NOLEGEIN Journal of
Operations Research & Management

ISSN: 2581-5458
Volume 5, Issue 1, 2022
DOI (Journal): 10.37591/NJORM

http://mbajournals.in/index.php/JoORM/index

Research NJORM

Kaizen and 5S: Productivity Improvement Tools for Automotive Assembly Line

Ashish Dahiya[1,*], Sunil Kadiyan[2], Rakesh Giri[3]

Abstract

Manufacturing ventures believe in the methodology which is taken on by the producers to work on their presentation in such a profoundly serious climate. Supporting the business execution and further developing it in constant mode is one more matter of worry for the business managers. The reliable improvement of assembling yields is basic for producers. The creation framework expected to give serious needs is chosen. Organizations perceive lean practices to be a helpful procedure for coming to more proficient execution in manufacturing processes. In the approach to choosing production strategies, lean manufacturing is an extensively acknowledged strategy to further develop business execution in such a cutthroat and unpredictable climate all through the world. The essential standard behind the progress of lean assembling is how manufacturing waste is recognized and removed from the framework. This study focuses on how handling waste in the production cycle of the Head Lamp Leveling Switch manufacturing system can be limited through the reception of lean assembling instruments. As a way of getting higher productivity by using the kaizen tool cycle time for the process, PCB soldering has been reduced from 49 sec to 35 sec in the HLLS assembly line.

Keywords: Productivity, improvement, Lean manufacturing, Processing waste, HLLS (Head Lamp Leveling Switch)

INTRODUCTION

All over the world, manufacturing organizations are confronting new difficulties to lay out and keep up with their exhibition in the present cutthroat climate. The world market has been coordinated to deliver products anyplace on the planet and the client is additionally allowed to move anyplace on the planet to buy things of his premium. The business climate has constrained the organizations to utilize their framework at the greatest level to stay serious in the market [1]. In the ongoing assembling situation, enterprises are confronting another kind of strain, where the business market is of refined and differing nature, client decision is changing quickly and an overall contest between the ventures is being harder step by step to keep up with their benefit. In such a serious climate organizations are remembering to look through new creative and useful techniques to support and stay on the planet market. Fabricating ability can be accomplished by taking on all-around paired vital and functional undertakings for accomplishing business targets and objectives. In this situation, just nimble, adaptable, cost-effective, and excellent makers can endure [2]. As a triumphant procedure effective lean standards and techniques can further develop the business

***Author for Correspondence**
Ashish Dahiya
E-mail: ashishd0@gmail.com

[1]Student, Department of Mechanical Engineering, School of Engineering and Technology (GTC), Soldha, Bahadurgarh, Haryana, India
[2]Assistant Professor, Department of Mechanical Engineering, School of Engineering and Technology (GTC), Soldha, Bahadurgarh, Haryana, India
[3]Lecturer (Retd.), Department of Mechanical Engineering, Hindu Institute of Technology, Sonipat, Haryana, India

Received Date: June 15, 2022
Accepted Date: July 15, 2022
Published Date: July 25, 2022

Citation: Ashish Dahiya, Sunil Kadiyan, Rakesh Giri. Kaizen and 5S: Productivity Improvement Tools for Automotive Assembly Line. NOLEGEIN Journal of Operations Research & Management. 2022; 5(1): 1–10p.

execution to a more significant level in all elements of efficiency, quality, process improvement, and cost-saving [3].

A critical effect on productivity might be seen by the various ventures of having lean. In the approach to following the idea, numerous ventures have become inclined toward distinguishing and disposing of waste [4]. Lean creation is broadly taken on by the undertakings by coordinating customary and piece creation ways to deal with make client situated market climate. A precise and logical methodology expects for smooth utilization of lean execution and acknowledgment of lean degree and its improvement bearing [5].

In India, auto parts are being made on a large scale and these are provided to automobile organizations all over the world to universally satisfy the prerequisite. Producers of automobile and auto parts have placed India in top request by keeping up with a great and imaginative methodology for assembling. Auto part producers and ventures have opened new entryways for India to improve monetarily by embracing new advances and functional techniques [6].

In this condition, Lean/Lean concepts/Lean assembling/lean production or rather lean administration is a scholarly and deliberate way to deal with getting a cutthroat express an assembling industry. Lean production is becoming significant for something other than manufacturing organizations. One counseling organization has worked on its productivity by 60% through lean process management [7].

The Kaizen reasoning is favored due to its straightforward plan for interaction, representatives, and in any event for end clients. It covers each cycle in an assembling framework to be gotten to the next level. It has the element of adaption to ideas for little and large changes in the framework to accomplish greater efficiency [8].

LITERATURE SURVEY

To further develop productivity and reinforce the thought process of the exploration of lean manufacturing rehearses; the examination work of the accompanying researchers might be incorporated as under:

As per H.J. Warnecke and M. Huser (1995), a methodical, logical, and scholarly methodology that can get potential express an organization in wording productivity and quality improvement is lean [9]. B. W. Braiden and K. R. Morrison (1996) contended that in the wake of executing the lean strategies in any association productivity might be expanded inside the association of concern. Likewise, the season of the machines and offices might be worked on by the execution of a similar hypothesis [10].

As indicated by B. H. Rho and Y. M Yu (1998) in a division of Hughes Aircraft an improvement was seen by dispensing with non-esteem added components from creation process as assembling cost cut significantly, process duration diminished to ten times, productivity further developed by 250% and in-process quality worked on by half [2]. As per J. Bessant's (2000) 'Persistent Improvement Research for Competitive Advantage project' UK, saw several organizations are embracing Continuous Improvement program, 65% of organizations think about it as an essential significance, and half have taken on a type of program to apply these ideas, 19% have supported the course of CI in activity and 89% of the organizations decidedly affects quality, conveyance execution or a blend of these [11].

As indicated by M. Holweg (2007) lean manufacturing with its parts in auto businesses might further develop the issues connected with large-scale manufacturing toward a certain path. Additionally, presumed that this hypothesis might determine issues looked at by the association in various streams separated from the creation [12]. As indicated by R. Giri and A. K. Mishra execution of lean parts (Kaizen, 5S, and poka-burden) with the DMAIC cycle has further developed efficiency and dismissal lessens to zero from 0.8% at light testing in the sequential construction system of a car industry [13].

H. Faye and P. Falzon (2009) considered and broke down the impact of lean ideas with its parts in the auto industry. The outcomes support the hypothesis by working on in execution of specialists, adaptability in changing requests, and quality issues by recognizing and handling waste [14]. S. Sivakumar and K. Muthusamy (2011) depicted after a contextual analysis of MNCs in Malaysia that productivity devices execution in global organizations in guaranteeing fruitful business is legitimate. Two principal techniques utilized by these organizations to further develop their productivity are to dispense with squander and to diminish varieties in their cycles by applying fitting efficiency apparatuses, for example, TQM, Six Sigma, and Lean procedures [15].

S.C. Raja and G. Sundararaja (2012) have presumed that a serious climate has been encountered via auto organizations in diminishing waste and working on quality. In this setting lean assembling devices are taken on by the organizations to decrease WIP inventories to contend in the world market. This examination contextual analysis is finished, in the auto industry with the target of waste decrease. An improvement of 11.95% in productivity was uncovered by investing some energy to diminish movement squander on the shop floor [16]. G.S. Nhlabathi and P. Kholopane (2013) portrayed in their procedures that significant business houses have been attempting to embrace new business techniques consolidated with lean and its part-producing kaizen. By the utilization of assembling kaizen underway framework, it might work on the cycles by wiping out squander and thus brings about further developing work efficiency [17].

As per H. Abdulmouti (2015), kaizen is a strategy through which associations improve by utilizing CI processes. The upgrades through kaizen partners with the least costs and without complex methods. By carrying out the kaizen devices at Toyota focus in Saudi Arabia, the accompanying outcomes might be summed up as saving around 5.5 million without putting resources into new offices, labor decreased by 26.9%, an expansion in viability by expanding the yearly result by around 13% and further developing in quality was noticed [18]. H.A.D. Perara (2016) has portrayed his situation concentrate on that SMEs in Sri Lanka need ceaseless improvement to take the upper hand by lessening waste and expanding benefits. In this setting lean devices with their part kaizen were tried in an industry. The review was made in three separate regions as work technique improvement, design change, and execution 5S. By executing lean ideas results were seen as expanding productivity by 41.14% [19].

Sara Antomarioni et al. (2018) have portrayed that the execution of kaizen activities to further develop the effective exhibitions of a creation framework investigated through esteem stream planning is a prerequisite. In this manner, by having the kaizen technique both cycle execution and ecological issues might be supported [20]. A. Elkhairi et al. (2019) have contended and expressed that lean theoretical methodology might prompt association towards higher productivity. Additionally, seriousness will work on saving their assets and removing waste through imaginative methodology upheld by lean devices [21]. A. Ghobadian et al. (2020) have portrayed that because of expanded intensity all over the planet and to fill the client's assumptions, numerous associations are embracing the lean assembling technique [22]. As per R. Nagaich et al., (2020) lean assembling alongside part kaizen has demonstrated its viability by further developing productivity, decreased piece, and diminished down season of the offices in a tire organization [23]. The locking issue has been eliminated utilizing the consistent improvement technique [24]. As indicated by R. Giri and A. K. Mishra (2020), in the setting of productivity improvement in the mechanical production system of HVAC switch fulfillment time for not many exercises was diminished by 31.22% [25].

OBJECTIVES

The executives of the organization were thinking about progress in efficiency execution, quality and cycle capacities of the HLLS manufacturing line by presenting a new assembling technique. The issue was that to make this line a model line, an improvement program can additionally be reached out to various sequential construction systems in the organization. In this setting to accomplish the

objectives related to the sequential construction system of item HLLS, the accompanying targets were set for making enhancements:

1. To decide the organization's ongoing performance and production capacity.
2. To examine and recognize issues in assembly line.
3. To make the potential solutions to the different distinguished issues.
4. Execution of solutions to improve productivity by ideal usage of assets, reducing waste and decrease in cycle time of the exercises.
5. Results and Recommendations for development in productivity of HLL Switch.

EXPERIMENTAL WORK

This research takes place in the context of production in the automotive industry. In the auto business, productivity is vital to an association's outcome in the present situation. Large scale manufacturing is made conceivable with mechanical production system work, which includes division of assignments into little undertakings and short work process duration to distinguish squander related with that specific movement. This approach underlines the distinguishing proof and consistent disposal of waste. Subsequently, it allows a quick reaction to showcase changes because of decrease in lead time [14]. In this context to improve the productivity of HLLS assembly line, the lean manufacturing tool (kaizen) will be used as follows:

Improvement Strategy

The ceaseless course of item advancement and further improvement expects a lot more noteworthy significance in the present cutthroat climate [9]. In this context to improve the HLLS assembly line status, current production process with its parameters and dimensions on line, quality issues during production at different levels were examined and analyzed to make it free from muda (processing waste). To reduce error in data collection and measurement phase, parameters were examined several times on assembly line. Before solution implementation to the identified problems root causes of the problems were searched to take effective measure in assembly line.

Introduction to the Assembly Line

To create head light leveling switch the straight mechanical production system was coordinated into 9 phases of gathering processes on various machines with 7 partners working in line. The various cycles finished in assembling of HLLS mechanical production system are: (Figures 1 and 2).

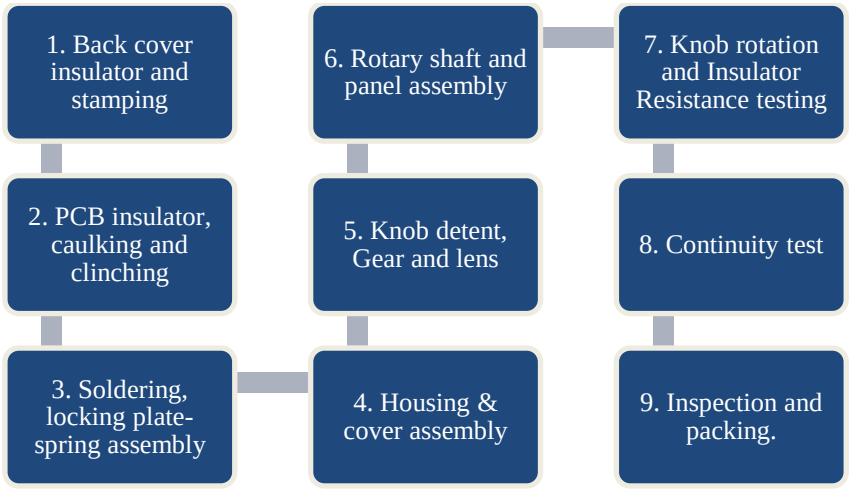

Figure 1. Process flow diagram of head lamp leveling switch**.**

Problem Formulation

Presently the capacity of HLLS assembly line is limited to 450 switches in a shift with 7 associates on line. It was decided by the management of the concern to increase the line capacity with existing

facilities and manpower to higher value. In this context lean manufacturing concepts were decided to implement in assembly line to improve line capacity by identifying and eliminating non value added work elements throughout manufacturing cycle. In measurement phase of the project 'quality issues' and 'larger cycle time for some processes' were identified in the path of improved line.

Figure 2. Head lamp leveling switch.

Now, to improve the productivity in HLLS assembly line for its product, we are taking one of the constraints i.e. 'larger cycle time for some processes' for improvement. In this context non value added work elements will be reduced to improve cycle time for the process/processes. Then, at that point, the consequence of this study might be applied to the head lamp leveling switch assembly line and lay out the consistent improvement plan for the organization to work on quality and productivity of head lamp leveling switch change to the ideal level by diminishing the interaction delays, cycle time and different wastes.

Measurement Phase: Objective 1

In this phase cycle time for the processes/activities associated with the main processes was calculated on assembly line considering 16% ILO recommended allowances. Cycle time for different processes associated with HLLS assembly line is illustrated in Table 1 with throughput time 360.5 sec (sum of cycle times for all the processes).

Table 1. Cycle time for process.

Process Sequence No.	Process	Cycle Time (Measured with Stop Watch in sec.)
1	Stamping-Back cover	11
2	Insulator assembly	12.1
3	Assembly and caulking of PCB	15.3
4	Clinching	10.4
5	Soldering	49
6	Assembly-Lock plate & spring	12
7	Assembly-Housing	18.7
8	Sub-Assembly	19
9	Assembly-Knob detent	24.1
10	Assembly-Gear and lens	14.4
11	Assembly-Knob head lamp leveling	13.3
12	Assembly-Rotor shaft	30
13	Panel and switch sub assembly	27
14	Assembly-Rotary Knob	11
15	Insulator Resistant & Continuity Testing testing	58
16	Final inspection and packing	35.2
Throughput Time (Total Cycle Time) —>		360.5 sec

Problem Identification for Improvement: Objective 2

In this context of productivity improvement in HLLS assembly line through kaizen and 5S tools, process PCB soldering (Table 1, Sr. No. 5) was identified as a problem for improvement. This problem is identified for improvement (cycle time reduction for the process) considering it in 2-phases as (i) walk time in collecting Insulator and PCB by the operator is more and (ii) PCB soldering time is more, which may be reduced to some lower value.

Description of Problems 'more walk time' and 'more PCB Soldering Time'

i. Presently before improvement Insulators and PCBs trays are kept in such a way that these occupy 700 mm space horizontally. Operator has to move a little more for picking Insulator and PCB during manufacturing cycle of switch and consequently takes more time, which increases throughput time for the switch assembly.
ii. During assembly of head lamp leveling switch soldering on PCB is carried out at two positions after rotating the product through 180° Figure 3. Presently with existing facility it cannot be completed at one position of PCB on locater, only lower side points are soldered properly in this position. In this position soldering operation can be completed for remaining upper points, which have less contact area with soldering iron bit causing wetting problem. Therefore, PCB is rotated through 180° for the remaining upper points. In this way it takes more time to complete soldering operation, which increases throughput time and ultimately decreases the productivity in the assembly line.

Root Cause Analysis for the Problems

After analyzing the whole process root cause of the first problem (more time in picking Insulator and PCB) is improper method of placing the trays on table. Due to this operator has to move a little more distance in picking the Insulators and PCBs, it may be improved by changing the pacing arrangement from horizontal to vertical.

Root cause for the second problem (rotation of PCB through 180^0 on locater) is improper design of locater due to which PCB is rotated through 180^0 for soldering on remaining points. This may be improved by changing the design of locater, so that soldering on all points may be done at same position of locater.

Developing and Implementation of Solution for the Problems: Objective 3 & 4

Problem No. 1: More time in Picking Insulator and PCB

Initially before improvement trays containing Insulators and PCBs were placed horizontally on the table. This arrangement was covering a horizontal distance of 700 mm. Now, in the way of finding solution for this problem, we have changed the design of pacing the trays from horizontal to vertical. By adopting this arrangement we have reduced 700 mm distance to 400 mm and consequently less time in collecting the Insulator and PCB for the switch manufacturing cycle.

Problem No. 2: Rotation of PCB through 180° on Locater

Initially the way of doing the soldering on PCB with terminals is that the locator which holds the PCB is kept it in horizontal position. In this first position soldering on lower side points are performed. The upper side points cannot be soldered in this position because of lack of wetting area at this angle of soldering iron. For proper soldering on PCB the angle should be between 45° and 60° otherwise favorable soldering action will not be there. Therefore, to make the proper angle, PCB is rotated through 180° and then soldering is done at upper points. As PCB is rotated at 180°, the points on which soldering is to be done, come at lower side. At this second position remaining points are soldered. Process time for this operation is 49 sec.

To remove the problem of doing soldering in two positions of the PCB, we changed the design of locater from horizontal to vertical. At this changed position of locater, the points to be soldered come

to lower left and right side. In this position all points can be soldered without changing the PCB through 180°. Soldering action before and after improvement is illustrated in Figures 3 and 4. This illustrates that when we have implemented the lean technique Kaizen to locator design, the problem of changing the position of PCB through 180° has been removed.

By using lean technique we have reduced the process time from 49 sec to 35 sec, which helped us in achieving our target to do the soldering on PCB in one position and reducing the cycle time.

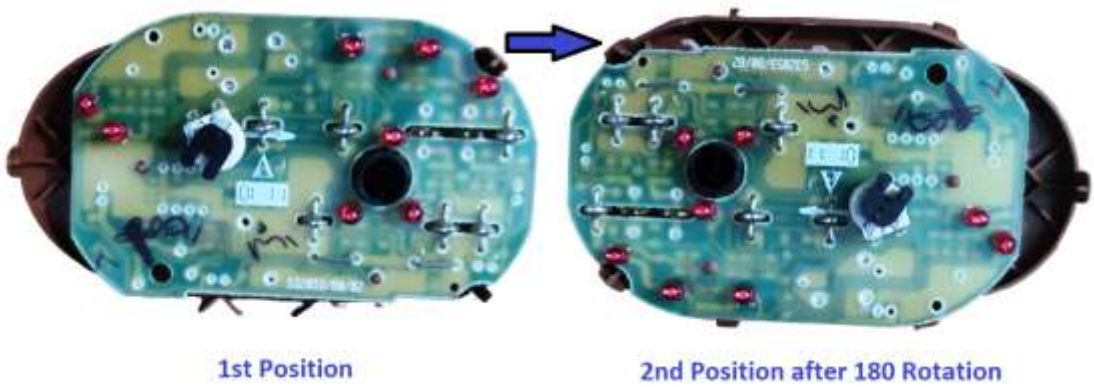

Figure 3. PCB soldering (horizontal) position before improvement.

Figure 4. PCB soldering (vertical) position after improvement.

RESULTS AND DISCUSSION: OBJECTIVE 5

This section presents a comparison of results before and after implementing the solutions on parameters, which are responsible in productivity improvement of HLLS switch assembly line. This study was focused to emphasize the elimination of waste associated with the activities in all forms for all the processes. Lean manufacturing concepts were used to explore the problems in assembly line by breaking up the main processes into sub processes and assigning these with type of works like auxiliary, muda and value added work elements. By using lean tools like Kaizen, and 5S muda time elements has reduced to lower value, consequently improved productivity on switch assembly line has observed. In this study muda (non value added) work elements were targeted and reduced for PCB soldering process. Kaizen and 5S lean tools were used to improve assembly line status for the process PCB soldering**.**

Cycle time is the time at which a unit of a product is to be produced, and this is given by the ratio of the actual daily operating time to the required daily quantity of production. In this context to improve the productivity of HLLS switch assembly line PCB soldering process was identified for reduction in cycle time by eliminating non value added work elements.

The problem associated with this process was targeted in 2-phases by eliminating muda time element by changing the tray's and locater design. By changing tray's design movement for the operator in collecting Insulator and PCB parts of the switch assembly was reduced to lower value as distance has reduced to 400 mm from 700 mm. Therefore, time taken by the operator in picking Insulator and PCB has reduced to some lower value in manufacturing cycle.

And by changing locater design for PCB soldering operation, rotation of PCB through 180^0 for soldering upper points has removed. Now, all points on PCB can be soldered in one position, no need to rotate PCB through 180^0. In this way by changing/modified design of tray and locater, we are able to reduce the cycle time for the process PCB soldering in manufacturing cycle of the switch on assembly line.

After improvement, in measurement phase it was observed that PCB soldering operation requiring 35 sec to complete it. Now, we can say that through the application of kaizen and 5S tools the cycle time for the process PCB soldering has reduced to 35 sec from 49 sec. It is a saving of 14 sec in terms of time in performing PCB soldering operation in assembly line of HLLS (Head lamp leveling switch) and consequently improved productivity on switch assembly line has observed. Table 2 illustrates a comparison in cycle time before and after implementing the solution on PCB soldering process, which shows a percentage reduction of 28.57% in cycle time.

Also, throughput time for the product has reduced to 346.5 sec from 360.5 by saving 14 sec in performing PCB soldering operation in manufacturing cycle of HLLS switch. It is equivalent to a percentage reduction of 3.88% in throughput time for the product (Figure 5).

The reduction in cycle time of the product shows a sign in improvement of productivity. The similar result was obtained by H. A. D. Perara during his research in a three-wheeler original equipment manufacturer (OEM) in Sri Lanka [19].

Table 2. Result Sheet after Improvement.

Description	Before (sec)	After (sec)	% Index
Cycle time	49	35	28.57% Reduction

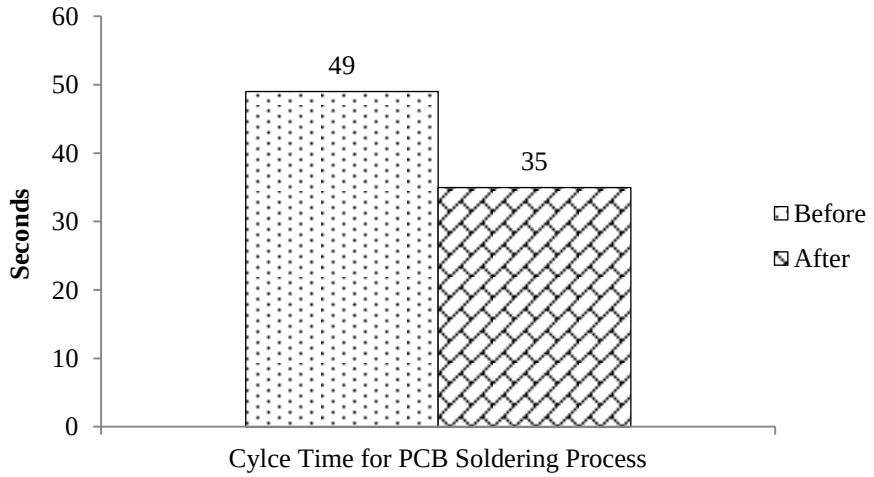

Figure 5. PCB soldering cycle time.

CONCLUSION

In view of the above study, the main objective was to improve the productivity of HLLS assembly line by using lean concepts in an automotive industry, it has been successfully achieved. This study acknowledges the theory in which implementation of lean manufacturing gives considerable positive effects on the performance of manufacturing industries. Lean manufacturing is capable of impacting positively with improved working efficiency, improved productivity, quality and organizational performance improvement. The results of the study conclude that lean manufacturing has shown its capabilities to improve overall performance of any industry. It may help to other assembly lines of the company to meet customer's increased future demand and to overcome the global competition increased. The following points may be projected to show the improvement in operational and productive performance in assembly line:

1. A reduction of 28.57% in cycle time for the process PCB soldering.
2. A reduction of 3.88% in throughput time for the product.

Along with quantitative results certain intangible results have also achieved through improvement activity like:

- Improved 5S culture
- Increased morale
- Better understanding of lean methodology
- Air and electricity saving through producing more switches on the same line.

The above study shows that serious needs of organizations are centered on further developing items by rolling out essential improvements in the way of manufacturing. Nonetheless, in this study, we focused on productivity improvement by utilizing kaizen and 5S apparatuses and further developed the line condition to more significant level effectively. The methodologies actually ought to be characterized barely. A cross functional administration framework ought to be made to guarantee the advantages of the change program and methodology. Also, by integrating the lean components JIT and TPM with improved methods and techniques, the productivity and quality in line for the product, may further be improved.

REFERENCES

1. J. Foster and J. Maguire, "Bottleneck", IEE Manufacturing Engineer, pp. 34–39, June/July, 2005.
2. B.H. Rho, and Y.M. Yu, "A comparative study on the structural relationships of manufacturing practices, lead time and productivity in Japan and Korea", Journal of Operations Management 16, pp. 257–270, 1998.
3. A. Digalwar, A. Bedekar, and M. Aggrawal, "System Dynamics Approach for the Assessment of Leanness of Organizations", IEEE, pp. 1406–1410, 2018.
4. H.D. Wan, and F.F. Chen, "Decision support for lean practioners: A web-based adaptive assessment approach," Elsevier, Computers In industry, pp. 277–283, 2009.
5. Z. Hongliang and Q. Ershi, "Appraisal of lean production's implementation", IEEE, pp. 771–774, 2009.
6. S.D. Kulkarni, R.J. Dhake, R.D. Raut, and B.E. Narkhede, "Achieving Operational Excellence through Integrated Approach of Lean Manufacturing and TPM Methodology in Mechanical Cluster Line: A Case Study", International Journal of Global Business and Competitiveness, Vol. 9, No 1, pp. 15–31, 2014.
7. C.R.A. Hallam, S. Hammond, and W. Flanner,"Comparative Analysis of Work Force Management Techniques between Lean and Traditional Manufacturing Companies"", A Quantitative Decision Tool for Choosing between Layoffs and Continual Improvement, IEEE, 2010.
8. G. Desmukh, C. Ramesh, and M.G. Desmukh, "Manufacturing industry performance based on lean production principles", International Conference on Nascent Tchnologies in the Engineering field, 2017.

9. H. J. Warnecke, and M. Huser, "Lean Production," Int. J. Production Economics, 41, pp. 37–43, 1995.
10. B.W. Braiden, and K.R. Morrison, "Lean manufacturing optimization of automotive motor compartment system", Computers industrial engineering, Vol. 31, No. 1/2, pp. 99-102, 1996.
11. J. Bessant, "Developing and sustaining employee involvement in continuous improvement John Bessant Centre for Research in Innovation Management University of Brighton"" IEE, pp. 1–18, March 2000.
12. M. Holweg, "The genealogy of lean production", Journal of Operation Management, 25, pp. 420–437, 2007.
13. R. Giri and A. K. Mishra, "Rejection Minimization through Lean Tools in Assembly Line of an Automotive Industry", Advances in Industrial and Production Engineering, Lecture Notes in Mechanical Engineering (Springer), pp. 255-266, Feb. 2021.
14. H. Faye and P. Falzon, "Strategies of performance self-monitoring in automotive production", Applied Ergonomics 40, pp. 915–921, 2009.
15. S. Sivakumar and K. Muthusamy, "Critical Success Factors in Six Sigma Implementation – A Case Study of MNCs in Malaysia," IEEE, pp. 536–540, 2011.
16. S.C. Raja and G. Sundararaja," Improving Productivity of manufacturing Division using lean concepts and development of material gravity feeder-A case study" International Journal of Lean Thinking, Vol. 3, Issue 2, pp. 117–134, 2012.
17. G.S. Nhlabathi and P. Kholopane, "Using Manufacturing Kaizen to Improve a Manufacturing Process", Proceedings of PICMET "13: Technology Management for Emerging Technologies, 2013.
18. H. Abdulmouti, "The Role of Kaizen (Continuous Improvement) in Improving Companies" Performance", a case study, Proceedings in International conference on Industrial Engineering and Operations Management, Dubai, UAE, March 3–5, 2015.
19. H.A.D. Perera, "Productivity Improvement Through Lean Tools in a Sri Lankan Small and Medium Enterprise", Proceedings of the 1st Manufacturing & Industrial Engineering Symposium, Colombo, Sri Lanka, 22 October 2016.
20. S. Antomarioni, M. Bevilacqua, and F.E. Ciarapicas., "More sustainable performances through lean practices: a case study" IEEE International Conference on Engineering, Technology and Innovation, 2018.
21. A. Elkhairi, F. Fedouaki, and S.E. Alami., "Barriers and Critical Success Factors for Implementing Lean Manufacturing in SMEs", Science Direct, IFAC papers on line, 2019.
22. A. Ghobadian, I. Talavera, A. Bhattacharya, V. Kumar, J. Arturo, G. Reyes, and N. O. Regan, "Examining legitimatization of additive manufacturing in the interplay between innovation, lean manufacturing and sustainability", International Journal of Production Economics, Vol. 219, pp. 457–458, Jan. 2020.
23. R. Nagaich, L. Tiwari, and S. Sahu, "Productivity Improvement by Kaizen: A Case study in a tyre company", Industrial Engineering Journal, Vol. 13, Issue 2, Feb. 2020.
24. A. Kumar. "Removing the Problem of Locking Not Good in Assembly of Lever Combination Switch using Continuous Improvement Process". International Journal of Manufacturing Technology and Management (Inderscience), Vol. 31, No. 5, Nov. 2017, pp 424–435.
25. R. Giri and A.K. Mishra, "Productivity Improvement by Using Lean Concepts in Assembly Line of an Automotive Industry", Industrial Engineering Journal, Vol. XIII, Issue No. 12, pp. 14–23, Dec 2020.

