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Application of Kaizen Lean approach to reduce rejections and failure cost at Shop floor of a wire harness manufacturing company

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Kaizen is a basic tool of lean manufacturing which is useful for better improvement and cost effectiveness in different organizations. This study describes a sequential method that uses kaizen continuous improvement approach to eliminate the lock release problem of band harness in a Wire Harness Manufacturing unit. Due to releasing of this self-locking type tie band, wire harness was not holding properly against the bracket and wires were not properly tightened which results in high rejection level of the product. Further, it also affects overall quality rating and increasing the rework cost significantly. In present study four problems which are responsible for rejections, are identified through brainstorming. Pareto analysis and rating method are used to know the major problem, responsible for highest rejections and why-why analysis is used to find out the root cause of the identified problem. To eliminate this cause, step by step procedure based on lean manufacturing approach, is applied in the case company. Statistical quality control tools are also used to analyze the problem. This study results in total cost saving of 535.20 $ per annum and beyond this some other tangible or intangible benefits were also observed.

Keywords: Kaizen, Root cause analysis, Failure cost, Process improvement, Rejection level

1 Introduction

In present global competitive market, customers are demanding the products as per their expectations so the small and medium enterprises (SME's) which is major sector striving for producing high quality products at lowest possible cost. According to the Ministry of Medium and Small Enterprises (MSME), under Act 2006, Government of India defined small-scale industry in which total investment comes under the category of 10 million rupees and Indian SMEs have major contribution in economic growth of the country. Kaizen approach is coined from Toyota Production System (TPS) and focuses to improve the production operations with the removal of non-value added activities and Indian SMEs also have implemented this improvement technique for betterment of the productivity and quality[1]. Lean-Kaizen offers a better path for the organizations to achieve the goals through continuous improvement for enhancement in quality of the product. Reduction of waste, increase in productivity and improvement in quality are the major's drivers for kaizen events[2]. To improve the productivity, it is very essential to aware the employees about the concepts of lean tools and apply them properly in the organization. Employees can contribute a lot in the lean journey by showing their willingness in identification and elimination of wastes in the organization. Similarly, proper implementation of lean tools brings down the wastes and rejection, and improves the overall performance of the organization. Lean manufacturing tools such as Kaizen, SMED etc., have been applied for continuous improvements in different industries to get better business results[3]. This will also create a way to explore hidden improvement opportunities in production line to increase productivity through value stream map[4]. Lean tools are used to eliminate wastes and non-value-added activities for increasing the effectiveness of machines and equipment[5]. SME's are adopting lean manufacturing tools/techniques i.e., Kaizen, JIT, value stream map etc. to meet customers' expectations of getting high quality product at low prices[6,7]. Waste elimination techniques are mostly used in Japan since 1980s to get rid on competitiveness in market through continuous improvement philosophy[8].

Organizations are conducting training programs to make aware of the employees about the benefits of the continuous improvement activities. Kaizen is basically a novel concept derived from Toyota way to sort out inefficiencies in any sort of organization. Kaizen is a popular technique that applies to eliminate wastes at all level of any organization[9]. Kaizen is a lean tool which creates perfection by reducing wastes and also exposes new areas for further improvement[10].

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Kaizen is applied easily and effectively to eliminate wastes by combining different improvement tools and techniques[11]. This continuous improvement lean tool can be applied effectively within each organization[12]. It has main objectives to remove rejections and improve procedures[13]. Kaizen activities result in continuous improvement that can be obtained through proper mapping of the processes with visualization of wastes[14]. Continues improvement program supports waste elimination in the production line and enhance product quality[15]. The organizations can improve internal and external quality of services through implementation of lean[16]. Quality improvement tools i.e. Kaizen, poke-yoke etc. are applied to improve leadership in process safety and team work[17]. Bhamu and Sangwan[18] has mentioned that in continuous improvement programs like Kaizen and quality circles, involvement of employees or human resources is very crucial for effective improvements. They implemented Kaizen lean approach in ceramic industry and achieved more than 40% reduction in rejections. SMEs which are considered to be backbone of economy needs to remain competitive in larger markets by applying the concepts of better and continuous improvements[19]. In present times, the companies are searching tools and methods to reduce costs but several SMEs are using poor quality methods to minimize the costs that further impact on effectiveness of the enterprise, hence one way of cost reduction is to focus on process improvements through continuous improvements methods[20]. Arya and Choudhary[1] have applied Kaizen activities in Indian small-scale industry and observed 87% reduction in inventory access time as well as 134 $ per month cost saving. Arya and Jain[21] have performed a case study based on Kaizen in small-scale Indian industry and observed 44.4% reduction in processing time with 874$ cost savings.

The purpose of this study is to eliminate the lock release problem by implementing Kaizen technique of continuous improvement. A case study of wire harness manufacturing company is presented to show that the implementation of lean tool bring down the rejection cost significantly and improves other tangible and intangible benefits.

2 Materials and Methods

This study follows the basic steps to resolve a problem occurring in wire harness manufacturing company. This methodology is based on kaizen philosophy. The methodology includes data collection of rejection quantities of lock at four stages of the product inspection i.e. Bill of Input (BOI) stage, process stage, Dispatch of Lot (DOL) stage and customer end as shown in Fig. 1. In second step a brainstorming is conducted to identify the different problems responsible for the rejections of the band lock. At the third stage major problem is selected through Pareto analysis and rating method. In the next step of the methodology, why-why analysis and root cause analysis or Ishikawa diagram are used to find out the root causes responsible for occurrence of the actual problem. After identifying the root causes of the problem, counter measures are taken to remove these causes. Countermeasures were implemented, effects of these were checked and cost of failure was calculated.

2.1 Case study

2.1.1 Company background

The ABC Company is a reputed small-scale industry for manufacturing auto electrical and electronic components and situated in north central region of India. Main wire harness, resistor assembly, register, rectifier etc. are the main products of the company.

2.1.2 Defining and understating of the problem

To identify the problem and its occurrence, rejections level inspected at each stage of the process for the month of January 2020. After data collection it was observed that out of total 54800 procured band harness; maximum 6000 wire harness rejected at BOI

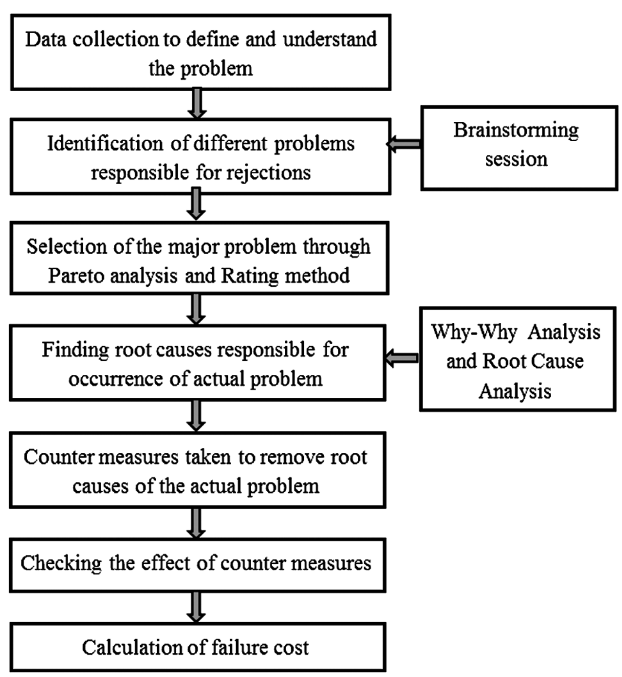

Fig. 1 — Methodology of the study.

stage, 680 pieces were rejected at in-process stage, 85 rejected at DOL stage and 35 rejected at customer end. As shown in Fig. 2, out of four stages, rejection level is highest at BOI stage so it has been chosen as a critical stage. Now, question arises to find out the main cause/s of these rejections. Team members comprising with different departments of this project conducted brain storming session for finding the main causes of the problem. Further, root cause of the problem can be short out for better productivity of the organization.

2.1.3 Problem identification

Team members along with facilitator conducted many brain storming meetings to identify the causes/problems which are responsible for the rejections. After observing data collected in month of January 2020, four main problems were identified; pieces were broken during handling, lock release, tight insertion and lock lance revert back. Out of the four problems, it is now required to identify the most critical problem which is responsible for major rejections. Further, Pareto analysis and Rating method were followed for the identification of the critical problem in the said case study.

2.1.4 Actual problem finding

Pareto analysis and Ranking method are adopted to find out the major problem out of identified four problems so that root causes can be derived. The economist Vilfredo Pareto developed Pareto methodology based on 80-20 rule for prioritizing the factors as per worthy of attention[22]. Rating method is also important method to prioritize the problems according to occurrence and impacts[23].

2.1.4.1 Pareto analysis

Pareto chart basically is used to find out most significant/critical problem which affects the major rejections. As shown in Fig. 3, out of four problems; lock release problem has contributed 98.67 percent in overall rejections of band harness. So, the team members decided to resolve this on priority basis. This problem occurs frequently in the manufacturing system. It is observed that out of 6800 rejected pieces of lock; 6710 pieces are rejected due to releasing of the lock strip during tighten of the band harness and 39 pieces are found broken. Further, it is also found that 35 pieces are rejected due to tight insertion in its matching part and 16 pieces are found not good due to back out of the lock lance. It is cleared from the observations that major rejections are due to releasing of the lock strip.

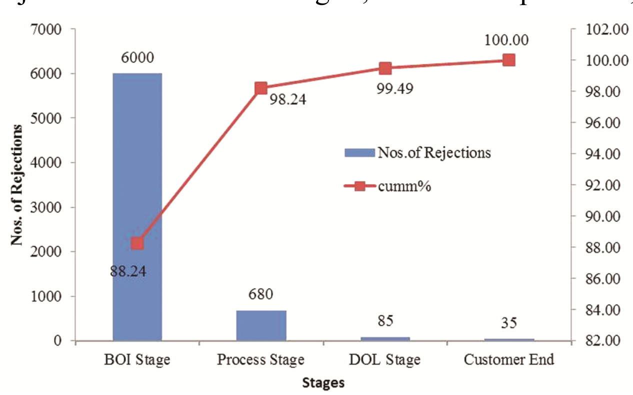

Fig. 2 — Rejections at different stages.

2.1.4.2 Rating method

Rating method is used to identify the problem which occurred most frequently and has severe impact on rejections. In this study rating from 1 to 5 scale is decided based on two factors i.e. occurrence and extent of impact as shown in Table 1. Rating for LOW and HIGH were given by 1 and 5 respectively. Problem selected on the basis of highest priority numbers which is calculated by adding the rating of given two factors.

Team members who are experts in their domain area, are assigned to rate the four problems on the basis of their knowledge. As shown in Table 2, maximum rating is assigned to lock release problem, so that it has been concluded from rating method that,

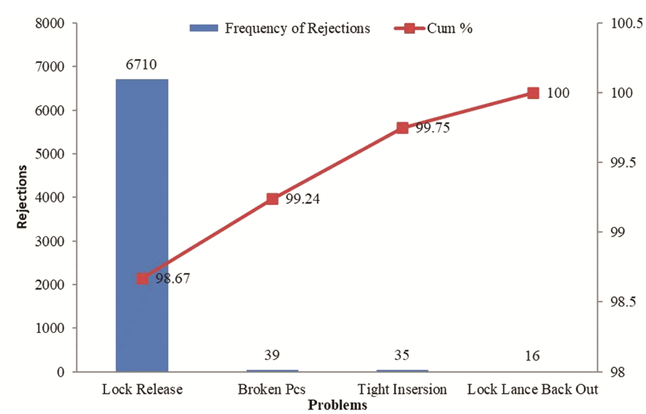

Fig. 3 — Pareto chart analysis.

Table 1 — Rating for two factors

Rating	Occurrence	Extent of impact
5	Every hour	Impact on safety
4	Every day	Functionality is affected
3	Every week	Secondary functionality is affected
2	Every month	Inconvenience to customer/user
1	6 or more month	Insignificant impact

Table 2 — Rating assigned by team members

Category of problem	Members					Total Not Good (NG) Pcs	Priority to select major cause
	A1	A2	A3	A4	A5		
Broken Pcs.	1	0	1	2	1	5	3
Lock lelease	5	5	4	5	5	**24**	**1**
Tight insertion	2	4	2	0	0	8	2
Lock lance back-out	1	0	1	1	0	3	4

Table 3 — Why-Why analysis

Problem	WHY1	WHY2	WHY3	WHY4
Locking released at angular force	Band harness being twisted while angular force applied	Improper clearance observed between lock and teeth at angular Force	1. Semi guide wall observed 2. Hardness variation observed	Less recess provided in mold at vendor end

this problem has severe impact on rejections. Problem got maximum percentage in Pareto analysis as well as in rating analysis, and it is directly related to esteemed customer of the case company and fit/function at customer end. This was observed that internal customer harassment arises due to this problem and it affects overall quality rating. This problem has created excessive work, operator fatigue, productivity loss, high rejections and cost. On the basis of all mentioned points it is justified that lock release problem is critical in this case and responsible for majority of rejections.

2.2 Illustration and finding of the root causes of the problem

The problem which is responsible for maximum rejections is lock release problem but the reason behind this is to be finding out yet so that counter measures can be taken. After analyzing the strength, it is observed that holding strength of the lock is required 14 Kgf but lo ck was loosened at angular pull force of 10Kgf. Why-Why analysis is applied to find out root cause of the problem by asking successive Why's, Table 3 shows that lock release can happens due to twisting of the band harness at the time of angular load on it and twisting can happens due to improper clearance between lock and teeth. Further, this is due to semi guide and hardness variations and finally due to less recess/ less semi guide length providing in mold of lock at vendor end. Thus, at the end of Why-Why session it is observed that lock releasing problem is frequently occurred due to less semi guide length provided in its mold at vendor end and enhancing the rejections. Cause and Effect diagram is also shown in Fig. 4. It represents faults existing and its effects in 4M's i.e. Man, Machine, Material and Method. It is observed by cause and

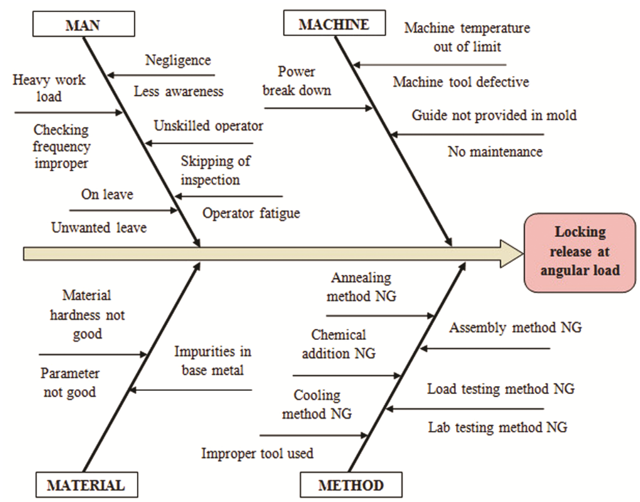

Fig. 4 — Cause and effect diagram.

effects diagram that following root causes are responsible for enhancing rejections: Operator negligence, Man power is not skilled adequately, inspection method found not adequate for angular load, variation in hardness of material and less guide length provided in mold.

2.2.1 Fault Analysis

Fault analysis was carried out in four stages (4M's-Man, Machine, Material and Method) with all team members. At first stage, team members inspected in perspective of operator/man. It was observed during the visit that frequency of inspecting the product and proper work distribution were as per the expectations but the operators were not having adequate skills. Also, operator's negligence was found in this stage. At second, fault analysis was performed in respect to the machine. During the inspection, machine pressure continuity, tool maintenance and accuracy were observed well but the guide length of the lock was found less in mould. Further, the team members visited to inspect faults present in the materials. During this stage, material quality, technical properties and purity were found very much satisfactory but the hardness of the material found less as expected in application. At the end, the team visited to check fault present in the method or process. Each stage of product manufacturing process is shown in Fig. 5 and was inspected. The manufacturing process consists of total six stages such as raw material receiving, melting, injection molding, visual inspection, load testing and final inspection. After verification, it was observed that load testing method was not proper. Therefore, proper counter measures are required to be applied for eliminating above discussed faults.

2.3 Counter Measures adopted against root causes of the problem

Table 4 shows the root causes and their corresponding countermeasures adopted to resolve these root causes. This is observed that operators are not caring about customer complains so this is required to display complains in assembly, final inspection and DOL area for the awareness of the operators so that they can work upon these complains. To enhance skill of manpower, training was given to operators and proper operating manuals of inspection were also provided on each machine. The objectives of the training were to make the employees aware about the lean tools and way of application of the tools for the improvement of the existing production processes. The training was conducted by the experts from recognized industries of the same domain. To enhance the skill of the manpower, industry experts from industries were called to arrange workshops based on lean tools and techniques. Quality circles were also presented to aware the employees of the case company about the continuous improvement activities.

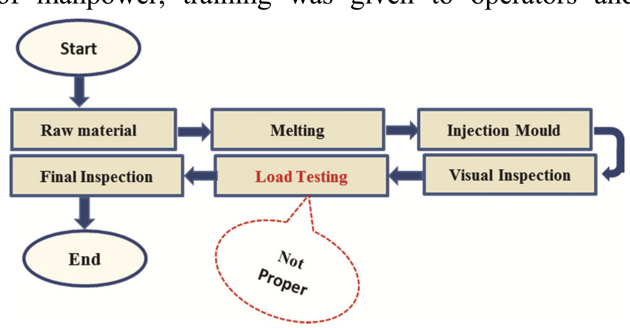

Fig. 5 — Flow chart of the manufacturing process.

Operators were not adopting any method to test the load capacity of the lock. Therefore, head light's left bracket as shown in Fig. 6 has undergone the actual load testing at supplier end to ensure defect free supplies. Material hardness increased by changing material grade from SRF (Low mechanical strength plastic material) to DSM (High mechanical strength plastic). This was necessary to change the grade of material because the material having lower strength was not able to sustain high angular load. Guide length was less in mold which results slippage of lock so throughout length was provided as shown in Fig. 7 which eliminates the twisting of belt of the lock. Detail of the action taken in mold is shown in Fig. 7, before improvement this length was less so the belt of the lock was slipping which resulting failure of lock so after improvement it was suggested to provide this length of guide throughout the length of the cap of lock so that holding strength of the lock will increase.

2.3.1 Poka-Yoke (Mistake-proofing)

Despite of the above measures, Poka-Yoke technique was also adopted to avoid re-occurrence of the minor problems or mistakes. In this technique regular monitoring of band harness was suggested in production and DOL stage and this has to be done on

Table 4 — Counter measures against root causes

Root cause	Counter Measure	Important date
Operator negligence	Customer complaint displayed on Assembly, FI & DOL area for awareness to operators	15/01/2020
Manpower skill not adequate	Training given to operator & also operating manual of inspection provided	15/01/2020
Inspection method not adequate for angular load	Stay head light left bracket provided for actual load testing at DOL stage as well as at supplier end to ensure defect free supplies	17/01/2020
Material hardness variation	Material hardness increased up-to 140 by changing material grade from SRF to DSM	20/01/2020
Guide length less provided in mold	Throughout guide length provided in mold so as to eliminate twisting of belt	24/01/2020

Fig. 6 — Head light bracket for testing.

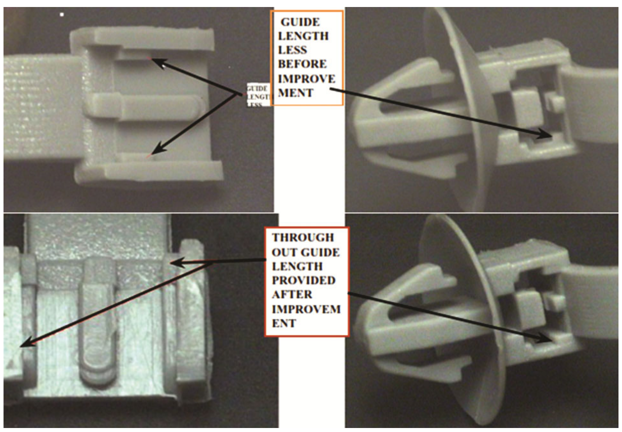

Fig. 7 — Action taken in mold of lock.

daily basis by visual inspection. Two employees were assigned to do this task as per instruction sheet. Monthly audit system was also incorporated at vendor end in first week of every month and QAV (Quality Assurance and Validation) report must be prepared of the audit. Two employees were appointed to facilitate this activity.

2.4 Effectiveness of counter measures

To check the effectiveness of the counter measures, observation was taken from July and August month as shown in Fig. 8. As before implementation of the counter measures the rejection level was 6800 pieces. Complaints received from the customers about the quality of the product, started to display at assembly, final inspection and DOL area so that employees can aware about these complaints and can ensure to improve the quality accordingly. Training is given to the operators to develop their skill about the machines and operating manuals of inspection were pasted near the machines so that operator can read and adopt these inspection points of respective machine. After implementation of counter measure 1 and 2 the rejection level is reduced to 520. As for angular load, testing method for checking holding strength of the lock was absent at DOL area so head light left bracket (Fig. 8) was provided for actual testing at DOL stage as

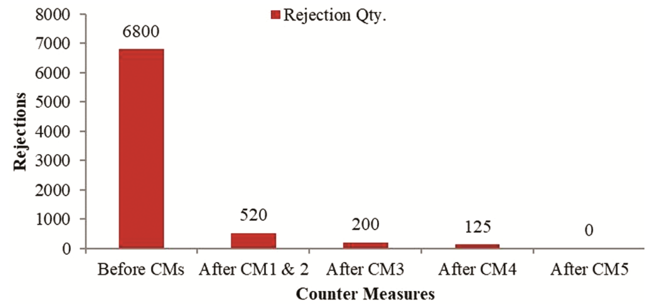

Fig. 8 — Effectiveness of counter measures.

well as at supplier end to ensure defect free supplies. This further reduced the rejection level to 200.

It is also found that the current material used is having low mechanical strength and hardness so it was suggested to change grade of material. After using material of DSM grade, hardness increased up to 140 and rejection level reduced to 125 pieces. As due to less length of guide, strip or belt of the lock was slipping and twisting so full length guide was provided in the mold to eliminate twisting of the belt. This further reduced rejection level to zero.

3 Results and Discussion

This study is based on process improvement and the kaizen methodology is applied to eliminate the problem arises in plastic lock manufacturing process. A quality circle was formed to work for better results. It was observed that the plastic lock was not holding the band harness properly. The members of the circle identified the problems which results high rejections of the product. Counter measures were adopted to remove the root causes of the arise problems. After adopting the suggested countermeasures better results were observed. Rejections level was 6800 pieces at starting which reduced to zero level after implementing five counter measures listed in Table 4. Following standard parameters have been confirmed from the case company before calculating the cost.

Manufacturing Cost per unit of the plastic lock is $0.016.

Average quantity of rejection in a month is 800 pieces/ month.

Travelling charge of the customer visit is $0.054/- per km + Toll tax and staff cost is $ 0.85/hour.

Operator cost $0.20/hour for internal working in company.

Operator cost $1.56/hour for external working at customer end.

Operator consumes 1min/piece for processing and ½ min/ piece for inspection.

After considering above listed parameters, the detail calculation made is as follows:

Monthly rejection at process end of band harness = 800 pcs.

Cost of reject band harness = 800*$0.016= 12.8$.

Internal failure

Operator cost for processing = 1min.* 800 pcs = 13.5 hrs.*0.20$. = 2.7 $.

Operator cost for inspection (Fl & DOL) = 800*1/2min. = 7hrs.* 0.20$. = 1.4 $.

External failure

Customer visit cost (2-times) = 100 km.* 4 = 5.42$. + 2.44$. (t.tax) = 7.86$.

Operator cost for rework at customer end = 4days * 1.56$. = 6.24 $.

Staff cost = 16 hrs.*0.85$. = 13.6$.

Total cost = 12.8$. +2.7 $. + 1.4 $. + 7.86$. + 6.24 $. +13.6$. = 44.60 $/month.

After implementation of the counter measures, it is calculated that 44.60 $are saved monthly and 535.20 $ annual saving was observed. After providing full guide length in mold, withdrawal load of belt of lock is increased from 14 kgf to 24 kgf. Despite of the cost effectiveness, customer satisfaction level was also enhanced as the rejections came down to zero level. Other intangible benefits were observed after implementation of improvements in the case company. During this case study, improvement in interpersonal relationships was observed with coordination in work as a team. The employees learned about technical problem analysis skill with the knowledge of computers. After implementation of Poka-Yoke technique, re-occurrence of the problems was mitigated. Lock slippage problem was completely eliminated by providing full length of guide in mold. Operators started working without negligence after getting required training. Load testing was successfully implemented after providing adequate load testing method.

4 Conclusion

It is cleared from this study that Kaizen tool is an excellent technique of Lean manufacturing to solve the existing problem in organizations and by using this technique cost effectiveness of 535.20 $ /- year is achieved and rejection level reduced to zero. For avoiding re-occurrence of the problem regular monitoring of band harness in production area and DOL stage is required. This study focuses to eliminate the rejections of the plastic lock in wire harness manufacturing company. This type of continuous improvement activities can be applied in other manufacturing industries and can give better shop floor results. The organizations have to motivate their employees to participate in quality circles. Kaizen is very simple tool to remove the small problems for better improvements. Many of the companies in India are arranging quality circles programs to make aware their workers about these continuous improvements methods so that employees can give their efforts to increase the quality of the product. Kaizen can be adopted in any of the sector i.e. education, healthcare, automobile, machine tools, banks etc.

Though many authors have adopted these techniques in their research but still there is scope to implement this at broad level including shop floor workers. Machine operators and shop floor workers have better practical knowledge about the actual working of the machines, tools and processes. But top management has to support and motivate them so that workers can communicate in a better way with higher authorities. Ground staff should be trained to develop their skills so that they can support to achieve the vision of the company.

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