PRODUCTIVITY ENHANCEMENT THROUGH LEAN CONCEPT

Sahil Kumar[1], Manoj[2]

[1]Research Scholar, [2]Assistant Professor
Department of Mechanical Engineering,
CBS Group of Institution, Jhajjar

***Abstract*: Manufacturing industries are very much dependent on the strategy which is adopted by the manufacturers to improve their performance in such a highly competitive environment. Sustaining the business performance and improving it in continual mode is another matter of concern for the business managers. The consistent improvement of manufacturing outputs is imperative for manufacturers. The production system required to give competitive priorities is selected. Companies recognize lean practices to be a useful methodology for the reaching of more efficient performance in manufacturing processes. In the way of selecting manufacturing strategies, lean manufacturing is a broadly accepted methodology to improve business performance in such a competitive and volatile environment throughout world. The basic principle behind the success of lean manufacturing is how manufacturing waste is identified and eliminated from the system. This study focuses how processing waste in manufacturing cycle of HLLS assembly line can be minimized through adoption of lean manufacturing tools. In the way of getting higher productivity by using kaizen tool cycle time for the process PCB soldering has reduced from 49 sec to 35 sec in HLLS assembly line.**

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

1. Introduction

Around the world, manufacturing companies are facing new challenges to establish and maintain their performance in today's competitive environment. World market has been integrated to produce goods anywhere in the world and customer is also free to move anywhere in the world to purchase things of his interest. Business environment has forced the companies to use their infrastructure at maximum level to remain competitive in the market [1]. In the current manufacturing scenario, industries are facing a new type of pressure, where business market is of sophisticated and varying nature, customer choice is changing rapidly and worldwide competition between the industries is being tougher day by day to maintain their profitability. In such a competitive environment companies are thinking to search new innovative and productive methods to sustain and remain in the world market. Manufacturing competence can be attained by adopting well matched strategic and operational endeavours for achieving business objectives and goals. In this scenario only agile, flexible, cost efficient and high quality producers can survive [2]. As a winning strategy successful lean principles and methodology can improve the business performance to a higher degree in all dimensions of productivity, quality, process improvement and cost saving [3].

A significant impact on productivity may be observed by the different industries of having lean. In the way of following the concept many industries have become lean by identifying and eliminating waste [4]. Lean production is being widely adopted by the enterprises by integrating traditional and piece production approaches to make customer oriented market environment. A systematic and scientific approach requires for smooth application of lean implementation and recognition of lean degree and its improvement direction [5].

In India auto components are being manufactured at large scale and these are supplied to the big automobile companies around the world to fulfill the requirement globally. Manufacturers of automobile and auto components have put India in top order by maintaining excellent and innovative approach towards manufacturing. Auto component manufacturers and industries have opened new doors for India to improve economically by adopting new technologies and operational methods [6].

In this context Lean/Lean concepts/Lean manufacturing/ lean production or rather lean management is an intellectual and systematic approach to bring a competitive state in a manufacturing industry. Lean manufacturing is becoming important for more than just manufacturing companies. One consulting company has improved their productivity as much as 60% by focusing on lean process management [7].

The Kaizen philosophy is preferred because of its simple design for process, employees and even for end users. It covers every process in a manufacturing system to be improved. It has the feature of adaption to suggestions for small and big changes in the system to achieve more productivity [8].

2. Literature Review

In improving productivity and strengthen the motive of the research on lean manufacturing practices, the research work of the following researchers may be included as under:

According to H.J. Warnecke and M. Huser (1995) a systematic, scientific and intellectual approach which can bring a potential state in a company in terms productivity and quality improvement is lean [9]. B. W. Braiden and K. R. Morrison (1996) argued that after implementing the lean techniques in any organizationproductivity may be increased within the organization of concern. Also, up time of the machines and facilities may be improved by the implementation of the same theory [10].

According to B. H. Rho and Y. M Yu (1998) in a division of Hughes Aircraft an improvement was observed by eliminating non-value added elements from production process as manufacturing cost cut by half, cycle time reduced to tenfold, productivity improved by 250% and in-process quality improved by 50% [2]. According to J. Bessant (2000) 'Continuous Improvement Research for Competitive Advantage project' UK, observed that number of companies are adopting Continuous Improvement programme, 65% companies consider it as a strategic importance, 50% have adopted some form of programme to apply these concepts, 19% have sustained process of CI in operation and 89% of the companies has claimed a positive impact on quality, delivery performance or some combination of these [11].

According to M. Holweg (2007) lean manufacturing with its components in automobile industries may improve the issues related to mass production in positive direction. Also, concluded that this theory may resolve issues faced by the organization in different streams apart from the production [12]. According to R. Giri and A. K. Mishra implementation of lean components (kaizen, 5S and poka-yoke) with DMAIC cycle has improved productivity and rejection reduces to zero from 0.8% at illumination testing in assembly line of an automotive industry [13].

H. Faye and P. Falzon (2009) studied and analyzed the effect of lean concepts with its components in automotive industry. The results support the theory by improving in performance of worker, flexibility in changing demands and quality issues by identifying and elimination of processing waste [14]. S. Sivakumar and K. Muthusamy (2011) described after a case study of MNCs in Malaysia that productivity tools implementation in multinational companies in ensuring successful business is well documented. Two fundamental methods used by these companies to improve their productivity are to eliminate waste and to reduce variations in their processes by applying appropriate productivity tools such as TQM, Six Sigma and Lean methodologies [15].

S. C. Raja and G. Sundararaja (2012) have concluded that a competitive environment has experienced by automotive companies in reducing waste and improving quality. In this context lean manufacturing tools are adopted by the companies to reduce WIP inventories to compete in world market. This research case study is done, in an automotive industry with the objective of waste reduction. An improvement of 11.95% in productivity revealed by putting an effort to reduce motion waste in shop floor [16]. G. S. Nhlabathi and P. Kholopane (2013) described in their proceedings that major business houses have been trying to adopt new business strategies incorporated with lean and its component manufacturing kaizen. By the application of manufacturing kaizen in production system, it may improve the processes by eliminating waste and consequently results in improving labour productivity [17].

According to H. Abdulmouti (2015) kaizen is a technique through which organizations improve by using C I processes. The improvements through kaizen associates with minimum expenses and without sophisticated techniques. By implementing the kaizen tools at Toyota centre in Saudi Arabia, the following results may be summarized as a saving about 5.5 million without investing in new facilities, manpower reduction by 26.9%, an increase in effectiveness by increasing the annual output about 13% and improving in quality was observed [18]. H.A.D. Perara (2016) has described in his case study that SMEs in Sri Lanka need continuous improvement to take competitive advantage by reducing waste and increasing profit. In this context lean tools with its component kaizen was tested in an industry. The study was made in three separate areas as work method improvement, layout change and implementing 5S. By implementing lean concepts results was found in increasing of productivity of 41.14% [19].

Sara Antomarioni et al. (2018) have described that the implementation of kaizen actions to improve the efficiency performances of a production system analyzed through value stream mapping is requirement. In this way by having kaizen methodology both process performance and environmental issues may be sustained [20]. A. Elkhairi et al. (2019) have argued and stated that lean conceptual approach may lead to organization towards higher productivity. Also, competitiveness will improve by saving their resources and elimination of waste through innovative approach supported by lean tools [21]. A. Ghobadian et al. (2020) have described that in response to increased competitiveness around the world and to fill the customer's expectations, many organizations are adopting lean manufacturing strategy [22]. According to R. Nagaich et al. (2020) lean manufacturing along with component kaizen has proved its effectiveness by improving productivity, reduced scrap and reduced down time of the facilities in a tyre company [23]. Locking problem has been removed using the continuous improvement method [24]. According to R. Giri and A. K. Mishra (2020), in context of productivity improvement in assembly line of HVAC switch completion time for few activities was reduced by 31.22% [25].

2. Objectives

Management of the company ABC Company was thinking towards improvement in productivity performance, quality and process capabilities of HLLS assembly line by introducing new manufacturing strategy. Issue was that to make this line as a model line, so that improvement program can further be extended to different assembly lines in the company. In this context to achieve the goals associated with the assembly line of product HLLS, the following objectives were set for making improvements:

1. To determine the company's current performance with respect to production.
2. To analyze and identify problems in assembly line.
3. To create the possible solutions of the various identified problems.
4. Implementation of solutions to enhance productivity by optimum utilization of resources, eliminating wastes and reduction in cycle times of the activities.
5. Results and Recommendations for improvement in productivity of HLLS switch assembly.

3. Experimental work

This research takes place in the context of production in the automotive industry. In the automotive industry, productivity is central to an organization's success in today's scenario. Mass production is made possible with assembly line work, which involves division of tasks into small tasks and short work cycle times to identify waste associated with that particular activity. This approach emphasizes the identification and steady elimination of waste. Therefore, it permits a rapid response to market changes due to reduction 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:

3.1 Improvement Approach

The continuous process of product innovation and further development assumes a much greater importance in today's competitive environment [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.

3.2 Introduction to HLLS assembly line

To produce head lamp leveling switch the straight assembly line was organized into 9 stages of assembly processes on different machines with 7 associates working in line. The different processes completed in manufacturing of HLLS assembly line are (1. Back cover stamping and insulator assembly. 2. PCB insulator assembly, caulking and clinching. 3. Soldering, lock plate and spring assembly. 4. Housing and back cover assembly. 5. Knob detent, Gear and lens assembly. 6. Rotor shaft and panel assembly. 7. Knob rotary and IR testing. 8. Continuity testing. 9. Visual inspection and packing). Its main components are Knob, head lamp, Knob detent, Gear, Rotor shaft, Back cover and housing, and PCB

3.3 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.

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 the result of this study may be applied to the head lamp leveling switch assembly line and establish the continuous improvement plan for the company in order to improve quality and productivity of head lamp leveling switch to the desired level by reducing the process delays, cycle times and other wastes.

3.4 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 362 sec (sum of cycle times for all the processes).

Table 1: Processes cycle time

Process No.	Process Name	Cycle Time (sec.)
1	Back cover stamping	10
2	Insulator assembly with back cover	12
3	PCB assembly, caulking	15.5
4	PCB clinching	10.5
5	PCB soldering	49
6	Lock plate and spring assembly	12
7	Housing assembly	18.5
8	Knob head lamp leveling sub assembly	19
9	Knob detent assembly	24
10	Gear and lens assembly	14.5
11	Knob head lamp leveling assembly	13.5
12	Rotor shaft assembly	31
13	Panel assembly with switch sub assembly	28
14	Knob Rotary assembly	10
15	Continuity and IR testing	59
16	Visual inspection marking and packing	35.5
Throughput Time —>		362 sec

3.5 Problem identification for improvement:

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.

3.6 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 fig. 3(a). 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° fig. 4(a). 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.

3.6.1 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.

3.6.2 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 fig. 3(a). Now, in the way of finding solution for this problem, we have changed the design of pacing the trays from horizontal to vertical as shown in fig. 3(b). 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.

(a) (b)

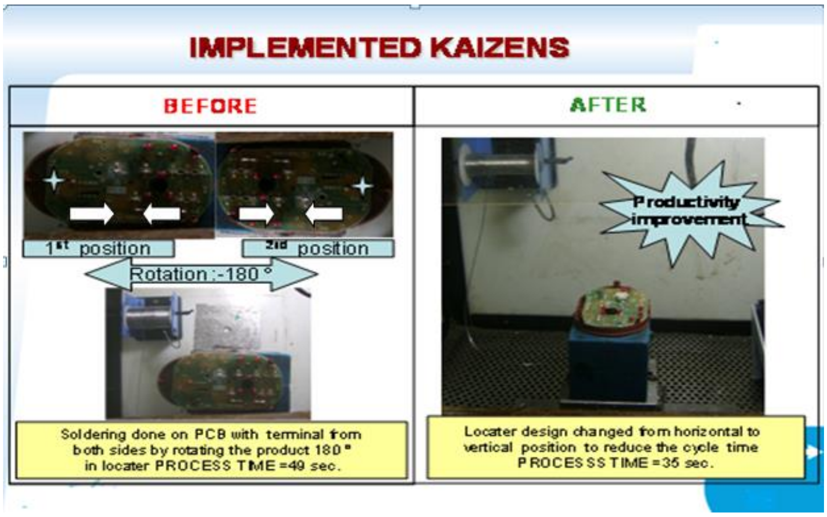
Figure 3: Insulators and PCBs Trays

Problem No. 2: Rotation of PCB through 180^0 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 fig. 4(a). 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 fig. 4(b). 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.



(a) (b)

Figure 4: PCB soldering

(* The White marked arrows shows the various points on PCB where soldering is to be done.)

4. Results and Discussion

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 348 sec from 362 by saving 14 sec in performing PCB soldering operation in manufacturing cycle of HLLS switch. It is equivalent to a percentage reduction of 3.86% in throughput time for the product.

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 study in a three-wheeler accessory manufacturing entity in Sri Lanka [19].

Table 2: Improvement Result Summary Sheet

Description	Unit	Before	After	Percentage Index
Cycle time	sec	49	35	28.57% Reduction

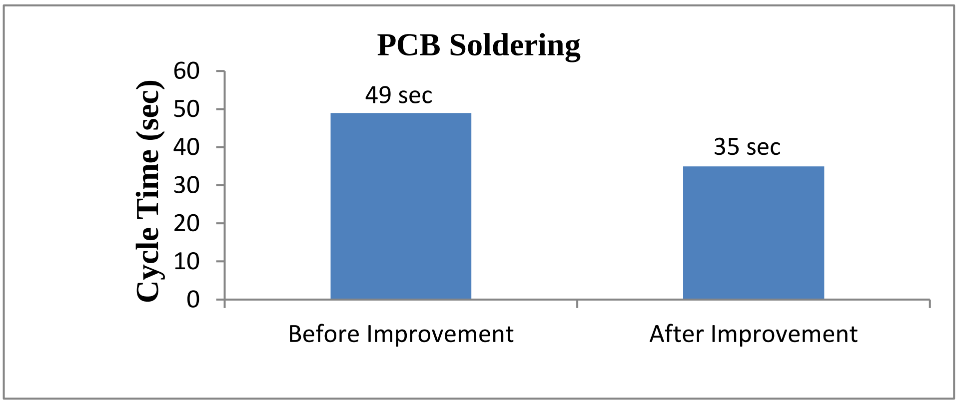


Figure 4: PCB Soldering Cycle Time

5. 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. The study supports the theory that the implementation of lean manufacturing has measurable positive impact on performance of manufacturing industries. Lean manufacturing has the capability to impact positively with improved operational efficiency, productivity improvement, quality and improved organizational performance. The outcome of the study concludes that lean manufacturing has shown its importance in improvement of overall competitiveness of any industry. It may help to other assembly lines of ABC 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 3.86% 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 indicates that competitive priorities of companies are focused on improving products by making fundamental changes in the way of manufacturing. However, in this part of the study, we focused on productivity enhancement by using kaizen and 5S tools and improved the line condition to higher level successfully. It is vital that the approaches should not be defined narrowly. A cross functional management infrastructure should be created to ensure the benefits of the change programme and strategy. 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. Agrawal, “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.