trimming that will be accomplished by rethinking the process flow. With this research, it will be possible to identify the impact of product changes that can reorganize the manufacturing process and develop a product that provides a shorter process to achieve lean manufacturing (LM). The process activity mapping maps the present condition before analyzing the measurement of Lean Manufacturing (waste) in the actual prior process. As a result of the proposed change, create a new design (using design for manufacturing and assembly) to predict future production processes (generating future state map predictions and cost estimates). So, production costs and lead time can be decreased due to the proposed enhancements and giving ideas for improvements.

Palange and Dhatrak (2021) According to the report, the cost of equipment, materials, and labor will rise in lockstep with inflation, which is the most crucial factor influencing product costs. A direct loss that happens is the underutilization of basic mathematics, equipment, materials, and labor. Without a doubt, the focus of attention should be on maximizing the use of this dominant characteristic, followed by a waste reduction in manufacturing activities. This research examines the effects of applying lean manufacturing strategies to enhance operations and eliminate waste in several manufacturing industries. They did a journal review to see how they may incorporate other approaches or technologies into lean manufacturing to boost its continuous improvement performance. The implementation of lean manufacturing practices, according to his article, considerably aids in increasing corporate

productivity. Several advantages exist, including using VSM techniques to reduce cycle times, wait times, and solve bottleneck problems, 5S to keep the workplace clean and tidy, cause and effect analysis to find root causes, and FMEA to prioritize problems. The mindset of companies and employees is the most significant impediment to its implementation. There is only one constant in life, and that is change, so that continuous improvement in our workplaces, good cross-disciplinary talks, platforms for expressing ideas, and awards make work settings enjoyable and better to work.

Sutharsan et al. (2020) says that Value Stream Mapping is known for exposing waste in manufacturing, production, and business processes by identifying and eliminating or streamlining value-added measures and eliminating non-value-added activities, according to the company. Understanding the current state of pump manufacturing, identifying key areas of waste, problems, and opportunities throughout the process, developing a future state vision of each process, increasing productivity, and developing action plans to achieve higher production and shorter wait times are the research objectives. Non-value activities that waste time and resources are discovered at each phase and between each step. The process dramatically reduces and simplifies it to the bare minimum of steps. Reengineered processes generate future states mapping, with the process stages and information flow revised, streamlined, and made more cost-effective through lean manufacturing.

Mulugeta (2020) According to the case study, a garment manufacturing company uses a traditional production system and has long production lead times, poor line balancing, long material transportation, movement, and other issues. This study aims to boost productivity by reducing and eliminating difficulties and waste in businesses and enhancing market competency by employing various lean manufacturing methods such as motion studies, work standardization through time studies, and line balancing. This study found high work-in-process, poor line balancing, high cycle time and production lead time, and imbalanced distribution/assignment of work throughout the company. The data for this study were analyzed using both primary and secondary sources. Following a time study, work standardization, and line balancing, describe how these lines are balanced. This study found that the implementation of lean manufacturing reduced cycle times, work stations, reduced production lead times, standardized goods, and enhanced productivity were all noticed once the lean tools. New manufacturing methods can lead to improved product quality and more employee participation in initiatives to enhance production processes, products, and the organization as a whole.

Conclusion of the above discussion shows that lean manufacturing can help identify and minimize waste. The results of several recent studies show that applying lean principles can minimize waste, increase productivity, reduce waiting time, create future value stream mapping and make new improvement proposals for organizations. The current implementation of lean manufacturing is very beneficial for the company. However, it is still not maximum because only with lean manufacturing can some problems not be resolved. For example, lean manufacturing cannot solve variance problems and often still uses trial and error methods. This problem requires the help of other methods to cover it up, such as Six Sigma, ECRS, 5S, and TRIZ.

4.2 Tools for Lean Manufacturing Improvement

From the conclusion above, authors see the need to add other tools to improve more effective improvements. Many tools are available, but with limitations in this study, researchers can only take a few tools (for example, Six Sigma, ECRS, TRIZ, and 5S). As shown in Figure 1, the following are some of the most recent studies using the above tools: Ghaleb et al. (2017) The purpose of this research is to apply the Lean Six Sigma (LSS) methodology to small and medium-sized businesses (SMEs). The LSS proposed in this study looks at both the framework and the application of LSS in SMEs. The LSS methodology is used in this study to reduce lost time, faults, and sigma levels. The outcomes of implementing the LSS methodology show that the production level and sigma level can both improve. On another side, Burawat (2019) discussed the increased productivity in the highway industry and the carton manufacturing business. Due to fluctuations in weather and rain, which caused wet boulders and stones to attach to the conveyor belt, his inquiry revealed that the operation plan was not in compliance with the plan. This bottleneck results in poor quality and delayed manufacturing because the rocks stuck to the conveyor belt make the machine work harder. Production issues in the carton sector occurred because of delayed cutting and die-cut divisions, dirty warehouse areas, and delayed and incorrect transportation. As a result of his research, recent studies have found that using Lean Six Sigma, TPM, ECRS, work studies, and 5S; it is possible to improve the overall efficacy of the equipment. If the placement of production equipment is following the 5S principle, employees can work more productively. Rafsanjani and Singgih (2018) used Six Sigma as a reference for the improvement process using the stages of the Define, Measure, Analyze, Improve, Control (DMAIC) flow. The define stage includes defining objects, creating an operation process chart (OPC), critical processes, critical to quality (CTQ), and determining defect priorities using a Pareto chart. The measuring stage uses Process Capabilities and DPMO to determine process performance. FMEA uses the Analyze stage to get

priority causes of product failure in critical processes; then, integrate FMEA with TRIZ in the improve stage to get recommendations for suitable improvements in critical process development. In their research, Hakim and Singgih (2019) also used Six Sigma and TRIZ to minimize defects and process flow. In their paper, Jadhav and Ekbote (2021) says that lean manufacturing is one of many corporations' approaches to remain competitive in the global market. This study intends to increase cost reduction, standardization, and optimizing packaging machines using lean methodologies. Various lean manufacturing engineering tools are applied, including waste removal, standard working ways, visual management, and so on. Wastes connected with packing equipment, such as mishandling, waiting, and unused employee ingenuity, were recognized and decreased among the eight forms of waste. Work instruction manuals are written to prevent waste from inefficient processing and to improve machine cycle times. With some of the preceding discussion, it may be possible to construct lean manufacturing processes to provide more diversified and effective improvement solutions in specific situations. As a result, we attempt to advocate combining lean manufacturing with the ECRS and TRIZ methodologies for reducing waste in this study. When lean manufacturing is combined with ECRS and TRIZ to reduce key waste and develop improvement solutions based on innovative challenges, lean manufacturing can identify waste that causes losses to the business. TRIZ can provide solution in the improvement of waste that have not been able to be solved by the ECRS approach using 40 inventive principles and 39 engineering parameters. for example, combining the ECRS and TRIZ methods, such as the ECRS method, proposes rearranging or simplifying a waste problem; therefore, combining the two ways will result in a more effective solution. The ECRS approach will support the TRIZ method in making judgments to eliminate, combine, reorganize, and simplify significant waste derived from lean manufacturing in this example. Why is it considered to be more effective? Because TRIZ will propose answers based on the engineering parameters provided, eliminating the requirement for a trial-and-error approach to finding a solution to the problem.

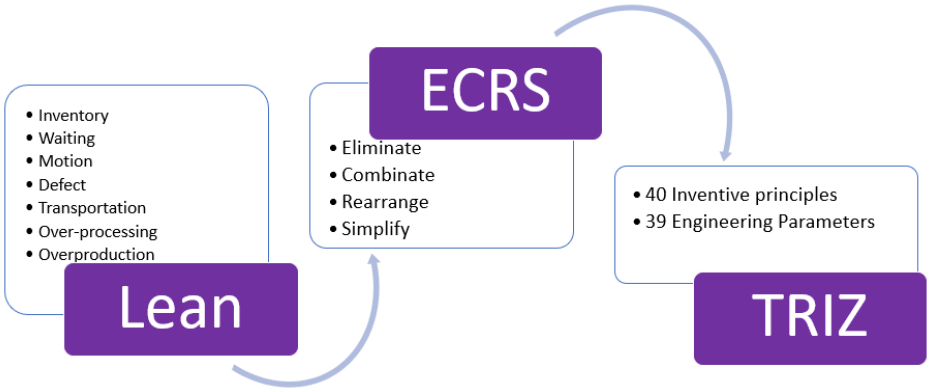

Figure 1. Relationship Between Lean, ECRS and TRIZ

5. Conclusion

This paper reviews the recent development of Lean Manufacturing and several Lean Manufacturing improvements. Several journals several tools such as Six Sigma, ECRS, TRIZ, and 5S were beneficial in providing improvement solutions that Lean Manufacturing could not result alone. The discussion above concluded that Six Sigma provides solutions to improve the problem of critical variance waste. Applying these tools can be beneficial both in terms of productivity and efficiency in the production line, enabling motivation, thus encouraging or building a work environment conducive to improvement and arguing for solutions to critical problems in the workplace. The authors suggest using TRIZ and ECRS for waste defect repair and minimization of waiting and motion waste based on the need and compatibility between each tool and the problems faced. TRIZ has inventive and contradictory problem-solving capabilities which simplify production lines and minimizes redundant time and movement. The problem of providing inventive solutions systematically and innovatively can be use TRIZ, ECRS is used to rearrange wasteful production lines, and 5S can help civilize workers.

This paper proposes using lean Manufacturing, ECRS, and TRIZ to reduce waste and increase production efficiency. The authors of this paper hope that implementing lean manufacturing with ECRS and TRIZ can contribute to the literature because of a more effective and efficient improvement solution. The implementation of Lean Manufacturing, together with ECRS and TRIZ, can respond to internal and external factors so that future development will positively impact increasing organizational effectiveness and efficiency. Further research needs to apply the principles of lean manufacturing, and its integration with the ECRS and TRIZ methods in company case studies to find out the benefits of these principles for problems in the field, how to meet/respond to company

organizational needs with the proper method and its correct application better and continue the search for gaps or possibilities for development with other tools.

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