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Productivity Improvement of HLLS Using Lean Technique in Assembly Line of an Automotive Industry

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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. Companies recognize lean practices to be a useful methodology for the reaching of more efficient performance in manufacturing processes. 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 Head Lamp Leveling Switch assembly line can be minimized through adoption of lean manufacturing tools. Lean techniques such as Kaizen and line balancing have been adopted to reduce the cycle time and ultimately to increase productivity of product head lamp leveling switch (HLLS) from 450 pieces to 586 pieces in a shift of 7.5 hour.

Keywords: Lean Tools; Kaizen; Productivity Improvement; HLLS; Processing waste.

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 endeavors for achieving business objectives and goals. In this scenario only agile, flexible, cost efficient and high quality producers can survive. 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].

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:

Lean technology provides a systematic, scientific and intellectual approach which can bring a potential state in a company in terms productivity and quality improvement is lean[9]. Implementing the lean techniques in any organization productivity 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].

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]. '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].

Lean manufacturing with its components in automobile industries may improve the issues related to mass production in positive direction and this theory may resolve issues faced by the organization in different streams apart from the production [12]. 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].

The effect of lean concepts with its components in automotive industry leads to an improvement in performance of worker, flexibility in changing demands and quality issues by identifying and elimination of processing waste [14]. In a case study of a MNC in Malaysia, two fundamental methods have been adopted to improve the productivity by eliminating waste and to reduce variations in their processes by applying appropriate productivity tools such as TQM, Six Sigma and Lean methodologies [15].

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. A research case study performed in an automotive industry with the objective of waste reduction found an improvement of 11.95% in productivity revealed by putting an effort to reduce motion waste in shop floor [16]. 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].

Kaizen is a technique through which organizations improve by using C I processes. The improvements through kaizen associate 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]. SMEs in Sri Lanka need continuous improvement to take competitive advantage by reducing waste and increasing profit. In these 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].

The implementation of kaizen actions to improve the efficiency performances of a production system analyzed through value stream mapping. In this way by having kaizen methodology both process performance and environmental issues may be sustained [20]. 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]. In response to increased competitiveness around the world and to fill the customer's expectations, many organizations are adopting lean strategy [22]. 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 during the assembly of lever combination switch has been removed using the continuous improvement method which finally leads to zero rejection of the product [24].

The success of lean manufacturing observes two main barriers i.e. "Lack of Long-Term Commitment to Change and Innovation" and "Individual Attitude" [25].

A number of research have been done by various researchers on managing green and sustainable environment, on selection and allocation of order of green supplier[26], on systematic review of green human resource management[27], on different factors influencing the selection of smart machines[28] and in a radioactive plant to make strategic project planning model[29].

Literature review reveals that the lean manufacturing techniques can be applied to the automotive parts processes to improve quality performance and establish the continuous improvement plan for the company in order to increase quality of product, increase productivity, reduce costs, and satisfy customers.

1.1 Company/Place of research work Profile

Company XYZ, with Rs. 1.5 billion in revenue, is India's largest 4 wheeler automotive switch manufacturer. It has deliberately advanced into a total plan and improvement community for four-wheeler auto switches. It offers rapid answers for the car business in the domain of item spontaneous creation and new item advancement. The center qualities of the company are gifted Labour, adherence to the best principles, and giving financially savvy arrangements.

Quality of automotive parts and customer service has been the focal point of the organization to acquire a piece of the pie and fulfill their clients. The organization's business has been expanded significantly in recent years. It is delivering a bigger assortment of car parts items than previously. They do have not sufficient opportunity to explore before creating to accomplish appropriate settings for every item as they had before. This influenced the item quality, expanded both inner and outer disappointment costs, and expanded client objections.

1.2 Problem Statement

One of the important and popular product of the company is head lamp leveling switch (HLLS) which has been shown below in Figure 1 .The function of head lamp leveling switch is to control on/off function of light and to change the tendency point of the optical framework in the head light so that the shine of light shaft stays in the endorsed and carport changed base position regardless of the condition of burden. In manual framework the point of tendency is changed by Knob detent. Its main components are Knob head lamp, Knob detents, Back cover and housing, printed circuit board (PCB) etc.

Figure 1- Schematic of HLLS[8)]

Recently Company XYZ noted the quality and less productivity related issue during the assembly Head Lamp Leveling Switch (HLLS) which leads to more production cost, lead time and customer complaints.

As per literature review this problem seems to be due to lacking of implementation of lean tools.

The **objective** of this research is to improve the productivity and capacity of assembly line of Head Lamp Leveling Switch S32053 from 450 pieces to 600 pieces in a shift of 7.5 hour.

2. Materials and Methods

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)]. The continuous process of product innovation and further development assumes a much greater importance in today's competitive environment[9)].

The capacity of the HLLS assembly line is currently limited to 450 switches each shift with 7 personnel on the line. The company's management intended to increase line capacity by putting existing facilities and personnel to optimum use.

After critical analysis of the data collected, root cause analysis will be made to identify the reasons responsible for lower production of HLLS. Then different lean tools/techniques will be identified to develop the solution to remove the problems causing lower productivity. Line balancing is a production approach that involves matching the production rate to the takt time by balancing operator and machine time. The rate at which components or goods must be manufactured in order to meet consumer demand is referred to as takt time. If production time is exactly equal to takt time for a certain production line, the line is perfectly balanced. Otherwise, bottlenecks and surplus capacity should be removed by reallocating or rearranging resources. To put it another way, the number of personnel and machines assigned to each task in the line should be rebalanced to achieve the highest possible production rate. Then these proposed solutions will be implemented on the assembly line and the results will be noted. If the proposed solutions give the better results they will be maintained to improve the productivity of the assembly line. The novelty of this research work lies in the fact that the adopted lean techniques have never been adopted and explained in such details for productivity improvement of such type of automotive part.

3. Experimental Work

3.1 Determination of company's current performance with respect to production of HLLS-

To produce HLLS, the straight assembly line was organized into 9 stages on different machines with 7

associates working in line. The different processes completed in manufacturing of HLLS assembly line are-

Stage 1-*Back cover stamping and insulator assembly*

The assembly of HLLS as shown in Figure 2 consists of the following operations-

1. Back cover stamping
2. Insulator assembly with back cover.

These operations are performed on machines PXS32053-001 00-01 001 and PXS32053-902 00-01 001 pneumatic machines respectively which are working on the air pressure 3-4 kg/cm^2. It has been observed that the-

a. Cycle time for back cover stamping is 10 sec.

b. Cycle time for insulator assembly with back cover is 12 sec.

For the operations performed on machines, the Cycle time includes the timings for picking the component, its inspection, putting it on the fixture for required operation, button pressing time, machine time and removing it from the fixture.

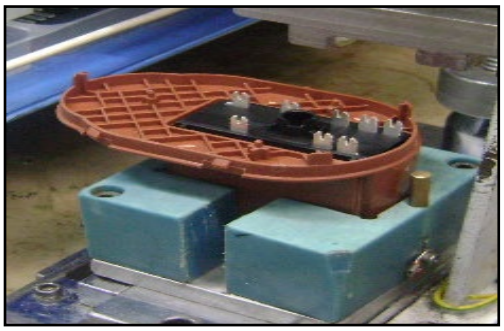

Figure 2 - Back cover stamping and insulator assembly

Stage 2- *PCB insulator assembly, caulking and clinching*

In second stage of assembly of head lamp leveling switch shown in Figure 3 following operations are performed:

1. PCB assembly with insulator.
2. Caulking and clinching operations on PCB to prevent its movement within the sub assembly.

These operations are performed on machines PXS32053-907 00-01 001 and PXS32053-907 00-01 002 respectively. These are also the pneumatic machines, working on air pressure 3-4 kg/cm^2. The Cycle time observed for PCB assembly with insulator and caulking is 15.5 sec whereas the Cycle time for PCB clinching is 10.5 sec.

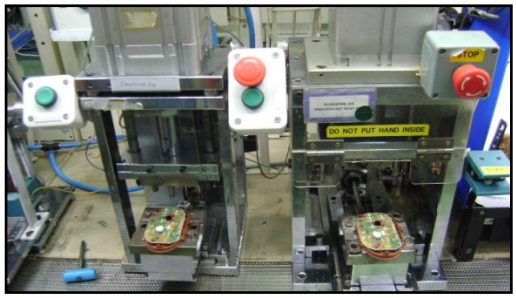

Figure 3 - PCB insulator assembly, caulking and clinching

Stage-3- Soldering, lock plate and spring assembly

The stage 3 as shown in Figure 4 consists of-

1. Soldering on PCB
2. Lock plate and spring assembly.

These operations are performed manually and the cycle time observed for these activities are-

a. For soldering on PCB is 35 sec.

b. For lock plate and spring assembly is 12 sec.

The Cycle time includes the timings for picking the component, inspection of it, putting it on fixture for required operation, manual time for operation and removing it from the fixture.

Figure 4 - Soldering, lock plate and spring assembly

Stage 4- Housing and back cover assembly

This stage, as shown in Figure 5 includes assembly of head lamp leveling switch housing and back cover. This operation is performed on machine PXS32053-908 00-01 001. Again this is a pneumatic machine, working on air pressure 3-4 kg/cm^2. The Cycle time observed for housing and back cover assembly is 18.5 sec.

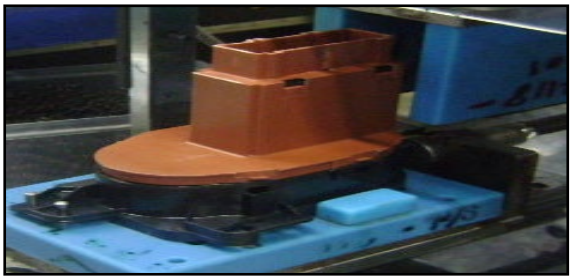

Figure 5 - Housing and back cover assembly

Stage 5- Knob detent, Gear and lens assembly

In fifth stage, as shown in Figure 6 of assembly of head lamp leveling switch S32053 following operations are performed:

1. Knob detent assembly.
2. Gear and lens assembly.

These operations are performed on machines PXS32053-704 00- 001 and PXS32053-705 00- 001 respectively. Also these are pneumatic machines, working on air pressure 3-4 kg/cm^2.The Cycle time for knob detent assembly is 24 sec. and the Cycle time for gear and lens assembly is 14.5 sec.

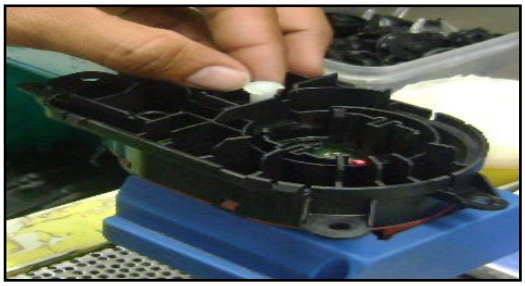

Figure 6 - Knob detent, Gear and lens assembly

Stage 6- Rotor shaft and panel assembly

In sixth stage of assembly of head lamp leveling switch shown in Figure 7, assembly of rotor shaft panel assembly has been made with switch sub assembly.

These operations are performed on machines. PXS32053-910 00- 001 and Cycle time for rotor shaft assembly is 31 sec. while the Cycle time for panel assembly with switch sub assembly is 28 sec.

Figure 7 - Rotor shaft and panel assembly

Stage 7- Knob rotary and IR testing

In this stage as shown in Figure 8, the following operations are performed:

1. Knob rotary assembly.
2. IR testing.

The process of assembly of Knob rotary with housing is performed manually while the IR testing is performed on machine PXS32053-000 00-01 001. It has been observed that the Cycle time for knob rotary assembly is 10 sec. and the Cycle time for IR testing is 20 sec.

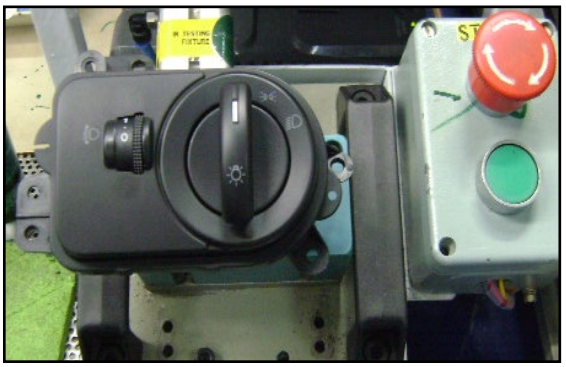

Figure 8 - Knob rotary and IR testing

Stage 8- Continuity testing

In eighth stage shown below in figure 9, the process of continuity testing is performed on machine PXS32053-000 00-01 001 and the Cycle time for continuity testing gas been found as 39 sec.

Figure 9- Continuity testing

Stage-9- Visual inspection and packing

In the final stage as shown in Figure 10, the assembly of head lamp leveling marking, visual inspection and packing is done. It is done manually and the Cycle time for this stage is 35.5 sec.

Figure 10- Visual inspection and packing

3.2 Selection of Process Parameters

The objective of this research is to improve the productivity and capacity of assembly line of Head Lamp Leveling Switch S32053 from 450 pieces to 600 pieces in a shift of 7.5 hour. For achieving this target, the first task is to collect the data of current performance of the assembly line, so that a process map can be prepared to understand the sequence of activities done in assembly line. In that respect, the current data and relevant process parameters of assembly line has been calculated in the following way:

1. Verification of existing assembly line.
2. Production Capacity (machines and manual)
3. Standardized Work combination
4. Takt Time Balance Chart

3.2.1 Verification of existing Assembly Line

As a first task, assembly line of head lamp leveling switch has been verified with respect to cycle time of different processes at each stage to find out production capacities of machines and manual operations. Then it will be used to make production capacity sheet for different machines. From this capacity sheet those machines and stages will be identified which have low capacity than required. For this focus has to be shifted to

those stages which have capacity lower than 600 switches in a shift of 7.5 hr. **Table 1** show the verified cycle times for different processes.

Table 1: Processes Cycle Time (Seconds)

S.N.	Process Name	C.T.
1	Back cover stamping	10
2	Insulator assembly with back	12
3	PCB assembly, caulking	15.5
4	PCB clinching	10.5
5	PCB soldering	35
6	Lock plate and spring assembly	12
7	Housing assembly	18.5
8	Knob head lamp leveling sub	19
9	Knob detent assembly	24
10	Gear and lens assembly	14.5
11	Knob head lamp leveling	13.5
12	Rotor shaft assembly	31
13	Panel assembly with switch sub	28
14	Knob Rotary assembly	10
15	Continuity and IR testing	59
16	Visual inspection marking and	35.5

3.2.2 Production Capacity Sheet of machines and manual operations

Production capacity of machines and manual operations for different processes in a shift of 7.5 hr is given below in Table 2. It has been calculated as per formula-

Production capacity (No.) =Time per shift (sec)/cycle time (sec).

Table 2- Production capacity

Process Name	Machine No.	Cycle Time (Sec.)	Capacity
Back cover stamping	PXS32053-001 00-01 001	10	2700
Insulator assembly (back-cover)	PXS32053-902 00-01 001	12	2250
PCB assembly, caulking	PXS32053-907 00-01 001	15.50	1742
PCB clinching	PXS32053-907 00-01 002	10.50	2571
Soldering on PCB	Manually	35	771
Lock plate and spring assembly	Manually	12	2250
Housing assembly	PXS32053-908 00-01 001	18.50	1459
Knob head lamp leveling sub assembly	PXS32053-910 00- 001	19	1421
Knob detent assembly	PXS32053-704 00- 001	24	1125
Gear and lens assembly	PXS32053-705 00- 001	14.50	1862
Knob head lamp leveling assembly	PXS32053-910 00- 001	13.50	2000
Rotor shaft assembly	PXS32053-910 00- 001	31	871
Panel assembly with switch sub assembly	PXS32053-916 00- 001	28	964
Knob Rotary assembly	Manually	10	2700
Continuity and IR testing	PXS32053-000 00-01 001	59	*458*
Visual inspection marking and packing	Manually	35.50	761

3.2.3 Standardized Work Combination

It is a combination of different types of work with their operation times, given to each associate. These combinations show about the variation in total time, taken by different associates for their respective work during assembly of Head Lamp Leveling Switch. The Table 3 shows the standardized work combination of times and works by seven associates in assembly line.

Table 3- Time taken by different Associates

Process name	Manual Time (s)	Walk Time(s)	Operation Time(s)	Associate
Back cover stamping	10	2	50	I
Insulator assembly back-cover	12			
PCB assembly, caulking	15.5			
PCB clinching	10.5			
Soldering on PCB	35	-	35	II
Lock plate and spring assembly	12	1.5	51	III
Housing assembly	18.5			
Knob head lamp leveling sub assembly	19			
Knob detent assembly	24	1.5	53.5	IV
Gear and lens assembly	14.5			
Knob head lamp	13.5			

leveling assembly				
Rotor shaft assembly	31	1	60	V
Panel assembly with switch sub assembly	28			
Knob Rotary assembly	10			VI
Continuity and IR testing	59	.5	59.5	VII
Visual inspection marking And packing	35.5	1.5	47	VI
Total	**348 Sec.**	**8 Sec.**	**356 Sec.**	

The above table shows the following at the starting of project:

Throughput time for switch in line *(356+8) = 356sec (Total operation time)*

Cycle time for switch in line *=60 sec (Maximum time taken by any associate)*

Line capacity*= (7.5x60x60/60) = 450 switches per shift in a shift of 7.5 hr.*

Takt Time *= Time available in a shift (sec) / Customer demand = 7.5x60x60 /600= 45 sec.*

3.2.4. Takt Time

Takt Time calculation explains the time taken by different associates to complete their respective works. Time taken by different associates in completion of their works is given below:

I Associate- 50 sec to complete four processes
II Associate -35 sec to complete one process
III Associate -51 sec to complete three processes
IV Associate -53.5 sec to complete three processes
V Associate -60 sec to complete two processes
VI Associate- 47 sec to complete two processes
VII Associate -59.5 sec to complete one process.

3.2.5 *Findings from the procedural details and data collection:*

From the thorough study of all the data it has been observed that –

1. Capacity of machine PXS32053-000 00-01 001 for process Continuity and IR testing is 450 pieces in a shift of 7.5 hr. This is below the required, which is 600 pieces per shift. Therefore, to increase the line capacity to 600 pieces per shift machine capacity of the machine which is producing less than 600 has to be increased to or greater than 600 by using lean tools and kaizen.

2. To increase the line capacity to 600 pieces per shift time taken to complete their respective operations by every associate should be equal or less than 45 sec (Takt time). But in this assembly line, apart from associate II all other associates have process completion time of more than 45 sec. Therefore to improve productivity process completion time of different associate has to be brought near to 45 sec.

3.3 Developing and implementing solution for improving the productivity

The critical examination of the collected data reveals that the major problems leading to lesser productivity during the assembly line of head lamp leveling switch are (i) More Time Consumed in IR and Continuity Testing and (ii) Improper Machine and Material Handling

3.3.1 More Time Consumed in IR and Continuity Testing

Initially the entire process of IR and Continuity testing as shown in Figure 11 was performed on a single machine.

Figure 11- IR and Continuity Testing Machine (Before Condition)

For required productivity improvements this process time should be less than 45 sec. (Takt Time). Therefore, to reduce this process completion time up to 45 sec., it has been decided that, instead of using a single machine, two separate machines have to be used for these two different operations. By doing this the single task consuming 59 sec. can be distributed among two operators.

So, after implementing the proposed solution of having separate machines for both the operations, the initial total cycle time of 59 sec. has been broke up into two separate cycle times i.e. 23 sec. and 33.5 sec. for IR and Continuity Testing respectively. These both the process completion times are as per requirements i.e. both the process cycle times are below the target cycle time of 45 sec. and now these two different operations can be distributed to two different associates, if required for line balancing**.** Figure 12 shows separate IR testing system after implementing the proposed solution leading to a new cycle time for IR testing process as ***23 sec***.

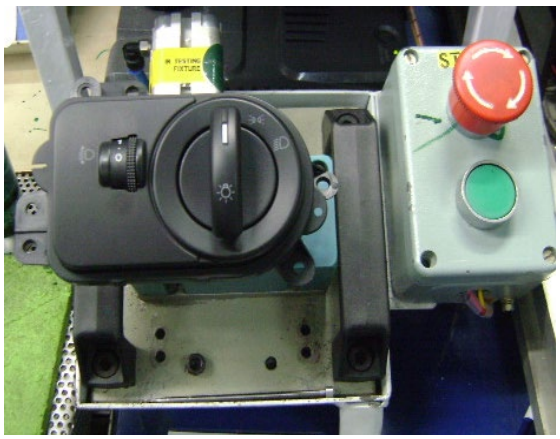

Figure 12- Separate machine for IR Testing (After Condition)

Similarly, Figure 13 shows separate Continuity testing system after implementing the proposed solution leading to a new cycle time for Continuity testing process as ***33.5 sec.***

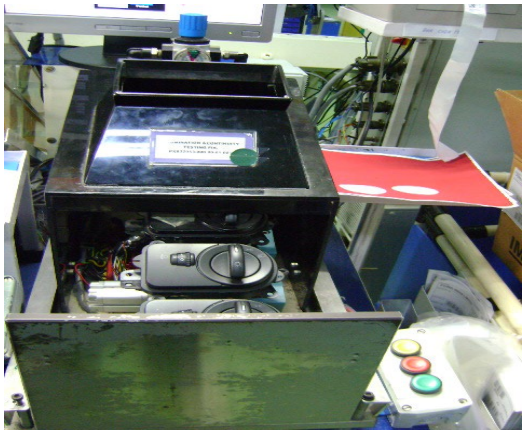

Figure 13- Separate machine for Continuity Testing (After Condition)

3.4 Material Handling Improvements

3.4.1 Improvement-1 (Separate Locater between the operators)

During the initial procedural work and data gathering, it was discovered that there is a shortage of locaters on which sub assembly activities can be performed during process distribution and line balancing. Between the two operators, an additional locater was provided in this regard. Material handling has improved as a result of incorporating this system into the assembly line, which has aided us in delegating lock plate and spring assembly tasks to various partners. The assembly line diagram in Figure 14 depicts the state of the line before and after the proposed remedy was implemented.

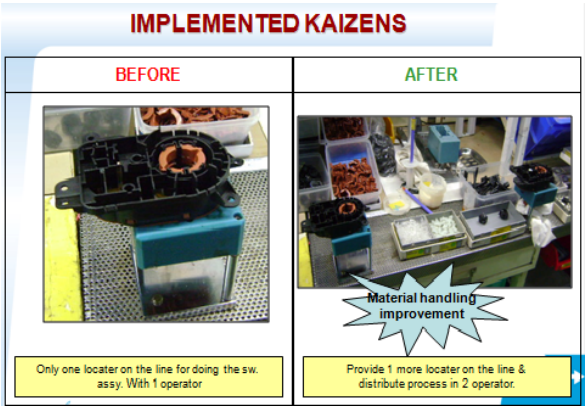

Figure 14- Position of locaters

3.4.2 Improvement-2- Making of In-Process Location

During study of initial procedural data it was found that there was no proper in process location on line for keeping the sub assembled switch. Many times it caused mixing of switches which were kept on different stages for different operations.

This type of difficulty or material handling problem was sorted out by placing a proper in process location between the two operators. This arrangement of in-process locations ultimately helped us in productivity improvement.

Figure 15 - In process locations

This assembly line diagram, shown in Figure 15, depicts the switch's in-process locations before and after the solution was implemented.

3.4.3. Improvement 3- Installation of Trays

Initially during the assembly of head lamp leveling switch a tray stand used for PCB and insulators. To improve the material handling condition and reduce walk time a three layer stand installed on the line. By implementing this arrangement material condition has been improved and walk time for operators during assembly process has been eliminated.

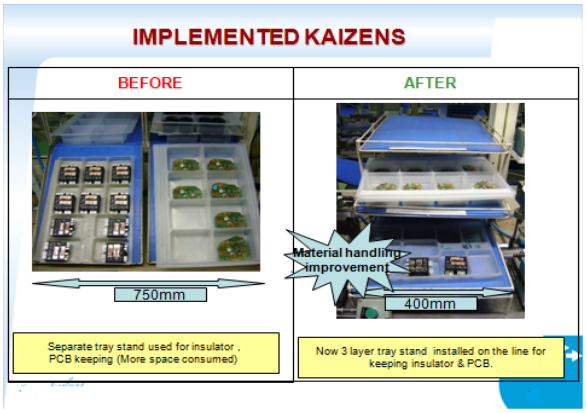

Figure 16- Installation of trays for PCB and Insulators

This assembly line diagram shown in Figure 16 shows the condition of material handling before and after implementing the solution in assembly line for keeping PCB and Insulators.

3.5 STATUS OF ASSEMBLY LINE AFTER IMPLEMENTING THE SOLUTIONS

This Table 4 shows the cycle times of processes and Production Capacity after completion of the project in a shift of 7.5 hr.

Table 4- Process Cycle times and Production Capacity after implementing the solutions

Process Name	Cycle Time (sec)	Capacity
Back cover stamping	10	2700
Insulator assembly with back	9	3000
PCB assembly, caulking	15.5	1741
PCB clinching	10.5	2571
Soldering on PCB	35	771
Spring assembly	8.5	3176
Lock plate	3.5	7714
Housing assembly	18.5	1459
Knob head lamp leveling sub assembly	19	1421
Knob detent assembly	21	1285
Gear and lens assembly	13	2076
Knob head lamp leveling assembly	12	2250
Rotor shaft assembly	25	1080
Panel assembly with switch sub assembly	10	2700
Panel assembly	10	2700
Knob Rotary assembly	10	2700
IR testing	23	1173
Marking on the box	4	6750
Making of the box	9	3000
Continuity testing	33.5	805
Visual inspection and marking	12	2250

The above production capacity table shows the capacity of different machines after implementing the solutions. Table 4 shows that the capacity of each machine has been increased more than 600, which is the ultimate target for required productivity improvement.

Table 5- Standardized Work Combination Table

Proc. No.	Process Name	Cycle time (Sec)	
1	Back cover stamping	10	45 sec I associate
2	Insulator assembly with back cover	9	
3	PCB assembly, caulking	15.5	
4	PCB clinching	10.5	
5	Soldering on PCB	35	43.5 sec II Associate
6	Spring assembly	8.5	
7	Lock plate	3.5	41 sec III Associate
8	Housing assembly	18.5	
9	Knob head lamp leveling sub assembly	19	
10	Knob detent assembly	21	46 sec IV Associate
11	Gear and lens assembly	13	
12	Knob head lamp leveling assembly	12	
13	Rotor shaft assembly	25	45 sec V Associate
14	Panel assembly with switch sub assembly	10	
15	Panel assembly	10	
16	Knob Rotary assembly	10	46 sec VI associate
17	IR testing	23	
18	Marking on the box	4	
29	Making of the box	9	
20	Continuity testing	33.5	45.5 sec VII Associate
21	Visual inspection and marking	12	
Total Time		**312 sec.**	

The above standardized work combination Table 5 shows the different processes distributed to all seven associates and total time taken by each associate in head lamp leveling assembly line.

The above Table shows the following after implementing the proposed solutions:

a. Cycle time = 46 sec

b. Throughput time=312 sec

c. Line capacity= (7.5x60x60)=586 switches (7.5 hr)

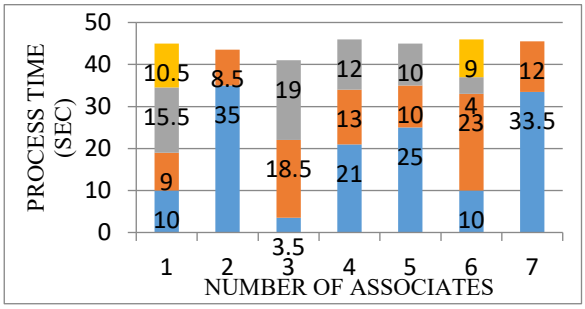

Figure 17- Takt balance chart (After condition)

The Takt balance chart as shown in Figure 17 gives the time taken by each associates for their respective works.

Time taken by different associates in completion of their works is given below:

I Associate - 45 sec to complete four process.
II Associate- 43.5 sec to complete two process.
III Associate- 41 sec to complete three process.
IV Associate- 46 sec to complete three process.
V Associate- 45 sec to complete three process.
VI Associate- 46 sec to complete four process.
VII Associate- 45.5 sec to complete two process.

3.6 FINDINGS AFTER IMPLEMENTING THE SOLUTIONS-

After implementing the proposed solutions in assembly line of HLLS at different stages, cycle times and production capacities of different machines have been improved at different stages. The following changes have been observed after implementing the proposed solutions in the assembly line.

- ***Throughput Time changed from 356 sec to 312 sec.***
- ***Cycle Time for completion the switch changed from 60 sec to 46 sec.***
- ***Line Capacity changed from 450 switches to 586 switches in a shift.***

4. Conclusion

After implementing the lean tools and techniques in assembly line of Head Lamp Leveling Switch at different stages the following conclusions have been made-

a. Cycle Time- Cycle time at the starting of project was 60 sec and after completion the project it has reduced to 46 sec. Ultimately ***the Cycle time of completion the switch assembly has improved by 23.33 %.***

b. Throughput Time- The throughput time of 365 sec. has been reduced to 312 sec. i.e. ***Throughput time has been improved by 12.1 %.***

c. Productivity - Initially the productivity was 60 (450/7.5) switches per hour. After implementing the proposed solution it has been increased to 78.13 (586/7.5) per hour. Ultimately **the *Productivity has been found improved by 23.2 %.***

So, finally it can be concluded that,

- ***Cycle time improved by 23.33 %.***
- ***Throughput time improved by 12.1%.***
- ***Productivity improved by 23.02 %.***

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Nomenclature

HLSS	Head Lamp Leveling Switch
Sec.	Second
PCB	Printed Circuit Board

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