International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Quality Improvement by using Six Sigma DMAIC in an Industry

Amit Yadav†* and V. K. Sukhwani†

†Department of Mechanical Engineering, Ujjain Engineering Collage, Ujjain, 456010 (M.P.) India

Accepted 01 Oct 2016, Available online 05 Oct 2016, **Special Issue-6 (Oct 2016)**

Abstract

In present era of competition, Six Sigma has been considered as a powerful business strategy that employs a well-structured continuous improvement methodology to reduce rejections within the manufacturing processes using effective application of statistical tools and techniques. This paper presents the implementation of Six-sigma methodology for reducing rejection of automobile part in an industry. The DMAIC methodology has been used to achieve quality level. During this process, data for all possible causes were collected analysed and thereby conclusions were drawn. Implementation of six sigma resulted in reduction of rejection and therefore reduced the Defect per Million Output (DPMO) from68181to 9090.9. This increased the Sigma level from 2.99 to 3.86, with optimal solution. Finally, implementation of Six-sigma methodology has resulted increase in quality level of assembly line for the automobile industry.

Keywords: *DMAIC Methodology, DPMO, Six Sigma, Sigma Level, Statistical Tools and Techniques.*

1. Introduction

Six Sigma is the most popular quality and process improvement methodology which strives for elimination of defects in the processes whose origin is traced back to the pioneering and innovation work done at Motorola and its adoption by many companies including GE, Ford, General Motors, Xerox etc. The primary objective of Six Sigma is to reduce variations, in products and processes, to achieve quality levels of less than 3.4 defects per million opportunities (DPMO) (Bhote K.R, 2007). The important point to be noted is reducing the defects involve measurements in terms of millions of opportunities instead of thousands. A term Sigma Quality Level is used as an indicator of a process goodness. Lower Sigma quality level means greater possibility of defective products, while, higher Sigma quality level means smaller possibility of defective products within process (Coskun A.R, *et al*, 2011).

Six sigma is the one of the most powerful management tool used to achieve process excellence. It has been successful in many western companies; most of them are fortune 500 companies like GE, Motorola, and Ford are few of them. Six Sigma is now started becoming important & popular tool to remove variation & to reduce defects from product, process & service. All over world organizations are implementing process excellence initiatives like Six Sigma to improve process & product quality. Many organizations in India are also implementing Six Sigma to improve Business processes (Coskun A.R *et al*, 2011).

This paper presents six sigma implementation conducted in an automotive parts producing industry with the aim of reducing rejection, and thereby increasing its sigma level, using Six-Sigma methodology. The application of the Six-sigma problem solving methodology, DMAIC (define– measure – analyse –improve – control), reduced the rejection and thereby improved quality level. Various statistical techniques were applied to analyse the data and to identify solution. For performing this research work various topic related literatures were studied and cases also discussed, following Table 1 shows summary of discussed cases.

After performing the literatures study and case discussion related to the topic, an understanding has been made for performing the research & it also felt that the need and importance of six sigma in today's manufacturing environment. But unfortunately less research has been conducted in this area of implementing six sigma in automotive industries in India. Therefore it was needed to investigate the implementation of six sigma in an automotive industry. In this study an effort has been made to implement six sigma with ease on single flow clutch assembly line in an automotive industry. To carry out this study, an automobile industry located in Vadodara Gujarat, India has been selected.

*Corresponding author: **Amit Yadav**

Table 1 Summary table of discussed case

S.N.	Author Name	Problem	Method Used	Supporting Tools	Results
1.	MehdiuzZaman *et al*, 2013	Rejection of welding electrodes in Manufacturing industry	Six sigma DMAIC	Process map Pareto chart Ishikawa (fishbone) diagram	Sigma level comes at 4.43 from 3.41
2.	PrabhakarKaushik *et al*,2012	Rejection of bush in bicycle chain manufacturing company	Six sigma DMAIC	Brain storming Process map Pareto chart Ishikawa diagram	Sigma level comes at 5.46 from 1.40
3.	Darshan D. Patel *et al*,2014	Reduction of production cost & process in bearing manufacturing industry	Six sigma DMAIC	Cause and effect diagram Process capability analysis	Sigma level comes at 3.76 from 2.47
4.	Sunil Dambhare *et al*, 2013	Rework up to 16% bores per month in an engine block manufacturing company	Six sigma DMAIC	Control charts MR chart Histogram	Rework reduced from 16% bores per month to 2.20% bores per month
5.	Mahesh S. Shinde *et al*, 2012	Weld defects in Tungsten Arc Welding (GTAW) process used for Aerospace application	Six sigma DMAIC	Detailed process flow chart Cause and effect matrix	Sigma level comes at 3.50 from 2.98
6.	M. Sokovic *et al*,2006	High production cost in automotive parts producing company	Six sigma DMAIC	Pareto chart Thought process map Control chart	Overall reduction in production cost

2. Research Problems & Objectives

A research problem is one which requires a researcher to find out the best solution for the given problem, i.e., to find out by which course of action the objective can be attained optimally in the context of a given environment. In this study the research problem is to implement the six sigma DMAIC method for the reduction in high rejections of automobile part clutch in an automobile parts producing industry to reduce the process variation. Detailed research problems are as follows.

1) High rejection of clutches in single shift i.e.15 out of 220 on single assembly line of the industry.
2) High Defect per Million Output (DPMO) that is68181
3) Low process sigma level which is only 2.99

Globalization has opened the doors of world market to Indian organizations, which in turn forcing them to bring their products & services to world class level. For that, along with various tools Six Sigma is becoming popular in India. Considering specific need of Indian companies to implement Six Sigma effectively; the main objectives of this research work are;

1) Understand the need of Six Sigma in an Organization.
2) Reduce the rejection of clutches producing in an automotive industry in single shift.
3) Reduce the Defect per Million Output (DPMO).
4) Increase the process sigma level of that particular process of clutch assembly.
5) Evaluate and compare Six Sigma and the existing way of working

To achieve the above mentioned objectives DMAIC methodology has been used in present research.

3. Methodology adopted

The paper deals with an application of Six Sigma DMAIC (Define– Measure- Analyse- Improve- Control) methodology. DMAIC is a process that eliminates unproductive steps, often focuses on new measurements, and applied technology for continuous improvement as shown in table 2. Implementation of DMAIC Methodology took place in five phases where Problem identification and definition takes place in define phase. After identifying main processes, their performance is calculated in measure phase with the help of data collection. Root causes of the problem were found out in analysis phase. Solutions to solve problem were implemented in improve phase. Improvement is maintained and assured in control phase.

3.1 Define phase

The present study has been conducted in an automobile industry "X automobileLtd." situated at Vadodara Gujarat, India. The industry produces various clutches used in heavy vehicles and also various assembly parts of clutch. The problem were found in a single flow assembly line of a clutch in which 15 clutches were rejected out of 220 in one shift due to clutch plate keyways depth not as per the specification. The data were obtained from monthly report of firm's quality department. Clutch plate is one of the many manufactured components for the transmission assembly. It's a flat metal circular plate into which 4 key ways.

Are made using stamping (manufacturing process) as shown in fig.1. The depth of the keyways should be 0.635cm and width should be 2.5 cm as per the specification of the firm.

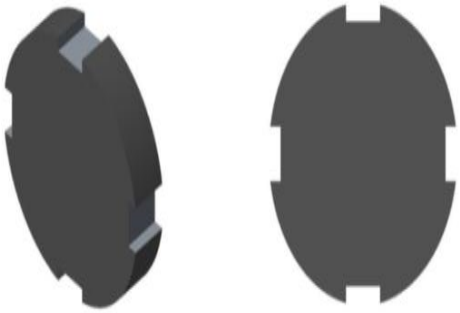

Fig.1 Clutch plate keyway depth

So, on the basis of above mentioned rejection data, DPMO has been calculatedfor that particular production line with the help of following formula (www.isixsigma.com)

DPMO

= (Total defect / Total opportunity) x 10^6
= (15 / 220) x 10, 00,000
= 68181

On the basis of this DPMO we have calculated the Process sigma level with the help of formula (www.isixsigma.com)

Process sigma level

= 0.8406+{SQRT[29.37 – 2.221 x Ln (DPMO)]}
= 0.8406+{SQRT[29.37–2.221 x Ln (68181)]}
= 2.99

Table 2 Details of DMAIC phases

Phase	Details
Define (D)	Set project goals and objectives
Measure (M)	Measure the defects where they occur
Analyse (A)	Evaluate data/information for trends, pattern and root causes
Improve (I)	Develop, implement and evaluate Solution targeted at identified root causes
Control (C)	Make sure that the problems has been cleared & method is improving

After getting this data it is clear that production of the line is at low sigma level and improvement is required.Since, the rejection of clutches occurs due to keyways depth of clutch plate, we decided to apply DMAIC process on press shop where keyways were made on clutch plate. For this purpose a process flow chart of keyway making process has been prepared which shows the various steps involve for defining the process.Process flow chart is shown in fig.2

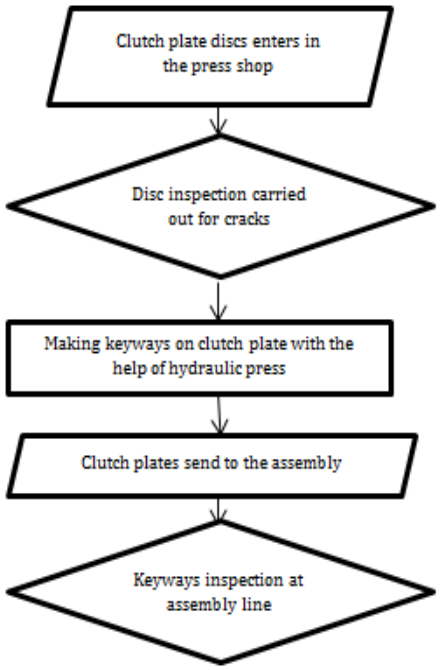

Fig.2 Process flow chart for keyway making process

3.2 Measure phase

The measure phase consists of knowing, understanding the process thoroughly, data collection, validation of the collected data and stating whether the process is capable or not.Knowing the process is important as we must know where to and what to collect the data from. It includes taking all the readings of the depths of the keyways and to see where the mean of all these readings lie with respect to the expected value of 0.635 cm. To solve the problem of identifying the exact keyway where there was variation in depth, a small mark was placed below one of the keyways and that keyway was identified as keyway 1 and going clockwise around the clutch plate the keyways was named 2, 3, 4 in successive manner. The measurements of the depth of all four keyways were taken in every 15 minutes are shown in the Table 3 and the data collected was as follows.

Table 3 Measurements of the depth of keyways

Keyways Serial No.	I	II	III	IV
1	0.635	0.663	0.635	0.61
2	0.637	0.658	0.632	0.615
3	0.635	0.655	0.637	0.622
4	0.632	0.653	0.635	0.617
5	0.635	0.659	0.635	0.619
6	0.637	0.66	0.632	0.622
7	0.637	0.655	0.635	0.612
8	0.635	0.658	0.632	0.627
9	0.635	0.653	0.635	0.622
10	0.632	0.65	0.637	0.619
11	0.633	0.66	0.635	0.617
12	0.636	0.655	0.637	0.619
13	0.635	0.653	0.635	0.622
14	0.635	0.65	0.632	0.625
15	0.635	0.653	0.635	0.625

The table 3 clearly shows that the depth of key way 2 and key way 4 is not as per the specification or there is high variation in the depth of them. Therefore in order to observe these variations clearly, a process variation chart has been prepared which is shown in fig.3 In process variation chart red and purple lines stands for keyways 2 & 4 which clearly shows the high variation of depth from mean, whereas green and blue lines stands for keyways 1 and 3. The process variation chart helps to show the variation of depth of keyways clearly and also provides strong base to move forward for analysis phase.

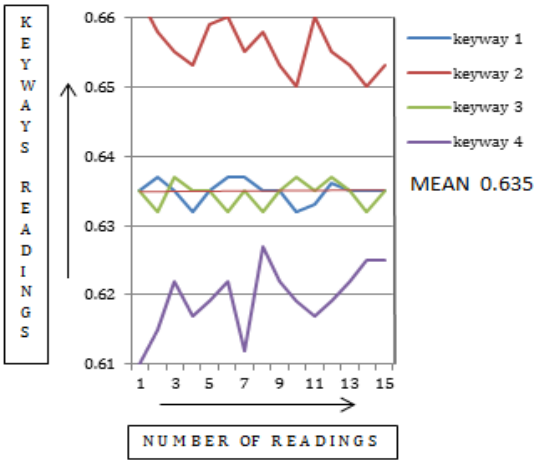

Fig.3 Variation in the keyway depth

3.3 Analyze phase

From the statistical processes performed we can safely say that keyway 2 and keyway 4 were rejected. Since the process variation chat clearly shows the variation of depth of keyway 2 and 4 is high, it is necessary to analyze and find the cause which is causing the variation in depths of keyway 2 and 4. A Cause and effect diagram shown in fig.4 is constructed to analyze the causes that are causing the depth variation.

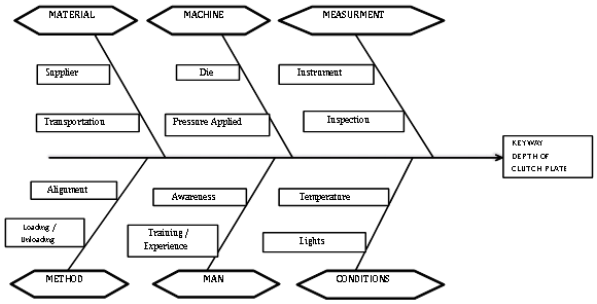

Fig.4 Cause and effect diagram

Cause & effect diagram provides areas of observation, on the basis of that, deep monitoring has been carried out with the help of industrial staff and experts of the process. Each and every area were deeply monitored and analysed by the team. From observations while overlooking the process it was noticed that the die teeth dimensions were not according to the requirements, which was causing the variations in keyway 2 and 4. Thus the 'Die Teeth Defect' was identified as the major cause of variation in the keyway depths of keyways 2 and 4 of the clutch plate. To summarize this Pareto chart shown in fig.5 has been prepared which includes the detailed observation readings like frequency of defects occurring and from which cause they occur and their percentage of occur.

A Pareto chart is given by Vilfredo Pareto(1848-1923) an Italian economist later it is adapted by Joseph Juran, is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line.

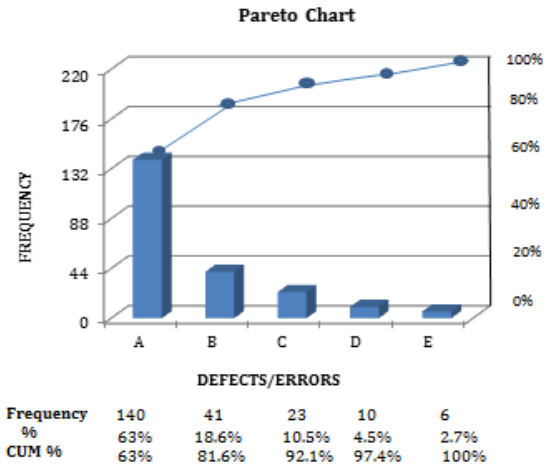

Fig. 5 Pareto chart

Where, in Pareto Chart

A = Defect due to die teeth
B = Defect due to clutch plate mounting
C = Defect due to pressure of cut
D = Defect due to material of clutch plate
E = Other

3.4 Improve phase

The goal of the DMAIC improve phase is to identify a solution to the problem that the project aims to address. This involves brainstorming potential solutions, selection solutions to test and evaluating the results of the implemented solutions. The major tool used in this phase is brainstorming, since the root cause encountered in analyse phase is die teeth defect which required the involvement of each and every person related to the process for getting the optimal solution. The major defect of the cutting keyway on clutch plate is found in die teeth as shown in fig.6, so the decision of Brain storming team is to replace the die with the new one.

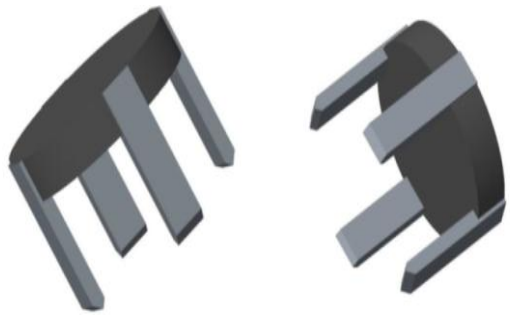

Fig.6 Die teeth

Some other solution wasalso discussed while brainstorming session like

1) A computer model or other simulation can be beneficial in the evaluation process using CAD software such as Cero which can assemble components as well as simulate the working.
2) Other manufacturing processes such as using a laser cut machine, CNC machine or a manual self-validated machine.

For the effective and efficient six sigma implementation, it is prime importance of choosing the optimal solution for improvement. Thus the best way was to modify the system by replacing the die and hence improving the process.

3.5 Control phase

The primary objective of the DMAIC Control phase is to make sure that almost the problems has been cleared and method is improving, hence to ensure this requirement of control phase we have again performed the DPMO and process sigma level calculation which are shown below

1) After implementation of the six sigma DMAIC, rejection of the clutch during one shift has been reduced from15 out of 220 units to 2 out of 220 units according to the data obtained by the firm's quality department.
2) Then DPMO has been calculated again for this data.
3) DPMO

= (Total defect / Total opportunity) x 10^6
= (2 / 220) x 10, 00,000
= 9090.9

4) After that process sigma level of improved process has been calculated on the basis of new DPMO,

Process sigma level
= 0.8406+{SQRT[29.37 – 2.221 x Ln (DPMO)]}
= 0.8406+{SQRT[29.37– 2.221 x Ln(9090.9)]}
= 3.86

A chart has been prepared on the basis of above calculations, to show the visible results of increase in sigma level achieved which is before and after 2.99 and 3.86 respectively as shown in fig.7

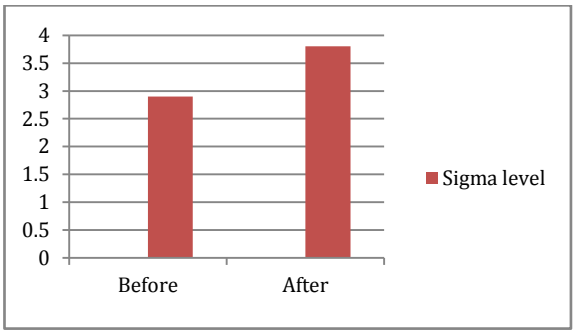

Fig.7 Visible results

4. Results &discussions

The present research work concerned with the successful implementation of Six Sigma DMAIC to reduce the rejection of clutches on single flow production line in an automobile industry. For the realization of the project, a Six Sigma DMAIC approach was implemented.

The use of the DMAIC methodology for the different phases of the project helped to eliminate some causes of rejection in the process. The application of the Six-sigma problem solving methodology, DMAIC (define–measure – analyze –improve – control) reduced the rejection and thereby improved quality level. Various statistical techniques were applied to analyze the data and to identify solution. Calculations such as the sigma level and DPMO helped the team to understand which causes were more critical to the process.

Analysis was carried out with the help of statistical tools like process flow chart, process variation chart, fish bone diagram and Pareto chart, where process variation chart, fishbone diagram and Pareto chart were played key role in this research work since, process variation chart helps to identify key problem area, fishbone diagram helps to find possible causes of that problem and Pareto chart helps to identify root cause.

After the successful implementation of six sigma DMAIC, clutches rejection were felt down from 15 to 2 out of 220 in single shift, defect per million opportunities were felt down on 9090.9 from 68181 and rise in process sigma level from 2.99 to 3.86 has been achieved and thus quality level of the assembly line has got improved.

Conclusions

This research is concerned with the analysis of the problem of rejection of clutch in an automobile industry due to the variations in depth of keyway of the clutch plate and to reduce them by six sigma DMAIC implementation following important conclusions were drawn

1) Results of this study reveal that Six Sigma implementation can provide a breakthrough improvement in an automobile industry.

2) Following improvements were obtained by six sigma DMAIC implementation
3) Rejection of clutches reduced from 15 out of 220 to 2 out of 220 in single shift, which is a huge reduction of 87%.

a) Reduction in DPMO from 68181to 9090.9.
b) Increase in process sigma level from 2.99 to 3.86, which is increased by 30%.
c) Finally, quality improvement of the assembly line has been achieved with sigma level 3.86.

Even though this is a small research work with a small impact on the company's production, it can be certainly concluded that, six sigma is really a tool that can be used to obtain positive results in process improvements. If the methodology is applied through all the production lines, it would be very beneficial for the company as it would result in significant saving of resources.

References

Bhote K.R, (2007), The Ultimate Six sigma beyond quality excellence to total business excellence, PHI Learning, New Delhi, India, pp. 2.

Coskun A.R, Tamer C and Serteser M, (2011), Six sigma projects and personal experiences, Intech,Turkey, pp, 5,772-679.

Dambhare Sunil, AphaleSiddhant, KakadeKiran, ThoteTejas, and BoradeAtul, (2013), Productivity Improvement of a Special Purpose Machine Using DMAIC Principles: A Case Study, Journal of Quality and Reliability Engineering, pp. 1-13.

Patel D D, Gawande K R, (2014), Productivity improvement through six sigma methodology in bearing manufacturing, International journal for research in applied science and engineering technology, 2,(3) pp, 233-239.

Prabhakar Kaushik, Dinesh Khanduja, Kapil Mittal, PawanJaglan, (2012), A case study: Application of Six Sigma methodology in a small and medium-sized manufacturing enterprise, The TQM Journal, 24, (1), pp, 4-16.

Shinde M S, Inamdar K H, (2012), Improving TIG Welding Quality using DMAIC, International Journal of Science and Research (IJSR), 3, (6), pp, 2379-2382.

Sokovic M, Pavletic D &Krulcik E, (2006), Six Sigma process improvement in automotive parts production, journal of Achievements in Materials and Manufacturing Engineering (JAMME), 19, (1), pp, 96-102.

Zaman Mehdiuz, Pattanayak S K, and Paul A C, (2013), Study of feasibility of six sigma implementation in a manufacturing industry: A case study, International Journal of Mechanical and Industrial Engineering (IJMIE), 3,(1) , pp, 96-100.