

Applied Lean Manufacturing: A Qualitative Analysis

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Abstract—The purpose of this study was to explore the concept of lean manufacturing. In specific, the paper majored on tools, practices, and impact of lean manufacturing to an industry or company. A questionnaire survey and an interview were used to explore these major areas of lean manufacturing. The respondent in this study was to give their view of the lean manufacturing implementation process in their industries, tools used, practices, benefits, and major obstacle associated with lean manufacturing. The survey showed that many large organizations are using the concept of lean manufacturing and more so in the last few years, many organizations need to adapt this concept of lean manufacturing to reduce waste to maximize financial performance.

Keywords—Lean, Lean Manufacturing, Applied Lean Manufacturing, Qualitative Analysis.

I. LEAN MANUFACTURING

Lean manufacturing is a technique that focuses on reducing waste within a manufacturing system while at the same time maximizing its productivity. Waste can be defined as anything that does not add value to a customer. The technique has originated from various fields over time and well-known companies such as Intel and Toyota are using this technology. The history of lean manufacturing can be dated back to the 1990s when it was introduced by the Toyota production system and named lean. This technique becomes well utilized with the significant growth of Toyota's company to become one of the world's most successful car manufacturers. Regardless, as a waste reduction idea, lean can be traced back to Benjamin Franklin when he composed about his poor Richard's Almanac. During this time, Benjamin Franklin had already observed that more profit would be attributed to unnecessary costs than increasing sales. The lean concept with time continued to grow with other great people such as Frederick Winslow Taylor who was a mechanical engineer and the person behind scientific management theory that synthesizes and analyzes workflow as a way of efficiency improvement. In his scientific management principles, Taylor discussed this process in 1911. Despite the idea having been there, the term "lean" as a manufacturing principle was first used in the article "Triumph of the lean production system" published by John Krafcik in 1998 based on his

master's thesis in MIT Sloan School of Management [1].

Lean manufacturing was adapted to achieve goals and strategies such as improved quality, reduce time, reduce waste, and reduce total cost. The major objective for lean manufacturing is to reduce waste. Organizations developing total quality management, an umbrella quality concept which includes lean, can improve the quality of their products enabling them to meet their customer's needs and wants in the ever-changing environment and therefore stay competitive. With waste elimination, there is reduced cost of material and thus increased productivity whereas reduction in time wastage results from the increased efficiency where the materials can be utilized fully with high efficiency in a project. All these goals lead to total cost reduction where the organization save on materials and time from unnecessary activities. More so, there is usually additional cost due to overproduction considering the need for storage and warehousing.

Regardless of the various goals of manufacturing organizations, general principles followed in lean manufacturing involves eliminating waste, building quality, creating knowledge, continuous improvement, and respect for people. The principle of waste elimination is the key element of the system in lean manufacturing to increase firm revenues and customer satisfaction. The principle of quality control is known as the tool to determine waste which is the largest result in many businesses. Creating a Quality Management System is beneficial to the organization in reducing production issues and excessive resource utilization. Another important principle is continuous improvement which aims to discover new and better processes that would improve the firm lean production system, its people, and its process. Lastly, is the principle of respect for people, forming a culture of encouragement distributed across teams and organizational departments [2].

According to Vorne Lean Production, it is approximated that around 60 percent of all world manufacturing production activities are waste [3]. When it comes to lean manufacturing, every firm has a chance of improving on their techniques of minimizing waste, lowering their production cost, and still maintain high quality. Considering this is a continued improving sector, it is important to gather and learn more about lean manufacturing.

II. LITERATURE REVIEW

Trout [3] has defined lean manufacturing as an idea based on efficiency and flow optimization. The main goals are to enable nimble manufacturing operations, acquisition of industrial jobs, and ensure the satisfaction of their customers. According to Trout, if successfully followed, lean manufacturing can lead to quality growth, output productivity, and reduction of non-value-added work within the organization. Additionally, Trout's research detailed essential steps in the implementation of lean manufacturing such as identification of waste, differentiating causes and types of wastes, choosing the best strategy of waste elimination, plan implementation, waste-ratio calculations, and leanness metrics. Identifying waste is a necessary step for the continuing improving organization. The identification leads to differentiating various types of waste and their causes, eliminating the cause of waste can lead to a reduction of the waste automatically. The other step is choosing the best strategy in identifying lean manufacturing waste should result in optimum solutions for the elimination plan. This plan is followed by calculating the waste-ratio – comparing current levels to the past. The last step of implementation of lean management is leanness measurement which can be done with various techniques.

Furthermore, according to Trout's research, waste can also be categorized into various categories such as overproduction, transportation, excessive inventory, waiting, unnecessary motion, and over-processing. Overproduction is a type of waste that involves manufacturing a product in excess demand resulting in wastage of time, money, and space. This type of waste happens if an industry produces demand products for the future which is more to the extent of affecting the future total system. Waiting is another form of waste that mainly involves time wastage and ineffective processes due to one process waiting for the other to finish. In an organization, the manufacturing process should be continuous and smooth to eliminate waiting wastage such as job planning time. Transportation waste occurs during the movement of products, machines, and tools between workstations and from the workstation to the consumer market. This type of waste can occur even by accident and it is usually costly for a company. Over-processing waste occurs when the industry conducts extra processing on a component or product. This type of waste consumes excess material, labor, time, and money. Then there is the waste of excessive inventory which according to Trout is directly related to preservation and inventory storage costs for both raw material and finished goods. Unnecessary motion between a workstation and other distances may be due to placement of tools too far away or arrangement of machine parts in relation to a worker. Lastly, defect waste is basically poor quality and bad products that may lead to a company losing its customer base due to lack of satisfaction.

This research has provided insight into the major techniques and requirements within lean

manufacturing. Some of these techniques include 5S, automation, Kan-Ban, continuous improvement, Kaizen, Six Sigma, cellular manufacturing, value stream mapping, flexible manufacturing system, and work standardization. 5S techniques are based on motion and time reduction to eliminate wastes in which automation is about decreasing human effort through automatic systems that are more accurate and efficient. The technique of continuous improvement has the goal of ensuring quality improvement each day. Six Sigma seeks to reduce process variation, resulting in quality improvement, higher operational performance, and significant system improvement. The Kan-Ban technique involves minimizing work involved in the process with scheduled production. Total Quality Management is a method of ensuring minimal defects occur within the manufacturing cycle. The visual management technique provides visual information essential for making correction decisions among the workers and during the manufacturing process. Work standardization, like Six Sigma, is variation reduction by undertaking each process task in a like manner. Generally, Trout's conclusion was that lean manufacturing as a concept that is both profitable to the manufacturing companies and also to the consumer as long as those same companies are determined to reduce waste through adaption of these proven methods over the long haul.

Huq [4] determined that lean philosophy used in manufacturing could be applied to other business sectors to supply commodities at a lower price to the customer. The research documented the need of creating lean management for an organized production system to eliminate waste, reduce costs, build quality, and enhance organization performance. Huq has stated that lean as a process is based on five phases that are continuous to get improvement. The first phase is considering the current process and measuring performance through analysis and documentation. Phase three brings about accurately defining stream network values and then suggesting changes after identifying unneeded effects. The fourth phase applies recommendations of the conclusion in the previous phases. Phase five seeks to document and assess system performance through measurement. According to the researcher, three major concepts connected to lean are the identification of value, waste elimination, and flow generation. Value identification defines the customer view on products and services offered by companies and how each company meets overall customer needs. Considering the manufacturing process is made of various steps, the producer aspect on value sometimes can be hard to determine unless customer views are considered. The concept of waste in an industry, or company for that matter, can be categorized to different wastes which generally results in lost time, misuse of resource, and increased manufacturing costs. The third concept focus is on flow where the main objective is to ensure value across all business processes. Essentially, applied lean manufacturing must instigate

and maintain a steady and continuous flow without blockages and fluctuations.

Huq [4] has also classified lean tools into quality lean tools, process lean tools, and method lean tools. Quality lean tools consist of Kaizen, Poka-Yoke, and Total Productive Maintenance which contribute to higher levels of quality for a customer. Production process tools like JIT helps to make manufacturing processes more efficient. Lastly, work standardization and setup reduction time brings about optimal operational performance manufacturing facilities who participate in these practices.

According to the researcher, lean manufacturing has impacted industries in various positive ways such as faster delivery times, improved quality, improved visual management, enhancement of worker efficiency, total company involvement, and safe work environments. There is delivery time reduction through lean principles such as just-in-time which has enabled the delivery of production orders faster to customers – bringing about higher and sustained satisfaction. There is also improved quality as lean manufacturing involves various techniques in problem-solving that may strengthen manufacturing process which eliminate errors that can affect sensitive commodity products. The process of lean manufacturing has also enhanced worker efficiency as employees work in a team and are trained daily on ways to improve manufacturing production processes. The process of lean manufacturing also brought about total industry involvement as the process can lead to better performance of other sectors of the organization such as marketing strategies. The last impact is ensuring a safe work environment resulting from a well-organized process from acquiring raw materials to manufacturing them to finished goods.

Mostafa, Dumrak, and Soltan [5] provide additional insight into the implementation framework for lean manufacturing. According to the researchers, lean implementation can be considered as a roadmap, framework, and assessment initiatives. Some of the implementation framework connected to lean factors includes expert team building, situational analysis, lean communication planning, and new process training. Expert teambuilding focuses on experienced team use in providing and managing the process of implementation of lean manufacturing. There is deep expertise in such team lean professionals that can facilitate lean manufacturing implementation and lead to changes in companies that will ultimately increase their performance. The second factor is a situational analysis of the industry in areas of services, product, location, facilities, and personnel to determine organizational weakness and strengths when it comes to lean manufacturing. This factor is essential in determining the current situation and the expected outcomes in the future. Lean communication planning is the third factor that aims at involving all the stakeholders within the industry for successful lean manufacturing implementation. More so, effective communication among the staff ensures that everyone

knows the goals and objectives of the organization in the short and long term. Regardless, it is good for the staff to communicate their level of understanding to ensure that there is no misapplication of the lean manufacturing tools and concepts.

Another factor resides in the training process for managers and employees on the general concept of lean manufacturing. Everyone in a company should possess knowledge on lean to help avoid cultural resistance to lean transformation. In most cases, employees and managers are resistant to lean implementation due to lack of enough training and commitment. Thus, the organization should emphasize this training aspect. Lean tools only exist for quality enhancement and should be integrated where improved quality should be implemented. If there is no adequate understanding of these tools, it can lead to ineffectiveness and misapplications diverting from the main agenda of waste elimination. Process mapping is essential in highlighting the challenges that may come with the process. These factors eliminate waste by identifying opportunities that can lead to effective lean manufacturing. Reviewing past lessons of lean implementation can also help any company to improve on their current processes. Lean assessment is another tool which entails evaluation of practices in different areas of the company. Lean assessment acts as a measurement metric through which the industry can evaluate its lean performance to know how it impacts processes and what needs to be improved. The last factor in the implementation of lean manufacturing in a company requires diligent sustainment of learned lean manufacturing practices. This involves monitoring, reviewing, and controlling the implementation to ensure continuous performance and progress [5].

Assen [6] postulates how lean tools and practices are positively related to performance, customer response, finance response, and customer satisfaction. Lean tools have had a positive relationship with lean practices and are shown to increase performance efficiency, reduce waste, and minimize dysfunctional variability. Various tools such as Kaizen and visual management tools are aimed at improving lean manufacturing processes and their success results in better operational performance. More so, the researcher has determined that lean practices have resulted in positive customer response performance. This is due to higher delivery reliability characterized by a quicker response to demand and shorter lead times hence better performance in responding to the customers. There has also been customer satisfaction which has been shown by empirical studies where better customer response performance leads to high satisfaction level creating more loyalty, growth in sales, an increase in profits, and reduction in operating costs. Considering customer satisfaction, there is a positive impact on financial performance.

III. RESEARCH

A. Research Question

This research was created to delve deeper into the concept of applied lean manufacturing. Also, to determine factors such as lean practices, lean tools, and implementation strategies utilized by organizations to ensure efficient lean manufacturing processing. More so, the intent was to determine the impact of lean manufacturing on organizational financial performance, waste elimination, and how generally industries benefit from lean manufacturing.

- i. How do industries engage in lean manufacturing?
- ii. The process of lean manufacturing implementation
 - Steps involved in the lean manufacturing implementation process
 - Factors affecting the lean manufacturing implementation process
 - Strategies used in lean implementation
- iii. Impact of lean manufacturing
 - Lean manufacturing impact on the industry
 - Lean manufacturing impact on organization culture
 - Lean manufacturing impact on employees and other stakeholders
 - Lean manufacturing impact on organization customers
 - Overall benefits of waste elimination

B. Methodology – Research Design

The research used a mixed-method approach that combines both qualitative and quantitative techniques. The main objective was to generalize the qualitative results based on a small sample size from a large population. This method was suitable for addressing our research question regarding the concept of lean manufacturing. A qualitative research design is the first phase of finding how industries are applying the process of lean manufacturing to eliminate waste. The study was carefully designed to ensure the process was bias-free and stayed alert to any sources of error which could have been brought by the sensitivity of the question asked during the interview.

The qualitative techniques was useful in this research to the complexity of the subject because more than yes or no answers were needed. According to Shuttleworth and Wilson [7], the qualitative technique will yield more insightful and richer data underlying the subject of the study. The other need for choosing a qualitative research design involving in-depth interviews due to restricted samples with small budgets towards achieving the objective of the study. One goal of a comprehensive interview was to achieve quality feedback instead of quantity. With a qualitative study, a detailed explanation of this area of study was

discovered providing a guide for the quantitative phase. This phase investigated systematically qualitative data to gather quantifiable data after performing statistical or computational techniques. The purpose of applying the quantitative research method was to try and understand different aspects that are involved in lean manufacturing such as the implementation process, and the impact on the customers, employees, and the overall organization.

The first study using qualitative methods to get the general idea of productivity and engagement in a different industry setting and also determine some of these factors in those different settings that may influence industries to embrace lean manufacturing. Also, in this first phase, determination of the implementation process and the factors that may lead to successful lean manufacturing processes and those that may create challenges in the implementation of this process. In the second phase, it was about expanding the knowledge of the first phase regarding the industrial use of lean manufacturing to eliminate waste. Some of the expanded information, in this case, included Lean manufacturing impact on the industry, on organization culture, and on employees and other stakeholders. Furthermore, determination of lean manufacturing impact on organization customers, and the overall benefits of waste elimination was key for the study. With this research design, it was possible to cover all those areas of concern.

C. Study Participants

A sample of industries were obtained through a random selection. These were industries with complete contacts and information details. In the first phase, 100 manufacturers were identified, selected, and afterward, questionnaires distributed to those manufacturing industries through post mail. These questionnaires were directed to the managing directors of these manufacturing industries. The reason for engaging these managing directors was due to the high probability that they may be in charge of lean manufacturing activities in their industries. Regardless, the organization had the authority to direct those questionnaires to the appropriate person. To ensure there was a high response rate, there was follow up through telephone calls, follow-up letters, and the letters provided were self-addressed stamped envelopes. From this sample size, they were 20 responses with 15 of them being valid for analysis. These questionnaires had two parts where the first one concentrated on the manufacturing industry background for instance product manufactured and the number of employees. More so it involved views on impact, awareness, and other limitations to lean manufacturing implementation. The second part concentrated much on lean implementation strategies, tools, and practices and on the impact of lean manufacturing within the organization. These items were created based on a prior literature review where a five-point scale was used to study each item's degree of implementation. In this case scale, 5 meant complete implementation, 4 extensive

implementations, 3 some implementation, 2 little implementations while 1 meant no implementation. More so in this case, the average mean value symbolized level of implementation for the key areas. Additionally, to save the respondent time and since they are busy people, several questions were of close-ended types. More so, there was a request to have an interview with some of the responsible persons in lean manufacturing where around organization personnel agreed to meet for about 20 to 30 minutes where they gave their views on lean manufacturing and the various factors of concern. The interview was led by a series of questions focusing mainly on the direct point to save the time of the respondents.

D. Results

Table 1

Profile of the manufacturing industry		
Size of the industry	No of the industries	No in percentage
Small and medium industries	6	40%
Large industries	9	60%
Number of years in Lean Manufacturing		
Below 5 years	7	46.67%
Between 5-10 years	3	20.00%
Above 10 years	5	33.33%

In the above data, the research investigated the size of the organization that is likely to use lean manufacturing where large industries were the common ones with 60 % as compared to small and medium industries with 40%. This data was mined from the analysis of the data given by the 15 industrial respondents and it was taken to represent the population. In terms of the number of years the industry has been using lean manufacturing, the data showed that most of the organizations started using the process less than five years ago at 46.7% while those industries who had used the process for more than 10 years became the second with 33.33 % followed by those organizations which have used the process for about 5 to 10 years.

The data was also classified according to what an organization, or respondent, perceives lean manufacturing to be. In this case, respondents gave different views such as continuous improvement process, waste reduction technique, management philosophy, and so on.

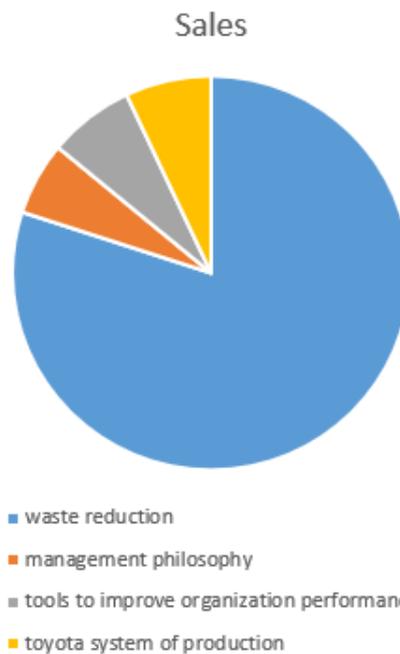


Figure 1: Understanding Lean Manufacturing

From the pie chart, one could conclude that most of the respondents view lean manufacturing as a way of waste reduction. Other views such as a management philosophy, Toyota system of production, and tools to improve the performance of an organization had an almost equal view from the respondent. This showed the respondent has a basic knowledge of lean manufacturing and its associated factors.

The data indicates a positive impact in the application of lean manufacturing on an organization.

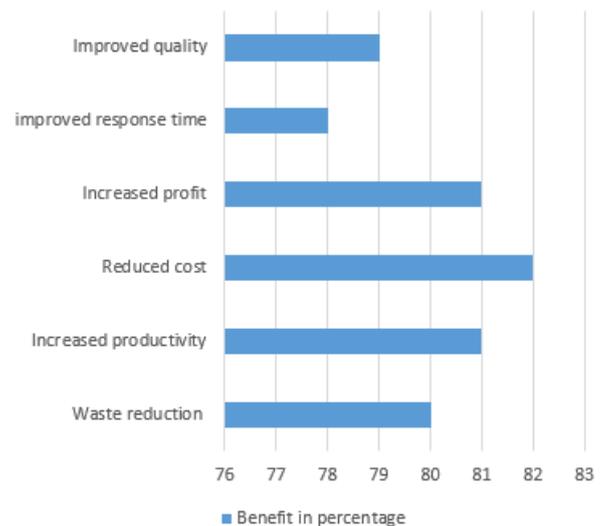


Figure 2: Benefits

From the data, it clear that most of the respondents indicated that lean manufacturing is leading to reduced manufacturing costs at 82%. 80% indicated that lean production has the benefit of waste elimination while 81% indicated the increased productivity as the benefit. 81% also indicate increased profit while 78 indicated improved response time with the improved quality benefit being 79%.

Additionally, the data was analyzed in terms of tools that most of these organizations used for lean manufacturing. Some of the tools of consideration were 5S, TQM, VSM, KanBan, Standardized work, and TPM.

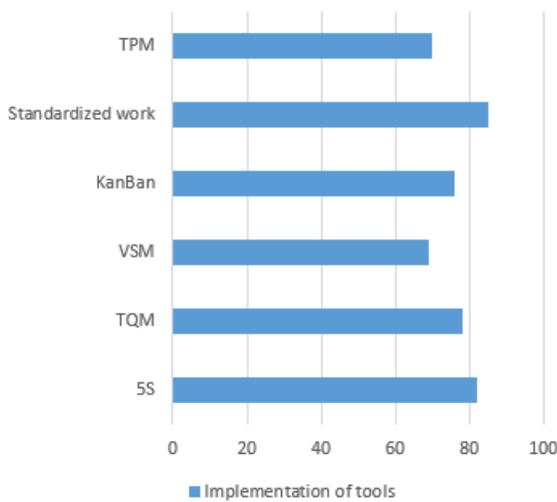


Figure 3: Implementation of Tools

From the analysis, standardized work is the tool that most of the industry is using for lean manufacturing at an 85% rate. It is followed at 82% by 5S while others such as Total Quality management is at 78%.

Another analysis of the data regarded factors that hinders the successful implementation of the lean manufacturing process. Factors that acted as obstacles included employee resistance, company culture, lack of support from top management, lack of time to implement, lack of knowledge to implement, non-recognition of financial benefits, and past lean project failures.



Figure 4: Obstacles to Lean Manufacturing Implementation

The data has shown that employees' resistance to lean manufacturing is the major obstacle to the implementation of this process. This may result from

various factors such as lack of knowledge on lean manufacturing resulting in employees not supporting the process. Other obstacles include past lean project failures at 80%, lack of implementation knowledge at 78%, and so on. Top management failure comes as the least obstacle to lean manufacturing implementation at 60%.

E. Discussion

The analysis of applied lean manufacturing practices in this industrial study supports the notion that these processes are becoming common in today's industrial sectors. Lean manufacturing is associated with major benefits to the organizations that are utilizing it to reduce waste. In this research paper, there has been an insight into how industries are engaging in lean manufacturing. The paper has also answered the research question regarding a different aspect of lean production as a result of careful analysis. Some of the insight from this paper has been understanding the concept of lean manufacturing as viewed by organizations, the implementation process, and other factors such as obstacles that may prevent successful implementation of the lean process.

To conclude, the paper has given important insights into the current status of lean manufacturing and the implementation of this process in different manufacturing industries. At the end of the day, organizations want to make a profit to stay in business, and thus they have to apply every strategy and tactics to meet their goals and objectives. Lean manufacturing is one strategy that can help an organization meet its goals in financial performance through waste reduction. Waste comes with added cost into terms of labor, storage, and other factors that may reduce the overall profit an organization can make [8]. More so with a lean manufacturing system, the quality of the product is ensured and thus becomes a satisfaction factor to the customer purchasing a product. With satisfied customers, loyalty increases, leading to more revenue for the organization. Thus, the lean manufacturing process is a continuous one and organizations need to maintain efforts to optimize on waste reduction techniques.

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