WORLD COMET RESEARCH GROUP

International Journal of Modern Research in Science & Engineering
Vol. 1, No. 2, 2018
Doi: 10.67228/30716357/IJMRSE-2018PII7C4Z
PP. 01-15

Original Article

Lean Manufacturing Implementation in Small-Scale Industries

Arvind Menon[1], Karthik Raman[2]

[1]*Senior Project Manager, Infosys Ltd., India.*

[2]*Software Architect, Tata Consultancy Services, India.*

Received: 11-03-2018 Revised: 11-19-2018 Accepted: 11-29-2018 Published: 12-04-2018

ABSTRACT

Lean Manufacturing is an important production philosophy that focuses on improving efficiency, reducing waste, and maximizing customer value. While it has been widely applied in large-scale industries, its implementation in small-scale industries (SSIs) presents unique challenges due to limited resources, low automation, skill gaps, and resistance to change. Despite these constraints, SSIs play a crucial role in economic development, employment generation, and supply-chain support. This study examines the implementation of lean manufacturing practices in small-scale industries and evaluates their impact on productivity, quality, lead time, and operational efficiency. Key lean tools such as Value Stream Mapping (VSM), 5S, Kaizen, Just-in-Time (JIT), and Total Productive Maintenance (TPM) are analyzed using empirical data from selected manufacturing firms. The research proposes a structured implementation methodology that includes organizational readiness assessment, waste identification, tool selection, pilot implementation, and performance monitoring. Quantitative analysis comparing pre-implementation and post-implementation performance indicates improvements in production efficiency, reduction in defects, better inventory turnover, and shorter lead times. The findings show that even partial adoption of lean practices can significantly improve performance in small-scale industries when supported by strong management commitment and employee participation. The study provides a practical and scalable lean implementation model for SSIs and demonstrates that lean manufacturing can be successfully applied even in resource-constrained environments.

KEYWORDS

Lean Manufacturing, Small-Scale Industries, Waste Reduction, Value Stream Mapping, Operational Efficiency, Continuous Improvement.

ISSN: 3071-6357
PP: 01-15.

1. INTRODUCTION

1.1. Background

Lean Manufacturing is a methodological and orderly manner of increasing the efficiency of operations since it entails the identification and removal of non-value addition involving activities in the production systems. The idea was created on the basis of Toyota Production System that was designed to be highly productive, with constant quality, and responsiveness to the demand of customers. The essence of the lean philosophy lies in the fact that this approach aims at the maximum customer value and the minimum amount of resources. Value is determined based on the customers perception or view thus any activity that does not necessarily add up to the customer requirement is wastage and should be minimized or avoided. Waste or muda as it is commonly called is a form of inefficiency that adds to the cost, makes the lead times longer and the whole quality performance poor. According to lean manufacturing, wastes are categorized into seven major groups, which include overproduction, waiting, transportation, over-processing, excess inventory, unnecessary motion and defects. Excess, unused inventory, and concealed issues are caused by overproduction, and it reduces the productivity and nativity, and distorting the workflow. Unneeded motion and transportation cannot contribute to any value but rather contribute to handling time and probability of damages. The over-processing causes unnecessary consumption of more resources compared to what is needed and excess stock neutralizes capital and fines process inefficiencies. Defects cause scrap and rework which directly influence the quality and satisfaction of customers. Bringing together these forms of waste systematically through standardized procedures, continuous improvement and engaging the employees, lean manufacturing helps organizations attend to increased efficiency and quality, reduced costs and enhanced competitiveness in a variety of industrial settings.

1.2. Importance of Small-Scale Industries

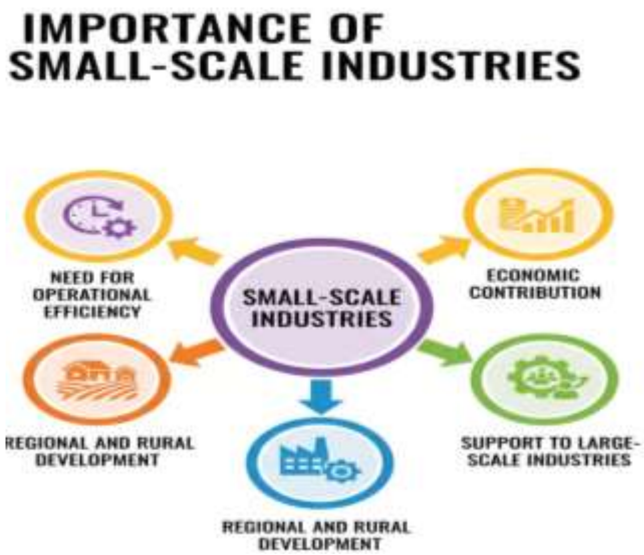

Fig 1 - Importance Of Small-Scale Industries

ISSN: 3071-6357
PP: 01-15.

1.2.1. Economic Contribution

The small-scale industry is an important part of both the national and regional economic growth because it has a crucial part in both gross domestic product (GDP) and industrial production. These business ventures may cut across various industries including manufacturing, textiles, food processing as well as engineering services and thus have contributed to an even-handed development of the industry. The fact that they operate with comparatively little capital investment makes them a tool that is useful in inculcating entrepreneurship and inclusive economic growth, particularly in the developing economies.

1.2.2. Employment Generation

The ability to create employment opportunity is one of the greatest things that small scale industries have done. They are usually labor-intensive industries that consume huge percentage of semi-skilled and skilled labor force. Offering employment opportunities on the local level, small-scale industry assists in minimizing the unemployment rate, decreasing rural-urban migration, and maintaining socio-economic stability. They are also training grounds which make workers acquire technical and managerial skills which make the work force worthwhile in the long run.

1.2.3. Support to Large-Scale Industries

The small-scale industries have a complementary role of supply, subcontractor and service provider to the large-scale industries. They give parts, subassemblies and specialized services, enhancing the industrial supply chains. Such interdependence increases flexibility, decreases lead times and lowers the production costs as well as gives consistent business opportunity to the small business.

1.2.4. Regional and Rural Development

Small-scale industries lead to the balanced growth of the region as it provides the dream of having industry in the rural and semi urban areas. These businesses utilize the local resources, decrease the regional differences in incomes and ignite the evolution of supportive infrastructure. This is because their localized aspect allows economic development outside key industrial centers which leads to sustainable development of regions.

1.2.5. Need for Operational Efficiency

Small-scale industries notwithstanding their significance have been associated with niggling issues like lack of resources, stiff competition, and variable demand. It is thus important to their survival and expansion to seek systematic ways of enhancing operational efficiency such as lean manufacturing. Efficiency also helps small-scale industries to save monies, produce quality, and be competitive in the domestic and international markets.

1.3. Need For Lean Implementation in Ssis

The SSIs are increasingly finding themselves in a very tough business environment which is highly competitive globally, customer needs which are evolving at a very high rate and profit margins which are dropping. The current customers want to receive high-quality products, reduced delivery

ISSN: 3071-6357
PP: 01-15.

time, and/or reasonable prices, putting a trolly on the small manufacturers in terms of the quality of to delivery and the ability to optimize operational performance, balance the costs. The use of traditional methods of mass-production, big stocks, huge amounts of batches, as well as inflexible processes, is no longer possible in the context of SSIs because it is limited in its financial provision and dynamic market circumstances. Such traditional practices tend to cause a lot of wastage and a prolonged lead time, lack of proper quality control and responsiveness to customer requirements. The Lean Manufacturing approach provides a highly flexible method that will serve as a way to cope with these issues as it aims at removing waste, simplifying the processes, and improving processes continuously. In contrast with the capital-intensive improvement strategies, lean focuses on low-cost and systematic changes, which can be completed with the help of the resources available. Value Stream Mapping, 5S, Kaizen and pull-based production systems are only some of the tools that help SSIs to find inefficiencies, streamline the process and better utilize the tools without significant investment in new equipment or technology. This is what renders lean specific to small business ventures that have to attain gains in their operations at a restricted budget. Moreover, lean adoption leads to increased flexibility which is essential in SSIs which are liked to be in high-mix and low-volume manufacturing conditions. Lean practices enable small manufacturers to react swiftly to shifts in demand by reducing setup times, reducing work-in-process inventory, enhancing process visibility, and so on. The involvement of the employees in lean initiatives is also important. Workers who are engaged in problem solving and constant improvement events will develop skills, become owners and inculcate a sense of responsibility that leads to long term effective performance. On balance, lean manufacturing lies not so much in the selection of the operational option by SSIs but in the status of strategy in enhancing competitiveness, guaranteeing long-term sustainability, and attainment of growth within an ever challenging industrial environment.

2. LITERATURE SURVEY

2.1. Evolution of Lean Manufacturing

The Lean Manufacturing system was born out of the necessity to address the shortcoming of the old approach to mass production that had high inventories, lengthy lead times and rigid processes. Initial investigations of lean manufacturing were strongly affected by the Toyota Production System in which practitioners mainly engaged in the systematic detection and removal of non-value-adding actions which is commonly called waste (muda). First researches had laid stress on process flow optimization, just-in-time production, and inventory reduction as major contributors to efficiency and cost minimization. As time went by, the definition of the lean manufacturing was broadened to encompass the organizational culture, the employee involvement, and the continuous improvement philosophies. The current literature emphasizes the combination of lean concepts and supply chain integration, online technologies, and sustainable manufacturing processes, which should be discussed as the transition to the overall enterprise-wide lean change. Such development shows that lean manufacturing is no longer regarded merely as a set of tools, but, instead, as a strategic management philosophy that will lead to the long-term excellence in the operations management.

2.2. Lean Tools and Techniques

The literature on lean manufacturing has abundantly registered numerous tools and techniques aimed at facilitating the process of waste reduction and process improvement. Value Stream Mapping (VSM) is often quoted as an exemplary tool, owing to the fact that it has been successful in graphically illustrating material and information flows so that bottlenecks, redundancies, and inefficiencies could be recognized within the organization. It is known that the 5S methodology, Sort, Set in order, Shine, Standardize and Sustain are regarded as essential facilitator to workplace order and discipline which is the foundation of stable and standardized operations. Kanban systems are also emphasized as controlling the flow of production and the reduction of work-in-process inventory whereas Kaizen focuses on the constant and gradual advancement of the system as a result of the engagement of the employees. The area of Total Productive Maintenance (TPM) is aimed at ensuring maximum efficiency of equipment using preventative and autonomous maintenance. All of these tools, used in an integrated fashion instead of fragmented, are the most effective as stressed by many empirical and conceptual studies.

2.3. Lean Implementation in Large vs. Small Industries

Based on the literature, some considerable discrepancy in lean application methods between large and small scale industries has been brought into focus. The structured and formalized lean programs emphasized in large organizations usually include lean teams, standard performance indicators, and sophisticated technologies, including automation and data analytics. These companies have more funds, qualified staff, and senior management effort, that encourage massive change programs. Small-scale industries, conversely, tend not to have resources to invest in any intensive lean training or even the complex systems, so such small-scale industries are in stark contrast with the large-scale industries. Therefore, the processes of lean deployment in small firms are informal, ad hoc and tools-based as opposed to strategy-based. According to researchers, the application of simplified lean systems tailored to the specifics of operations in small industries is better than the direct imitation of those developed in large companies.

2.4. Challenges in Small-Scale Industries

Some of the research papers report some long-standing problems that communicate their implementation of lean in the small-scale industries. The absence of knowledge and the lack of awareness of lean principles among the owners and employees is a common concern, which is often cited as one of the key obstacles. Fear of job loss or work overload can also be a source of resistance to change and worsen implementation efforts. The lack of training and skill development make employees unable to use lean tools effectively and a lack of the commitment by the strong leadership reduces the sustainability in the long run. Moreover, small companies also have faulty predictability, less financial resources to invest in capital, and unformal organizational management that make lean initiatives less productive. These mostly lead to disjointed or provisional implementations so small-scale industries cannot fully enjoy the fruits of lean manufacturing.

2.5. Research Limitations in Existing Studies

Although much has been researched on lean manufacturing, various constraints are depictable in the literature especially in the small scaled industries. Most studies heavily emphasize qualitative research including interviews and single case-studies that limit the external validity of research. The quantitative methods tend to focus on simple indicators of performance without significant validation models. Moreover, the standardized models of measuring the lean maturity and performance outcomes in the special specific environment of small-scale industries in particular are notably absent. The available evaluation frameworks are mostly based on mainly large manufacturing setting so that when applied on a smaller company, it becomes irrelevant. The following research gaps point to the necessity to develop systematic, data-driven and scalable assessment methods to learn more about and justify the application of lean in the mini-industries.

3. METHODOLOGY

3.1. Research Design

This research uses a structured case based research design in a systematic assessment of the effect of the implementation of lean manufacturing in the sampled small scale manufacturing units. It is believed that a case-based approach should be used since it would allow understanding of the real-life conditions of functioning, constraints and improvement opportunities of small-scale industries in detail. The study will be based on the before and after performance appraisal design, where the most important operational measures will be assessed before lean implementation and reassessed following the implementation of the chosen lean tools. The direct measurement of improvements in performance that could be attributed to lean practices and reduced the effect of other variables are possible through this comparative approach. The research starts with the strict selection of representative small-scale production plants in accordance with the criteria of the volume of production, size of labor forces, complexity of the processes, and readiness to engage in the improvement programs. Baseline data are gathered by using direct observations, production records, time studies and interviewing the shop-floor personnel and management. The pre-implementation state is defined by revenue indicators like cycle time, lead time, work in process inventory, defect rate and equipment utilization as well as labor productivity. Subsequently, lean tools such as Value Stream Mapping, 5S, and Kaizen are introduced sequentially and ensure that operations continue as normal. Data on the post implementation is gathered within a specific time of stabilization to reflect long-term gains and not short-term impacts. Comparative and descriptive methods are used then to examine the before-and-after outcomes in order to measure the performance change and detect the improvement trends. Besides quantitative analysis, qualitative data in form of employee review and management review are added in order to perceive and comprehend behavior trend and organizational changes. The research design is a mixed-method study that helps in increasing the strength of the results and offers a feasible groundwork of assessing the effectiveness of lean manufacturing through small scale industry sized manufacturing units on the basis of the volume of production, the number of employees, the complexity of the production process, and their preparedness to engage in an improvement project. Direct observations, production records, time studies, and interviews with shop-floor staff and management are used in obtaining baseline data. The pre-implementation state is determined by performance indicators ensuring cycle time, lead time,

ISSN: 3071-6357
PP: 01-15.

work-in-process, defect rate, and equipment utilization as well as labor productivity. After that, lean tools such as Value Stream Mapping, 5 S, and Kaizen are introduced in a phased approach in a way that they cause minimum disturbance to other processes. Data collected during post-implementation is gathered within a stabilization time to obtain sustainable improvements as opposed to transitory changes. Comparative and descriptive analysis techniques are then utilized to measure the performance changes and determine trends on improvement after and before the outcomes. Besides a quantitative analysis, qualitative information gathered through employee feedback and management reviews are brought in to gain comprehension about behavioral and organizational consequences. Such a mixed-method study design promotes the credibility of the results and offers a practical model of assessing the effectiveness of lean manufacturing among small-scale industrial settings.

3.2. Lean Implementation Framework

The presented framework of the lean implementation is aimed to be pragmatic, scaled, and adaptable to the operational capacity of small-sized manufacturing businesses. It encompasses five consecutive stages which are interrelated and each stage brings in the systematic adoption as well as sustainability of lean practices.

Fig 2 - Lean Implementation Framework

3.2.1. Organizational Readiness Assessment

The first phase is concerned with gathering of the readiness of the organization to implement lean. This is done by evaluating management dedication, staff sensitivity on the principles of lean, resource accessibility, and pre-existing organization culture. This is done through interviews, questionnaires, and initial observations in the shop-floor, which would determine possible barriers, including resistance to change, skills gaps, and communication. Awareness of readiness at this level assists in attaching the strategy of implementation and realistic goals of improvement.

3.2.2. Waste Identification and Process Mapping

During this step, the existing manufacturing operations are examined in a manner that will determine the numerous types of waste such as overproduction, waiting time, excess transportation,

ISSN: 3071-6357
PP: 01-15.

defects and unnecessary movement. Value Stream mapping (VSM) is used to represent flow of material and information of the production system. Such mapping allows defining the bottlenecks, activities that do not add value and the process simplification opportunities.

3.2.3. Selection of Appropriate Lean Tools

Depending on the wastes and process inefficiencies identified, appropriate lean tools are chosen that are to be put into practice. The accent is made on the selection of simple and low-cost tools like 5S, Kaizen, Kanban, and simple TPM practices that can be corresponded to the abilities of small-scale industries. The choice of tools is determined by the possible effectiveness of the performance advancement and the possibility to implement it easily.

3.2.4. Pilot Implementation

The chosen lean tools are first used in a pilot region or process to determine their effectiveness and possibility. There is a reduction in operational risks in this controlled implementation and employees get to experience lean practices in practice. The pilot stage provides feedback to improve implementation plans prior to general implementation.

3.2.5. Performance Measurement and Continuous Improvement

The last step is taken to measure the performance changes based on the predetermined key performance indicators, including: cycle time, productivity, defect rate and inventory levels. Frequent reviews and feedback systems are also put in place to maintain the changes and to encourage a culture of continuous improvement. The learning on implementation leads to ongoing optimization through lessons learned on implementation throughout the organization.

3.3. Data Collection

The data collection in this research was aimed in a manner that would allow it to be accurate, reliable and cover extensively the operational performance of the business prior to and after the introduction of lean. Primary and secondary data sources were used to record both the quantitative performance numbers and the contextual information about practices in manufacturing in small-scale industries. The main data collection also involved direct observations in the shop-floor where the researchers were able to record the real processes in the actual operating conditions, material flow, operator activity and sources of waste. Strategically planned time studies observed at major workstations supported these observations in order to determine the cycle times, set up times, waiting time and general process variations. There was also consistency in terms of the stages of production through the use of standardized observation sheets and timing. Moreover, records of the defects were actively accumulated to measure the performance of products in terms of quality. These records contained the categories of defects, the rate of occurrence, rework rates and the amount of scrap, which could give the insights into the process stability, and the major causes of quality losses. Physical verification and inventory report were used to obtain inventory data used in measuring the levels of work in process, raw material, and finished goods. It was necessary as it was the information to evaluate the wastes related to inventory and to recognize the possibilities of improvement in flow. The

ISSN: 3071-6357
PP: 01-15.

primary data was supplemented with secondary data sources, which gave information of the past and longitudinal performance. To determine production trends, machine usage patterns and machine downtime patterns over the long-run, production logs were investigated. The quality reports were checked to test the adherence to quality standards, results of inspection, and records of corrective actions. Data triangulation through the incorporation of primary and secondary data also minimized the possibility of bias and increased validity of results. All the data collected were tabulated, checked and standardized before analysis, whereby the performance comparing activities were rightful to represent the difference of lean implementation programs.

3.4. Performance Measurement Metrics

In order to measure the success of the implementation of lean manufacturing, it was decided to use a set of key performance indicators (KPIs) that would help measure the improvement of productivity, quality, inventory management, and responsiveness. These measures also offer a numerical point of reference in terms of performance of the system prior to and after lean application.

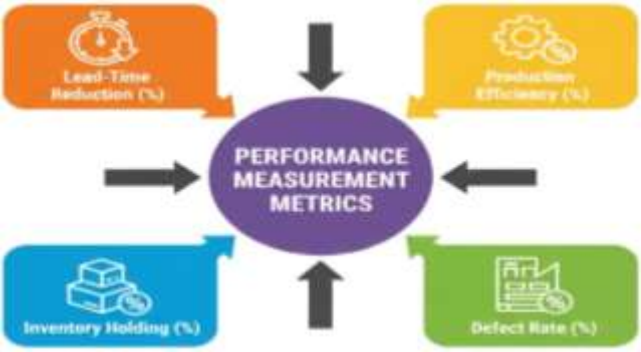

Fig 3 - Performance Measurement Metrics

3.4.1. Production Efficiency (%)

Production efficiency is a measure to determine how the available resources have been used efficiently in order to attain planned output. It is commonly determined as the standard or planned production output divided into the actual production output which is expressed as a percentage. Enhanced efficiency in production is an indicator of less idle time, more efficient flow of processes, better balance of workload, and the better use of labor and machine based on the lean approaches like elimination of waste and standardization of work.

3.4.2. Defect Rate (%)

The defect rate is that ratio of defective products to the total production output. The measure is key concerning the evaluation of the quality performance and stability of the process. Decreased rate of defects implies enhanced control over the process, proper analysis of the root causes, and increased compliance with systemized operating procedures. Kaizen, 5S and simple quality-at-source are lean tools that would help reduce defects and work-in progress.

3.4.3. Inventory Holding (%)

The measure of the inventory in relation to the production requirements is inventory holding. High inventory also hides the fact that there is inefficiency in the processes and it adds carrying costs. Loss of inventory holding percentage shows that the flow was improved, less overproduction and that the material was put under control, which is normally done by lean techniques of Kanban and pull-based production systems.

3.4.4. Lead-Time Reduction (%)

The reduction of Lead-time is a measure of the time saved in total while receiving orders and delivering the products. Lower lead times will mean better responsiveness, less waiting and transportation time and smooth processes. The goals of lean implementation are to reduce the time spent on non-value-added activities and thus lead to a shorter order fulfillment time and optimization of customer satisfaction.

3.5. Validation Approach

The validation method used in this research was aimed to ascertain consistency, reliability and credibility of the findings achieved in the implementation of lean manufacturing. To do this, the performance measurements were consistently gathered in numerous production cycles in the lead up to the implementation of the lean practices and during the implementation too. The element of repetition eased the impact of the variation that is running. Measures were repeated with the aim of reducing the effect of random and short disruption as well as fluctuation in demands that are common with small scale manufacturing setting. In gathering the data through multiple cycles, the study was able to ensure that the perceived improvements in performance were not a onetime issue but a consistent and a repeatable phenomenon. Constantity of measurement procedures during the study period also helped to validate it. All production cycles passed through the same data collection technique, performance measures, and measurement periods in order to compare outcomes. The usage of common standardized formats and tools conducted time studies, defect tracking, inventory evaluation and production efficiency calculation diminishing the chances of measurement bias. Moreover, production logs and quality reports were also cross-verified in order to verify accuracy and completeness of data. Quantitative and qualitative validation methods had to be used to increase reliability. To find the consistent patterns of improvement, quantitative trends, and the qualitative feedback of the shop-floor operatives and supervisors was used to prove the practical usefulness of lean interventions. Management reviews were also carried out to determine improvements in relation to the operational goals as well as strategic goals. Any irregularities or inconsistencies detected in the course of the validation process were reported by the root cause analysis and the corresponding correction measures were implemented where appropriate. The very rigorous way of validation contributed to the fact that the obtained results are reliable indicators of the actual effect of the introduction of lean manufacturing and that can be generalized to other small-scale industrial environments.

ISSN: 3071-6357
PP: 01-15.

3.6. Validation Approach

The validation procedure used in this research was meant to provide accuracy, consistency as well as reliability of the results obtained on the implementation of lean manufacturing. The validation was done by a repeated measurement of the performance of various production cycles before and after implementing the lean practices. This longitudinal measurement plan served to compensate natural fluctuations in the producing conditions like fluctuation in demand and human resources, and machine efficiency that are common especially in small-scale production contexts. The study was designed to observe periodic performance trends to ensure that the progress that was made was not short-term due to various operational changes. There was consistency created on how all of the production cycles utilized the same data collection techniques, measurement tools and assessment criteria. Standardized procedures were measured used as key performance indicators, such as production efficiency, defect rate, inventory holding, and the lead time, so that before-and-after comparison was possible. The risk of bias in measurement was also minimized by the use of identical time-study methods and the defect recording formats. The integrity of the data was also supported by cross checking with the production logs, quality records and inventory documents that were kept by the organization. Along with the quantitative validation, the qualitative validation was achieved by talking with the employees of the shop-floor and supervisory staff to verify the practical relevance of the measured improvements. Feedback on the implementation ease, process stability, and operational advantages was taken into consideration to assist numerical results. The detected irregularity or anomalies at the validation stage were analyzed with the help of simple root cause analysis methods. This holistic approach to validation increased the strength of the research results and their viability to the other small-scales manufacturing settings.

4. RESULTS AND DISCUSSION

4.1. Impact of Lean Implementation

When lean manufacturing practices were implemented, the results were highly positive and quantifiable in various parameters of operation of the small-scale manufacturing units that were chosen. The systematic waste reduction during the production process was one of the most significant effects. The total flow of materials was facilitated and became more predictable, as a result of labeling and removing non-value-added processes, which included unnecessary material handling, unnecessary waiting time, and unnecessary processing steps. This occurred as a result of improved flow that had a direct effect on decreased work-in-process inventory which in on its part decreased the congestion on the shop floor and reduced visibility of the status of production. Less inventory also reduced carrying costs and assisted in the uncovering of the underlying process inefficiencies which could be improved through specific activities. There was a significant improvement in labor productivity after the introduction of lean. The use of standardized work practices, enhanced workplace organization using 5S reduced operator fatigue, as well as idle time. Consequently, employees could do their work more effectively without adding workload or undermining of quality. Also, availability of equipment was enhanced through simple preventive maintenance procedures which also enhanced steady production. Employee engagement was important in maintaining these gains. The inclusion of active engagement on Kaizen activities and solving problems sessions made

ISSN: 3071-6357
PP: 01-15.

workers think of ideas on how to improve the processes and get rid of the waste. This engagement did not only improve operational performance, but a feeling of ownership and responsibility among the employees also came up. Better communication between the management and the shop-floor staff enhanced the team work and helped in solving the operations related problems much faster. Altogether, it is possible to note that lean implementation resulted in an environment of greater responsiveness, efficiency, and discipline of the production area, which indicates that this method of practice-oriented improvement is applicable to the small-scale manufacturing industries.

4.2. Performance Improvement Analysis

It is evident that lean manufacturing implementation has been very effective in revealing the percentage-based performance results across the important dimensions of operational activity. All of the metrics of the performance are indicators of the goals that are accomplished via a consistent reduction of waste, standardization of the processes, and employee participation.

Table 1: Performance Improvement Analysis

Performance Metric	Before Lean (%)	After Lean (%)	Improvement (%)
Production Efficiency	62	81	19
Defect Rate	12	5	7
Inventory Holding	100	68	32
Lead Time	100	70	30
Machine Utilization	65	84	19

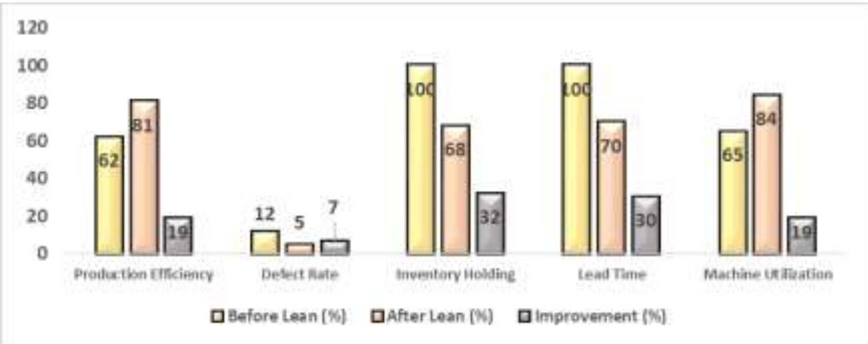

Fig 4 - Performance Improvement Analysis

4.2.1. Production Efficiency (19% Improvement)

An increase in productivity ratio of 19 is a good indication of efficient usage of resources available, such as labor, machines, and time. This benefit can be credited to faster working processes, less work idleness, and enhanced communication among succession processes. The introduction of standard work practices and the removal of unnecessary operations facilitated the efficient completion of the tasks, and a greater output was also realized with the help of saving the resources.

4.2.2. Defect Rate (7% Reduction)

The difference in the defect rate of 7% shows the quality growth and consistency of the product and process. Lean programs including root cause analysis, 5S workplace organization and greater awareness of both operators led to a reduction of errors and incidences of reworks. Though the percentage change seems to be moderate, it is a huge quality improvement to the small-scale industries where any small change in quality defects can save the industry a lot of money.

4.2.3. Inventory Holding (32% Reduction)

The largest improvement was in the case of inventory holding (32), which demonstrates a significant move towards lean, productions that are flow oriented. The presence of better work-in-process and finished goods inventory was entailed by the enhancement of better scheduling, enhanced material movement, as well as embracing of the principles of pull-based. Inventory reduction minimized the storage space requirements, carrying costs, material obsolescence, and enhanced the production transparency.

4.2.4. Lead Time (30% Reduction)

A decrease in the lead time by 30 percent makes it clear that the responsiveness has improved, and orders are fulfilled quicker. This would have been enhanced by eliminating waiting time, minimizing the number of batches to be processed, and simplifying process material flow. The reduction of lead times made customers happier and allowed responding faster to changing demand conditions.

4.2.5. Machine Utilization (19% Improvement)

The use of machine increased by a percentage of 19 because of lessen downtimes, better maintenance processes and enhanced planning of production. Simple Total Productive Maintenance (TPM) operations were useful to avoiding unforeseen failures, and all of this was utilized as more steadfast machine availability, and, most importantly, as a part of the overall productivity improvement. The combination of these findings validates the use of lean as a method that brings a balanced sustained improvement of performances in a small-scale manufacturing setting.

4.3. Discussion

Findings of this study show that lean manufacturing could be an efficient and realistic improvement tool to be used in manufacturing small sized industries under a planned and gradual implementation process. The improvements in the identified areas of the key performance indicators indicate how inseparably the lean practices are in that one area can improve as a result of the system overall performance. As an example, the crucial decrease in inventory maintenance and reduction of lead time implies a more efficient flow of the process and coordination of operations directly contributing to increased production efficiency and the effective use of machines. These results support the lean philosophy according to which the eradication of waste and optimization of flows are the core elements of sustainable operational excellence. The sound yet statistically significant evidence of a reduction in defect rate indicates that, the quality improvement in small-scale industries is usually slow and directly related to behavioral and cultural shift. More active participation of the employees in the process of problem solving and continual improvement was an essential part of promoting awareness about the processes and raising the level of responsibility. This is in line with the available literature

literature which stresses on human factors and employee involvement as the key to an effective lean implementation. However, in contrast to large-scale industries, where automation and sophisticated analytics tend to promote improvements, the findings of this case indicate that the results of small-scale industries can be improved significantly with the help of simple and low-cost lean tools that require employee involvement and management commitment. In addition, the results help to fill some gaps in other previous research that lacks the quantitative/percentage-based measures of lean increase of performance in a small-scale industrial environment. The reliability of the results may be reinforced by repeated measurements, the validation of the results on other production cycles, which contributes to its applicability in similar manufacturing facilities. On the whole, it has been discussed that lean manufacturing is not only a tool but a philosophy of continuous improvements which with a certain adjustment to organizational strengths can be used to provide small-scale manufacturing industries with quantifiable and sustainable advantages.

5. CONCLUSION

This research paper is conclusive in proving that Lean Manufacturing can be competitably and sustainably applied to the practice of small-scaled industries with the help of a systematic but adaptable methodological framework. Opposite to the general belief that lean practices are only applicable in large organizations with significant resources, the results of this study prove that small-sized manufacturing companies can achieve great gains in terms of operating performance, as well. The systematic investigation aimed at waste removal, streamlining of operations and enhanced workflow saw the industries concerned make significant gains on production efficiency, reduction of inventory, lead time, quality performance and use of machinery. These findings underscore the fact that the success of lean implementation among small firms is less dependent on sophisticated technology and more on disciplined implementation, employee participation, and managerial involvement. Small-scale industries managed to cross the implementation barriers despite the inherent disadvantages, which included limited finances, absent skills and informal organization, by deploying the simple lean tools that, which were selective and phased. Value Stream Mapping, 5S, Kaizen, and simple preventive maintenance practices were particularly found to be effective in generating quick and obvious improvements. Employee participation proved a decisive success factor, since focusing participation in the ongoing improvement endeavors resulted to greater problem solving skills, which led to a feeling of ownership, and an internalization of responsible and teamwork culture. These cultural and behavioral shifts were instrumental in maintaining changes and improvements that proceeded past the implementation phase. The presented methodology can be regarded as an effective blueprint of a lean implementation that has a specific focus on the operational realities of small-scale manufacturing settings. The framework focuses on the alignment of the lean initiatives to organizational capabilities and strategic objectives because it focuses on organizational readiness assessment, pilot implementation, performance measurement, and ongoing validation efforts. Moreover, quantitative, percentage-based measures of performance and repetition of the research findings through several production cycles contribute to the increased reliability and generalizability of the research findings. The proposed study can be further developed by future research by addressing the topic of how digital technologies and Industry 4.0 ideas can be used alongside lean manufacturing.

ISSN: 3071-6357
PP: 01-15.

Major efficiency, responsiveness, and competitiveness of small-scale industries can be further improved by the implementation of low-cost digital tools of real-time collection of data, monitoring of performance, and predictive maintenance. Such integration would be one of the logical developments of lean manufacturing, encompassing its original principles and the new technological potential to help the long-term sustainability and variations of industry.

REFERENCES

[1] J. P. Womack, D. T. Jones, and D. Roos, The Machine That Changed the World, New York, NY, USA: Free Press, 1990.
[2] J. P. Womack and D. T. Jones, Lean Thinking: Banish Waste and Create Wealth in Your Corporation, 2nd ed., New York, NY, USA: Simon & Schuster, 2003.
[3] T. Ohno, Toyota Production System: Beyond Large-Scale Production, Portland, OR, USA: Productivity Press, 1988.
[4] M. L. Emiliani, "Lean behaviors," Management Decision, vol. 36, no. 9, pp. 615–631, 1998.
[5] J. Liker, The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer, New York, NY, USA: McGraw-Hill, 2004.
[6] M. Rother and J. Shook, Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA, Brookline, MA, USA: Lean Enterprise Institute, 1999.
[7] R. Shah and P. T. Ward, "Lean manufacturing: Context, practice bundles, and performance," J. Oper. Manage., vol. 21, no. 2, pp. 129–149, 2003.
[8] A. P. Mishra and V. Sharma, "Lean manufacturing implementation in small and medium enterprises," Int. J. Eng. Res. Technol., vol. 4, no. 6, pp. 118–123, 2015.
[9] R. Bhamu and K. S. Sangwan, "Lean manufacturing: Literature review and research issues," Int. J. Oper. Prod. Manage., vol. 34, no. 7, pp. 876–940, 2014.
[10] A. Achanga, E. Shehab, R. Roy, and G. Nelder, "Critical success factors for lean implementation within SMEs," J. Manuf. Technol. Manage., vol. 17, no. 4, pp. 460–471, 2006.
[11] J. Antony, A. Kumar, and C. N. Madu, "Six sigma in small- and medium-sized UK manufacturing enterprises," Int. J. Qual. Reliab. Manage., vol. 22, no. 8, pp. 860–874, 2005.
[12] M. Dora, M. Kumar, A. Van Goubergen, D. Molnar, and X. Gellynck, "Operational performance and critical success factors of lean manufacturing in European food processing SMEs," Trends Food Sci. Technol., vol. 31, no. 2, pp. 156–164, 2013.
[13] S. Vinodh and R. Balaji, "Fuzzy logic based leanness assessment and its decision support system," Int. J. Prod. Res., vol. 49, no. 13, pp. 4027–4040, 2011.
[14] J. Bhasin and P. Burcher, "Lean viewed as a philosophy," J. Manuf. Technol. Manage., vol. 17, no. 1, pp. 56–72, 2006.
[15] A. N. Rose, B. Deros, and M. N. A. Rahman, "Lean manufacturing practices implementation in Malaysian SMEs," Int. J. Innov. Manag. Technol., vol. 2, no. 4, pp. 381–385, 2011.