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PRODUCTIVITY IMPROVEMENT BY USING LEAN CONCEPTS IN ASSEMBLY LINE OF AN AUTOMOTIVE INDUSTRY

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Abstract

This research focuses, how lean concepts and work study methods can be used to eliminate waste in manufacturing cycle to improve the productivity and quality of the concern. Its impact was tested in assembly line of an automotive industry Mindarika Pvt. Ltd. to improve the productivity of its product 'Heating Ventilation and Air Control (HVAC)' switch. The line is associated with activities performed manually as well as equipped with improved methods and processes to manufacture and control the quality parameters. In this course of action, lean concepts such as 5S, Kaizen and Poka-yoke in combination of DMAIC cycle were used to drill into the MUDA, auxiliary and value-added work elements to search and eliminate misaligned components of work cycle. The research will also differentiate and reflect thin issues in traditional and lean oriented approach to make a clear and transparent thinking. That, why lean approach should be adopted to make a system productive, efficient and overall profitable from customer and management point of view.

Keywords: Lean concepts, HVAC (Heating Ventilation and Air Control), Productivity, 5S, Kaizen, FG (Finished Goods) bin.

1. INTRODUCTION

Across nations and regions, companies are facing new challenges in a changing environment. With the integration of world markets, the goods can be produced anywhere in the world, where the cost of production is minimum. In the current manufacturing scenario, industries are facing tremendous market pressure of diversified nature due to more sophisticated market, changing customer choice and global competition. Market pressure now necessitates a strategic and tactical framework that allows companies to behave in an adaptive/ flexible manner that permits continuous evolution in the market. In such a competitive scenario companies have to search for new processes, new materials, new vendors, new shop floor design and new channels to deliver their products and services at competitive prices (Dr. Balkrishna E Narkhede).

Automotive industry in India is considered the engine of growth driving the Indian manufacturing sector which is one of the largest and fastest growing globally. India manufactures over 18 million vehicles (including 2-wheeler and 4-wheeler) and exports more than 2.3 million every year (Ministry of Heavy Industries & Public enterprises,2006). Auto component industry is a major sub-sector of automobile manufacturing sector and the largest feeder industry that has put India on global map for excellence and innovation. Market liberalisation, particularly for the domestic firms in emerging economies like India, has opened new avenues of advanced technologies and global competition in manufacturing sector (Saurabh D. Kulkarni et al.).

Now, companies worldwide are searching for innovative operational concepts to improve their productivity, quality and competitiveness and emphasizing new manufacturing strategy in sustaining and improving shop floor activities. As a result, traditional production systems are being challenged and changed by the use of improved and innovative production methods to reduce the non-value-added elements in manufacturing cycle. This research takes place in the context of focusing in achieving improvements in productivity, quality, cost, service of its product (HVAC Switch), customer satisfaction and profitability of management to remain alive in competitive environment. In this journey of achieving business goals company is adopting new manufacturing strategy, where the impact of lean concepts such as 5S, kaizen and poka-yoke in combination of DMAC cycle will be used to improve the productivity in assembly line of its product. This approach emphasizes in identification and removing the amount of waste in the form of non-value-added activities.

1.1. Introduction to product and assembly line of Mindarika Pvt. Ltd

Mindarika Pvt. Limited is India's largest 4-wheeler automotive switch manufacturer. HVAC switch is produced on assembly line where, workers and machinery are arranged strategically in straight line where, product moves down the line from one station to the next until product is completely assembled. Presently 6 workers are arranged to perform the different activities to complete processes on line. The HVAC assembly line facilitates the associates to do manual operations as well as line is equipped with pneumatic hand and automatic presses to perform the operations. The main components of the HVAC switch are body, panel, gear shaft, gear knobs, balls and springs.

Figure 1: HVAC Switch

2. LITERATURE REVIEW

Since the evolution of term 'lean' it is being used in many dimensions with its components to improve productivity performance and quality in automotive industries. In this journey of improving the system efficiency to be competitive in global market, lean concepts assisted by DMAIC cycle is a newly approach to be implemented in Indian automobile sector. Also, major sectors are insisting to their suppliers or ancillaries to be associated with any component of lean manufacturing to achieve their business goals. They are linking their goals to be effective in global market through zero breakdowns, zero defects, reduced cycle time, reduced manpower, innovative methods and reduced throughput times within the manufacturing cycle.

Management of the concern organization was facing a problem in adoption of improvement strategy either lean concepts integrated with DMAIC cycle as a newly formulated strategy or others. In order to way out authors after consulting with the people of concerns on line and above managerial position proposed an integrated approach of 'Lean concepts (5S, Kaizen, Poka-yoke)-DMAIC' with review of available literature and considering operating situations on the line. In this context few of the terms associated with lean concepts are being explained to understand the key issues in adopting the lean approach to gain its benefit:

Lean Approach is very effective at eliminating and reducing waste. Lean may be defined as 'a way to do more with less human effort, less equipment, less time, and less space, while coming closure and closure to providing customers exactly what they want'. It is based on the principles to add values to the process or product according to the customer's satisfaction by eliminating the MUDA waste in the manufacturing cycle or service. For industrial companies, this could involve any of the following (Womack et al., 1990; Ohno, 1997).

1. Material: Convert all raw materials into end products. Try to avoid excess materials and scrap.
2. Inventory: Keep constant flow to the customers and do not have idle material.
3. Overproduction: Produce the exact quantity that customers need, and when they need it.
4. Labor: Get rid of unwarranted movement of people.
5. Complexity: Try to solve the problems in uncomplicated way.
6. Energy: Utilize equipment and people in the most productive way.
7. Space: Reorganize equipment, people and workstations to get a better space arrangement.
8. Defects: Make every effort to eliminate defects.
9. Transportation: Get rid of transportation of materials and information that does not add value to the product.
10. Time: Avoid long setups, delays and unexpected machine downtime.

DMAIC (Define, Measure, Analyze, Improve and Control) approach refers to a data driven improvement cycle used for improving, optimizing and stabilizing business process and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. However, DMAIC is not exclusive to Six Sigma but an integration of Lean and DMAIC approach can be used as a new tool for other improvement applications. A wide spread application of this theory has been seen in automotive industries. It produces intense impact on the manufacturing cycle and service with the integration of advanced methods and techniques, which works as a catalyst in finding the solution and reduce the MUDA elements with the activities of concern. Now, its impact has been spread out from mass production industry to discrete nature of production.

Productivity is the expression of the quantitative productiveness of an economic activity and defined as output divided by the input factors (manpower/workforce, machinery, material). [10]

Work study is a generic term for those techniques, particularly method study and work measurement, which are used in all its context and which lead systematically to the investigation of all the factors, which affect the efficiency and economy of the situation being reviewed in order to effect improvement. The main objective of work study is to improve productivity of men, machines and materials. The aim of work study is to determine the best method of performing each operation and to eliminate wastages so the production increases with less fatigue. The work study is also used in determining the standard time that a qualified worker should take to perform the operation when working at a normal pace.

Standardization of work a very improvement principle of waste reduction is the standardization of worker actions. Standardization work basically ensures that each job is organized and is carried out in the most effective manner. A tool that is used to standardize work is what is called "takt" time. Takt time is calculated based on the following formula (Feld,2000):

Takt Time (TT) = Available work time per day/Customer demand per day

Kaizen Japanese name for "improvement" or "change for the better" refers to philosophy or practices that focus upon continuous improvement of processes in manufacturing, engineering, game development, and business management. When used in the business sense and applied to the workplace, kaizen refers to activities that continually improve all functions, and involves all employees from the CEO to the assembly line workers.

5S is the name of workplace organization methodology to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. These are five Japanese words Seiri (sorting), Seiton (setting in order), Seiso (systematic cleaning), Seiketsu (standardizing), Shitsuke (sustaining the discipline), provide a method for organizing, cleaning,

developing, and sustaining a productive work environment.

Poka-yoke a mechanism in any process that helps to avoid mistakes, to eliminate or catch defects at source.

In the way of finding improved methods to improve quality and productivity of the system, many researchers have put their efforts in that direction. The findings of few researchers in brief are mentioned as under:

Abdul Talib Bon and Tan Siok Kee [1] described that in Malaysia, lean manufacturing is a unified system that entailed with a set of philosophies, rules, guidelines, tools and techniques which imposed to eliminate significant waste in all businesses for continuous improvement.

Ana Louis Ramos et al. [2] explained clearly the advantages of lean manufacturing tools and simulation in improving productivity of a company's packaging line of communication boards at Bi-silque S.A. This study is a result of business internship program focusing to solve the unbalanced packaging line issue which was throughout below the required target. This on-site project combined the knowledge of lean tools and simulation to stabilize and improve the productivity by 40% representing direct gain to Bi-silque.

Anup Prabhakarraochaple et al. [3] stated that companies have been implementing Lean manufacturing to improve their business performance. However, many of them have difficulties in the implementation because of various barriers like insufficient management time, insufficient supervisory skills and insufficient senior management skills. They analyze the lean barriers for better understanding and interpretation for successful lean implementation.

Arnout Pool et al. [4] a case study described that if lean theory is applied in an appropriate way than it may impact and improve the operations management field of the industry. Its application started in automotive industry, now has been showed its importance in discrete industry also.

C. W. Gan et al. [5] described in his study that in Singapore, the Quickaizen technique based on the concepts Lean, Quick Changeover, Single Minute Exchange of Die (SMED) and methods like Kaizen event tested successfully with thirty-eight companies from seven different industries and achieved productivity improvements of 15% to 95%.

Chairat Thammatutto and Chayakrit Charoensiriwath [6] described that build up the ideas of improving flexibility, efficiency and productivity inside a manufacturing plant by introducing Lean Flexible Cellular Manufacturing System (LFCMS) to fight the complex issues and uncertainties being faced in manufacturing industry. LFCMS model can improve the productivity and flexibility, while reducing production cost of a manufacturing facility facing uncertainties in business environment.

Colin Herron and Christian Hicks [7] studied and concluded that North East Productivity Alliance in England has helped to increase the profit of companies based in north-east England by eight times after implementing the lean theories.

David Losonci et al. [8] described the perception regarding successful lean transformation of employee during reorganization of the company. Basically, the purpose of the study was to investigate male and female employee perception during a lean transformation and how it is affected by commitment, communication, belief and work methods.

Dr. Balkrishna E. Narkhede [9] emphasized that Manufacturing strategy is always a matter of concern to manufacturers for sustaining and improving the manufacturing outputs. The research assessed the implications of organizational knowledge, source of information and functional orientation, resource-based view of the manufacturing and global orientation, on manufacturing practices which include advanced manufacturing technology.

G. S. Nhlabathi and P. Kholopane [10] emphasized in his study that the application of lean manufacturing tool called manufacturing kaizen can be established to eliminate waste within an organization to improve the labour productivity and resultant transformation would lead to enhanced productivity within the organization.

Hassan Abdulmouti [11] emphasized in his study that after implementing the Kaizen principles including TPS, 5S and seven Muda enabled to understand the system and identify the most critical problem areas at Port Installed Options Center in Toyota Saudi Arabia and results was found an increased annual output of 13% with 26.9% reduced man power.

H.A.D. Perara [12] stated that effectiveness of some lean tools along with kaizen and standardization of work was tested in a three-wheeler accessory manufacturing entity in Sri Lanka and result found in productivity improvement by reducing cycle time (44.14%).

Helene Faye and Pierre Falzon [13] this study focused that production in the automotive industry, based on assembly line work, is now characterized by lean manufacturing and customization. This results in greater flexibility and increased quality demands, including worker performance self-monitoring, results in the construction of a variety of cars on the same assembly line.

Krisztina Demeter and Zsolt Matyusz [14] explained, how inventory turnover ratio in the companies may be improved after implementing the lean manufacturing theory and companies may retain their competitiveness for improved results.

Matthias Holweg [15] studied and concluded that lean theories may be used to challenge the mass production issues in automotive industries. It may also be used to accept the challenge for different streams of manufacturing and service activities apart from productivity performance and quality of the concern.

M. Murugesan and S. Thai Subha [16] stated that after

implementing the lean concepts with a methodology E-AIR (Eliminate, Automate, Integrate, Re-engineering) productivity was improved by 34% and line inventory was reduced by 57% of window lift motor assembly line and engine cooling fan motor assembly line.

Osama Al-Baik and James Miller [17] provided a summary that application of lean thinking kaizen to software centric organizations has helped in improving team's productivity by more than 20%, enhanced the responsiveness of the team by more than 62% increased the overall customer satisfaction by more than 17% and still is improving.

P. Kuhlang et al. [18] introduced a methodical approach connects value stream mapping and methods time measurement and offers new distinct advantages to reduce lead time and increase productivity based on lean principles and standardized processes in assembly line and logistic processes.

Rakesh Kumar and Vikas Kumar, 2015 [19] stated that a large number of services and manufacturing industries across the country have adopted lean manufacturing as a tool to improve their organizational performance but still there is a large gap exists in its implementation to gain the full benefits of lean manufacturing.

Sara Antomarioni et al. [20] stated that companies recognize lean practices to be a useful methodology for the reaching of more efficient performances in manufacturing processes. After having implemented kaizen actions to a large manufacturing company producing steel caps for food and beverage packages, improvements both regarding operational performance and environmental sustainability were detected.

SJ Thanki and Jitesh Thakkar, 2014 [21] concluded that the current status of lean implementation and awareness in Indian industries is not so encouraging because of human related issues and areas of quality and process technology, where industries are indicating inadequate efforts and poor insight.

Sourabh D. Kulkarni et al. [22] concluded after studied in an Indian auto component firm, emphasizing on 'sustainable Catching-up efforts' that integrate Lean-TPM approach helps to secure continuous improvement in quality, cost and delivery, by focusing on manufacturing competitiveness. And found that line imbalance ratio reduced from 48% to 16%, production per man improved from 70/hour to 133/hour, motion losses at work stations and 30% saving in space utilization.

William G Sullivan et al. [23] analyzed the relationship between equipment's replacement decisions and lean manufacturing. This is done by demonstrating the use of value stream mapping (VSM) to record the current status of production line and to design a required future state of production. VSM can also provide all the necessary information for analysis of equipment replacement decision problems facing in lean manufacturing implementation.

X. F. Sun et al. [24] studied and concluded after implementing the lean principle with its components 'eliminate, combine, rearrange and simplify', production efficiency of a packing machine manufacturing industry increased to a higher level than the initial phase.

2.1 Objectives

Management of the company was thinking to improve the line condition of HVAC switch assembly in respect of productivity performance, quality and process capabilities 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 HVAC switch, the following objectives were set for making improvements under integrated Lean-DMAIC improvement program.

1. To determine the company's current performance with respect to production and rejection rate on line.
2. To analyze and identify problems in assembly line.
3. To create the possible solutions of the various identified problems and finally
4. To enhance productivity by optimum utilization of resources, eliminating wastes and reduction in cycle times of the activities.

3. METHODOLOGY

An experimental methodology, in which integration of lean concepts such as 5S, Kaizen and Poka yoke was made and synchronize with DMAIC strategy in improving HVAC assembly line. For data collection the major processes were broken up into sub processes or work elements and categorized into different types of work like MUDA, auxiliary and value-added work. Observed time for the activities in assembly line was calculated in frequency of ten to reduce variance in average time. Then, observed time was multiplied by performance rating factor of operators considering as 0.95 and 16% ILO recommended allowances were added to get standard times for the activities and processes. Problems/losses throughout the manufacturing cycle were observed and identified in all activities and root cause of the identified problems were analyzed, and then put into solution implementation mode to improve productivity and quality by minimizing the waste at different work stations. In consolidation the following methodology was adopted for improving operational performance of HVAC assembly line.

1. Detailed study of HVAC assembly line.
2. Studying data collection and losses for activities throughout manufacturing cycle.
3. Existing layout with material flow pattern on line.
4. Initial time study and categorization of work elements into value added and non-value-added elements.
5. Line balancing and resource optimization.
6. Design and implementation of modified layout at work stations.
7. Quality Kaizens and 5S for eliminating wastes in manufacturing cycle.

4. EXPERIMENTAL WORK

Measurement Phase:

In order to improve the productivity of its product 'Heating Ventilation and Air Control' (HVAC) switch on assembly line, where each worker is assigned one very specific task at each station along the line, which he or she simply repeats, and then the process moves to the next worker, until the task is completed and the product is made. It is a way to produce goods in effective manner. In existing condition six workers are arranged to perform twelve main processes to produce switch on straight assembly line. These main processes are performed in sequence as under:

Table No. 1: Process in Switch Assembly

Sr. No.	Process	Sr. No.	Process
1	Body greasing	7	Knob assembly
2	Gear greasing	8	Movement checking
3	Gear shaft assembly with body	9	Illumination testing
4	Body blower assembly	10	Clip cable assembly
5	PCB light guide assembly	11	Torque testing
6	Panel assembly	12	Visual inspection and packing

Also, in this phase standard/completion time for the activities and processes before and after improvement was calculated. Problems were identified and analyzed at each work station, and root cause analysis was made for each to reach to optimal solution. These are summarized as below.

Table 2: Problems related to Switch Assembly

Sr. No	Problem Related to Switch	Activity	Process	Effect
1	More time taken	Picking springs and assembly with gear shaft	Gear Shaft Assembly with Body	Productivity Loss
2	More time taken	Picking balls and assembly with gear shaft	Gear Shaft Assembly with Body	Productivity Loss
3	More time taken	Picking and removing polycover from light guide	PCB & Light Guide Assembly	Productivity Loss
4	More time taken	Picking switch for illumination testing	Illumination Testing	Productivity Loss
5	More time taken	Placing switch in FG (Finished Goods) bin	Visual Inspection & Packing	Productivity Loss

5. ROOT CAUSE ANALYSIS AND SOLUTION IMPLEMENTATION PHASE:

Problem 1: 'more time taken' (Sr. No. 1, Table No. 2) in activity picking springs and assembly with gear shaft.

Description: In this activity of picking springs and assembly with gear shaft (fig. 2), operator was picking springs from left and right crates and made assembly with gear shafts. Left and right crates were located at 200 mm and 205 mm respectively from operator and took 9 sec to complete the activity.

Root Cause: To reduce muda time element with the activity, the crates can be located near to operator. So, root cause of the problem was more distance of crates from the operator.

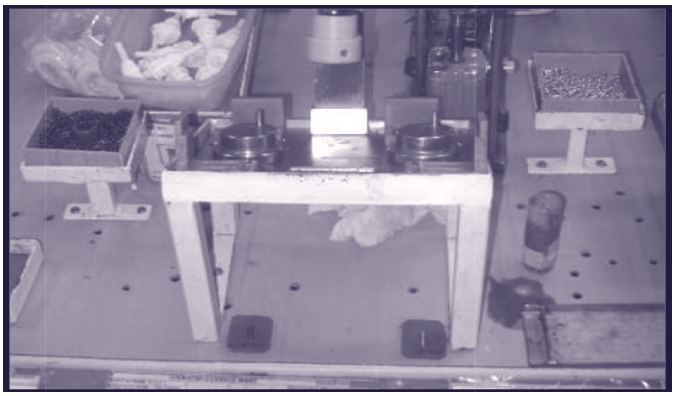


Fig. 2: Spring crates before improvement

Solution: To reduce springs picking time, crates location modified and shifted near to operator on line (fig. 3). After implementing the solution, completion time for the activity again calculated and found 6.1 sec in improved condition.

Effect: A net saving of 2.9 sec was observed after implementing the solution.

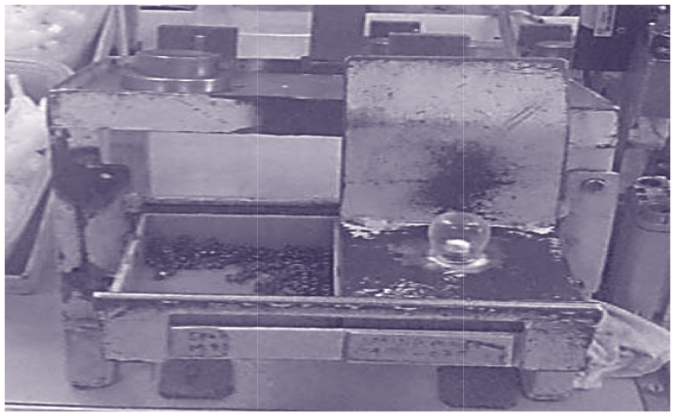


Fig. 3: Spring crates after improvement

Problem 2: 'more time taken' (Sr. No. 2, Table No. 2) in activity picking balls and assembly with gear shaft.

Description: In this activity of picking balls and assembly with gear shaft (fig. 4), operator was picking balls from ball dispenser located at left side of the operator with a cross hand movement and took 7.1 sec to complete the activity.

Root Cause: Due to cross hand movement in picking the balls, the activity was associated with some muda time element also, which can be reduced by shifting the ball dispenser at appropriate location. So, root cause of the problem was found as improper location of the ball dispenser.

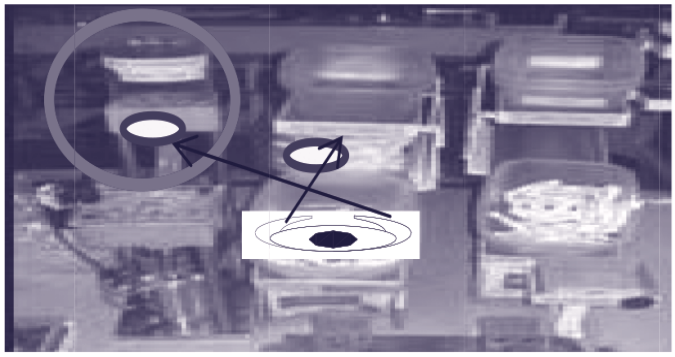


Fig. 4: Ball dispenser before improvement

Solution: In order to reduce the muda time element associated with the activity 'picking balls and assembly with gear shaft' (fig. 5), ball dispenser location shifted near to operator at right side to eliminate cross hand movement during picking. In this way after implementing the solution activity completion time reduced to 5.3 sec.

Effect: In improved condition a saving of 1.8 sec was observed in performing the activity.

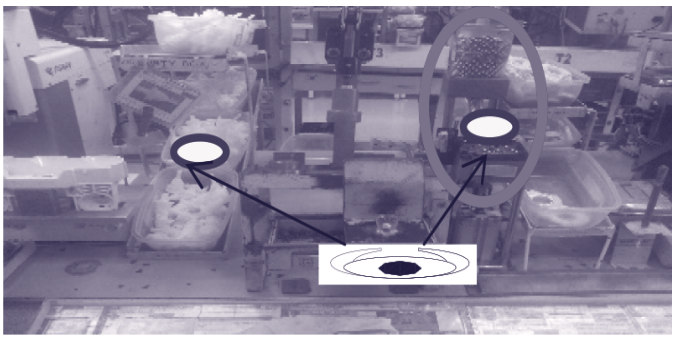


Fig. 5: Ball dispenser after improvement

Problem 3: 'more time taken' (Sr. No. 3, Table No. 2) in activity picking and removing polycover from light guide.

Description: In performing activity 'picking and removing polycover from light guide' (fig. 6), operator was picking light guide from the tray and removed polycover from it before assembly with body and took 5.6 sec to complete the activity.

Root Cause: Component light guide is an internal part of the switch assembly. Presently these are fed in assembly line with polycover. If these are fed carefully in assembly line without polycover then time associated in removing polycover can be eliminated without affecting quality of the switch. So, root cause of the problem was feeding of light guides with polycover.

Fig. 6: Light guides before improvement

Solution: In order to reduce MUDA time element with the activity (fig. 7), material feeder was allowed to feed the light guides in tray carefully on line and reduced time for the activity was calculated as 4.5 second.

Effect: After implementing the solution a saving of 1.1 sec in performing the activity was gained.

Fig. 7: Light guides after improvement

Problem 4: 'more time taken' (Sr. No. 4, Table No. 2) in activity picking switch for illumination testing.

Description: In this activity 'picking switch for illumination testing' (fig. 8), operator was picking switch from in-process location, for that he had to move a little distance and took 2 sec to complete the activity.

Root Cause: Activity completion time can be reduced to some lower value, if operator picks the switch easily without moving. So, root cause of the problem was movement of the operator in picking the switch for illumination testing.

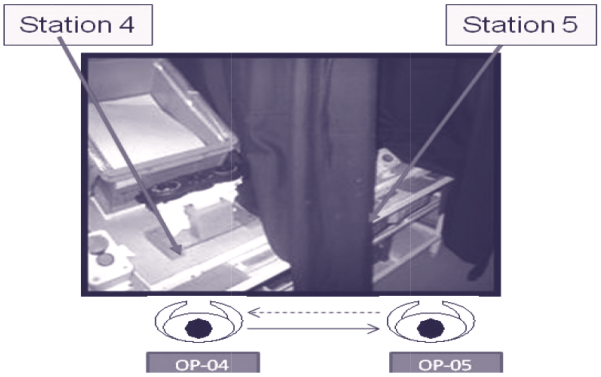


Fig. 8: Switch In-process location before improvement

Solution: In order to eliminate muda time element associated with the activity (fig. 9), a gravity feed wire chute was provided on line between the operators and activity completion time for the operator was observed as 1.2.

Effect: After implementing the solution a saving of 0.8 sec in performing the activity was gained.

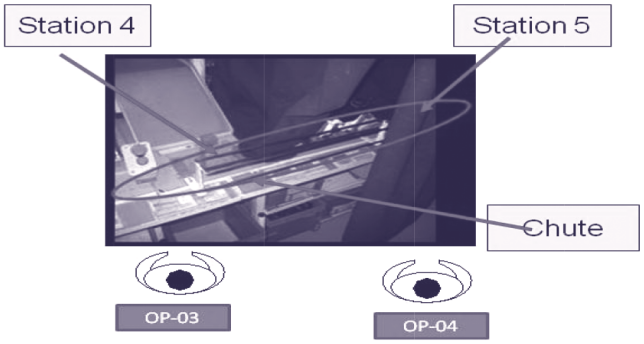


Fig. 9: Switch In-process location after improvement

Problem 5: 'more time taken' (Sr. No. 5, Table No. 2) in activity placing switch in FG bin.

Description: In this activity 'placing switch in FG bin' (fig. 10), operator had to place final switch assembly in Finish Goods (FG) bin and took 4.8 sec to complete the activity, then this inventory in a lot of 32 pieces was shifted at Mock-Up station for double check. Mock-Up station was at 20 m distance from the line. If any problem is noticed at this station, immediately it is sent to line associates.

Root Cause: Due to layout of assembly line at these stations (FG bin and Mock-Up station) operator was taking more time in placing the final switch assembly in bin. Also, it was difficult to maintain one piece flow to Mock-Up station. So, root cause of the problem was improper layout at these stations.

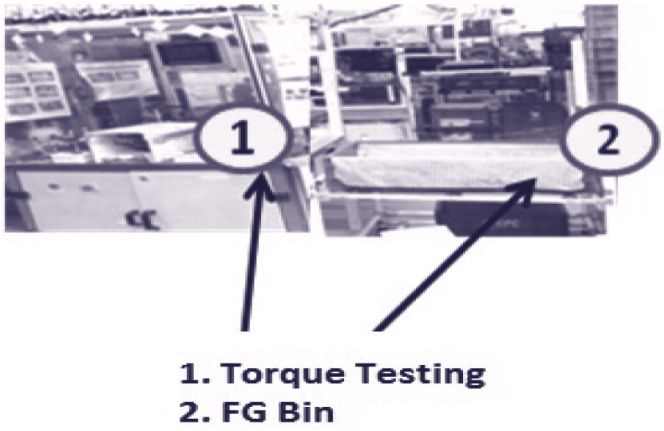


Fig. 10: FG bin before improvement

Solution: To reduce time to put switch assembly in FG bin and to make 1-piece flow to Mock-Up station, layout was changed to bring Mock-Up station just after last station on assembly line (fig.11) and then FG bin. In this improved condition, operator after visual inspection has to put switch on Mock-Up station and takes 2.5 sec to complete the activity.

Effect: After implementing the solution a saving of 2.3 sec in performing the activity and 1-piece flow of switch to Mock-Up station was maintained.

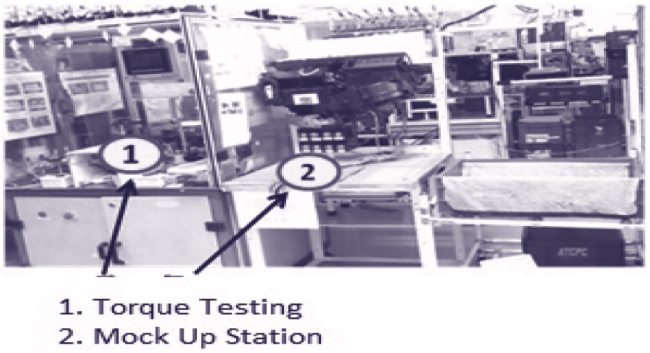


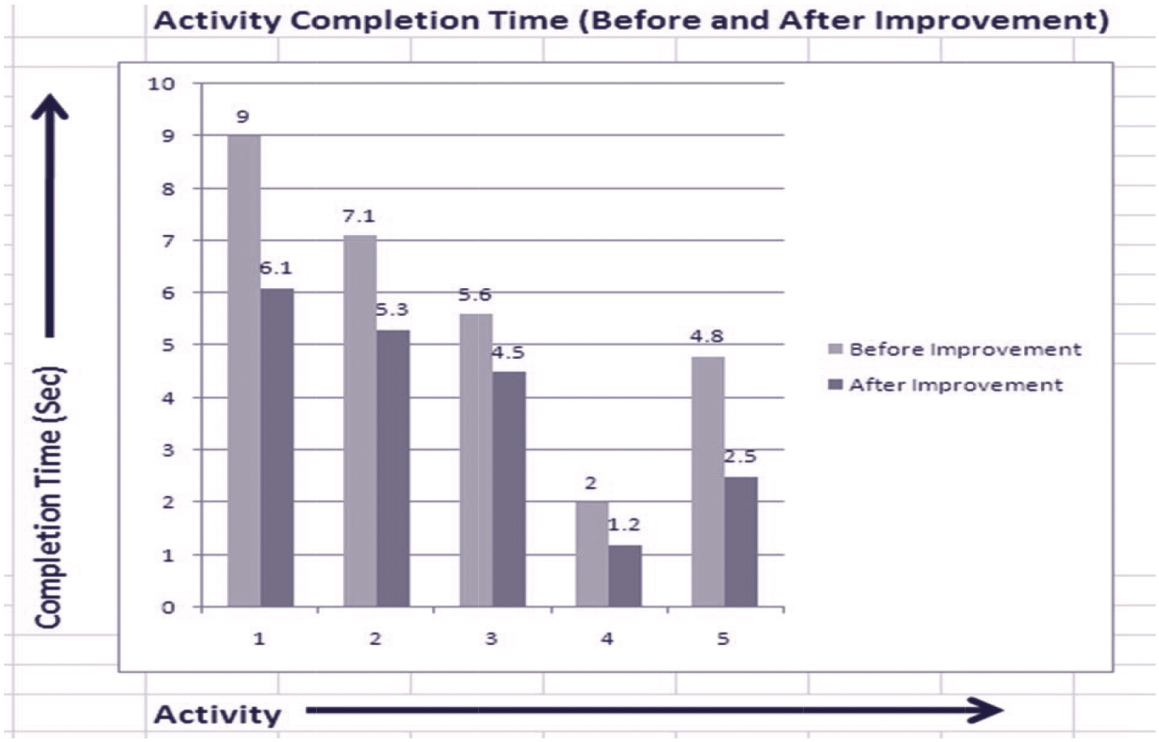
Fig. 11: FG bin after improvement

6. RESULTS AND DISCUSSION

After implementing the lean concepts on few of the activities associated in manufacturing of HVAC switch on assembly line, completion time for the activities reduced, which results in productivity improvement. In this journey of productivity improvement focus was made to eliminate waste by using 5S, kaizen and Poka-yoke tools and at the same time importance of lean concepts was addressed to the concerns on line to reach to the optimal solutions. Following table shows a comparison before and after completion time for the activities and consequently improvement in productivity by induction of less or same efforts in terms of man, material and machines.

Table 3: Comparative Statement in 'Completion Time' before and after improvement

S. N.	Activity	Completion Time (sec)	
		Before Improvement	After Improvement
1	Picking springs and assembly with gear shaft	9	6.1
2	Picking balls and assembly with gear shaft	7.1	5.3
3	Picking and removing polycover from light guide, and assembly with body	5.6	4.5
4	Picking switch for illumination testing	2	1.2
5	Placing switch in FG (Finished Goods) bin	4.8	2.5
	Total	**28.5 sec**	**19.6 sec**



Activity 1: Picking springs and assembly with gear shaft.

Activity 2: Picking balls and assembly with gear shaft.

Activity 3: Picking and removing polycover from light guide, and assembly with body.

Activity 4: Picking switch for illumination testing.

Activity 5: Placing switch in FG (Finished goods) bin.

From the above table 3, we can conclude that a saving of 8.9 sec in completion of few activities has gained for a switch assembly in line, due to that gain completion time for the above activities has reduced to 31.22%. It will impact remarkably in productivity improvement throughout manufacturing cycle in a shift of 7.5 hr and will lead to improve line capacity, man hour saving, throughput time, cost saving and customer satisfaction.

7. CONCLUSION

Manufacturing strategy is always a matter of concern to manufacturers for sustaining and improving the manufacturing outputs. The consistent improvement of manufacturing outputs is imperative for manufacturers. The manufacturing level is decided by competitive priorities required in the market and then production system required to give these competitive priorities is selected (Dr Balkrishna E. Narkhede). In this context Integrated Lean-DMAIC strategy have helped the studied organization, to optimize available resources and produce world class products as per changing market demand. Also, this approach will lead to continuous improvement in operational performance in terms of quality, productivity, cost and delivery performance of the organization. As a conclusion, a productivity based lean concepts along with DMAIC strategy is presented in this research and investigates the effect of lean concepts on firm performance in improving of productivity performance, quality and overall profitability. Also, this research successfully projected cause and effect relationship

for those parameters, which are responsible in reducing the productive performance and quality of the product in assembly line of HVAC switch. This research emphasized that gains can be made in productivity, quality and overall profitability of the concern by focusing on lean concepts in a systematic way.

However, in this part of the study, we focused on productivity enhancement and quality issues by using Kaizen, 5S and Poka-yoke tools with DMAIC cycle and improved the line status to higher level successfully. Also, it may be concluded that integrating the lean concepts with JIT, TPM or other lean tools with improved methods and techniques in assembly line, the quality and productivity of the system may further be improved to a higher degree. The findings of this research may also be applied to improve the status of other lines within the company in the same way.

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