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Defect Rate Analysis of the Brake Component Using The Statistical Approach

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Abstract

A brake is an essential mechanical device used to slow down the motion of a vehicle, so the quality of the brake is more important. This work objective is to improve the quality of the disc brake component by minimizing the number of defects during production. The manufactured disc brake has over 20 manufacturing defects which increases rework in the production unit. Here the statistical approach is used to analyze the rejection rate for the 20 different manufacturing defects in the production unit. Analysis of the rejection component for 20 manufacturing defects is carried out using the ANOVA test, chi-square test, and Regressive test is done to find the difference between the observed and expected rejected components for the various manufacturing defects. Then the causes for the manufacturing defect are analyzed using a Pareto chart. By, this Pareto chart analysis the exact reason for the manufactured disc brake will be studied. This investigation makes the organization unit focus on the area where the defect rate can be reduced. This statistical study makes the manufacturing unit identify the key reason for the 20 different defects in their production. Also, this defect rate minimization helps them to produce defect less quality disc brakes to retain their customers in future.

Keywords*: Brake, Productivity, Analysis, Defect Rate, Quality, Statistical approach*

Introduction

The brake is one of the most important parts in the automobile where it is used to stop the running motion of the object. This caliper brake is mostly used in cars and trucks it can stop the vehicle and slow the vehicle by creating friction between the pad and the disc. Now a day these caliper brake is fixed on both the front and the rear wheel of the vehicle. In the majority of vehicles, the disc brake is standard due to its low cost and high standard compared to other types of the brake. This caliper brake is the fixed type caliper and hydraulic were used in these brake for the movement of the piston.

Quality is very important for every product in the market to satisfy the customer. In the brake system quality should be very necessary because if any quality defect occurs it may cause a major accident to the customer, so improving the quality is important for an organization to satisfy the customer and minimize the scrap cost of the product. The analysis is to improve the quality of maintenance and reduce the scrap cost by using the analysis methods. The objective of the analysis is to improve the quality by using the figure 8 approach where the approach tells to sustain and improve. Finding the existing situation where the problem

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occurred and analysing the problem to find the best alternative to solve the problem.
In the caliper brake system, many machining processes were done to form the full assembly of the brake, while doing the machining process any defect may occur due to improper maintenance or due to any change in parameters, these can be analysed using the quality controls to improve the quality. The law used in the caliper brake system is the Pascal law.
The principle of Pascal's law, in a fluid a pressure change in one part is transmitted without any loss to every part of the fluid. Using this law the piston in the caliper brake system moves forward direction, and the inner pad near the piston is also moved due to the movement of the piston.

In caliper brake system, housing is the major part in which pinhole machining process is done, these pinholes are oversized from side datum position due to these side datum position offset many hosing jobs where scraped .so the scrap rate of the organization is increased and also the quality of the organization is decreased. Nowadays the customer requires a high quality product. To improve the quality of the organization analysis is done in every machining process of the brake and find out the quality defects to decrease the scrap rate of the product and the organization. Jishu-Hozen check sheet analysis is done whether maintenance is done regularly and these can improve the quality of the product.

Role of Quality in the manufacturing process

Varsha M. Magar (2014) 7 Quality Control used in the manufacturing process will help to reduce the quality-related problem and these 7 tools are the easy statically tool to solve a difficult problem in the organization. Seven quality control tools are nowadays used in the manufacturing process it helps to solve the quality-related problem. The organization or the industry using these 7 quality control tools will reduce 95% of the quality problem in their industry. The seven quality control tools are the Pareto diagram, histogram, scatter diagram, control chart, cause and effect diagram, graph and check sheet. These seven quality control tools represent their solution in graphical format, so it is easy to understand and observation is simple. Quality defects can be observed every month, weekly, or daily so it helps to improve the quality defect and improve the process in the organization. Shanmugaraja, M., Nataraj, M. and Gunasekaran (2011) the research aims to analyse the limitation of defects that occurred in the industry or the machining process. In the two stroke engine, the body of the oil pump is rejected due to a blowhole in the die casting industry, where the industry tries to use the six sigma technique to reduce these quality defects because six sigma is the zero defect approach. Six sigma tells about defining, measuring, analysing, improving, and controlling. Taguchi's method is used for the improvement in quality, problem solving and problem analysis is done. The step in the six sigma makes to improve the quality. That is why the rejection rate of the casting industry is reduced from 18.6% to 5.2% by using the six sigma technique.

Reduction of defect rate in production

Shyam H. Bambharoliya (2015) The purpose of the research paper is to improve and eliminate the reduction rate and solve the quality related problem in the manufacturing sector.

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The research paper is made in the fan manufacturing industry to solve the quality problem by using these seven quality control tools to eliminate the reduction rate. These seven quality control tools are easy statically tools to solve the problem in the manufacturing sector. In the manufacturing sector to detect and analysis, a problem these quality control tool is used. The main use of the quality control tool is to detect and control the quality related defects by graphical diagrammatical method and this quality control tool is the method for solving a problem in the manufacturing sector. This quality control tool is the most effective in the manufacturing sector to detect the problem and eliminate the defect. Shen,XX .,Tan,KC., Xie,(2001) Quality function deployment is a quality development and product management system. This quality function deployment transfers the customer voice into engineering characteristics. This method is achieved for greater customer satisfaction. This method is worked in linguistic data which means industrial data, government data etc. quality function development is the systematic approach to the problem. These methods mainly work on the customer requirement and the need of the customer. House of quality is the basic design tool for quality function deployment. This method is used in all types of manufacturing sectors to improve the quality of an organization.

Rathi N., Punjabi S., Jain M. L (2016) This review aims to improve the parameters in an industry. Parameter plays the main role in the development of process and product development depends on the improvement of a parameter in an organization. The purpose of this paper is to reduce the cost and increase the efficiency in the manufacturing process and new technology like the Taguchi method and ANOVA software are used in the process and their product to increase the efficiency in their organization. Taguchi is one of the powerful tools and quality improvement techniques to reduce the cost and increase the efficiency, this method is one of the simplest methods and systematic approaches for improving parameters, improving quality and reducing the cost. ANOVA is software used for analyzing the scrap components and also to analyse the quality of the machinery and its product. To improve the parameter in the organization analysis and quality technique will be useful, where Taguchi method plays a major role in this improvement.

Concept of zero defects

Wang, K-S. (2013) The quality depends on the facilities and manufacturing process and their equipment if any error occurred in these affects the quality of the production process and their products. To avoid these errors the industry will prefer the Zero Defect Manufacturing process to improve the quality of the product. The data mining method is the method where discovering patterns in large data sets intersects with machine learning and statistics. These data mining method is applied in the manufacturing sector to provide reliability and to improve the quality of the product. The analysis is more important for the better alternatives, where the data mining method analysis the data of the machine and product. This analysis is done to eliminate errors in the manufacturing process. These techniques enable the quality of the product.

Abu Saleh Md. Sohel-Uz-Zaman, U. Anjalin (2016) Quality education is more important in

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society. To improve the quality, education in management should be more important, so a technique called total quality management is implemented in an organization. Total quality management provides quality management, effective organization, customer satisfaction and excellent organization. This technique creates a flawless. Total quality management plays a major role in the improvement of an organization, so educating this technique is more important. Shantanu Kulkarni, (Dec 2017)A study on the quality circle explains that today in this modern world manufacturing industry is running at high speed, with more productivity in less time. Seven quality tools were for statically related problems and the quality circle is used to improve the quality. This system is an effective and flexible suggestion system and is also used in cause effect analysis to improve productivity. The majority of the industry uses quality circles because this is the simplest and easy system. By reducing the rework and rejection rate by using 7 quality tools we can improve the quality. These quality circle tools show better results in quality improvement.

Chung, C. H. (2018) use the kaizen tool for continuous improvement of quality and productivity. Kaizen means continuous improvement, there are four steps in kaizen for the improvement they are plan, do, check and act. A steering manufacturing company they are facing many problems in their industry, so they referred to the kaizen tool for their improvement, these tool found the root cause of the problem and reduce 70% percentage of a quality defect in their industry. This tool is effective and flexible and helps in the improvement of the quality of the organization. Teti, R. (2015) The review explains the zero defects in the manufacturing machines. In the cutting machine process some variables are their cutting speed, and temperature these are measured by the sensor which is implemented in the machine. These advanced technologies were implemented in the machining process nowadays to improve the process tool. This advanced technology can find out the defect or any damage in the machine in less time, so the technology can reduce the defect and increase the quality of the process.

Problem Identification

In this robotic world, every industry and organization is running at high speed to overcome their competitor and to satisfy their customer requirement with a better quality product, so the organization implements many techniques to find out the mistake and damage in the component. This organization has also implemented many quality techniques to find the quality of a product. The main production of the Brakes India is the caliper brake, where more than 5000 no of caliper brakes were produced per day and more than 20 models of brakes were produced for the different models of cars, in these caliper brake housing is the important component.

Housing is the important component in the caliper brake it is also the body of the brake where this housing component contains many machining operations done in the machine shop. Due to the target of output, many labourers are not maintaining their machines properly so scrap components will occur.

A pinhole is an operation which is used for the movement of a brake. In the model O2 brake we have found that many no of brake are scraped due to oversize in the pinhole from its

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side datum position. If the pinhole in the housing is oversized then all the operations next to the pinhole machining will be changed from its position. Due to this problem, every operation next to it will be changed from its position because after the pinhole machining operation clamping is done by the pinhole if it is an oversized boring operation will be changed. Scrap components in O2 model housing are more with these complaints.

To reduce these problem identification and analysis of the pinhole operation is required. By reducing these defects the quality of the brake can be improved and reduce the customer complaints and the scrap component can be reduced to increase the profit of an organization. Quality product is the best goal for the organization to overcome the competitor and to stand in the market.

Figure .1.Pinhole operation in brake

Scrap rate over the year

For an organization to increase its profit, the scrap rate is to be minimized. To minimize the scrap the analysis should be made in the organization. In these organizations the main production is the caliper brake, where the scrap rate is high due to heavy production and improper maintenance of the machines. . In these organizations many types of caliper brake were produced models like YL7, O2, YAD, W105, MK, Scorpio, Ford etc. In these model O2 model caliper brake which is used for cars contains more scrap than other models. Due to these scrap components, there will be a loss in their profit for the organization.

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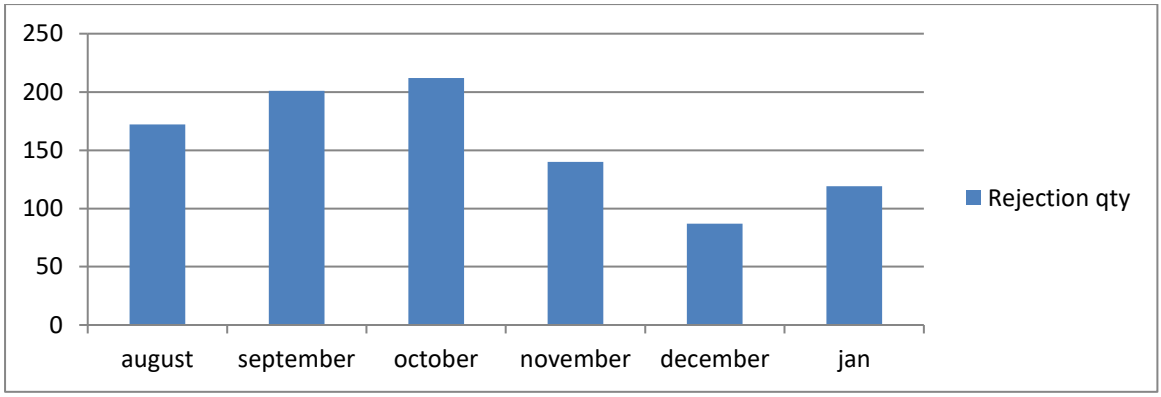

Figure.2.Scrap data over the years of brake component

The scrap rate of the component is increased monthly while the scrap rate is increased the time for machining, casting and also profit of the organization will be decreased, so analysis should be made on the scrap component and also should know the future scrap by analysis and also find the solution to decrease the rework component.

Materials and Methods:

Data which are corrected should be analysed, analyzing data improves the solution. The scrap data which are collected in these organizations are analysed using minitab18 software to find the comparison between expected and actual value.

Chi-Square Test

The Chi-square test is the non-parametrical test used to find the difference between the observed value from the expected value. In these tests, the scrap components of housing data collected from the organization are installed to find the difference between the expected value.

Table.1.Datum position

Period	**Expected**	**Actual**
Apr 18	150	172
May 18	190	201
June 18	200	212
July 18	160	140
Aug 18	100	87
Sep 18	130	119

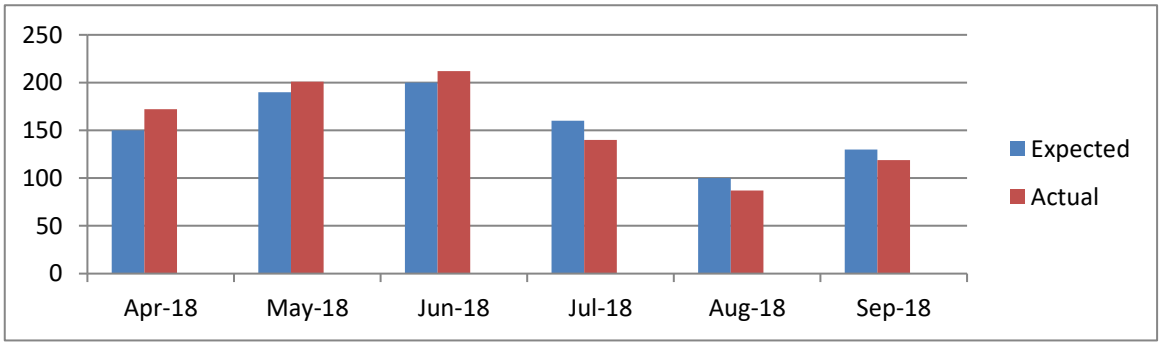

Figure.3.Datum position of expected versus actual

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Table.2.Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: expected

Category	Test			Contribution Chi-square fit test
	Observed	Proportion	Expected	
1	150	0.166667	155	0.1613
2	190	0.166667	155	7.9032
3	200	0.166667	155	13.0645
4	160	0.166667	155	0.1613
5	100	0.166667	155	19.5161
6	130	0.166667	155	4.0323

N	DF	Chi-Sq	P-Value
930	5	44.8387	0.000

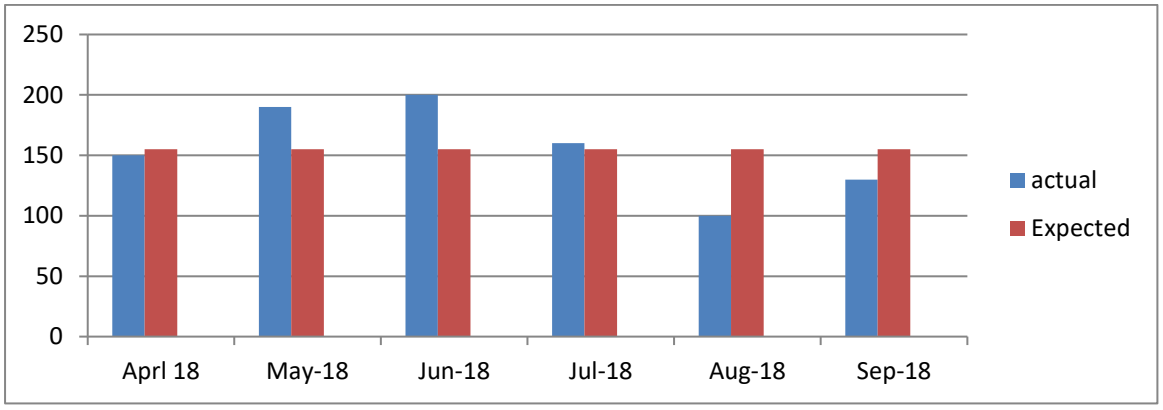

Figure.4.Chi-square fit test expected versus actual

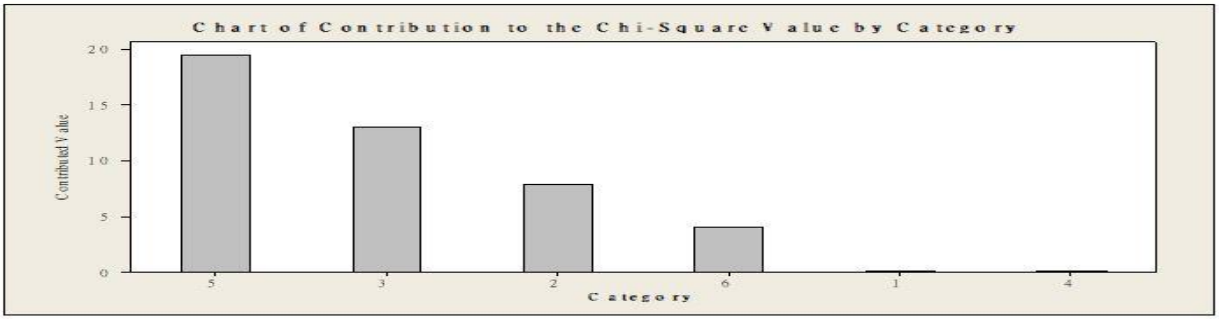

Figure.5.Chart contribution to the chi-square value

Table.3.Chi-Square Test: expected, actual

Si.no	Counts	Expected	Actual	Total
1	Observed Count	150	172	322
	Expected count	160.91	161.09	
	Chi-square contribution	0.740	0.739	

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2	Observed Count	190	201	391
	Expected Count	195.31	195.61	
	Chi-square contribution	0.149	0.149	
3	Observed Count	200	212	412
	Expected Count	205.89	206.11	
	Chi-square contribution	0.168	0.168	
4	Observed Count	160	140	300
	Expected Count	149.92	150.08	
	Chi-square contribution	0.678	0.677	
5	Observed Count	100	87	187
	Expected Count	124.43	124.57	
	Chi-square contribution	0.249	0.249	
	Observed Count	130	119	249
	Expected Count	124.43	124.57	
	Chi-square contribution	0.249	0.249	
	Total	930	931	1861
Chi-Square = 4.885, DF = 5, P-Value = 0.430				

Regression Analysis:

Regression analysis is the analysis where the data are analysed in a statistical process for eliminating the dependent variable from the independent variable. These analyses were used in these for the scrap data analysis. The regressive analysis is used to analysis actual versus expected scrap components in the organization.

The regression equation is actual = - 37.9 + 1.25 expected

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	-37.86	30.41	-1.25	0.281
Expected	1.2453	0.1916	6.50	0.003

S = 15.9731 R-Sq = 91.4% R-Sq(adj) = 89.2%

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Table.4.Analysis of Variance

Source	**DF**	SS	MS	F	P
Regression	1	10778	10778	42.2	0.003
Residual Error	4	1021	255		
Total	5	11799			

Pareto chart

A Pareto chart is a chart used to represent or analysis the value in the static form. This technique is a simple and easier method of analyzing a problem and it can be easy to understand what type of problem occurred. This Pareto chart is used to find the expected and actual values statically.

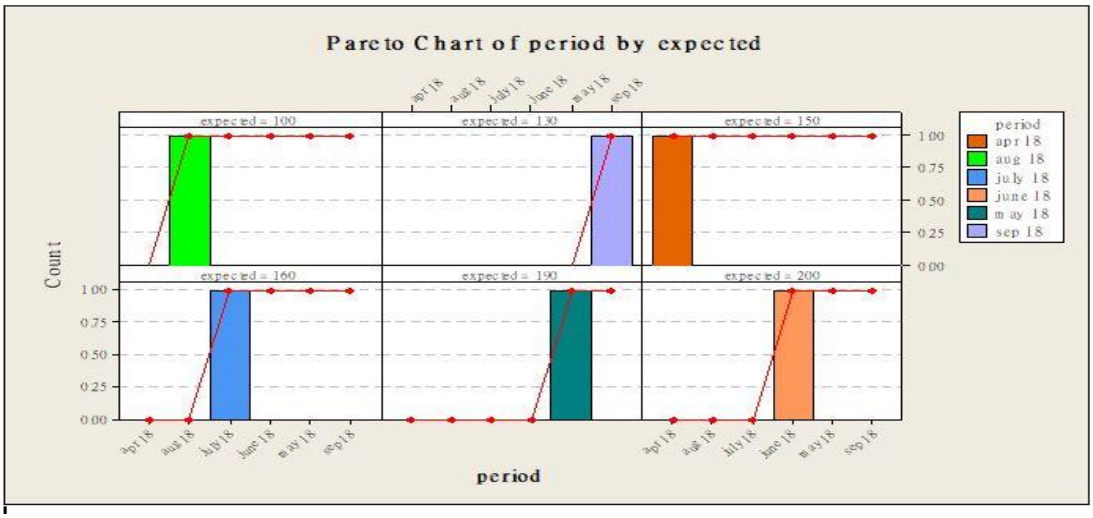

Figure.6.Pareto chart of period by expected

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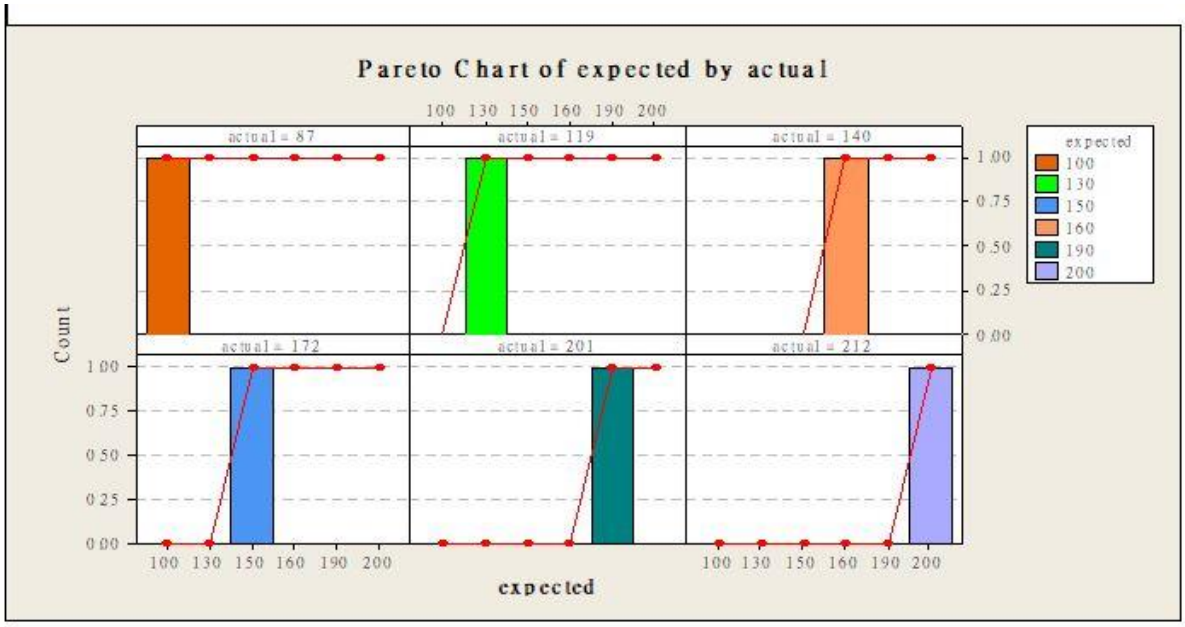

Figure.7.Pareto chart of expected by actual

Pareto chart is one of seven basic tools for quality maintenance. This Pareto chart is used for finding the accurate defect in an organization, it represents the defect in the order. This Pareto chart is analysed in the minitab18 software.

Goodness fit test for components

Goodness fit test analysis is done for rejected component, which process has more defect and their problem for the solution can be identified. Comparing the actual and expected value of the rejected and rework components according to their process will give better results and improvement. Actual and expected data are compared and noted first. This analysis of data helps for better improvement and alternative solutions can be implemented.

Table.5.Data for scrap components

Si no	Component	Expected	Actual
1	Bore dia	1534	1600
2	Pin hole Oversize	931	970
3	Bore step	670	720
4	Lug damage	484	580
5	Lug step	396	420
6	Spot face damage	441	470
7	Disc path under size	368	390
8	Seal groove us	363	368
9	Seal groove os	365	400
10	Bleed port Oversize	280	290
11	Feed port oversize	296	310
12	Bore chatter	269	280
13	Bore groove	268	280
14	Bore diameter us	268	280
15	Seal groove	227	240

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16	Disc path	208	220
17	Bleed port Oversize	164	180
18	Lug undersize	146	160
19	Boot groove Oversize	139	160
20	Bore damage	96	110
21	Spot face	96	110
22	Counter bore	91	100
23	Banjo damage	90	100
24	Bore depth undersize	90	100

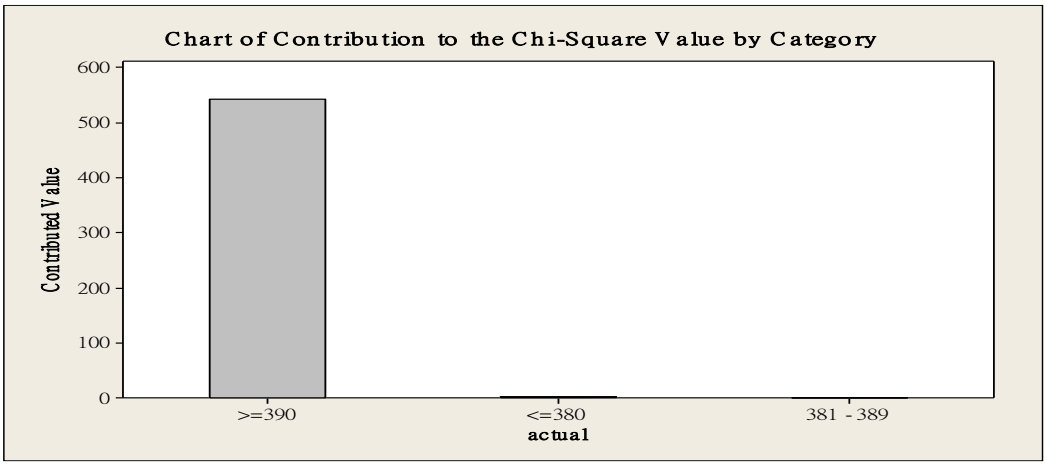

Figure.8.Contribution of chi-square

Goodness-of-Fit Test for Poisson Distribution

Data column: Actual
Position mean for actual =340

Table.6.Goodness-of-Fit Test for Poisson Distribution

Actual	Observed	probability	Expected	Contribution of chi-square
<=380	19	0.984757	26.5884	2.166
381-390	0	0.010997	0.2969	0.297
>=390	8	0.0004276	0.1146	542.399

Result:

- cell(s) (66.67%) with expected value(s) less than 1. Chi-Square approximation probably invalid
- 2 cell(s) (66.67%) with expected value(s) less than 5.

One way ANOVA:

One way ANOVA is a technique is used statically technique used to compare the difference between two mean variables. In these ANOVA is used for analyzing the components which are rejected and reworked, mean standard deviation and pooled standard deviation are

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compared using ANOVA software.

Table.7.one way ANOVA

Si no	Component	N	Mean st deviation	Pooled st deviation
1	Bore dia	1	1600	*
2	Pin hole Oversize	2	970	*
3	Bore step	1	720	* (---*----)
4	Lug damage	1	580	* (---*----)
5	Lug step	1	420	* (---*----)
6	Spot face damage	1	470	* (---*----)
7	Disc path under size	1	390	* (---*----)
8	Seal groove us	1	368	* (---*----)
9	Seal groove os	1	400	* (---*----)
10	Bleed port Oversize	1	290	* (---*----)
11	Bore diameter us	N	280	* (---*----)
12	Seal groove	1	240	* (---*----)
13	Disc path	1	220	* (---*----)
14	Bleed port Oversize	1	180	* (---*----)
15	Lug undersize	1	160	* (---*----)
16	Boot groove Oversize	1	160	* (---*----)
17	Bore damage	1	110	* (---*----)
18	Spot face	1	110	* (---*----)
19	Counter bore	3	100	* (---*----)
20	Banjo damage	1	100	* (---*----)
21	Bore depth undersize	1	100	* (---*----)

```
---+---------+---------+---------+------
          0     500     1000    1500
```

Result: Pooled Standard Deviation =73.3

Regression Analysis: actual versus expected

The regression equation is actual = 6.59 + 1.04 expected

Table.8.Regression Analysis for component

Predictor	**Coef**	**St coef**	**T**	**P**
Constant	6.590	1.627	4.025	0
Observed	1.0416	0.00368	283.28	0

S = 5.83519 R-Sq = 100.0% R-Sq(adj) = 100.0%

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Table.9.Analysis of Variance for component

Source	DF	SS	MF	F
Regression	1	2731749	2731749	80228.99
Residual Error	25	855	34	
Total	26	2732600		

Conclusion

The objective of the work is to eliminate the pin hole oversize from the side datum position to reduce these defects figure of 8 approach technique is used which helps to reduce the rework and reduction rate. In this analysis of scrap component by ANOVA test, chi-square test, and Regressive test are useful to identify the reduction component accuracy. The quality matrix plays a major role in these projects which helps to identify the defect where it happens and it is easy to solve the problem. Efforts to decrease the reduction rate and rework rate and increase the productivity were obtained by identifying the fault zones. Maintaining the quality of an organization improves the quality of the product and also helps to satisfy the customer, so maintenance of the product is more important than the output of an organization.

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Conflicts of interest

There is no conflicts of interest among the authors.

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