Received 13 March 2018
Revised 7 June 2018
Accepted 3 August 2018

Defect reduction in an electrical parts manufacturer: a case study

Raja Sreedharan V.
Department of Management, Amrita Vishwa Vidyapeetham, Kochi, India
Rajasekar S.
Department of Industrial Engineering, CEG, Anna University, Chennai, India
Santhosh Kannan S.
Department of Management, Amrita Vishwa Vidyapeetham, Kochi, India
Arunprasad P.
Dubai Business School, University of Dubai, Dubai, United Arab Emirates, and
Rajeev Trehan
Department of Industrial and Production Engineering,
Center of Training and Placement,
Dr. B.R. Ambedkar National Institute of Technology, Jalandhar, India

Abstract

Purpose – Defective parts in manufacturing is a serious issue faced by every manufacturer. Even after proper care in design, material selection and manufacturing of product, there exists a defective part. The purpose of this paper is to explore the quality of the manufacturing, and find the use of effective quality tools to reduce the part defect rate in an electrical parts manufacturing unit, thereby, reducing the replaced cost of defective parts.

Design/methodology/approach – With the help of quality initiatives, like total quality management (TQM) and Lean Six Sigma (LSS), the firms can produce quality product in each stage of production. The paper focuses on the primary data collected from the XYZ electric manufacturer.

Findings – The main finding of this case analysis is that by the effective use of quality tools, the defective part return rate can be reduced, because of which the firm can observe reduction in replaced cost of almost INR24 lakh. In addition, 10A switch part contributes more in replacement cost. Further, it adds to the 35 percent of the overall part rejection.

Research limitations/implications – The study is more focused on particular type of switch product and can extend to other types of products. In addition, the analysis reveals the results of only 88 percent of the defective products.

Practical implications – The study provides results of the improved quality by effective use of quality tools and discusses the different types of defects in the electrical parts manufacturing. Introducing TQM and LSS to manufacturing can reduce the customer return rate to 1,300 parts per million (PPM) and even to 1,000 PPM in future.

Originality/value – The paper discusses the quality issues in the electrical manufacturer. Moreover, the case analysis briefs effective ways to improve the product quality and reduce the rejection rate.

Keywords Quality tools, Customer return, Electrical parts

Paper type Case study

1. Introduction

Quality is to make products without defects, bridging the gap between existing problems in quality and emerging challenges of quality with respect to organizations, people and societies (Anttila and Jussila, 2017). To improve the quality of the product, it is necessary to identify the defects in a structured manner and try to eliminate them. The common practice of improving both product and process quality is by use of quality tools (Bacoup *et al.*, 2018). The continuous improvement of quality in organizations was driven by competition on one side and on the other side by the increasing requirements of the customers (Weckenmann *et al.*, 2015; Ismyrlis, 2017). The main challenge for a multinational company to increase global market share is to

The TQM Journal
Vol. 30 No. 6, 2018
pp. 650-678
© Emerald Publishing Limited
1754-2731
DOI 10.1108/TQM-03-2018-0031

understand their global customers. Companies to enrich their manufacturing performance employ business process strategies like lean and Six Sigma (SS).

Total quality management (TQM) has become a motto for all the successful organizations worldwide. The management of people and organizational learning are the two major TQM principles that business organizations should focus on to withstand in long-term business (Lau *et al.*, 2016). All business organizations worldwide have understood the potential benefits of TQM approach in quality management. According to Harrington *et al.* (2012), there has been a gentle change over from QC to TQM. TQM means different things to different people. It has an impact on commitment and job satisfaction of workforces in manufacturing firms (Arunachalam and Palanichamy, 2017). Good QM practice, in technical as well as in organizational aspect, serves as a moral cause for the implementation of TQM in firms (Majstorovic and Sibalija, 2015). The focus of the organizations should be on firming operations and the supply chain. The managers need to line up resources and processes based on realistic approach of decision making for accomplishing greater organizational performance (Sinha *et al.*, 2016). For component parts with multi-faceted topologies and geometries, there is no need to be always instinctively obvious for the normal hidden probability of every orientation. Regardless of material or dimensions, the best feasible natural inactive position will be the same (Udhayakumar *et al.*, 2013). Incorporating the outcomes of rejection cost on best maintenance planning decisions helps in exhibiting the relationships between quality control policy and preventive maintenance (Pandey *et al.*, 2013).

2. Literature review

2.1 Basic quality tools

Quality is an important phenomenon for businesses to be successful. It is essential for manufacturers to give quality products and services to the customers, as they should be benefited for what they pay. To achieve success in business, the primary goal of the organization should be customer satisfaction. With the competition in the market growing tougher across the world, it is crucial for the firms to give some extra effort to enhance the quality of their products (Reyes *et al.*, 2018). Moreover, continuous improvement in quality is indispensable to achieve and maintain stable economic growth and, ultimately, gain desired profit.

The manufacturing firms should consistently monitor the quality of their products and ensure that only the best products and services are delivered to customers. There are some basic quality control tools used by the business organizations which include check sheets, scatter diagrams, cause and effect diagrams, histograms, Pareto charts, control charts and stratification. These tools are very much useful for manufacturing firms in controlling and eliminating quality-related problems which occur during different phases of production. Identifying the possible causes for the problem/defect can be done by using a tool called cause and effect diagram (Meybodi, 2005; Ambekar and Hudnurkar, 2017). Similarly, a bar chart showing the various factors for a problem/defect can be known using the Pareto analysis has their own function in improving the quality (Mandal *et al.*, 2000). It is essential for organizations to utilize the best out of these methods, thereby helping in effective use of resources to be efficient, make good profits and be successful.

2.2 Quality tools and techniques in organizations

The literatures related to use of quality tools in the organization have been collected and some of the relevant papers have been discussed in this section.

Liang (2010) describes about TQM and the aspects of quality tools in organizations. From this paper, it is obvious that in a quality improvement process, it is important to have a system view to assess the quality methods and tools. Quality is the main pillar of the TQM methodology. Lutters *et al.* (2014) explained about the tools and techniques used in product design. This paper gives an overview about structural use of tools/techniques based on decision making and creativity in the work environment. The tools/techniques are considered as key assets that can make a layout for designers to develop products which are not only excellent in meeting the market requirements, but also permit designers to prompt their capacities. Sreedharan and Raju (2016) expressed a creative problem-solving method, theory of inventive problem solving (TRIZ), organized by Altshuller for product design. He prepared a contradiction matrix which is used to solve contradictions that occur in designing. TRIZ cannot solve each and every problem, but it helps in exploring a creative solution to solve problems. It is not only used in products, but also in solving quality-related problems. This method also requires creative researchers to generate appropriate suggestions.

Sreedharan *et al.* (2017) analyzed the impact of quality tools and techniques on quality-related costs. This paper presents data regarding quality-related costs and the effects after using quality tools and techniques. The study was carried out as an online survey of quality experts of German companies from three industries: automotive, mechanical engineering and electronics. Survey results are compared to literature, discussed and then conclusions are drawn. Findings indicate that the implementation rate of quality tools and techniques and the amount of total quality costs vary starkly among industries. The companies with a high implementation rate of quality methods have significant lower quality costs. This should motivate other companies to introduce methods for quality improvement. Koitiro Nisiyama *et al.* (2016) demonstrated the positive effects by the use of OM and MCSs techniques on organizational performance through new product introduction and cost reduction. This production-focused research was executed in the auto parts manufacturing company with the help of a survey with the related companies. The results obtained in this structural equation modeling showed that the analytical use of MCSs is positively related with the cost reduction goals.

Uluskan *et al.* (2016) used path analysis for their research study on organizational performance. It is a special case of SEM, from which he evaluated the hypotheses of the research. The survey data collected from various apparel industry members are used for the study. As a moral support to earlier literatures, the results in this research study suggested that both SS and CRM on successful implementation directly influence the overall performance of the organization. The findings of this research work reinforced the QM literatures with an emphasis on implementation of SS practices in organization. However, this paper reveals that CRM is very critical and it has a direct significant influence on organizational performance.

2.3 SS in organizations

Many researchers have focused on the effective employment of SS practices in organizations worldwide. Various studies have been done on the success points of implementing the SS practices in the manufacturing industries, and some of the relevant papers have been discussed in this section.

Antony and Banuelas (2002) presented the essential factors required for the implementation of SS in organizations. These factors are based on a pilot survey conducted in various service companies and manufacturing organizations. The study contains a questionnaire consisting of two main sections – the key ingredients and the background of the firm. The most important factor or ingredient identified is involvement and management commitment. These findings will help the key factors of other quality functions such as TQM. It is essential that the factors which have low rank in the survey are also considered as key drivers of SS practices in the organization. Therefore, for quality improvement, it is necessary to understand the use of tools and techniques within the SS method. Another similar study has been made on analysis of implementation of SS in SMEs. The study results are that most of the SMEs do not have the sufficient resources to implement SS practices and most of the SMEs are not aware of SS. This research study is one among the few pilot surveys that were piloted in the manufacturing SMEs. Brun (2011) described the outcomes of his research project study dedicated to SS implementation process to understand the operating position of enterprises and, consequently, the managerial implications of implementation of SS in the typical manufacturing company.

Augusto Cauchick Miguel *et al.* (2012) conducted a survey-based study in a developing country where they benchmarked the use of SS tools and techniques. The aim of this paper is to identify the use of quality tools and techniques within SS framework with the help of the survey developed to analyze the results of SS implementation in organizations. More than 60 SS customers answered the postal questionnaire of the descriptive survey, and, in the study, a part of the results of the survey was discussed. Some specific effects of the quality tools and techniques practiced in SS were compared with that of the literature.

Linderman *et al.* (2003) established an understanding of the SS occurrences from a hypothetical theory which can serve as a foundation for emerging scientific knowledge and critical thinking about SS practices. This goal theory delivers a basic theory for understanding the association between setting of goals and achievement of goals. To understand this phenomenon better, the paper presents some interesting questions about integrating goal theory with knowledge management. There exist wide varieties of exciting SS based research questions, and there is also a criticism that SS merely puts traditional QM techniques in new companies. Zu *et al.* (2008) discussed the role of SS in QM and inspected the concern of SS as traditional QM. The paper studied both the traditional SS and QM literatures and acknowledged three new critical practices for the implementation of SS concepts and methodology in organizations.

Koripadu and Subbaiah (2014) explained the effective use of SS and LSS tools and techniques for performing a practical problem solving method with higher profits along with improved effectiveness and efficiency. In problem management, the use of SS tools and techniques has delivered exponential benefits to customers. It also becomes as a more structured approach to identify and understand the root cause of the problem. Tlapa *et al.* (2016) analyzed the CSFs of SS implementation in manufacturing firms in Mexico, and found that CSFs seem to group in three components. Understanding CSFs, obstacles and experiences with SS provides opportunities for practitioners to better support their organizations. Therefore, information on the correct implementation of SS in Mexican manufacturing companies could be considered to future SS implementation (Pun and Furlonge, 2012). This could help these organizations increase their productivity and competitiveness in the region.

2.4 Lean Six Sigma (LSS) in organizations

Thomas *et al.* (2008) developed and implemented a combined LSS method for manufacturing sector. In order to achieve significant development in company's cost, delivery and product quality, a simple yet extremely effective LSS model is designed, developed and implemented in this study.

Sokovic *et al.* (2010) introduced the features of SS (DFSS, DMAIC) techniques, PDCA tool and RADAR matrix (EFQM excellence model) which are possibly used for the continuous improvement of quality of processes, products and services in an organization. Based on the specific needs and demands of the firm's quality methodologies, tools and techniques are properly selected and utilized. Karim and Arif-Uz-Zaman (2013) developed a structured methodology for the implementation of lean strategies and proposed a new leanness evaluation metric (CPM) method. In this method, with the help of process mapping and time study, different types of wastes are identified. By using CPM metric for the type of waste identified in the manufacturing area, an upgraded process map is developed from which effectiveness and process efficiency are evaluated. Tyagi *et al.* (2015) exploited the lean concepts to develop, implement and manage the product at a faster phase for maintaining or improving the quality and performance level of the product. Lean thinking concepts include a wide range of tools and techniques intended to yield bottom line results. In this study, value stream mapping (VSM) method is used to discover the inefficiencies, wastes and non-value added stages in a particular definable practice out of the whole product development process (PDP). The research paper discusses the problems associated with PDP for a case study of a gas turbo generator unit manufacturer.

3. Case study

3.1 Company profile

For an organization to be competitive, quality plays a predominant role. To improve the quality of the products or service, essential quality tools and techniques are needed. The majority of companies apply a selected set of quality tools and techniques to improve their product or service quality (Malik *et al.*, 2016). The study was conducted in a major company, headquartered in Riyadh, Saudi Arabia, which operates in design and development centers, manufacturing and construction businesses, and hosts facilities mainly in Middle East and other countries. Due to confidentiality, the company is referred as XYZ in this paper. XYZ is involved in electrical, manufacturing and marketing electrical construction products, electro mechanical, civil engineering construction and allied engineering services. XYZ's main divisions are XYZ electric and XYZ construction.

XYZ electric is an industrial arm of XYZ. XYZ electric manufactures and markets a wide variety of wiring fixtures in Saudi Arabia and distributes to a number of countries in the Middle East. XYZ electric presently manufactures a complete range of switches, dimmers and sockets. XYZ electric provides only best-quality products for its customers by applying industries best practices. For XYZ, quality means delivering only the best products and services on time to its customers.

3.2 Statement of problem

3.2.1 Identifying problem. In every quarter of the year, XYZ arranges a meeting regarding the customer complaints and on their products. In the April 2016 meeting, it discussed the customer returns in terms of parts per million (PPM). Comparing to the last year, this year, XYZ received more number of defects in their products. Due to the warranty policy of the company, the company will replace all the defective products with the good one without asking any question.

In the meeting, this issue, comparing to the past five years, was seriously discussed, and it is decided to analyze the issue to improve the quality of the products. For identifying the problem, past five years of customer complaint and customer returns are discussed in the meeting. Table I shows the number of products delivered to the customers and the number of defective products returned from the customers for the past five years. The overall result which is also posted in terms of PPM starts from 2011–2012 to 2015–2016 for identification purpose.

Figure 1 describes clearly that the year 2015–2016 is worse than the past two years. Therefore, it is necessary to take necessary action to minimize the quantity of defective electrical products through quality initiatives.

3.2.2 Defining the problem. The brainstorming session is conducted to improve the quality of the products by minimizing the defects. As per the decisions of the meeting, it is

Defective quantity received wise	(All products) Delivered quantity	Period	PPM
30,009	15,641,264	2011–2012	1,919
30,784	15,549,092	2012–2013	1,980
31,503	22,818,410	2013–2014	1,381
32,549	24,356,067	2014–2015	1,336
47,927	28,532,529	2015–2016	1,680

Table I.
Customer return report

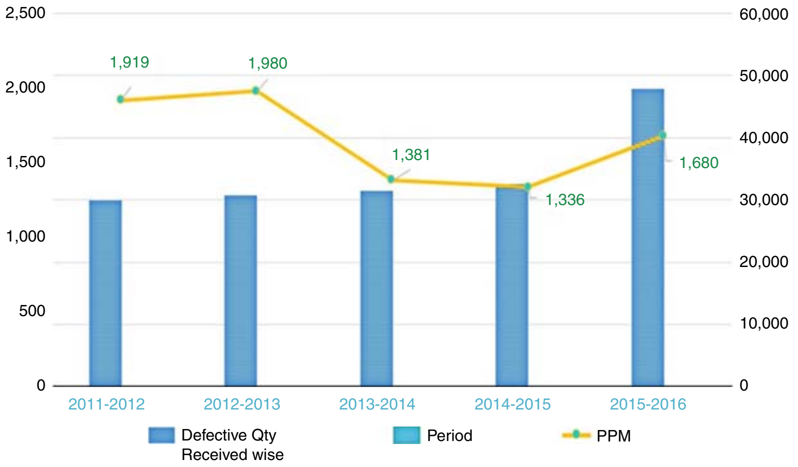

Figure 1. Customer return in PPM

necessary to develop the quality of the products with the help of quality tools and techniques followed or used in the organization. Following are the most common and effectively used quality tools in the organization:

(1) flow chart;

(2) failure mode effective analysis;

(3) check sheet;

(4) control chart;

(5) PDCA; and

(6) matrix diagram.

After a brainstorming session with the employees, all the quality tools were discussed in detail considering the number of products delivered in the year 2015–2016. Each Product was examined with respect to the quality tools used and tabulated in Table II. Table II indicates how effectively these tools are used in the products with the number of products and product groups. From these details, we can easily identify the effective usage of the tools with respect to the products. Taking this as motivation, the study focuses on the following:

- The reason for this case analysis study is to examine the defects that could tarnish the reputation of the organization. By eliminating these defects, there could be an image makeover and regaining customer confidence.

	Quality/lean tools used					
Period	Flow chart	DFMEA	Check sheet	Control chart	PDCA	Matrix diagram
2011–2012	43	28	28	30		
2012–2013	28	14	14	16	16	
2013–2014	28	14	14	16	16	
2014–2015	15	8	8	8	8	8
2015–2016	14	7	7	7	7	7

Total no. of product groups = 15
Total no. of products = 128

Table II. Quality/lean tools used in products

- To minimize the defects from 1,680 PPM to 1,300 PPM within the second quarter of 2017 by effectively implementing the quality tools and techniques that can be more profitable for the organization.

4. Data collection and analysis

4.1 Customer return report

As per the organization policy, the standard range of wiring accessories covers the real-time warranty up to 25 years. Any product having a fault during this period will be replaced free of charge. The replaced products' cost is huge, and heavily affects the net profit of the organization. This is the point of concern to analyze in this study and there is a need to provide the solutions that will solve the major issues of the defective products, which will restrict the defects in future.

Table III shows the number of products delivered to the customers and the number of defective products returned from the customers for the past five years. The overall result is posted in terms of PPM, which starts from 2011–2012 to 2015–2016 for easy identification purpose. Then the replaced cost of defective products is shown in Saudi Riyal and the same in Indian Rupee as well. Even a 10 percent reduction in the defective products will provide the cost reduction of INR1.3 lakh SAR (INR24 lakh).

4.2 Collection of defective products list

After noticing the effect of reduction on defective products, the defective products are segregated as per the production batch wise in the period April 2015–March 216. The received defective products are properly segregated as per the required batch wise. Then the team wanted to brainstorm the possible issues in each product group, all the issues in the below tables are listed down. Table IV shows the possible defects of the 10A products along with batch, and the overall result shows the quantities of each possible defect. From these defects, the quantities were further identified with the "Quality" related defects and all are listed in the table for further process.

Similarly, Table V shows the possible defects of the 20A products along with the batch; Table VI shows the possible defects of the 45A products along with the batch; Table VII shows the possible defects of the 13A products along with the batch; Table VIII shows the possible defects of the tele jack products along with the batch; and Table IX shows the possible defects of the data jack products along with the batch, and all are listed as explained for 10A products for further progress.

4.3 Quality- and non-quality-related defects

After identifying the quality-related defect quantities for each product group, the next step would be calculating the overall quantities for quality-related defects and non-quality-related defects. This is very important since the decision can be taken to process further is based on

Product group	Sold quantity	Complaint quantity	PPM	Replaced cost in SAR	Replaced cost in INR
10A switch	7,232,087	14,659	2,027	432,441	7,783,929
20A switch	1,472,349	1,446	982	52,056	937,008
45A switch	1,514,155	4,627	3,056	238,291	4,289,229
13A switched socket	4,486,062	8,381	1,868	360,383	6,486,894
Tele jack sockets	1,326,250	1,881	1,418	69,597	1,252,746
Data jack sockets	3,182,169	4,455	1,400	187,110	3,367,980
				1,339,877	24,117,786

Table III. Customer return report with replaced cost

Defects	April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
	Total no. of defects													
Color faded		8	2	14	10	4	11	6	2	6			63	63
Marks/scratches				2	9	9	24	55	31	182	165	430	907	907
Cap damage								1		1			2	2
Screw thread damage										1	36		37	37
Damage mishandling	134	240	303	388	409	352	470	562	450	890	1,003	1,159	6,360	
Cover plate broken	25	66	89	148	289	149	383	240	441	434	72	73	2,409	2,409
Lock broken	38	77	99	62	65	56	98	68	80	45	16	5	709	709
LED not working								2		2			4	4
Terminals missing				1	3		2	6	6	10	17	49	94	94
No defect-product found working							1	1	2		1	963	968	
Housing melted	8	16	15	28	55	46	43	35	51	73	26	3	399	399
Plunger melted	27	131	188	319	141	59	100	75	77	164	105	83	1,469	1,469
No continuity	12	11	15	14	40	38	129	94	160	307	74	15	909	909
Silver erosion	1	9	17	27	19	9	11	16	15	60	61	72	317	317
No rocker movement								3		6	1	2	12	12
Overall result	245	558	728	1,003	1,040	722	1,272	1,164	1,315	2,181	1,577	2,854	14,659	7,331

Table IV.
10A products – defect vs batch

Table V.
20A products – defect vs batch

Defects	April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
	Total no. of defects													
Marks/scratches						1	1	4	9	10	73	43	141	141
Screw thread damage												1	1	1
Damage mishandling	1	10	8	26	27	7	33	39	77	102	145	156	631	
Cover plate broken		1			4	1	6	3	7	6	10		38	38
Lock broken				0	1	1	1	10	17	44	58	74	206	206
Housing melted				2			1	2	12	18	35	35	105	105
No defect-product found working	1	2		2	2			1	1		4		13	
Plunger melted	1	8	2	7	15	8	15	16	36	50	72	29	259	259
No continuity							1					1	2	2
Silver erosion		1		1	1	2	1	1	1	6	7	19	40	40
No rocker movement									1	1	1	7	10	10
Overall result	3	22	10	38	50	20	59	76	161	237	405	365	1,446	802

Table VI. 45A products – defect vs batch

Defects	April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
	Total no. of defects													
Color faded									1				1	1
Marks/scratches						1	6	4	2	5	17	35	70	70
Screw thread damage											2	188	190	190
Damage mishandling	9	15	21	22	74	17	61	58	54	165	146	208	850	
Cover plate broken	2	9	12	9	32	6	59	30	97	91	22	2	371	371
LED not working											3	17	20	20
Terminal head slot missing											1	5	6	6
No defect-product found working				2	2	3	1	2	2	12	17	17	58	
Housing melted	23	74	77	72	195	91	110	111	68	99	117	333	1,370	1,370
Plunger melted	5	11	31	54	117	61	186	252	162	365	189	73	1,506	1,506
No continuity					2			1	1			1	5	5
Silver erosion	6		5	13	20	14	18	23	10	41	21	9	180	180
Overall result	45	109	146	172	442	193	441	481	397	778	535	888	4,627	3,719

Table VII.
13A products – defect vs batch

Defects	April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
	Total no. of defects													
Color faded				1	5			8		12		32	58	58
Marks/scratches	5		3		5	1	1	1		14	4	30	64	64
Screw thread damage											2	9	11	11
Damage mishandling	192	328	247	241	470	315	144	242	354	189	634	720	4,076	
Cover plate broken	82	128	83	113	77	39	69	45	68	49	73	82	908	908
Terminals missing			2			1			1		1	4	9	9
Terminal head slot missing									1			1	2	2
Short circuit		2										1	3	3
No defect-product found working										41	280	440	761	
Housing melted	45	57	138	29	146	59	18	127	34	95	38	87	873	873
Plunger melted	32	62	29	136	44	92	172	49	162	87	42	92	999	999
No rocker movement			72			81			42	62	23	335	615	615
Shutter struck											2		2	2
Overall result	356	577	574	520	747	588	404	472	662	549	1,099	1,833	8,381	3,544

Table VIII. Tele jack products – defect vs batch

Defects	Total no. of defects April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
Color faded			4						2	1			7	7
Marks/scratches	1	2	15	1				1	21	13			54	54
Shutter struck	32	121	192	42	10	4	29	1	426	276	1	34	1,168	1,168
Screw thread damage	5	28	48	3		1	1		170	79		8	343	343
Cover plate broken	9	34	61	5	7	1	5		71	57		16	266	266
No defect-product found working	1	6	9	2			1		15	9			43	
Overall result	48	191	329	53	17	6	36	2	705	435	1	58	1,881	1,838

Table IX.
Data jack products – defect vs batch

Defects	April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result	Quality-related defect qty
	Total no. of defects													
Color faded		1										8	9	9
Marks/scratches								9	15	6	21		51	51
Shutter struck		7	4	5	12	6	18	75	495	25	257	34	938	938
Damage mishandling	2	6		1	6			24	63		54	16	172	
Cover plate broken								20	110	2	46		178	178
Terminal damage		1						27	270	2	69		369	369
No defect-product found working	1	7	12	14	16	16	22	28	120	17	45		298	
Housing broken		314		211	142		112	215	161	411	427	118	2,111	2,111
Module coming out								26	255	13	35		329	329
Overall result	3	336	16	231	176	22	152	424	1,489	476	954	176	4,455	3,985

the amount of defective quantities. Further, Table X shows the sold quantity, complaint quantity and quality-related defect quantity for each product group along with percentage for easy understanding. The table clearly shows that the quality-related defect quantities are 60 percent of the total complaint quantities. The remaining 40 percent of the total complaint quantities are non-quality-related defects. The non-quality-related defects are the prime focus for the management since the implementation time could be very less.

4.3.1 For non-quality-related defects. The team conducts one brainstorming session for the prime focus of non-quality-related defects, and the following are the effective ideas which help to reduce the non-quality-related defective products:

- a product leaflet prepared with big bold letters of do's and don'ts;
- product information labels introduced;
- product installation seminar conducted with technicians; and
- incentives introduced for technicians.

4.3.2 For quality-related defects. For quality-related defective products, the team decides to use the Pareto chart to prioritize the products which need to be targeted early to reduce the defective products within the second quarter of 2017. From Figure 2, the quantities of each product group are shown along with the percentage to make decision for further process. From the Pareto chart, 10A products comprise 35 percent of the overall quality-related products. The team decided that analyze 10A products, data jack products,

Product group	Sold quantity	Complaint quantity	Quality-related defect quantity	Quality-related defect quantity in %
10A switch	7,232,087	14,659	7,331	50
20A switch	1,472,349	1,446	802	55
45A switch	1,514,155	4,627	3,719	80
13A switched socket	4,486,062	8,381	3,544	42
Tele jack sockets	1,326,250	1,881	1,838	98
Data jack sockets	3,182,169	4,455	3,985	89
		35,449	21,219	60

Table X.
Quality- and non-quality-related defects

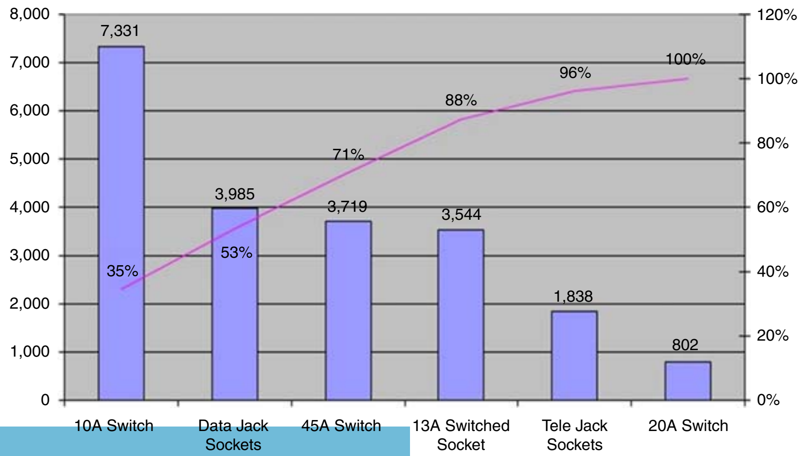

Figure 2.
Pareto chart for defective products

45A products and 13A products which can be reduced to 88 percent of the total quality-related defective products.

4.3.3 Identifying the causes. A Pareto chart is used to identify the causes which need to be solved to reduce the quality-related defective products. Table XI shows the quality-related defective quantities along with the batch in the period April 2015–March 2016 for 10A products. Figure 3 shows the quantities of each issues along with the percentage, which clearly indicates that the cover plate broken issue has the maximum of 33 percent of overall issues. Similarly, Table XII shows the quantities along with the batch in the period April 2015–March 2016, and Figure 4 shows the quantiles for data jack products, which clearly indicates that the housing broken issue has the maximum of 53 percent of overall issues. Table XIII shows the quantities along with the batch in the period April 2015–March 2016, and Figure 5 shows the quantiles for 45A products, which clearly indicates that the plunger melted issue has the maximum of 40 percent of overall issues. Table XIV shows the quantities along with the batch in the period April 2015–March 2016, and Figure 6 shows the quantiles for 13A products, which clearly indicates that the plunger melted issue has the maximum of 28 percent of overall issues.

4.4 Cause and effect analysis for cover plate broken issue

From the Figure 6, it is clear that these issues should be taken as top priorities to reduce the defective products and to achieve our objective of 1,300 PPM within the second quarter of 2017. First, the cover plate broken issue was taken and analyzed using the cause and effect analysis. Figure 7 shows the various causes for this issue, and Figure 8 clearly shows the selected causes which will solve the issue at the maximum extent. The following is the short summary of the cover plate broken issue from the cause and effect analysis:

- alternate material to be developed to reduce deformation in cover plate;
- rib pattern design in the cover plate to be modified to withstand over-tightening scenarios; and
- a metal base plate option would be a good solution instead of a plastic plate for future projects.

4.5 Cause and effect analysis for housing broken issue

As shown in Figure 8, the housing broken issue was taken into consideration, and after brainstorming on the issue using the cause and effect analysis, some useful conclusions have been drawn. Figure 9 highlights the various causes for this issue, and Figure 10 shows the selected causes which will solve this issue at the maximum extent. The following is the short summary of the cover plate broken issue from the cause and effect analysis:

- alternate material to be developed to reduce deformation in housing;
- rib pattern and snapfit design in housing to be modified to withstand over-tightening scenarios; and
- product mounting box conditions need to be improved by specifying the importance of cleaning the box in the product installation manual.

4.6 Cause and effect analysis for plunger melted issue

Similarly, the plunger melted issue was taken and a conclusion was drawn after brainstorming the issue using the cause and effect analysis. Figure 11 shows the various causes for this issue, and Figure 12 clearly shows the selected causes which will solve this

Defects	Total no. of defects April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result
Color faded		8	2	14	10	4	11	6	2	6			63
Marks/scratches				2	9	9	24	55	31	182	165	430	907
Cap damage								1		1			2
Screw thread damage										1	36		37
Cover plate broken	25	66	89	148	289	149	383	240	441	434	72	73	2,409
Lock broken	38	77	99	62	65	56	98	68	80	45	16	5	709
LED not working								2		2			4
Terminals missing				1	3		2	6	6	10	17	49	94
Housing melted	8	16	15	28	55	46	43	35	51	73	26	3	399
Plunger melted	27	131	188	319	141	59	100	75	77	164	105	83	1,469
No continuity	12	11	15	14	40	38	129	94	160	307	74	15	909
Silver erosion	1	9	17	27	19	9	11	16	15	60	61	72	317
No rocker movement								3		6	1	2	12
Overall result	111	318	425	615	631	370	801	601	863	1,291	573	732	7,331

Table XI.
Identifying the causes – 10A products

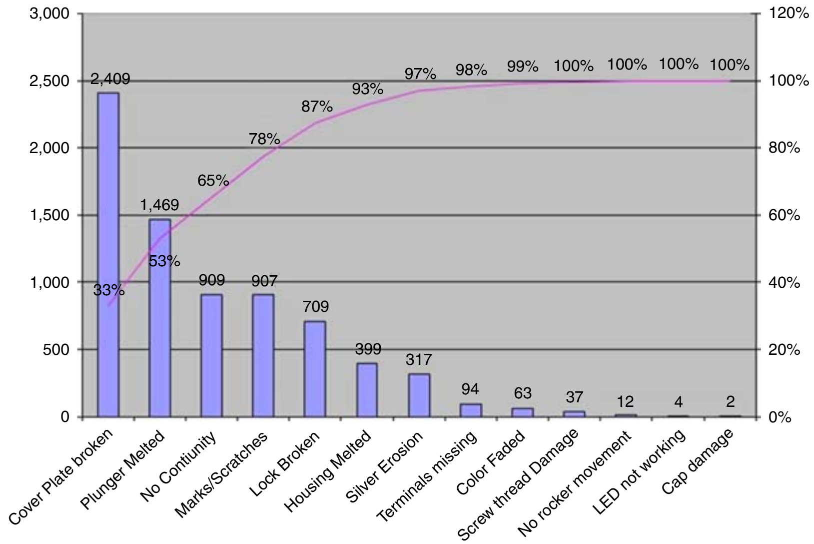

Figure 3.
Pareto chart for identifying the causes – 10A products

issue at the maximum extent. The following is the short summary of the cover plate broken issue from the cause and effect analysis:

- substitute material to be established to improve the lubrication property in plunger;
- alternate material can be developed to increase the plunger spring efficiency;
- plunger and plunger spring assembly design to be modified to overcome the plunger melted issues; and
- insufficient space in the mounting box needs to be improved by specifying the importance of cleaning the box in the product installation manual.

5. Result and discussion

From this study, it is evident that with the effective use of quality tools like Pareto chart and the cause and effect analysis, the rejected parts can be reduced. The cause and effect diagram or Ishikawa diagram has unlimited applications in not only manufacturing, but also in research studies for the following reasons: to analyze the cause and effect relationship; to provide solution for defect-related problems; and to educate and train the employees in decision making and making corrective actions.

Similarly, the Pareto diagram or ABC analysis is also commonly used for separating the vital causes that are responsible for quality loss. This diagram is based on the principle that a few defects account for most of the effects. It is used as a risk assessment technique in all levels of an organization. As a result of the defective products produced, the quality cost incurred by organization gets increased. A quality cost is considered as the cost associated with the prevention of poor-quality products.

In this study, the majority of defects occur in 10A products analyzed for the period April 2015–March 2016. In addition, on further analysis, the major defect is due to the cover plate broken issue. Of the total defects, the cover plate broken issue is almost 33 percent (refer Figure 3), and some of the causes for this defect are analyzed and shown in Figure 7, where it can be observed that the major causes for the defect are due to

Defects	Total no. of defects April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result
Color faded		1										8	9
Marks/scratches								9	15	6	21		51
Shutter struck		7	4	5	12	6	18	75	495	25	257	34	938
Cover plate broken								20	110	2	46		178
Terminal damage		1						27	270	2	69		369
Housing broken		314		211	142		112	215	161	411	427	118	2,111
Module coming out								26	255	13	35		329
Overall result	0	323	4	216	154	6	130	372	1,306	459	855	160	3,985

Table XII. Identifying the causes – data jack products

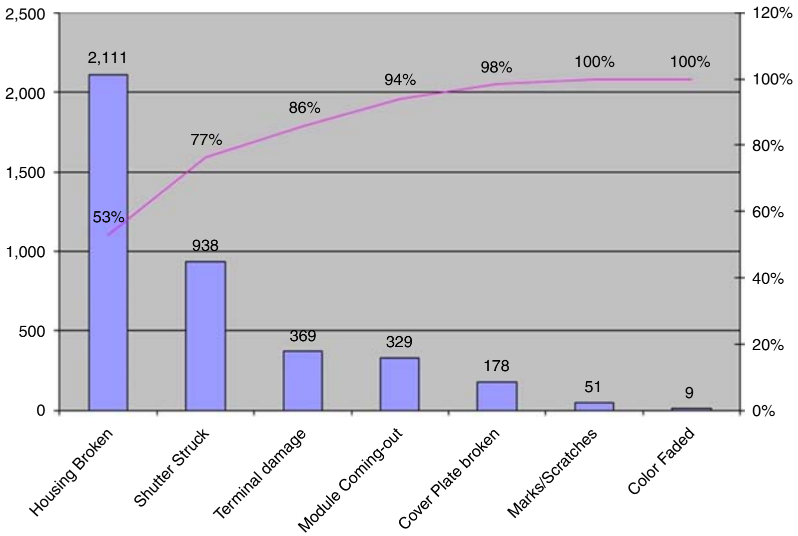

Figure 4.
Pareto chart for identifying the causes – data jack products

tightening torque, over-tightening, rib patterns in the base plate and due to unfilled materials leading to defective products.

The other major defect is due to the housing broken issue which accounts for almost 53 percent of the total defects in data jack products (refer Figure 4). The causes for this failure are given in Figure 9, which shows that the major causes for the defect is due to mounting box conditions, improper use of tools, stress due to snapfit, unfilled materials leading to deformation and rib patterns in the base plate leading to defective products.

Finally, the major defect in 45A products and 13A products is because of the plunger melted issue which accounts to 20, 40 and 28 percent in 10A, 45A and 13A products, respectively. The major causes for the defect are shown in Figure 11, which explains that the major reasons for the defects are to insufficient space, higher torque, mistakes in plunger and spring assembly, lubrication errors and the improper plunger spring selection. So, from these results, we can conclude that the use of quality tools plays a significant role in reducing the product defects and reducing the unnecessary cost spent on poor quality. The short summary of this project and the recommendation to achieve 1,000 ppm are as follows.

5.1 Summary

- The data of the total products delivered and the number of products returned are collected year wise for a period between 2011 and 2016.
- The cost for replacing the different products is collected. It is found that 10A switches contribute more to the replacement cost.
- Different types of defects for each product are captured batch wise.
- The quality defects and non-quality defects are identified, and Pareto analyses of different products are done. 10A switches contribute to 35 percent of total defective products.
- The various causes for the defects and the Pareto analyses are analyzed for each product. The cause and effect analysis is used for the selection and analysis of each defect.

Defects	Total no. of defects April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result
Color faded									1				1
Marks/scratches						1	6	4	2	5	17	35	70
Screw thread damage											2	188	190
Cover plate broken	2	9	12	9	32	6	59	30	97	91	22	2	371
LED not working											3	17	20
Terminal head slot missing											1	5	6
Housing melted	23	74	77	72	195	91	110	111	68	99	117	333	1,370
Plunger melted	5	11	31	54	117	61	186	252	162	365	189	73	1,506
No continuity					2			1	1			1	5
Silver erosion	6		5	13	20	14	18	23	10	41	21	9	180
Overall result	36	94	125	148	366	173	379	421	341	601	372	663	3,719

Table XIII.
Identifying the causes – 45A products

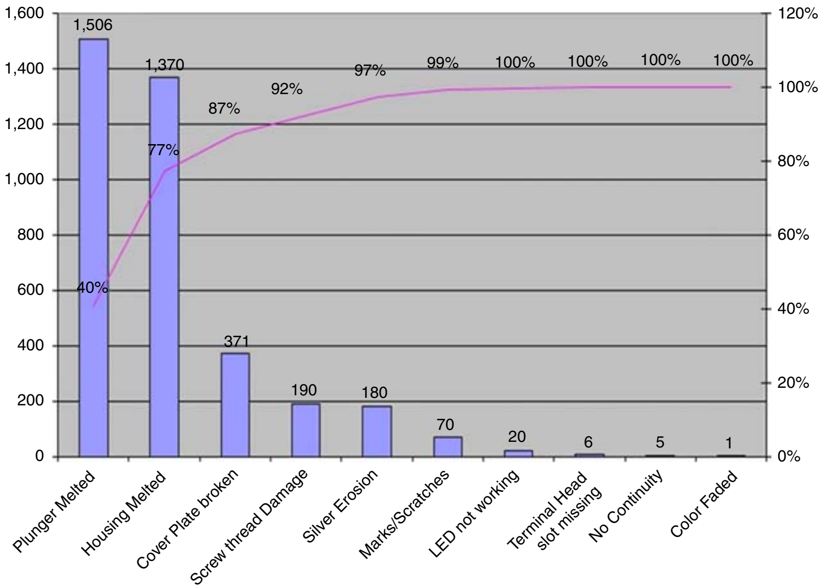

Figure 5.
Pareto chart for identifying the causes – 45A products

5.2 Recommendations

- Prioritizing the issues in short time to reduce the defects by effectively using the Pareto chart.
- Minimizing the time on finding the root cause for issues by effectively using the cause and effect analysis tool.
- Implementation feedback to be received from customers on non-quality-related issues to analyze more for further improvement.
- For quality-related issues, implementation program to be submitted to the management for using the quality tools effectively.
- We analyzed only 88 percent of the defective products; the remaining defective products are to be analyzed by following the same procedure to reduce further defects.
- Need to explore the quality tools effectively as we did in this study in future to achieve 1,000 PPM, the target set by the organization.

5.3 Limitations of the study

Like several studies, the study has its own limitations. The research work focused on Saudi-based industries. The study was conducted in a private organization, and public sector companies were not included due to data privacy and budgetary constraints. Further, the study has focused on the quality tools, which were frequently used by the employees to reduce the defects. However, this scenario can be improved by introducing a structured approach like PDCA, DMAIC, etc. Further, based on the results and discussion, the findings cannot be generalized to other electrical parts manufacturing industries; it requires a larger sample to improve the findings. Moreover, the researcher can test the findings using other techniques like AHP, Topsis and Structural equation modeling.

Table XIV. Identifying the causes – 13A products

Defects	Total no. of defects April 15 batch	May 15 batch	June 15 batch	July 15 batch	August 15 batch	September 15 batch	October 15 batch	November 15 batch	December 15 batch	January 15 batch	February 15 batch	March 15 batch	Overall result
Color faded				1	5			8		12		32	58
Marks/scratches	5		3		5	1	1	1		14	4	30	64
Screw thread damage											2	9	11
Cover plate broken	82	128	83	113	77	39	69	45	68	49	73	82	908
Terminals missing			2			1			1		1	4	9
Terminal head slot missing									1			1	2
Short circuit		2										1	3
Housing melted	45	57	138	29	146	59	18	127	34	95	38	87	873
Plunger melted	32	62	29	136	44	92	172	49	162	87	42	92	999
No rocker movement			72			81			42	62	23	335	615
Shutter struck											2		2
Overall result	164	249	327	279	277	273	260	230	308	319	185	673	3,544

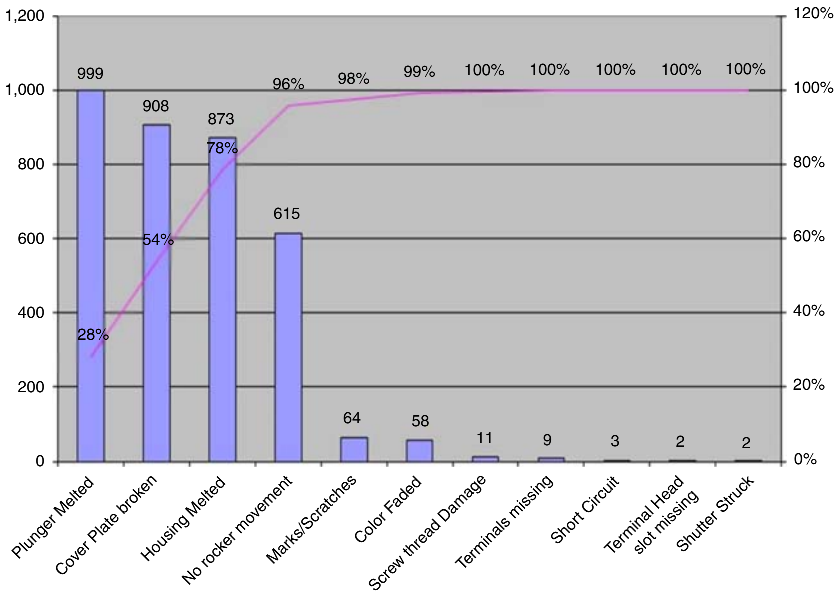

Figure 6.
Pareto chart for identifying the causes – 13A products

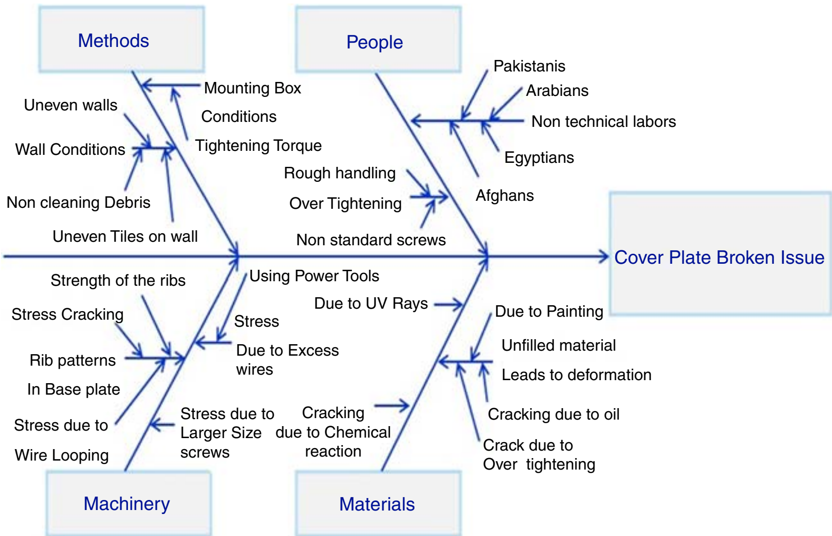

Figure 7.
Cause and effect diagram for cover plate broken issue – analysis

6. Managerial implications

The main implication of the analysis is one of the few cases that have addressed the part rejection in electrical parts manufacturer. Moreover, the identification of defective parts in a mass production is a challenging task. The case highlighted the causes for various defects that occur in electrical manufacturer company. Further, the study shows how manufacturers

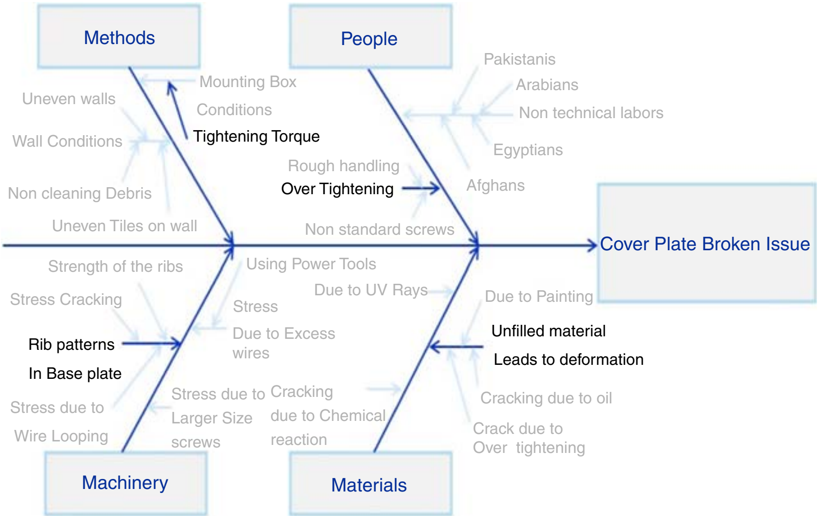

Figure 8.
Cause and effect diagram for cover plate broken issue – selection

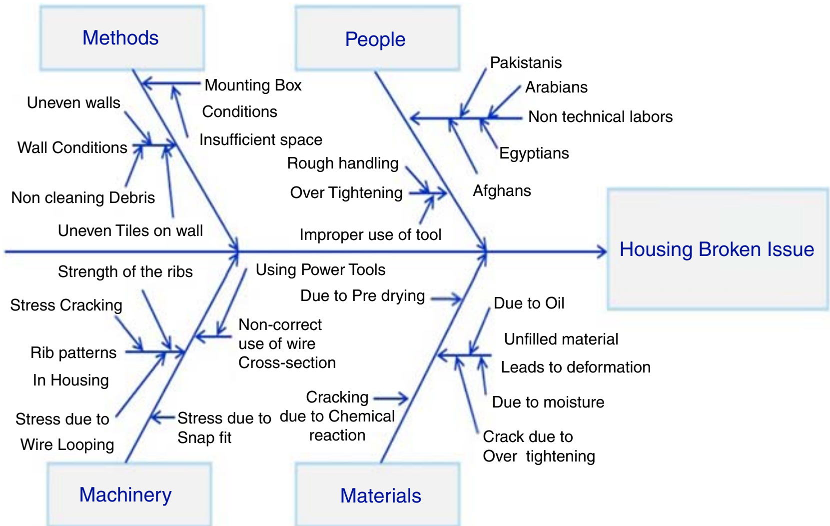

Figure 9.
Cause and effect diagram for housing broken issue – analysis

can reduce the defective components in their regular day-to-day activity through quality initiatives. Moreover, the case analysis shows that the customer return rate could be minimized to 1.300 PPM by the effective use of quality tools.

7. Conclusion

Before coming to the conclusion, it is important to consider few of the past reviews. Maleyeff *et al.* (2012) emphasized on LSS in the changing business culture and LSS being a support for the organization's competitiveness. Lande *et al.* (2016) identified the list of CSFs of LSS framework that affect and influence quality, financial and operational performance of SMEs

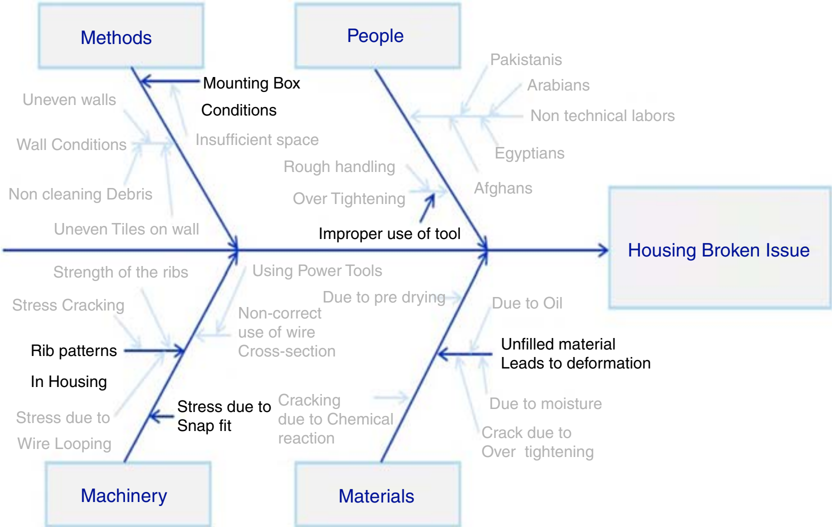

Figure 10.
Cause and effect diagram for housing broken issue – selection

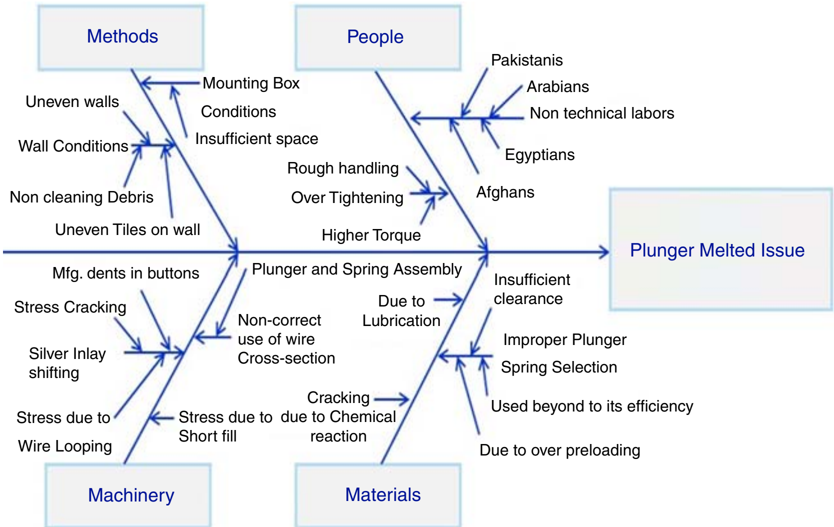

Figure 11.
Cause and effect diagram for plunger melted issue – analysis

in the Indian subcontinent. The resulting case-based analysis demonstrates how the LSS methodology can be used to assist the effective defect reduction process. Like other studies, this case analysis also has limitations, which were discussed earlier. This study can be used for further analysis, and almost 100 percent defective parts can be analyzed for results that are more effective. In addition, the results of this study can be used for further quality-related problems and the quality tools can be implemented for achieving 1,000 PPM customer returns in future. The study also focuses more on one product 10A switch, and

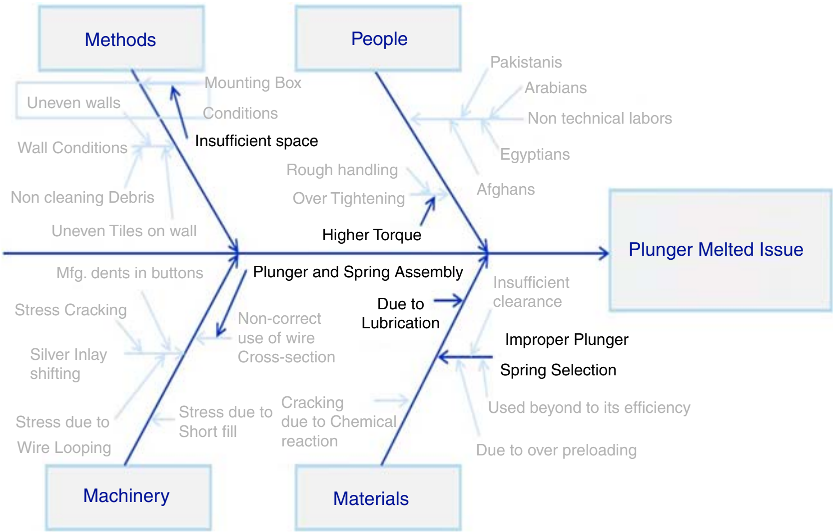

Figure 12.
Cause and effect diagram for plunger melted issue – selection

similar studies can be made for all products. The future researchers can focus on the employee skill set and the working environment, which causes defective parts in manufacturing. Therefore, different quality tools and techniques help in controlling the overall process of the organization, thereby increasing the efficiency of the work process and better cost savings for the organization.

References

Ambekar, S. and Hudnurkar, M. (2017), "Factorial structure for Six Sigma project barriers in indian manufacturing and service industries", *The TQM Journal*, Vol. 29 No. 5, pp. 744-759.

Antony, J. and Banuelas, R. (2002), "Key ingredients for the effective implementation of Six Sigma program", *Measuring Business Excellence*, Vol. 6 No. 4, pp. 20-27.

Anttila, J. and Jussila, K. (2017), "Understanding quality–conceptualization of the fundamental concepts of quality", *International Journal of Quality and Service Sciences*, Vol. 9 Nos 3/4, pp. 251-268.

Arunachalam, T. and Palanichamy, Y. (2017), "Does the soft aspects of TQM influence job satisfaction and commitment? An empirical analysis", *The TQM Journal*, Vol. 29 No. 2, pp. 385-402.

Augusto Cauchick Miguel, P., Satolo, E., Marcos Andrietta, J. and AraújoCalarge, F. (2012), "Benchmarking the use of tools and techniques in the Six Sigma programme based on a survey conducted in a developing country", *Benchmarking: An International Journal*, Vol. 19 No. 6, pp. 690-708.

Bacoup, P., Michel, C., Habchi, G. and Pralus, M. (2018), "From a quality management system (QMS) to a lean quality management system (LQMS)", *The TQM Journal*, Vol. 30 No. 1, pp. 20-42.

Brun, A. (2011), "Critical success factors of Six Sigma implementations in Italian companies", *International Journal of Production Economics*, Vol. 131 No. 1, pp. 158-164.

Harrington, H.J., Voehl, F. and Wiggin, H. (2012), "Applying TQM to the construction industry", *The TQM Journal*, Vol. 24 No. 4, pp. 352-362.

Ismyrlis, V. (2017), "The contribution of quality tools and integration of quality management systems to the organization", *The TQM Journal*, Vol. 29 No. 5, pp. 677-689.

Karim, A. and Arif-Uz-Zaman, K. (2013), "A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations", *Business Process Management Journal*, Vol. 19 No. 1, pp. 169-196.

Koitiro Nisiyama, E., Tiomatsu Oyadomari, J.C., Yen-Tsang, C. and Braga de Aguiar, A. (2016), "The use of management control systems and operations management techniques", *BBR – Brazilian Business Review*, Vol. 13 No. 2, pp. 56-81.

Koripadu, M. and Subbaiah, K.V. (2014), "Problem solving management using Six Sigma tools & techniques", *International Journal of Scientific and Technology Research*, Vol. 3 No. 2, pp. 91-93.

Lande, M., Shrivastava, R.L. and Seth, D. (2016), "Critical success factors for Lean Six Sigma in SMEs (small and medium enterprises)", *The TQM Journal*, Vol. 28 No. 4, pp. 613-635.

Lau, A.W., Li, Y.S., Tang, S.L. and Chau, K.W. (2016), "TQM application by engineering consultants in Hong Kong", *The TQM Journal*, Vol. 28 No. 4, pp. 561-587.

Liang, K. (2010), "Aspects of quality tools on total quality management", *Modern Applied Science*, Vol. 4 No. 9, pp. 66-74.

Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S. (2003), "Six Sigma: a goal-theoretic perspective", *Journal of Operations Management*, Vol. 21 No. 2, pp. 193-203.

Lutters, E., van Houten, F.J., Bernard, A., Mermoz, E. and Schutte, C.S. (2014), "Tools and techniques for product design", *CIRP Annals-Manufacturing Technology*, Vol. 63 No. 2, pp. 607-630.

Majstorovic, V. and Sibalija, T.V. (2015), "From IMS and Six Sigma toward TQM: an empirical study from Serbia", *The TQM Journal*, Vol. 27 No. 3, pp. 341-355.

Maleyeff, J., Arnheiter, E.A. and Venkateswaran, V. (2012), "The continuing evolution of Lean Six Sigma", *The TQM Journal*, Vol. 24 No. 6, pp. 542-555.

Malik, T.M., Khalid, R., Zulqarnain, A. and Iqbal, S.A. (2016), "Cost of quality: findings of a wood products' manufacturer", *The TQM Journal*, Vol. 28 No. 1, pp. 2-20.

Mandal, P., Love, P.E.D., Sohal, A.S. and Bhadury, B. (2000), "The propagation of quality management concepts in the Indian manufacturing industry: some empirical observations", *The TQM Magazine*, Vol. 12 No. 3, pp. 205-213.

Meybodi, M.Z. (2005), "Strategic manufacturing benchmarking", *The TQM Magazine*, Vol. 17 No. 3, pp. 249-258.

Pun, K.F. and Furlonge, S.J. (2012), "Impacts of company size and culture on quality management practices in manufacturing organisations: an empirical study", *The TQM Journal*, Vol. 24 No. 1, pp. 83-101.

Reyes, J.A.G., Yu, M., Kumar, V. and Upadhyay, A. (2018), "Total quality environmental management: adoption status in the Chinese manufacturing sector", *The TQM Journal*, Vol. 30 No. 1, pp. 2-19.

Sinha, N., Garg, A.K. and Dhall, N. (2016), "Effect of TQM principles on performance of Indian SMEs: the case of automotive supply chain", *The TQM Journal*, Vol. 28 No. 3, pp. 338-359.

Sreedharan, V.R. and Raju, R. (2016), "A systematic literature review of Lean Six Sigma in different industries", *International Journal of Lean Six Sigma*, Vol. 7 No. 4, pp. 430-466.

Sreedharan, V.R., Raju, R. and Srivatsa, S.S. (2017), "A review of the quality evolution in various organisations", *Total Quality Management & Business Excellence*, Vol. 28 Nos 3-4, pp. 351-365.

Sokovic, M., Pavletic, D. and Pipan, K.K. (2010), "Qua lity improvement methodologies – PDCA cycle, RADAR matrix, DMAIC and DFSS", *Journal of Achievements in Materials and Manufacturing Engineering*, Vol. 43 No. 1, pp. 476-483.

Thomas, A., Barton, R. and Chuke-Okafor, C. (2008), "Applying Lean Six Sigma in a small engineering company – a model for change", *Journal of Manufacturing Technology Management*, Vol. 20 No. 1, pp. 113-129.

Tlapa, D., Limon, J., García-Alcaraz, J.L., Baez, Y. and Sánchez, C. (2016), "Six Sigma enablers in Mexican manufacturing companies: a proposed model", *Industrial Management & Data Systems*, Vol. 116 No. 5, pp. 926-959.

Tyagi, S., Choudhary, A., Cai, X. and Yang, K. (2015), "Value stream mapping to reduce the lead-time of a product development process", *International Journal of Production Economics*, Vol. 160, pp. 202-212.

Udhayakumar, S., Mohanram, P.V., KeerthiAnand, P. and Srinivasan, R. (2013), "Determining the most probable natural resting orientation of sector shaped parts", *Assembly Automation*, Vol. 33 No. 1, pp. 29-37.

Weckenmann, A., Akkasoglu, G. and Werner, T. (2015), "Quality management – history and trends", *The TQM Journal*, Vol. 27 No. 3, pp. 281-293.

Zu, X., Fredendall, L.D. and Douglas, T.J. (2008), "The evolving theory of quality management: the role of Six Sigma", *Journal of Operations Management*, Vol. 26 No. 5, pp. 630-650.

Further reading

Antony, J., Kumar, M. and Madu, C.N. (2005), "Six sigma in small-and medium-sized UK manufacturing enterprises: some empirical observations", *International Journal of Quality & Reliability Management*, Vol. 22 No. 8, pp. 860-874.

Dangayach, G.S. and Deshmukh, S.G. (2008), "Implementation of manufacturing strategy: a multisector study of the Indian manufacturing industry", *International Journal of Services and Operations Management*, Vol. 4 No. 1, pp. 1-33.

Franceschini, F., Galetto, M. and Maisano, D. (2006), "Classification of performance and quality indicators in manufacturing", *International Journal of Services and Operations Management*, Vol. 2 No. 3, pp. 294-311.

Hejazi, A. and Hilmola, O.P. (2006), "Manufacturing lot sizing as a source of the Bullwhip effect: a case study of electronics and furniture supply chains", *International Journal of Services and Operations Management*, Vol. 2 No. 3, pp. 237-255.

Hong, S.W. and Huang, C.L. (2011), "Total quality management implementation in research and development organisations: a comparative study of South Korea and Taiwan", *International Journal of Services and Operations Management*, Vol. 8 No. 3, pp. 365-389.

Nordin, N., Deros, B.M., Wahab, D.A. and Rahman, M.N.A. (2012), "A framework for organizational change management in lean manufacturing implementation", *International Journal of Services and Operations Management*, Vol. 12 No. 1, pp. 101-117.

Pandey, D., Kulkarni, M.S. and Vrat, P. (2010), "A model for optimal maintenance interval incorporating the cost of rejections in manufacturing", *Journal of Advances in Management Research*, Vol. 7 No. 2, pp. 219-232.

Tuck, C., Hague, R. and Burns, N. (2006), "Rapid manufacturing: impact on supply chain methodologies and practice", *International Journal of Services and Operations Management*, Vol. 3 No. 1, pp. 1-22.

Uluskan, M., Godfrey, A.B. and Joines, J.A. (2017), "Integration of Six Sigma to traditional quality management theory: an empirical study on organizational performance", *Total Quality Management & Business Excellence*, Vol. 28 Nos 13-14, pp. 1526-1543.

About the authors

Dr Raja Sreedharan V. is Assistant Professor at the Department of Management Studies, Amrita School of Business, Kochi campus. He has attended many international conferences and has published many articles on Lean Six Sigma, MCDM approach and structural equation modeling in peer-reviewed journals like *IJQRM*, *Benchmarking*, *TQM&BE*, etc. His current research interests are centered in the field of Lean Six Sigma for services, quality management in healthcare, circular economy and Industry 4.0. He serves as Active Consultant to the public and private sectors. Dr Raja Sreedharan V. is the corresponding author and can be contacted at: rajasreedharan@hotmail.com

Rajasekar S. was PG student in Department of Industrial Engineering CEG, Anna University. Recently, he has graduated from the Quality engineering program. He has worked in major electrical companies and presently working for a major electrical company in UAE.

Santhosh Kannan S. is MBA student at the Department of management, Amrita Vishwa Vidyapeetham, Kochi campus, before joining Amrita School of business. He worked as Mechanical Engineering in SME in Southern part of India.

Dr Arunprasad P. is Associate Professor of Human Resource Management at the University of Dubai. He has 14 years of professional experience of which ten years of corporate work experience in banking, manufacturing, retail, financial, IT/ITES and consulting, as HR-business partner and benefits/

recruitment and HR analytics domain and four years of research, teaching and consulting experience in strategic human resource management and organizational learning. His research and consulting interests are in the area of HRM. He published widely on these subjects in peer-reviewed international journals.

Dr Rajeev Trehan is Assistant Professor at the Department of Industrial and Production Engineering, Dr. B.R. Ambedkar National Institute of Technology Jalandhar. He has attended international conferences and has published articles on Cost of quality, SMED, Lean Six Sigma and MCDM approach in peer reviewed journals. His current research interests are centred in the field of Lean Six Sigma for manufacturing industry/services, quality management in SMEs. He has completed two industry related projects sanctioned by TIFAC. He guided more than 16 PG dissertations and has two PhD students. He serves as an Active Consultant to industry of the region.