

# Optimisation Of Machining Rejection Of Shift Fork By Using Seven Quality Tools

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**Abstract** - In order to survive in a competitive market, improving quality and productivity of product or process is a must for any company. This study is about to apply the 7QC tools in the production processing line and on final product in order to reduce defects by identifying where the highest waste is occur at and to give suggestion for improvement. The approach used in this study is direct observation, thorough examination of production process lines, brain storming session, fishbone diagram, and information has been collected from potential customers and company's workers through interview and questionnaire, Pareto chart/analysis, histogram and control chart was constructed. This paper intends to exhibit the exact application of seven quality tools in fork industry.

**Key Words:** Flow Chart, Pareto Chart, Scatter Diagram, Histogram, Cause & Effect Diagram, PP & Ppk , Why - Why Analysis, Hypothesis Test

## 1. INTRODUCTION

In today's world, business has become more and more competitive. All industries and organizations have to perform well in order to survive and be profitable. "Quality" means those features of products which meet customer needs and thereby provide customer satisfaction. In this sense, the meaning of quality is oriented to income. The purpose of such higher quality is to provide greater customer satisfaction and, one hopes, to increase income. However, providing more and/or better quality features usually requires an investment and hence usually involves increases in costs. Higher quality in this sense usually "costs more." One of the strongest motivating forces is "Delighted Customer". Industries believe that prosperity is directly linked with prosperity of customers. Mutual trust, healthy relationship, ethical values, innovative technologies, quality products and services are the constituents of commitment towards the customers. If defects are in large number it not only does an organization waste its resources and time to re-manufacture the products, but it also contributes to the loss of customers' satisfaction and trust. Customer satisfaction comes from those features which induce customers to buy the product. Dissatisfaction has its origin in deficiencies and is why customers complain. Some products give little or no dissatisfaction; they do what the producer said they would do. Yet they are not saleable because some competing product has features that provide greater customer satisfaction. So it is important to reduce defects and maintain quality of product. Quality of the product is achieved by minimization of rework, reducing scrap rate and minimizing

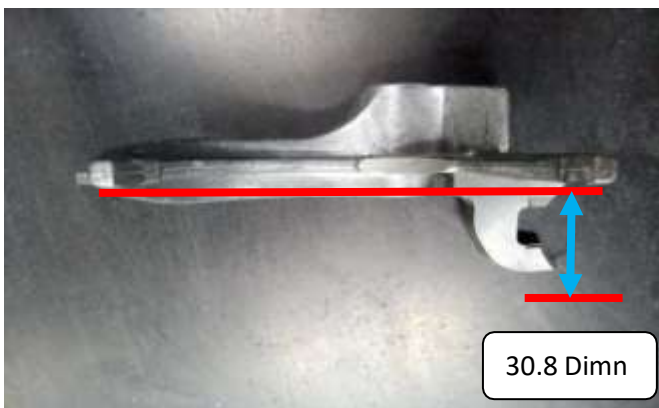
man hour on rework. Now a day's rework of rejected parts are common but rework add losses to the company net profit, if the company is a continuous mass production where the products go through a series of process to come out with final product. The Seven Quality Control Tools popularly called the 7 QC Tools, According to kaoru Ishikawa more than 95% company problems can be solved using these tools. It comprise of graphical methods and help to transform the data into easily understandable diagrams or charts. This further helps to understand the situation or to analyze the problem easily and leads to developing solutions which aim towards quality improvement. Further, these charts and diagrams help to highlight the important aspects of a problem clearly so that the concerned persons can focus attention on them and start developing the solution. Pareto analysis helps to identify and classify the defect according to percentage significant. Cause and effect diagram is a useful tool in identifying the major causes. This diagram helps to build a relationship. Brainstorming is done with utilizing these quality tools to provide an effective solution. Thus quality management tools are effective and significant in reducing the rework and rejection rate.

## 2. PROBLEM STATEMENT

The rejection of shift fork 3<sup>rd</sup> 4<sup>th</sup> (S101) is very high due to machining defect of 30.8 dim not ok. Due to this variation in dimensions it cannot be assembled in gearbox. About 313 no's job are rejected monthly at final inspection stage. So we lose productivity & face shortage in supply to customer.

Required size - 30.8 mm (variation +/- 0.12 mm is acceptable)

Maximum reading - 30.92 mm Minimum reading - 30.68 mm



**Fig -1:** Defective Part

### 3. OBJECTIVES

- To increase productivity and profitability in an organization.
- To reduce rejection rate of product.
- To reduce rework and scrap of product.
- To increase moral of internal customer of an organization.
- To provide better solution for process improvement.
- To get standardization for product using 7 QC tools.
- To increase number of customer as getting high level of satisfaction of them including features like good design, value or price of product etc.

### 4. METHODOLOGY

The Seven Quality Control Tools popularly called the 7 QC Tools, comprise graphical methods and help to transform the data into easily understandable diagrams or charts. This further helps to understand the situation or to analyse the problem easily and leads to developing solutions which aim towards quality improvement. Further, these charts and diagrams help to highlight the important aspects of a problem clearly so that the concerned persons can focus attention on them and start developing the solution.

The 7 QC Tools listed in alphabetical order are:

1. Cause and Effect Diagram
2. Check sheet
3. Control Chart
4. Flow Chart
5. Histogram
6. Pareto chart
7. Scatter Diagram

These 7 QC tools can together enable a quality problem to be analysed and solved and also help to prevent a problem from recurring so that the quality problem is once for all solved. It is not the intention here to describe these tools in greater details as these tools are described in all quality related literature particularly textbooks and training manuals. It would not be exaggerating to say that almost all the quality control and management books include a description of the QC tools. Hence a detailed description can be found in many popular books, written by different authors, (Austrom & Lad, 1986), (Kume, 1987), (Chang, 1993), (Mears, 1994), (Wadsworth, Stephens, & Godfrey, 2001), (Evans & Lindsay, 2004), (Tague, 2005), (Defeo & Juran, 2010), and (Montgomery, 2012). As stated in <http://www.beyondlean.com/7-quality-tools.html>, the 7 Quality Tools are problem solving tools which can:

- Help to identify and prioritize problems quickly and more effectively
- Assist the decision making process
- Provide simple but powerful tools for use in continuous improvement activity

- Provide a vehicle for communicating problems and resolution throughout the business
- Provide a way of extracting information from the data collected. To provide a continuity of reading a brief overview of all the seven tools is provided here.

### **Cause and Effect Diagram**

The cause and effect diagram is also sometimes called as “fishbone diagram” or “Ishikawa diagram” after the Japanese quality expert late Dr. Kaoru Ishikawa. It is a useful method for listing and classifying the causes under different categories that lead to a problem or result or effect. The causes are classified according to their type or nature and represented in proper order.

#### **The Diagram Consists of Two Sides**

- (1) Cause side – factors that influence the related effect or characteristic, and
- (2) Effect side – represents a problem or an outcome in a given situation or a result. The two sides are connected by a thick arrow called the trunk. The arrow head leads to the effect side while branches and sub-branches added to the trunk represent the causes responsible for that effect. The major branches added to the trunk represent the main categories of causes and the small and tiny branches represent the sub-category of causes. The branches can be expanded or new branches can be introduced depending on the number of causes.

### **Check Sheet**

A check sheet is a list in the form of a diagram or table format, prepared in advance to record data and is useful for later analysis. It is also called as a tally sheet. There are five basic types of check sheets as given below:

- a) Classification - To classify the items under different headings
- b) Location - To indicate position of an item
- c) Frequency - To indicate the presence or absence of an item, and also the number of occurrences of that item
- d) Measurement scale - To provide a measurement scale divided into intervals to enable easy marking
- e) Check list - To indicate the items or tasks to be performed to complete a task

### **Control Charts**

A control chart is a line graph used to assess and validate the stability of a process. The graph consists of a horizontal center line and two parallel lines called upper control limit and lower control drawn on either side of the center line. Data pertaining to a quality characteristic is collected over a period of time and the values are plotted as points on the graph in the chronological order. The points are connected by straight lines.

The spread and position of the points on the graph relative to the center line and the control limits indicate the state of control of the process. They also help in distinguishing the random causes from the assignable causes which need to be investigated further. When all the points are within the control limits, and these points do not exhibit any abnormal pattern, then the underlying process is said to be under statistical control. In such cases no action may be necessary and the process is allowed to continue. If the points fall outside the control limits or display any abnormal pattern, then the process is deemed to be out of control and under the influence of special causes. In such cases the process would be stopped and investigated for causes. Then the required corrective action is taken and the process is continued. The control charts used in industries are divided into two groups namely Control charts for variables, and Control charts for attributes.

### **Flow Chart**

A flowchart is a graphical method of displaying a system's operation or sequence. A familiar type of flowchart is

the computer program flowchart, which is used in programming. A flowchart consists of several standard symbols connected in a logical manner to depict the flow of operations or information or tasks in the desired sequence.

### **Histogram**

A histogram is a frequency distribution diagram which displays the distribution of data in the form of a bar graph. It is constructed from the data collected in a frequency table which shows the data distributed across several class intervals and the frequency of occurrence under each class. The histogram drawn from the frequency table is composed of columns whose widths represent the class interval and the height represents the frequency. The histogram provides a visual representation of the data distribution and gives a quick assessment on the spread and shape of the distribution.

### **Pareto Diagrams**

A Pareto diagram, named after Vilfredo Pareto, an Italian economist, is a specialized bar graph that can be used to show the relative frequency of events such as defects, repairs, claims, failures, or any other entity, in the descending order. This helps to focus on the vital few and not to start with the trivial many, to improve the quality.

### **Scatter Diagram**

A scatter diagram represents the relationship between two types of data or two variables. The two variables are plotted along the two conventional coordinate axes and the relationship between the variables will be evident by the scatter or spread of the points. Thus a scatter diagram helps to find the correlation between two variables.

## **5. LITERATURE REVIEW**

The key to the vast storehouse of published literature may open doors to sources of significant problems and explanatory hypothesis and provide helpful orientation for definition of the problem, background for selection of procedure and comparative data for interpretation of results. In order to be creative and original one must read extensively and critically as a stimulus to thinking. Every research begins from where the previous researches have left it, and goes forward, may be one inch or even less, towards finding the solution of a problem or answer to a question.

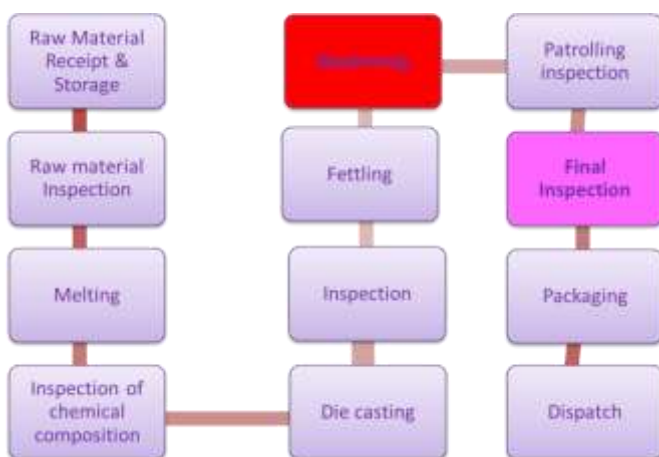
Varsha M. et al (2014) provides an easy introduction of 7 QC tools and to improve the quality level of manufacturing processes by applying it. Pareto Diagram is a tool that arranges items in the order of the magnitude of their contribution, thereby identifying a few items exerting maximum influence. A Cause-and Effect Diagram is a tool that shows systematic relationship between a result or a symptom or an effect and its possible causes. It is an effective tool to systematically generate ideas about causes for problems and to present these in a structured form. Histograms or Frequency Distribution Diagrams are bar charts showing the distribution pattern of observations grouped in convenient class intervals and arranged in order of magnitude. Histograms are useful in studying patterns of distribution and in drawing conclusions about the process based on the pattern. Control chart makes possible the diagnosis and correction of much production troubles and brings substantial improvements in the quality of the products and reduction of spoilage and rework. It tells us when to leave a process alone as well as when to take action to correct trouble. When solving a problem or analyzing a situation one needs to know the relationship between two variables. A relationship may or may not exist between two variables. If a relationship exists, it may be positive or negative, it may be strong or weak and may be simple or complex. A tool to study the relationship between two variables is known as Scatter Diagram. Graphs of various types are used for pictorial representation of data. Pictorial representation enables the user or viewer to quickly grasp the meaning of the data. Different graphical representation of data is chosen depending on the purpose of the analysis and preference of the audience. As

measurement and collection of data forms the basis for any analysis, this activity needs to be planned in such a way that the information collected is both relevant and comprehensive. Check sheets are tools for collecting data. They are designed specific to the type of data to be collected. Check sheets aid in systematic collection of data. Some examples of check sheets are daily maintenance check sheets, attendance records, production logbooks, etc. Statistical QC is chiefly concerned in making sure that several procedures and working arrangements are in place to provide for effective and efficient statistical processes, to minimize the risk of errors or weaknesses in procedures or systems or in source material. Seven QC tools are most helpful in troubleshooting issues related to quality all processes are affected by multiple factors and therefore statistical QC tools can be applied to any process. The continuous use of these tools upgrades the personnel characteristics of the people involved. It enhances their ability to think generate ideas, solve problem and do proper planning. Chiragkumar S. Chauhan et al (2013) this article states that Quality tools can be used in all phases of production process, from the beginning of product development up to product marketing and customer support. Once the quality improvement process is understood, the addition of quality tools can make the process proceed in a systematic manner. Many quality tools are available for quality professionals for this purpose. Many organizations use total quality management (TQM) tools to identify, analyze and assess qualitative and quantitative data that are relevant to their processes. The flowchart is simply a visual description of a process. A cause-and-effect diagram is a brainstorming- based problem-solving procedure. Check sheets and Pareto diagrams are simply common sense tools. Histograms scatter diagrams, and control charts are the only statistical tools in the list. The key to their success in problem-solving and process improvement initiatives are their simplicity, ease of use and their graphical nature. They can easily be taught to any member of the organization. In the paper the systematic approach to the quality improvement is shown on the simple example of a company in process industry. The company defined the principle of quality management as basic principle with goals of continuous improvement. Customer satisfaction is placed on the top of value scale, while data analysis is conducted permanently in order to recognize opportunities for process quality improvement. Selected company from process industry has certified quality management system in accordance with ISO 9000:2000. Company that manage its quality system in accordance with ISO 9000:2000 has to plan and implement process control, measurement, analysis and improvement in order to: Demonstrate conformity of its products, achieve conformity of its quality management system, continuously improve efficiency of its quality management system. The number of customer claims is collected for three consecutive business years. On the end of each business year customer claims are systematically analyzed in order to identify type and amount of customer claims for year in consideration. Also, the undertaken corrective and preventive actions are analyzed to verify their effectiveness. One of broadly used tools to visualize collected data is histogram. Other 7QC tools are used in order to evaluate is there more opportunities to improve process and meet customer demands. Research has been conducted in order to define role and importance of seven basic quality tools (7QC tools) within quality management system. In modern production processes it is necessary to implement integrated quality management system that involves quality management, responsible environmental performance and safe working environment. Systematic application of 7QC tools will enable successful quality improvement process. Quality tools has important place in data collecting, analyzing, visualizing and making sound base for data founded decision making. The paper stresses on the use of the seven basic quality tools to improve processes and to solve problems.

Kirti Singh et al (2016) The study exhibited in this chapter includes simple approach in the analysis of rejection rate in particular production line in gloves manufacturing shop. The production line consists of sequence of operation in making final product. Defects occur due to deficiency in manufacturing process. The study aims at analyzing the rejection rate using quality tools like, Pareto chart and cause and effect diagram (Ishikawa diagram). Quality of the product is achieved by minimization of rework, reducing scrap rate and minimizing man hour on rework. Quality control at every workstation is important. The results drawn by calculation and analysis are as tearing, weak spots and beading defects from Industry A during first month production are respectively 5%, 2% and 10%. Tearing,

weakspots and beading defects from Industry A during second month production are respectively 5%, 2.18% and 8.18%. Tearing, weak spots and beading defects from Industry B during first month production are respectively 8.67%, 1% and 1.53%. Tearing, weak spots and beading defects from Industry B during second month production are respectively 12.5%, 1.66% and 2.16%. Prevention of defect rejection through root cause analysis not only helps to give a quality project, but it is also a valuable investment. Defect prevention practices enhance the ability of manufacturer to learn from those errors and, more importantly, learn from the mistakes of others. The benefits of adopting defect reduction via root cause analysis would be enormous and to list a few, Defect root cause analysis reduces development time and cost, increases customer satisfaction, reduces rework effort, thereby decreases cost and improves product quality. We found that overall 5% rejection rate can be reduced by mainly concentrating on areas of defect as tearing, weak spots, and beading. We have provided some suggestion related to defect types. So by taking corrective and effective measure it is possible to meet nearer to zero defects. The rejection due to these above mentioned defects are 5% 2% and 10% from 1<sup>st</sup> month production of industry A and 5%, 2.18% and 8.18 % from 2<sup>nd</sup> month production of industry A and also the average percentage defects of total production from 1<sup>st</sup> and 2<sup>nd</sup> month of industry B is 27.17% and on the other hand by applying RCA approach the average percentage defects of total production from 1<sup>st</sup> and 2<sup>nd</sup> month of industry A is reduces up to 17.25%. The methods by these above mentioned defects can be reduced are: 1) There is gap between coagulant and oven (if removed can reduce cycle time). 2) There is gap between dipping tank and oven. 3) Coagulant and latex in dipping tank are always stirred in tank, so the stirring is done inside the tanks that will create waves and improper coating on formers. (stirring should be outside the tank and then stirred liquid come smoothly in tank with proper passage that removes bubble and have proper coating). 4) Latex should be matured. 5) Acid solution must be change after 24 hours. 6) Alkali solution must be maintained at ph-9-11. 7) There should be no bubbles in coagulant. 8) Coagulant gravity must be maintained as per gloves. 9) In coagulant dipping tank latex should be stirred properly. 10) Flocking should be proper and smooth. Minimization of defect and rework is an important factor ensuring the quality of product. The importance of manufacturing industry in the economy is high. So manufacturing the quality product is essential to sustain in the global market. Customer satisfaction depends on quality of product. Good quality results in good establishment of brand name, good providers and builds reputation in market. We should know that 1 % defect leads to 100% defective for customer to buy product. This study indicates reducing defects in manufacturing process like rework, man hour spent on rework and taking effective measures will enhance the net profit, saves time and improve overall quality of product.

## 6. PROCESS FLOW DIAGRAM



**Fig -2:** Process Flow Diagram

Problem generated at machining stage and detected at final inspection stage.

**7. DATA COLLECTION AND ANALYSIS**

Data collected consist of mainly defects that occur in a manufacturing of fork. But our area of interest is the defects causing at machining process. The defects causing rejection of product from the production process were identified from the data. To identify main problems which cause frequent defects of fork production, a six month data had been collected (July to December 2017). The actual rejection is grouped in their respective type of defect identified.

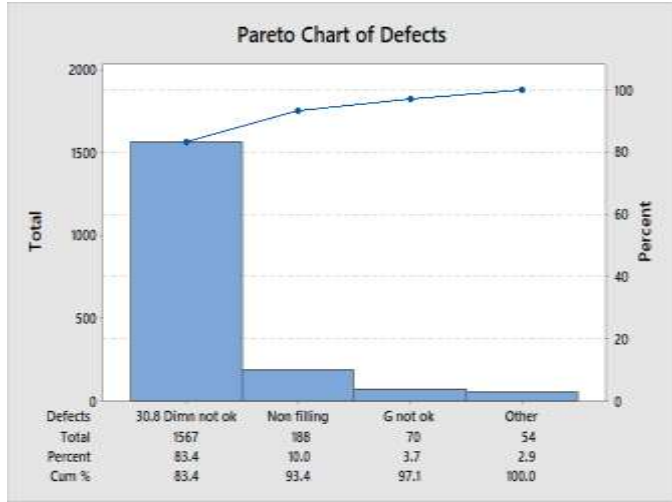
**Table -1:** Data of six months

Defects	Total	Total Sum	Rej%	Cum Rej
30.8 Dimn not ok	1201	1513	79.38	79.38
Non filling	188	1513	12.43	91.80
G not ok	70	1513	4.63	96.43
Blow Hole	21	1513	1.39	97.82
Patch mark	17	1513	1.12	98.94
Dent/Damage	13	1513	0.86	99.80
Crack	2	1513	0.13	99.93
Bush crack	1	1513	0.07	100.00

**7.1 Pareto Chart**

Pareto chart is constructed based on data collected and to identify most common defects.





**Chart -1:** Pareto Chart

Pareto chart revealed that 2.9% constitutes of other defects, 3.7% G not ok, 10% is of non filling and 83.4% is of 30.8 dimn not ok.

Only the major defect identified is chosen for analysis. According to pareto, 80-20 rule we have to need take action for 30.8 dimn not ok.

## 7.2 A REAL TIME 4M CONDITIONS

4M consists of man, machines, material and method.

**Table -2:** 4M Conditions

4M condition	Control items (Managing points)	Specification	Observation	Current status
Machine	Clamp condition of fixture	After clamping clamp should not be loose	found one clamp loose after clamping the job	ok
	Coolant concentration	4-6 %	1.60%	x
	Clamp pressure	25-35 Kg/Cm <sup>2</sup>	31 Kg/Cm <sup>2</sup>	ok
Method	Tool life	As per tool life defined monitoring sheet	Tool life not Monitored	x
	Insert wear out	No wear out	Built up edge wear not found on tool	ok
	Wrong Gauge	should be calibrated	Gauge is calibrated	ok
Material	Metal composition	As per drawing	As per drawing found within spec	ok
	As cast bend	No bend	No Bend	ok

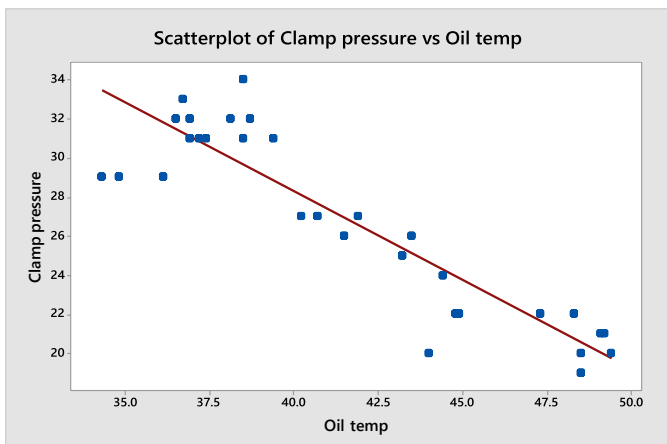
Man	unskilled operator/inspector	skill matrix	As per skill matrix, found semi skilled	ok

Current status: O - Ok for 4M condition  
 X - Not ok for 4M condition

### 7.3 SCATTER DIAGRAM

20	7.05	7.04	0.01	7.07	-0.02
21	7.03	7.04	-0.01	7.04	-0.01
22	7.03	7.03	0	7.05	-0.02
23	7.04	7.03	0.01	7.1	0.06
24	7.03	7.04	-0.01	7.05	-0.02
25	7.04	7.05	-0.01	7.09	-0.05
26	7.03	7.03	0	7.07	-0.04
27	7.04	7.04	0	7.08	-0.04
28	7.05	7.04	0.01	7.08	-0.03
29	7.04	7.05	-0.01	7.09	-0.05
30	7.03	7.04	-0.01	7.06	-0.03
31	7.04	7.03	0.01	7.05	-0.01
32	7.04	7.05	-0.01	7.08	-0.04
33	7.04	7.04	0	7.08	-0.04
34	7.05	7.05	0	7.09	-0.04
35	7.04	7.04	0	7.08	-0.04
36	7.03	7.04	-0.01	7.06	-0.03
37	7.03	7.04	-0.01	7.07	-0.04
38	7.04	7.05	-0.01	7.1	-0.06
39	7.04	7.06	-0.02	7.09	-0.05
40	7.03	7.03	0	7.08	-0.05
41	7.03	7.04	-0.01	7.08	-0.05
42	7.02	7.03	-0.01	7.09	-0.07
43	7.02	7.03	-0.01	7.02	0
44	7.05	7.05	0	7.1	-0.05
45	7.04	7.03	0.01	7.08	-0.04
46	7.03	7.04	-0.01	7.06	-0.03
47	7.05	7.06	-0.01	7.09	-0.04
48	7.02	7.02	0	7.09	-0.07
49	7.03	7.04	-0.01	7.09	-0.06
50	7.05	7.05	0	7.04	0.01

The data of oil temperature and clamping pressure is collected time to time and scatter diagram is plotted.



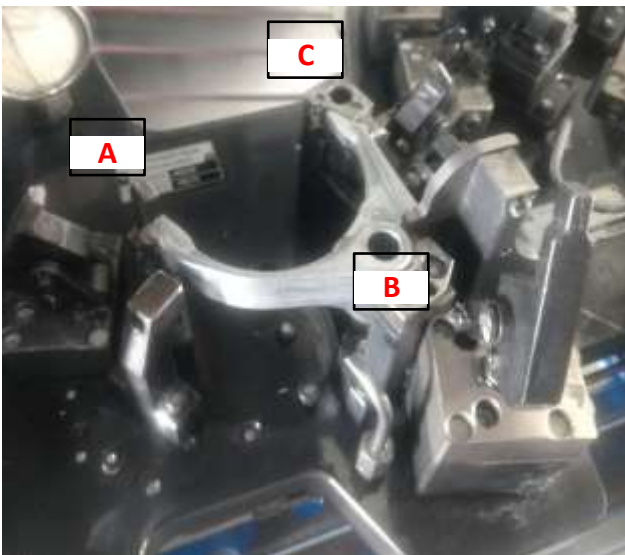
**Fig -3:** Scatter Diagram

From above scatter plot we get that lubricate oil temp increased then clamping pressure is to be decreased so there is negative correlation.

## 8. ANALYSIS

**Table -3:** Measurements of 50 no's of samples

Sr No	Thicknes s at A	Thickne ss at B	Variati on A to B	Thickne ss at C	Variati on A to C
1	7.04	7.03	0.01	7.1	-0.06
2	7.04	7.03	0.01	7.04	0
3	7.02	7.03	-0.01	7.05	-0.03
4	7.05	7.04	0.01	7.1	-0.05
5	7.04	7.04	0	7.08	-0.04
6	7.04	7.03	0.01	7.06	-0.02
7	7.05	7.05	0	7.09	-0.04
8	7.03	7.03	0	7.04	-0.01
9	7.03	7.03	0	7.06	-0.03
10	7.04	7.04	0	7.04	0
11	7.02	7.02	0	7.03	-0.01
12	7.05	7.04	0.01	7.07	0.02
13	7.04	7.05	-0.01	7.1	-0.06
14	7.04	7.05	-0.01	7.07	-0.03
15	7.03	7.04	-0.01	7.06	-0.03
16	7.05	7.04	0.01	7.09	-0.04
17	7.04	7.05	-0.01	7.08	-0.04
18	7.05	7.06	-0.01	7.1	-0.05
19	7.02	7.03	-0.01	7.07	-0.05



**Fig -4:** Positioning of fork on fixture

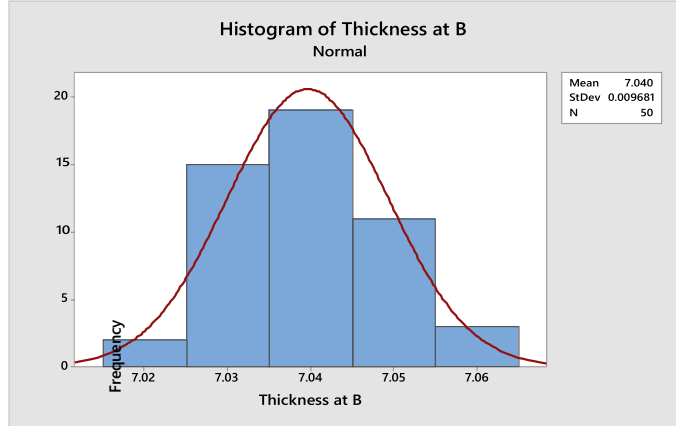
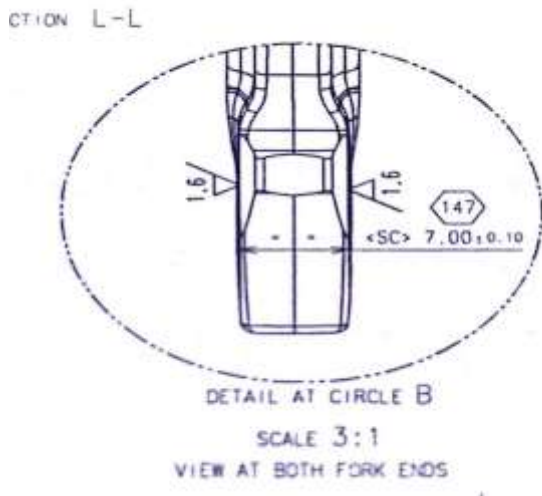
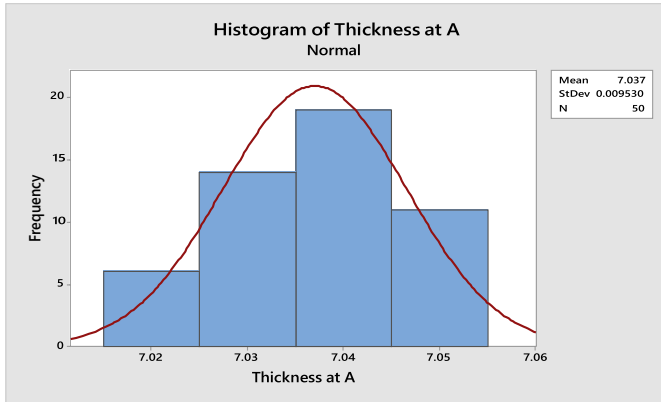


Fig -7: Histogram of B

**Fig -5:** Thickness of resting pad



**Fig -6:** Histogram of A

**Calculation**

Mean = 7.037

Standard deviation ( $\sigma$ ) = 0.00953 USL = 7.1

LSL = 6.9

Range (R) = Xmax - Xmin

= 7.05 – 7.02

= 0.03

Average (X) = 7.037  $PP = \frac{(USL - LSL)}{6\sigma}$

= (7.1 – 6.9)/6 \* 0.00953

= 3.4977

$PpU = \frac{(USL - X)}{3\sigma}$

= (7.1 – 7.037)/3 \* 0.00953

= 2.2035

$PpL = \frac{(X - LSL)}{3\sigma}$

= (7.037 – 6.9)/3 \* 0.00953

= 4.791

$Ppk = 2.2035$

( $Ppk \geq 1.67$  is desirable)

**Calculation**

Mean = 7.04

Standard deviation ( $\sigma$ ) = 0.009681 USL = 7.1

LSL = 6.9

Range (R) = Xmax - Xmin

= 7.06 – 7.02

= 0.04

$$\text{Average (X)} = 7.0396 \text{PP} = \frac{(USL - LSL)}{6\sigma}$$

$$= (7.1 - 6.9)/6 * 0.009681$$

$$= 3.4431$$

$$PpU = \frac{(USL - X)}{3\sigma}$$

$$= (7.1 - 7.0396)/3 * 0.009681$$

$$= 2.0796$$

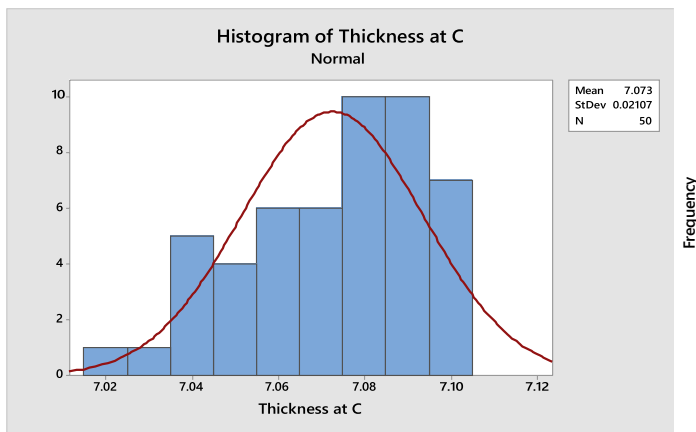
$$PpL = \frac{(X - LSL)}{3\sigma}$$

$$= (7.037 - 6.9)/3 * 0.009681$$

$$= 4.8066$$

$$Ppk = 2.0796$$

(Ppk ≥ 1.67 is desirable)



**Fig -8:** Histogram of C

### Calculation

$$\text{Mean} = 7.073$$

$$\text{Standard deviation } (\sigma) = 0.02107 \text{USL} = 7.1$$

$$\text{LSL} = 6.9$$

$$\text{Range (R)} = X_{\text{max}} - X_{\text{min}}$$

$$= 7.1 - 7.01$$

$$= 0.09$$

$$\text{Average (X)} = 7.0726 \text{PP} = \frac{(USL - LSL)}{6\sigma}$$

$$= (7.1 - 6.9)/6 * 0.02107$$

$$= 1.5820$$

$$PpU = \frac{(USL - X)}{3\sigma}$$

$$= (7.1 - 7.037)/3 * 0.02107$$

$$= 0.4334$$

$$PpL = \frac{(X - LSL)}{3\sigma}$$

$$= (7.037 - 6.9)/3 * 0.02107$$

=2.7305

Ppk = 0.4334

(Ppk ≥ 1.67 is desirable)

At location 'C' pp & ppk ≤ 1.67 so location c is only creating the problem.

Probable causes for thickness variation at location "C"

1. warpage in casting at location "c".
2. Fixture rest pad plane variation.
3. In adequate clamping.
4. Clamping pressure variation is already concluded in quick win solution.

## 10. HYPOTHESIS TEST

**Table -5:** Hypothesis

**Table -4:** Result table

Sr No	PROBABLE CAUSES	TESTING & OBSERVATIONS	CONCLUSION
1	CASTING BEND	50 NOS NOT OK PART AS CAST BEND CHECK FOUND ALL ARE WITHIN SPEC	Hypothesis invalid
2	FIXTURE REST PAD VARIATION	ALL REST PAD CHECKED AND FOUND DIFFERENCE WITHIN 0.010 MM AS PER SPEC	Hypothesis invalid
3	IN ADEQUATE CLAMPING	AFTER CLAMPING PLAY OBSERVED AT LOCATION "C" UPTO 0.50 TO 1.0MM ( CHECKED BY DIAL GAUGE )	Hypothesis valid

	Location A	Location B	Location MC	REMARKS
Average/xbar	7.03	7.04	7.07	
Range	0.03	0.04	0.09	location c is more range
sigma	0.0095	0.0096	0.021	location C is more sigma
6sigma	0.057	0.058	0.126	location c is more
USL	7.1	7.1	7.1	
LSL	6.9	6.9	6.9	
PP	3.49	3.44	1.58	Location c not capable
PPUSL	2.20	2.07	0.43	
PPLSL	4.79	4.8	2.73	
PPK	2.20	2.07	0.43	Location c not capable

	Location A	Location B	Location MC	REMARKS
Average/xbar	7.03	7.04	7.07	
Range	0.03	0.04	0.09	location c is more range
sigma	0.0095	0.0096	0.021	location C is more sigma
6sigma	0.057	0.058	0.126	location c is more
USL	7.1	7.1	7.1	
LSL	6.9	6.9	6.9	





## 12. ACTION

### Immediate Action

Coolant concentration checking & monitoring started by refractory meter shift wise (specification - 4-5 %)

Tool change frequency set (25,000 ) and started monitoring.

**Table -6:** Root Cause Analysis

PP = 2.75027

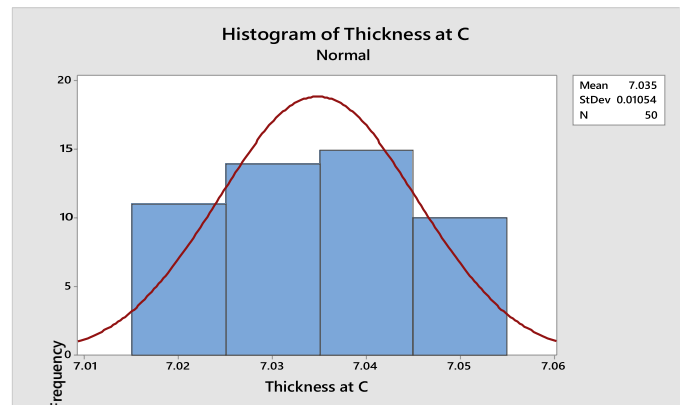
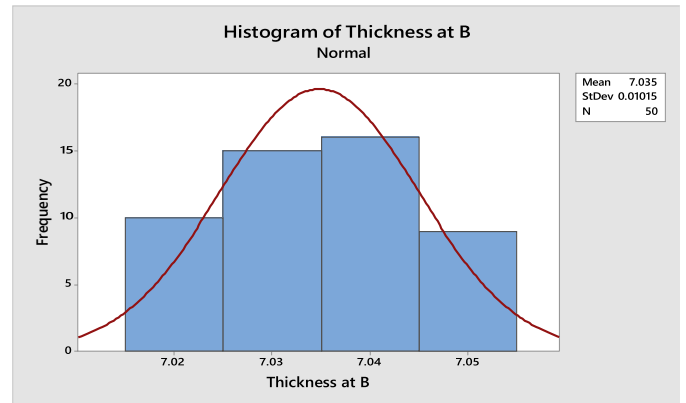
Ppk = 1.70517

(Ppk ≥ 1.67 is desirable)

Root causes	Action plan	Remarks
variation in part height (at location "a" & "c")	casting height is to be maintain at same level by modifying part design	not possible due to design constant
clamp not able to accommodate casting height variation	single part machining at a time in single fixture	low productivity
	individual clamp is to be used for individual part	not feasible due to space constant in fixture
	clamp design is to be modify to accumulate casting height variation	ok

PP = 3.28407

Ppk = 2.14121



**Fig -11:** Histogram of B

**Actions Decided**

**Table -7:** Action Planning

(Ppk ≥ 1.67 is desirable)

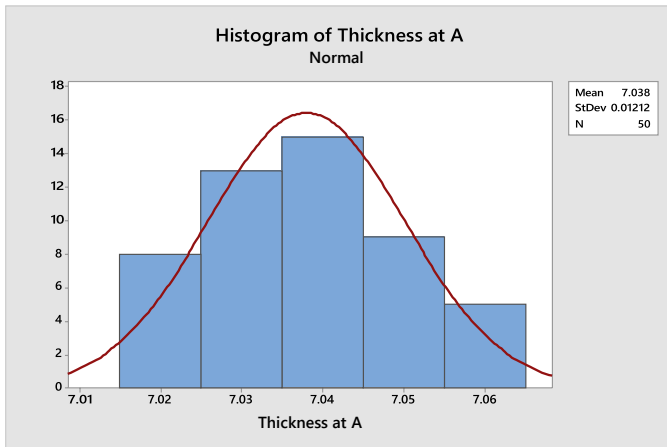
Root Cause	Action Plan	Target Date	Actual Date	Status
Clamp not able to accommodate casting height variation	Clamp design is to be modify to accumulate casting height variation	25.03.18	18.04.18	close

PP = 3.16255

Ppk = 2.06198

**Fig -12:** Histogram of C

**13. RESULTS**



**Fig -10:** Histogram of A

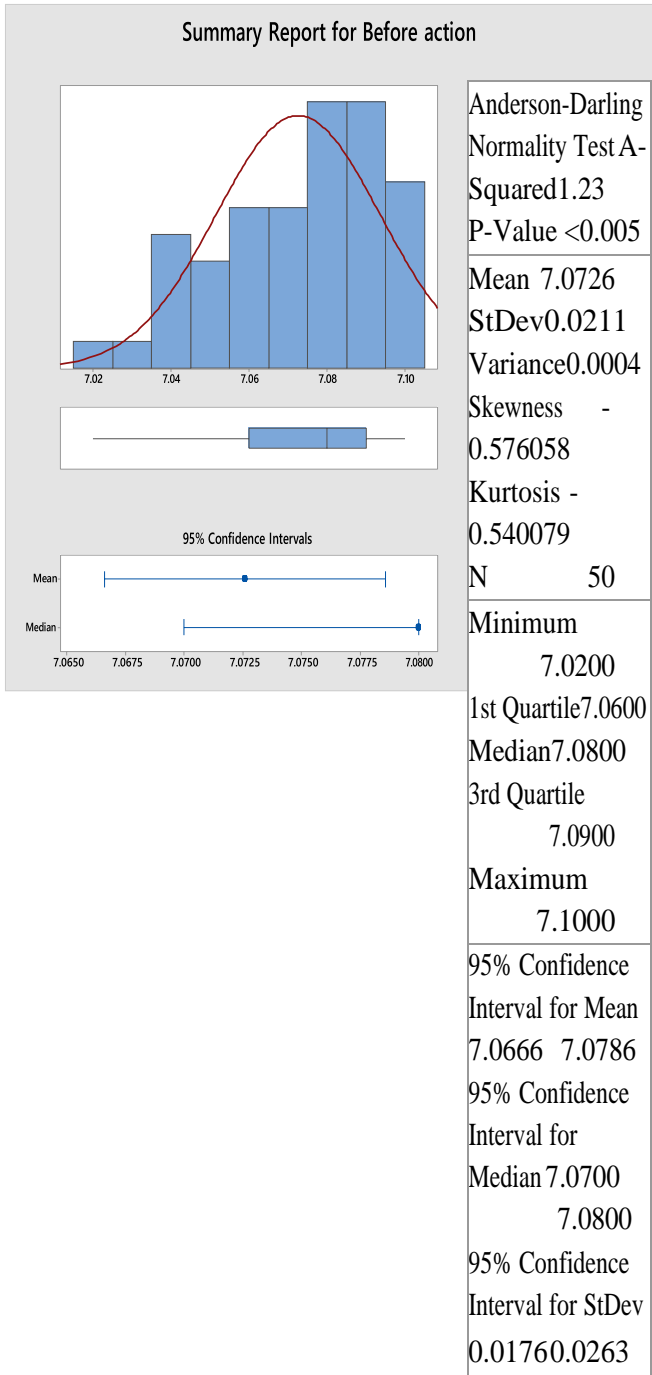
( $P_{pk} \geq 1.67$  is desirable)

**Table -8:** Final Result Table

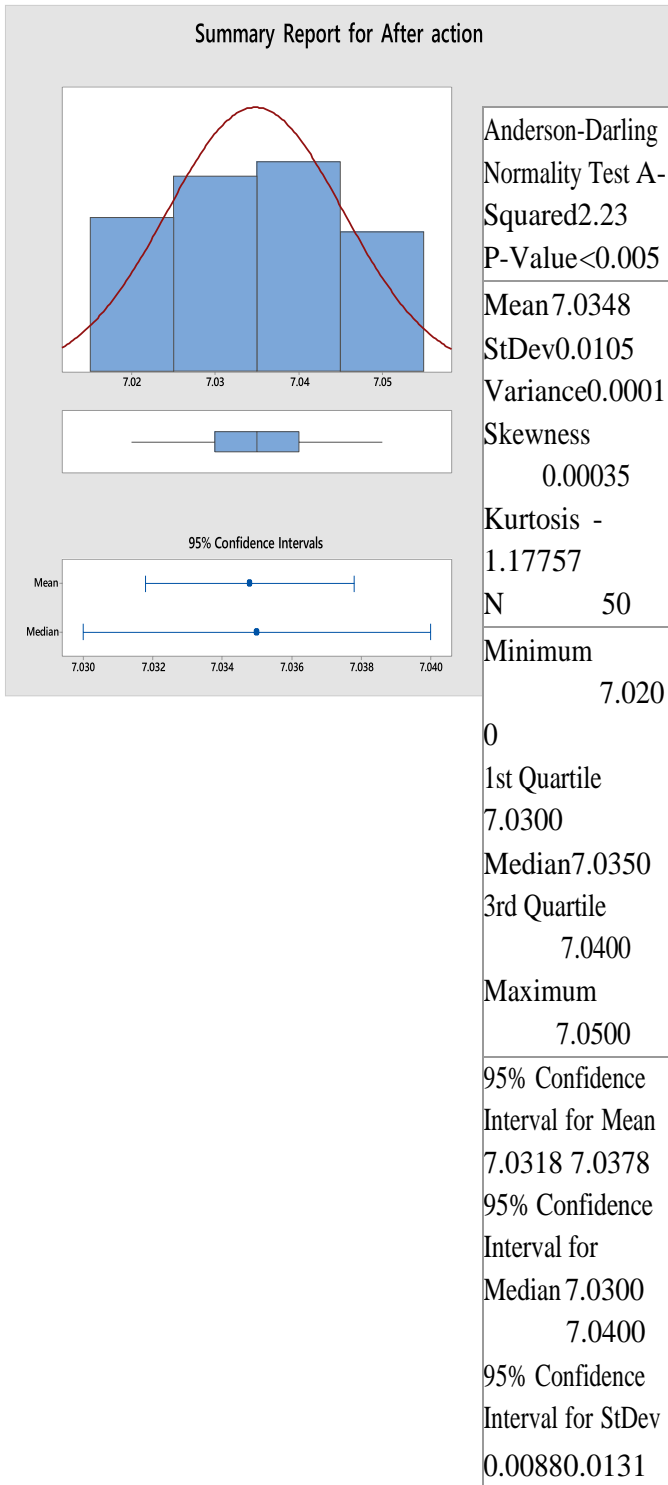
Location A		Location B	Location MC	Remarks
Average/xbar	7.038	7.034	7.034	
Frequency				
Range	0.04	0.03	0.03	
sigma	0.0121	0.0101	0.0105	
6sigma	0.072	0.06	0.063	
USL	7.1	7.1	7.1	
LSL	6.9	6.9	6.9	
PP	2.75	3.28	3.16	ocation "c" is capable
PPUSL	1.70	2.14	2.06	
PPLSL	3.79	4.42	4.26	
PPK	1.70	2.14	2.06	ocation "c" is capable

	Location A	Location B	Location MC	Remarks
Average/xbar	7.038	7.034	7.034	
Range	0.04	0.03	0.03	
sigma	0.0121	0.0101	0.0105	
6sigma	0.072	0.06	0.063	
USL	7.1	7.1	7.1	
LSL	6.9	6.9	6.9	
PP	2.75	3.28	3.16	Location "c" is capable
PPUSL	1.70	2.14	2.06	
PPLSL	3.79	4.42	4.26	
PPK	1.70	2.14	2.06	Location "c" is capable

From the table we see that  $ppk \geq 1.67$  in all locations so action is effective.

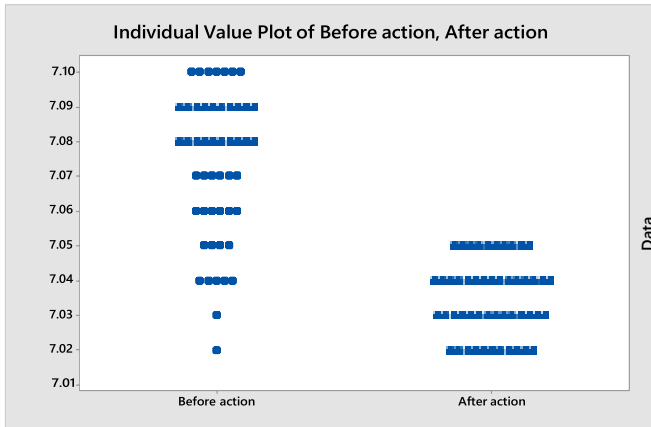


**Fig -13:** Summary report before action



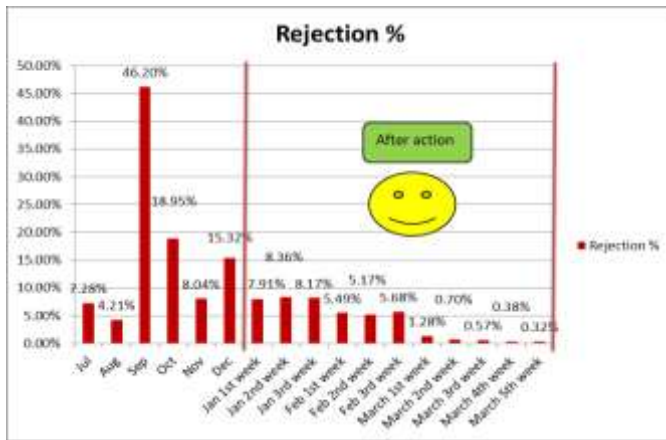
**Fig -14:** Summary report after action Both data are not normal as p value is < 0.05 Null hypothesis (Ho);  $\sigma A = \sigma B$   
 Alternative hypothesis (Ha);  $\sigma A$  is significantly different from  $\sigma B$ .

Here p value is  $\leq 0.05$  so we reject  $H_0$  & Accept  $H_a$  i.e. The variation After action is significantly improved from Beforeaction.



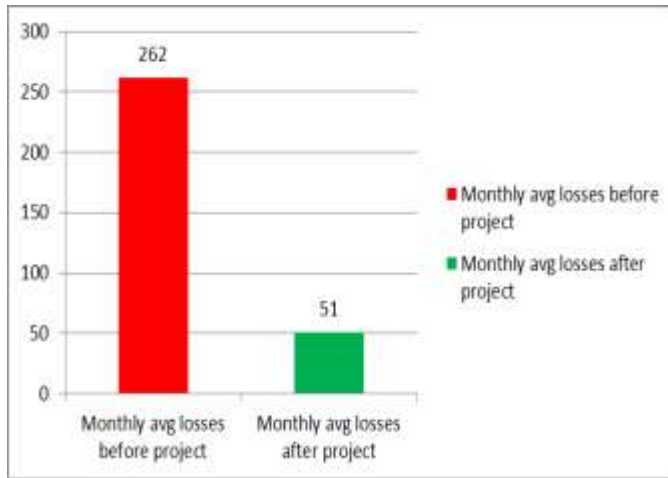
**Fig -15:** Individual Value plot Before & After Action

This graph cleared that thickness variation after action is significantly improved then before action.



**Chart -3:** Bar Graph of Effectiveness of Actions

After action taken % rejection reduced to 0.65 % from average 16.66 % before project.



**Chart -4:** Production Loss Before & After Project

Production loss reduced from 262 no's per month to 51 no's per month (Rejection reduced 211 no's/per month).

### 13.1 BENEFITS AND IMPROVEMENT

**Table -9:** Direct Benefits

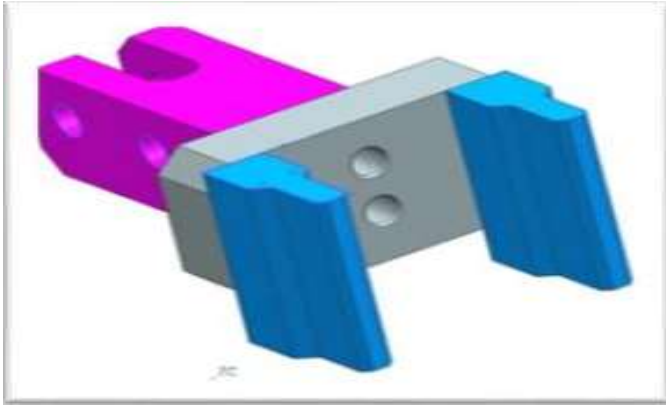
Cost Details	Before Project	After Project	Cost saving inRs per annum
Avg Number of pieces scrapped per month	262	51	
Cost of scrapped per month	31440	6120	
Total saving in cost per year			303840

Intangible benefits;

1. Customer demands are fulfilled.
2. Increase productivity.
3. Increase in employee's moral.
4. Cost of poor quality decreased.

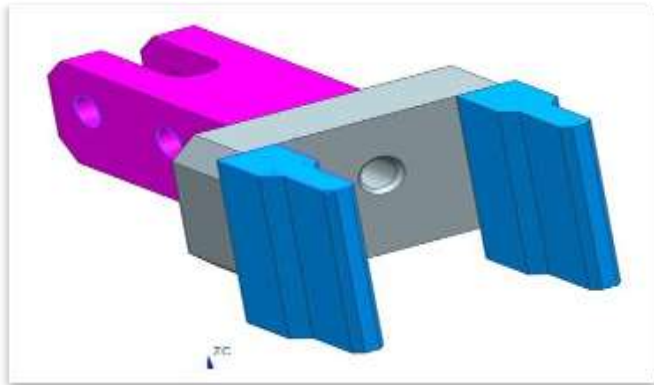
Improvement;





**Fig -16:** Clamp Before Status

As clamp is bolted in 2 positions there is no scope for adjustment for variable height of 2 different forks.



**Fig -17:** Clamp After Status

As clamp is bolted in 1 position there is scope for adjustment for variable height of 2 different forks as it allows clamp to float.

#### **14. CONCLUSION**

Quality leads to improvement in productivity and at the same time it also leads to customer's satisfaction. Study has been conducted to define the role of quality control tools in fork manufacturing industry. Quality tools are not so widespread as expected although they are quite simple for application and easy for interpretations. Main goal of the study is to reduce the cost per component by reduction in monthly rejection of the components. After studying the problems, various parameters affecting the quality of the final product were identified and data was collected with accuracy and precision. Most of the quality tools are used in the study. The main conclusions of the study are summarized as below.

- Fixture design validation is to be done during process designing & approval.
- Rejection of the fork has been reduced from 16.66% to 0.65% for overall production of components.
- Saving of Rs. 3.03 lakhs per year.
- Process is standardized and additional audit is started.

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