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A Study on Process Capability on Connecting Rod in Assembly Line

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Abstract

This paper presents the improvement in the cleanliness of the machine part of connecting rod in machine shop which belongs to the value stream of compressor and braking system. The machined parts of the connecting rod are taken for Millipore test to calculate the amount of dust particles present in the machined part. The values obtained from the Millipore test is taken for process capability analysis through which process capability index value is less than the standard specific limit. To increase the process capability index value the washing machine of the machined parts are audited and the defects are rectified. The washed machined parts are taken for Millipore test in which it results as process capability index value is increased than before.

Keywords: Machined Connecting rod, Process Capability, Millipore Test.

INTRODUCTION

This project deals with Study on Process Capability On Connecting rod In Assembly Line which belongs to the braking system of an automobile vehicle, In which Connecting rod is the component taken from the compressor and Braking System-1 to detect the amount of dust particles present in the connecting rod in order to reduce the leakage of the braking system and to avoid the road accidents of the automobile. The connecting rods of 16 parts are taken from machine shop and assembly line for Millipore test to detect the amount of dust particles present in the components. The Millipore values of 16 parts of connecting rod is taken and placed in the process capability through which Cpk value is obtained from the process capability chart. The Cpk value which is obtained from the values is less which is not equal to the specific standard limit. So, In order to improve the Cpk value, the Washing machines are introduced which are used for washing the connecting rod in which audit is done on

the washing process and the abnormalities are identified and rectified. The connecting rods are taken for washing machines to avoid the dust particles in the connecting rods and again the parts are taken for test in which the Millipore values are placed in the process capability and the Cpk value is improved compared to the previous test. Thus the quality of the product will be increased by improvement in the process through which it satisfies and meets the customer requirements.

LITERATURE REVIEW

A pragmatic view on process capability studies in recent years an increasing number of organizations use process capability studies on a regular basis. Contemporaneous with the increasing number of organizations using process capability studies, warnings have been launched that imprudent use of numerical measures of capability, the so-called process capability indices, might lead the user to make erroneous decisions. As a result, many practitioners of today are left with a somewhat ambivalent attitude towards process capability studies.

Jeh-Nan Pan and Chung- I Li [1] states that Process capability indices have been widely used in industry to provide quantitative measures of process performance that lead to quality improvement. Andreas Archenti [2] explains that Machine tool capability is commonly reflected on the tool– work piece interface in terms of kinematic/positioning, thermal, static and dynamic accuracy. Existing capability evaluation of machine tools requires laborious testing procedures that can be separated into ‘‘indirect’’ and ‘‘direct’’ methods. Indirect methods require multi-axes simultaneous motion of the machine under test for estimating overall geometric errors. Direct methods are implemented through error motion measurements of a single axis.

John S. Oakland [3] explains that A process capability index is a measure relating the actual performance of a process to its specified performance, where processes are considered to be a combination of the plant or equipment, the method itself, the people, the materials and the environment. The absolute minimum requirement is that three process standard deviation each side of the process mean are contained within the specification limits. This means that 99.7percent of output will be within the tolerances. A more stringent requirement is often stipulated to ensure that produce of the correct quality is consistently obtained over the long term.

METHODOLOGY

Method to conduct Millipore test, process capability, washing machines abnormalities and its improvements are discussed and better comprehension of the problem is presented.

Washing machines are used to remove dust particles from the part. The washing machines were audited as per operation standard sheet and Quality control process chart. A sample operation standard sheet and Quality control process chart and its characteristics are given in Table 1,Table 2 and Table 3 the parameters to be controlled are air pressure, temperature, cleaning media, and cleaning media level.

Table I. Operation Standard sheet

Method	*Parameter*	*Specification*	*Check method*	*Check frequency*
Wash	Air pressure	6 kg/cm^2	Visual pressure gauge	Once at the start of shift
	Temperature	45-50°C	Temperature indicator	Once at the start of shift
	Cleaning oil	Oil level	Visual oil level indicator	Once at the start of shift
	Concentration ratio	5:100	Refrectrometer	Once at the start of shift

Intolerance process parameters ± 10% variation allowed

Table II. Quality control process chart

MACHINE	***PARAMETER***	***SPECIFICATION***
Connecting rod	Washing oil	Solution water cleaning
	Nozzle	Nozzle cleaning
	Washing time	1 minute
	Water pressure	5-7 bar

Table III. Quality Control Characteristics

Control item	*Specification*	*Gauge no*	*Checking frequency*
Washing effectiveness	Free from oil and other foreign particles	Visual	100%
Cleanliness	<3 mg	Millipore tester	1/shift

	Temperature	45-50
	Cleaning media	Washing level

The washing effectiveness is evaluated visually for all the parts free from oil and other foreign particles. The frequency of checking parameters is once at the start of the shift .The quality characteristics, Cleanliness is evaluated by a Millipore tester once in a shift.

Experimental:

Millipore apparatus is identified as the experimental set up for testing the Connecting rod in the organisation.

Procedure:

Before beginning the Millipore test the tray in which machined part is placed has to be cleaned with cotton cloth so that the dust particles present in the tray does not affect the machined part. Open the lid of pressure pot and fill the pressure pot with the isopropyl alcohol through which the hand gun is connected to pressure pot. The machined part is placed in the tray after cleaning from washing machine. Press the hand gun manually so that the isopropyl alcohol is sprayed on the machine part at the pressure of 2bar and after 10 minutes release the hand gun by removing fingers on the hand gun .So the flow of alcohol from hand gun is stopped and the machined part is removed from the tray. After removing the machined part some alcohol is present in the tray with some oil and dust particles. Remove the vacuum funnel cup and place the weighed Millipore paper without dust particles on the top of vacuum funnel and close the vacuum funnel with cup.

Later the alcohol present in the tray is poured into the vacuum funnel by lifting the tray manually and at the same time put on the vacuum pump so that alcohol present on the top of funnel is flown into the funnel and the dust particles are remained on the Millipore paper which is placed on the top of funnel. Switch of the vacuum pump after filtration of dust particles from alcohol and remove the vacuum cup and remove the Millipore paper on the vacuum cup. Place the Millipore paper in the hot oven, close the door and switch on the hot oven and temperature indicator to dry the Millipore paper from wet particles on the Millipore paper and also fan is present in the hot oven to dry the Millipore paper. Switch off the hot oven after 10 minutes and open the door and remove the Millipore paper from the hot oven. Take the Millipore paper to the analytical weighing machine to weight the amount of dust particles present in the Millipore paper in milligrams. Calculate the weight of the paper before test and after test so that weights of dust particles are calculated of the particular machined part. Therefore same process is repeated for 16 similar parts and the values are tabulated. Later they obtained Millipore values of 16 similar parts are taken to Minitab by using stat from which quality tools by which process capability chart is generated from capability analysis. In which Millipore values are taken for comparing Cpk value that is produced from process capability before and after improvement of washing machines. And the run chart is also produced from process capability. Later to improve the Cpk value of the machined parts the cleaning machines of machined parts are audited based on process control parameters. Abnormalities in washing machines are detected visually by auditing the washing machines and the abnormalities are rectified and implemented.

After the improvement of washing machine again 16 similar machined parts from the machine shop which belongs to compressor and braking system-1 assembly line are taken for Millipore test and the values are taken to process capability in which Cpk value is obtained. The Cpk value of machined part is increased after rectification of abnormalities found in the washing machines. The Cpk value obtained before and after rectification of abnormalities of washing machines is compared.

CONNECTING ROD WASHING MACHINES ABNORMALITIES AND IMPROVEMENTS

Abnormalities found in the washing machines during auditing and its remedial actions are

Table IV. Abnormalities and Improvements of washing machine

SNO	*PART NAME*	*WASHING MACHINE ABNORMALITIES*	*ACTION PLAN*	*SUGGESTIONS*
	Connecting rod	Air pressure indicator is not working	air pressure indicator is within the standard air pressure i.e within the 6.1 bar.	Air pressure indicator has to be checked 1/shift
		Actual water pressure is below the standard water pressure i.e from 10 to 15 bar.	water pressure indicator is working within the standard pressure	Water pressure has to be checked 1/shift
		Washing machine stand contains lot of dust particles	Washing machine stand is cleaned	Washing machine has to be checked 1/shift

		The work piece locator contains dust particles present in it.	Work piece locator is cleaned.	Work piece locator is cleaned 1/shift.
		The temperature indicator is working below standard temperature i.e 33.7 due to the failure of heater	The temperature indicator is working within the standard temperature i.e from 45 to 55 and heater is rectified.	The heater has to be checked daily.

Process Control

In the existing procedure 16 parts are collected in a batch. Each part is cleaned separately in washing machine. The amount of dust particles collected through the Millipore test is recorded. The data collected for all the 16 parts are statistically analyzed. The data are fit into the established control charts to check the process in control. If the process is out of control, an analysis is made on 4M (i.e. men, method, machine, material continuously) to check whether the men is working properly or not and whether the correct method is followed by men , whether the machine is working properly or not, and material used for part is checked properly or not. Corrective actions are taken to bring the process under control.

Using the statistical tool, the mean, the standard deviation ‘s’, Cp , CpKu , CpkL and Cpk which are process capability indices are calculated .

Cp is calculated by formula

(USL - LSL) / 6s where USL is upper specific limit and LSL is lower specific limit.

CpKu upper specification limit is calculated by formula

(USL - X-Bar) / 3s

CpkL lower specification limit is calculated by formula

(X-Bar - LSL) / 3s

Cpk value is taken as Min. of (CpKu, CpkL) or Distance between mean of the process and the closest specific limit. In this project Cpk value plays an very important role in improvement in the washing machine process of the machined part. In the existing process the Cpk value is used for process improvement in the washing machine. If the Cpk Value is not within the standard specification limit i.e. 1.33 the process should be improved by continuous improvement in the washing machine.

RESULTS AND DISCUSSION

Process capability analysis solves the basic statistical problem in process quality controls, which is establishing a state of control over the manufacturing process, i.e. eliminating special causes of variation and then maintaining that state of control through time. Process capability analysis gives process capability chart and run chart. Process capability chart is produced by taking the Millipore values of machined parts which gives the comparison of natural tolerance limits with specification limits and the natural tolerance range with the specification range.

The normal distribution is used for the capability analysis. The graph represents capability statistics associated with within variation (Cp, Cpl, Cpu, Cpk) and with overall variation (Pp, Ppl, Ppu, Ppk). Whereas Cp, Cpl, Cpu, Cpk represents the potential capability of the process which estimates σ within considering the variation within the process and Pp, Ppl, Ppu, Ppk represents the overall capability of the process which estimates σ overall considering the variation for the whole process. Overall capability explains how the process is actually performing relative to the specification limits. Within capability explains how the process could perform relative to the specification limits. A substantial difference between overall and within variation may indicate that the process is out of control. A run chart, known as a run-sequence plot is a graph that displays observed data in a time sequence. In this project run chart is produced by Millipore a value which explains about the sequential flow of Millipore values that displays the data of the machined parts in a time sequence.

PROCESS CAPABILITY AND RUN CHART BEFORE AND AFTER IMPROVEMENTS IN CONNECTING ROD

The weight of dust particles of each connecting rod of 16 parts found out from the Millipore test is tabulated in Table V through which process capability chart and run chart is produced. The Cpk value is obtained by process capability chart. Table V

gives Cpk value of connecting rod before the process improvement.

Table V: Amount of Dust Particles Present in Connecting Rod before Washing Machine Improvement

USL=2.0 LSL=0.0

Part No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Amount of dust particles in mg	3.8	1.6	1.6	1.2	1.2	1.3	1.8	1	0.3	0.2	2.2	1.1	1	0.7	0.5	1.5

From Table V the actual Minimum value and Maximum value obtained in Millipore test are 0.2 and 3.8 respectively. It is found two components are out of range i.e 3.8 and 2.2. As two components are out of range the washing machine of the particular components has to be audited for detecting whether there is any abnormality in the washing machine and should be rectified and then the component has to be cleaned again the process is repeated until the range of component comes within the range i.e 2.The above Table V gives process capability chart through which Cpk value is obtained as shown in the Figure The obtained Cpk value is 0.31 which is less than the customer requirement i.e 1.33. So in order to get the Cpk value which satisfies customer requirement the amount of dust particles in the machined parts has to be reduced by improving the washing machine performance of the machined part. And the machined part has to be cleaned again. And the run chart represent the observed Millipore values of 16 parts of connecting rod in sequence which is tabulated in Table V is shown in Figure 1 Using the data in the table V the process capability chart and Run chart were drawn as shown in Figure 1 and Figure 2.

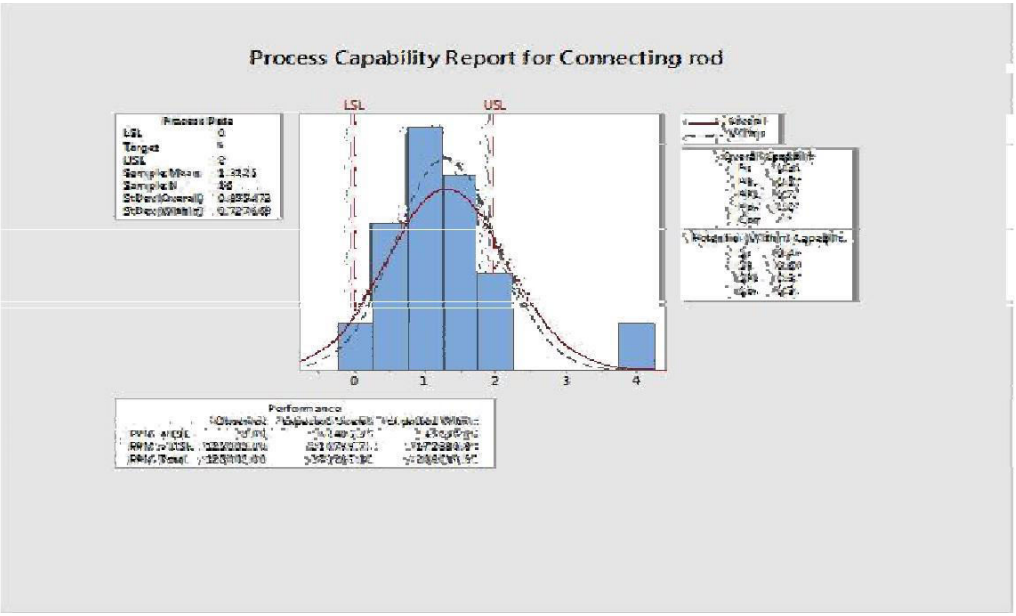

Figure 1: Process Capability of Connecting Rod before Improvement in Washing

Machines

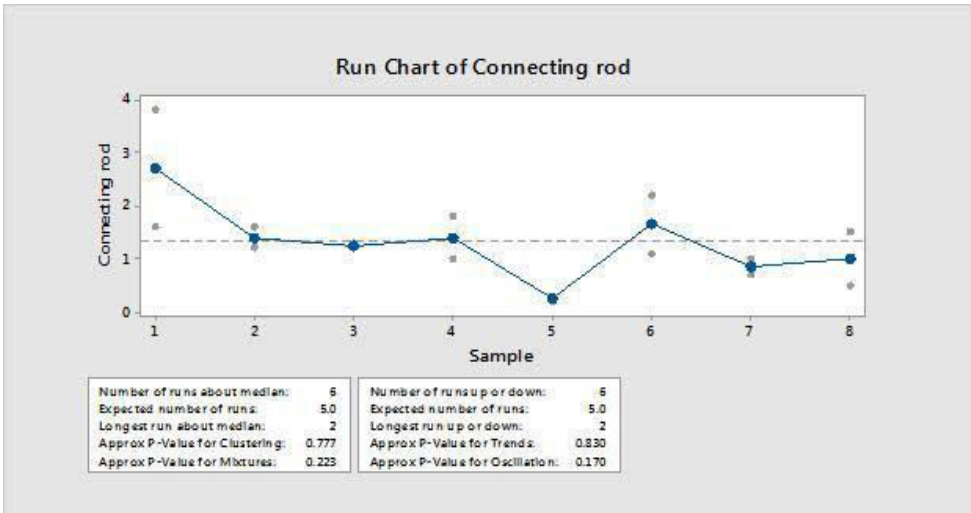

Figure 2: Run Chart of Connecting Rod before Improvement in Washing Machines

From the analysis it is found that Cpk value is 0.31 which is less than 1.33 given by the customer. And the two components are out of the range in which corrective action is taken place to improve the process by reducing the variability and centring the process on the target. And the run chart represents the observed Millipore a value of 16 parts of connecting rod in sequence which is tabulated in Table V is shown in Figure 2.

PROCESS CAPABILITY AFTER THE PROCESS IMPROVEMENT IN CONNECTING ROD

The washing machines of the machined parts are audited for the improvement in the washing machines to detect the defects in the washing machines and improve the washing machine process. So some of the abnormalities are found from the washing machines of connecting rod and the abnormalities got rectified. Thus the weight of the dust particles of connecting rod is taken after the improvement in the washing machines. The weight of the dust particles of the machined parts each of 16 components are tabulated in the following table VI through which the process capability chart and run chart are produced. The Cpk value generated by the process capability is improved after the washing machine defects are detected and rectified. The weight of dust particles of each connecting rod of 16 parts found out from the Millipore test is tabulated in Table VI through which the process capability chart and run chart is produced. The Cpk value is obtained by process capability chart. Table.VI gives Cpk value of connecting rod after the process improvement.

Connecting Rod

The weight of dust particles of each connecting rod of 16 parts found out from the Millipore test is tabulated in Table VI through which the process capability chart and run chart is produced. The Cpk value is obtained by process capability chart. Table.VI

gives Cpk value of connecting rod after the process improvement.

Table VI: Amount of Dust Particles Present in Connecting Rod after Washing Machine Improvement

USL=2.0 LSL=0.0

Part No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Amount of dust particles in mg	0.4	0.1	1.7	0.5	1.5	1.9	0.9	0.7	1.6	1.3	1	0.5	0.9	1.2	1.1	0.5

From Table VI the actual Minimum value and Maximum value obtained in Millipore test are 0.1 and 1.9 respectively. It is found that the values are within the range. Using these data process capability chart and Run chart were drawn as shown in Figure VI and .The Cpk value obtained by the process capability chart of connecting rod after the improvement is 0.80 which is more than the Cpk value of the connecting rod before improvement .And the Cpk value after the improvement in washing machines is 0.80 in which it does not meet the customer requirement i.e 1.33

In order to increase the Cpk value the continuous improvement in the washing machine has to be done. And the run charts represent the observed Millipore values of 16 parts of connecting rod in sequence which is tabulated in Table VI is shown in Figure 3. Using these data process capability chart and Run chart were drawn as shown in Figure3 and Figure 4.

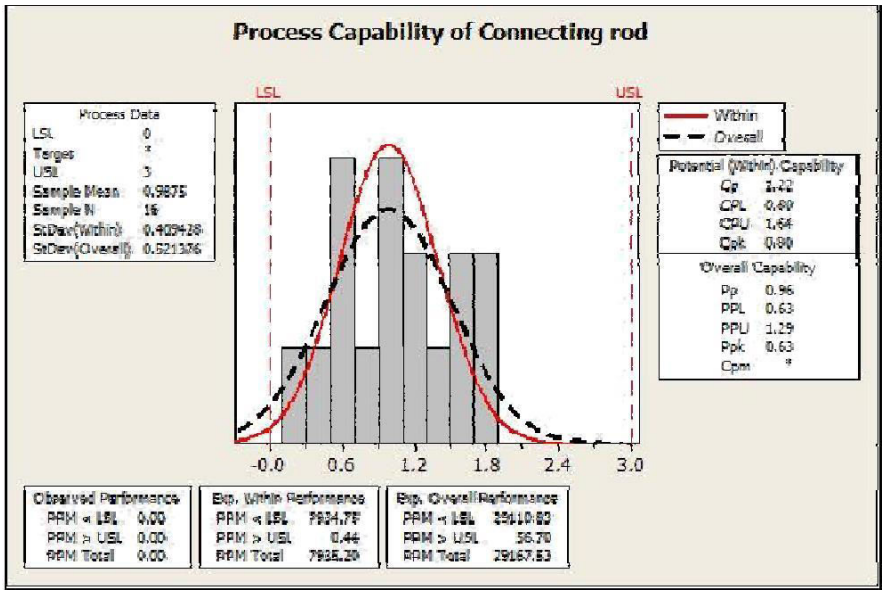

Figure 3: Process capability of Connecting Rod after Improvement in Washing

Machines

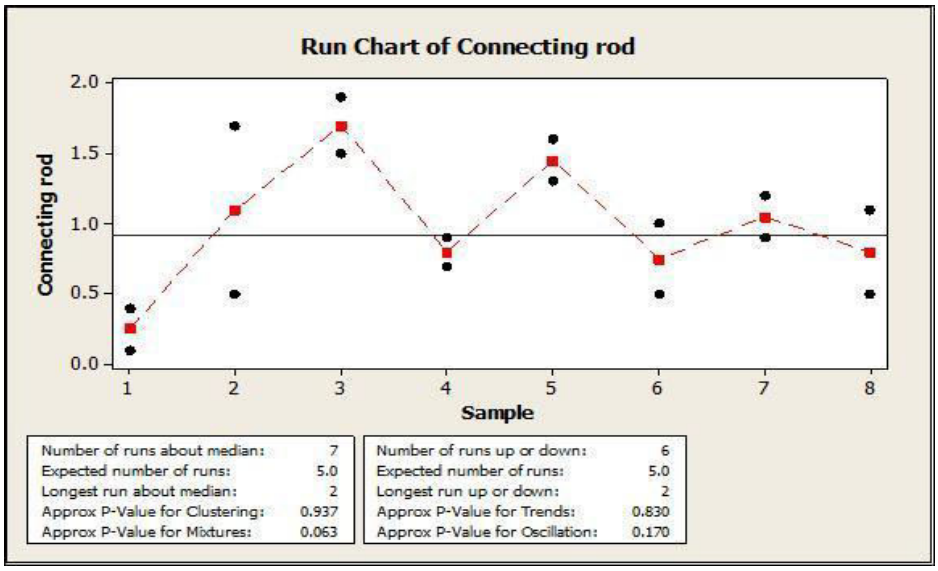

Figure 4: Run Chart of Connecting Rod after Improvement in Washing Machines.

COMPARISION OF VALUES BEFORE AND AFTER THE IMPROVEMENT IN THE WASHING MACHINES

The amount of dust particles of the machined part before and after the improvement in the washing machines are tabulated above and the comparison of minimum values ,maximum values, range, Cpk values are represented in the below figures.

Minimum value

The minimum weight of dust particles of the connecting rod machined parts represents the values before and after the improvement in the washing machine process. The minimum values are randomly obtained as shown in the Figure 5.

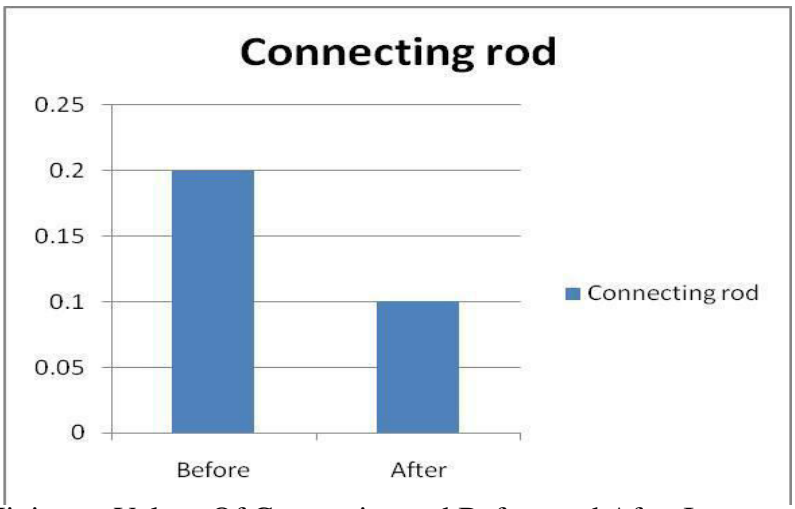

Figure. 5 .Minimum Values Of Connecting rod Before and After Improvement in

Washing Machine.

Maximum values

The maximum weight of dust particles of connecting rod machined parts represents the values before and after the improvement in the washing machine process. The maximum values are randomly obtained as shown in the Figure 6.

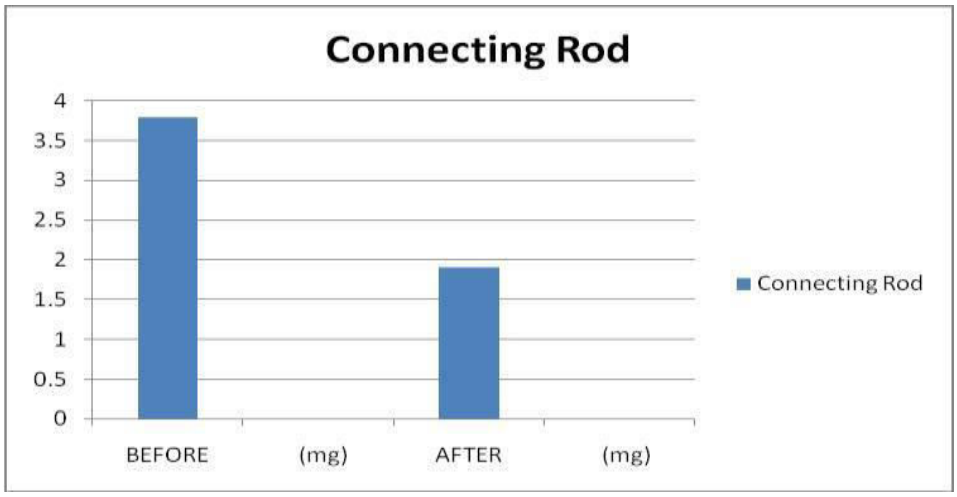

Figure 6: Maximum Values Obtained Before and After Improvement in Washing Machine.

Range Values

The weight of dust particles of connecting rod machined parts represents the range values before and after the improvement in the washing machine process. The range values are randomly obtained as shown in the Figure 7.

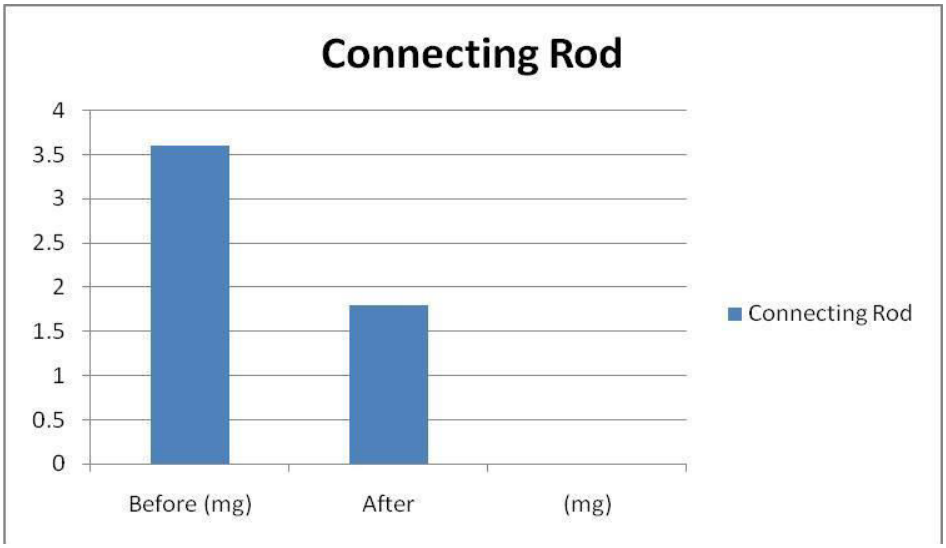

Figure. 7 .Range Values Of Connecting rod Before and After Improvement in

Washing Machines.

Cpk values

The weight of dust particles of the connecting rod machined parts represents the Cpk values before and after the improvement in the washing machine process. The Cpk values are randomly obtained as shown in the Figure 8.

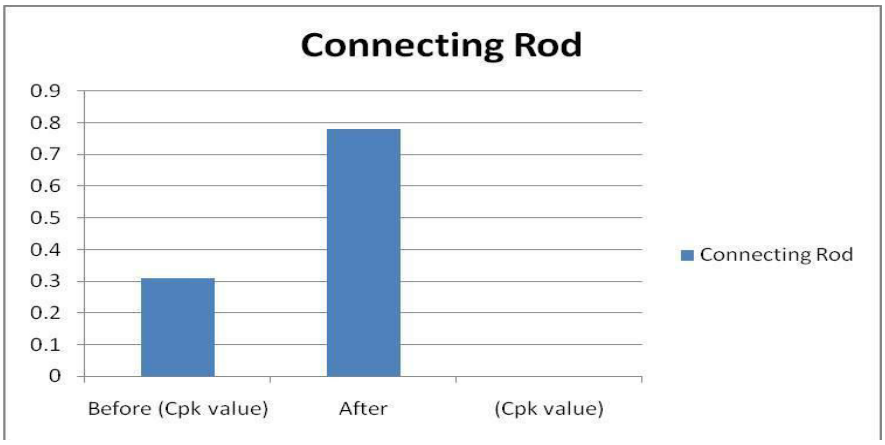

Figure. 8 .CpK Values Of Connecting rod Before and After Improvement in Washing Machines.

DISCUSSIONS

At present Millipore test is done only for one part per shift because of this the amount of dust particles are present in the machined parts as the other parts are not tested which leads to the leakage in the assembly part. In order to avoid the large amount of dust particles in the machined part the Millipore test has to be conducted thoroughly. And a standardized process is followed to reduce the amount of dust particles in the machined part by cleaning the machined part as shown in the Figure 9.

Diagram

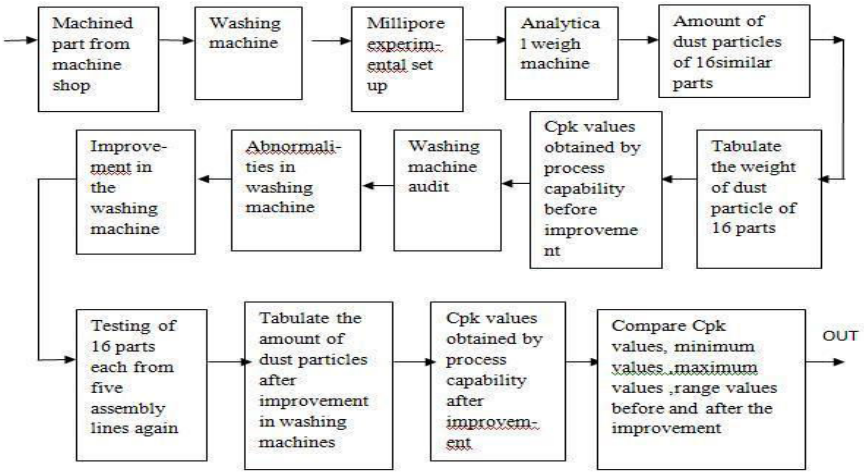

Figure 9 The Standardised Process to reduce the amount of dust particles in the machined part.

In the standardized process the Millipore test is conducted thoroughly for different machined parts of 16 parts and the amount of dust particles are tabulated which gives the process capability chart and run chart in which Cpk is obtained. The obtained Cpk value is less to increase the Cpk value the washing machines are audited to detect abnormalities and get rectified. Later again the machined parts are taken for Millipore test in which Cpk value is increased than before. Thus the continuous improvements of washing machines are necessary to improve the washing machine performance and to increase the Cpk value up to the 1.33 to satisfy the customer.

CONCLUSION

The connecting rod of 16 parts belongs to Compressor and Braking System-1assembly line from the machine shop is taken for Millipore test to calculate the amount of dust particles present in the machined part per shift. In which only one part each from machine shop is taken for Millipore test and the other parts are not taken for testing which leads to the leakage in the assembly part and the rejection of part from the customer. So in order to reduce the amount of dust particles in the machined part the standardized process is followed in such a way that the machined parts of machine shop each of 16 parts belongs to assembly line are taken for Millipore test and the values obtained by Millipore test is given in the Minitab in which the process capability chart and run chart is generated and the Cpk value which is given by process capability chart plays a very important role to improve the cleanliness of the component. The Cpk value is taken before and after the improvement in the washing machines by testing the machined parts and the Cpk value is increased after the improvement in the washing machines the cleanliness of the component is improved. Thus the amount of dust particles in the machined part is reduced by this the rejection components are reduced to from 2% to 0.5% which satisfies customer requirement.

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