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A Case Study On Process Capability Of Crankshaft In The Assembly Line

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Abstract: This paper presents the improvement in the cleanliness of the machine part of the crankshaft in the machine shop which belongs to the value stream of the compressor and braking system. The machined parts of the crankshaft are taken for the Millipore test to calculate the amount of dust particles present in the machined part. The values obtained from the Millipore test are taken for processcapability analysis through which the process capability index value is less thanthe 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 the Millipore test which results in a process capability index value increased than before.

***Index Terms* - Machined Crank shaft, Process Capability, Millipore Test.**

1.INTRODUCTION

This project deals with a Study on the Process Capability of a Crankshaft In an Assembly Line which belongs to the braking system of an automobile vehicle, in which the Crankshaft is the component taken from the compressor and Braking System-1 to detect the number of dust particles present in the crankshaft in order to reduce theleakage of the braking system and to avoid the road accidents of the automobile. The crankshafts of 16 parts are taken from the machine shop and assembly line for the Millipore test to detect the number of dust particles present in the components. The Millipore values of 16 parts of the crankshaft are taken and placed in the process capability through which the 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, to improve the Cpk value, washing machines are introduced which are used for washing the crank shaft an audit is done on the washing process and the abnormalities are identified and rectified. The crankshafts are taken for washing machines to avoid the dust particles in the crankshafts 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.

2. 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 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 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 explains that A process capability index is a measure relating the actual performance of a process to its specified performance, where processes are 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 withinthe 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.

3. METHODOLOGY

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

Washing machines are used to remove dust particles from the part. The washing machines were audited as per the 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 1. Operation Standard Sheet

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

Table 2. Quality control process chart

Parameter	Specification	Check method	Check frequency
Air pressure	5-7 bar	Visual pressure guage	Once at the start of shift
Temparature	45-50	Visual temparature indicator	Once at the start of shift
Cleaning media	Level	Visual level indicator	Once at the start of shift

Intolerance process parameters ± 10% variation allowed.

The Quality characteristics are washing effectiveness and cleanliness. Table 3. provides sample Quality characteristics and specifications of the crankshaft

Table 3. Quality Control Characteristics

Control item	Specification	Guage no	Checking frequency
Washing effectiveness	Free from oil and other foreign particles	Visual	100%
Cleanliness	<10 mg	Millipore tester	1/shift

The washing effectiveness is evaluated visually for all the parts free from oil and otherforeign 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.

3.1 Experimental Procedure

The Millipore apparatus is identified as the experimental setup for testing the Crank shaft in the organization.

Before beginning the Millipore test the tray in which machined part is placed must becleaned 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 handgun is connected to pressure pot. The machined part is placed in the tray after cleaning from washing machine. Press the handgun manually so that the isopropyl alcohol is sprayed on the machine part at the pressure of 2bar and after 10 minutes release the handgun by removing fingers on the handgun. So, the flow of alcohol from handgun 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 theweighed 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 the alcohol present onthe topthe of funnel is flown into the funnel and the dust particles are remained on the Millipore paper which is placed on the top of the 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 theMillipore paper from wet particles on the Millipore paper and fan is present in thehot oven to dry the Millipore paper. Switch off the hot oven after 10 minutes and openthe 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 machined part. Therefore, same process is repeated for 16 similar parts and the values aretabulated. Later they obtained Millipore values of 16 similar parts are taken to Minitabby 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 valuethat 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 partsare 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 andafter rectification of abnormalities of washing machines is compared.

3.2 Crankshaft Washing machines abnormalities and Improvements

Abnormalities found in the washing machines during auditing and its remedial actions are shown in Table 4.

Table 4. Abnormalities and Improvements of Washing machine

SNO	Part Name	Washing Machine Abnormalities	Action Plan	Suggestions
1	Crankshaft	Only three nozzles are working out of twelve nozzles	Coolant is flowing from all the nozzles	Nozzles has to be checked 1/shift

3.3 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 the Distance between the mean of the processand the closest specific limit. In this project, Cpk value plays a very important role in the improvement of 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 beimproved by continuous improvement in the washing machine.

4. 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 andthe 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 performing relative to the specification limits. Within capability explains how the process could perform relativeto 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 ofMillipore values that displays the data of the machined parts in a time sequence.

4.1 Process Capability and Run Chart before and After Improvements in crankshaft.

The weight of dust particles of each crank shaft of 16 parts found out from the Millipore test is tabulated in Table 5 through which process capability chart and run chart is produced. The Cpk value is obtained by process capability chart. Table 5. gives Cpk value of crank shaft before the process improvement.

Table 5. Amount of Dust Particles Present in Crank shaft before WashingMachine Improvement

USL=3.0 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	0.7	1	1.3	1.5	1.3	1.5	0.3	1.2	1.9	0.7	0.6	1.1	1	0.7	0.5	1.5

From Table 5 the actual Minimum value and Maximum value obtained in the Millipore test are 0.3 and 1.9 respectively. In above Table 5 all the values are within the range which gives the process capability chart of the crankshaft and the actual Cpk value is also obtained by process chart is 0.80 as shown in **Fig 1.** which is less than the customer requirement i.e., 1.33. So, to get the Cpk value that satisfies customer requirements the amount of dust particles in the machined parts must be reduced by improving the washing machine performance of the machined part. And the machined part must be cleaned again. And the run chart represents the observed Millipore values of 16 parts of crankshafts in sequence which is tabulated in Table 5 is shown in **Fig 1.** Using the data in Table 5 the process capability chart and Run chart were drawn as shown in **Fig 1.** and **Fig 2.**

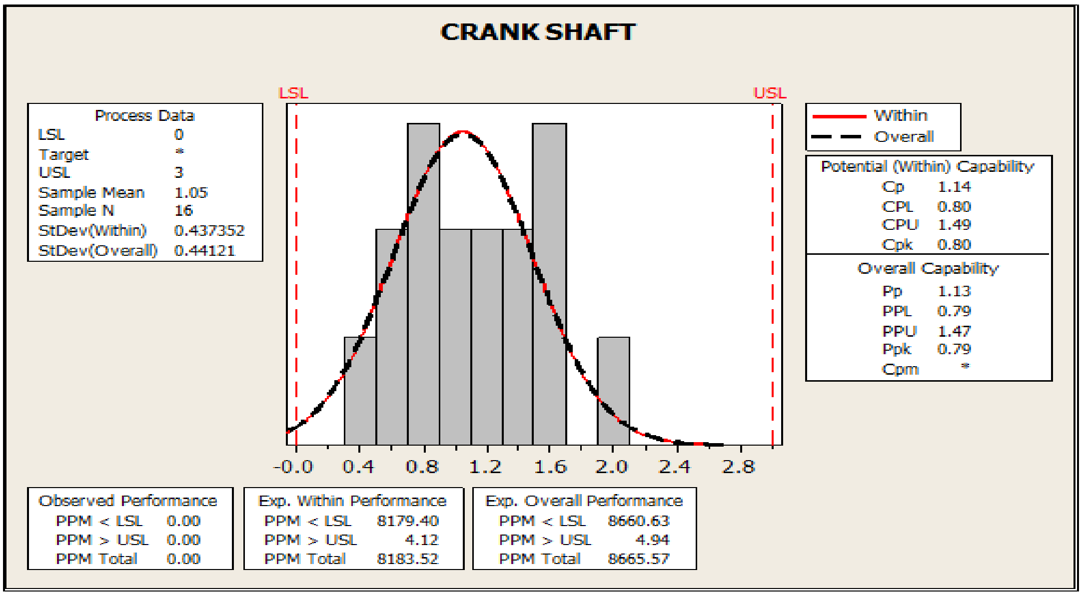

Figure 1. Process Capability of Crank Shaft Before Improvement in Washing Machines

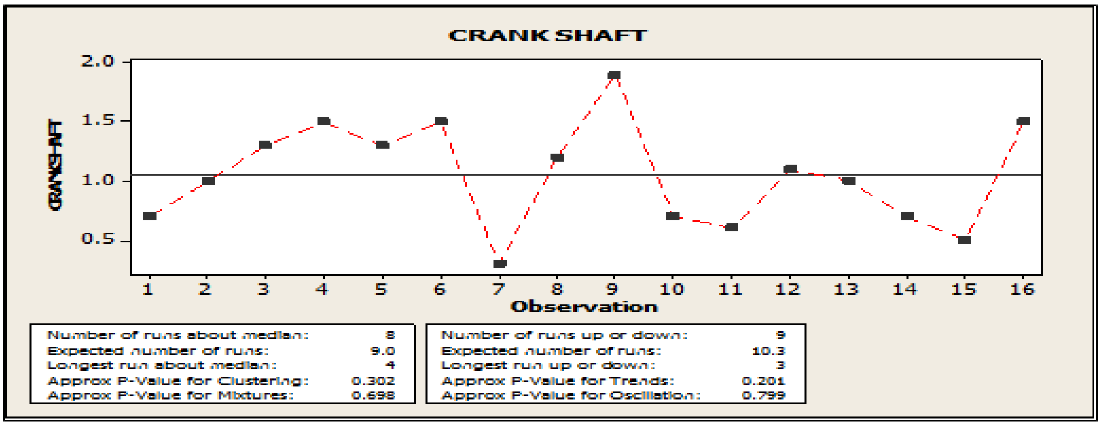

Figure 2. Run Chart of Crank Shaft Before Improvement in Washing Machines

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 centering the process on the target. And the run chart represents the observed Millipore a value of 16 parts of crank shaft in sequence which is tabulated in Table 5 is shown in Figure 2.

4.1 Process Capability After the Process Improvement in Crankshaft

The washing machines of machined parts are audited for improvement in the washing machines to detect defects in the washing machines and improve the washing machine process. So, some of the abnormalities are found in the washing machines of the crankshaft and the abnormalities got rectified. Thus, the weight of the dust particles of the crankshaft is taken after the improvement in the washing machines. The weight of the dust particles of the machined parts of each of the 16 components are tabulated in the following Table 6 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 crankshaft of 16 parts found out from the Millipore test is tabulated in Table 6 through which the process capability chart and run chart is produced. The Cpk value is obtained by the process capability chart. Table.6 gives Cpk value of the crankshaft after the process improvement.

Crankshaft

The weight of dust particles of each crankshaft of 16 parts found out from the Millipore test is tabulated in Table 6 through which the process capability chart and run chart is produced. The Cpk value is obtained by the process capability chart. Table.6. gives Cpk value of crank shaft after the process improvement.

Table 6. Amount of Dust Particles Present in Crankshaft after WashingMachine Improvement

USL=3.0 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	0.7	1.9	2.2	0.6	0.7	0.5	0.4	1.5	1.2	1.3	0.5	0.9	0.5	0.7	0.5	0.7

From Table 6. the actual Minimum value and Maximum value obtained in Millipore test are 0.4 and 2.2 respectively. It is found that the values are within the range. Using this data process capability chart and Run chart were drawn as shown in **Fig 3**. The Cpk value obtained by the process capability chart of the crankshaft after the improvement is 0.5 which is less than the Cpk value of the crankshaft before improvement. And the Cpk value after the improvement in washing machines is 0.5 which 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 chart represent the observed Millipore values of 16 parts of crank shaft in sequence which is tabulated in Table 6 is shown in **Fig 3.** Using this data process capability chart and Run chart were drawn as shown in **Fig 3** and **Fig 4.**

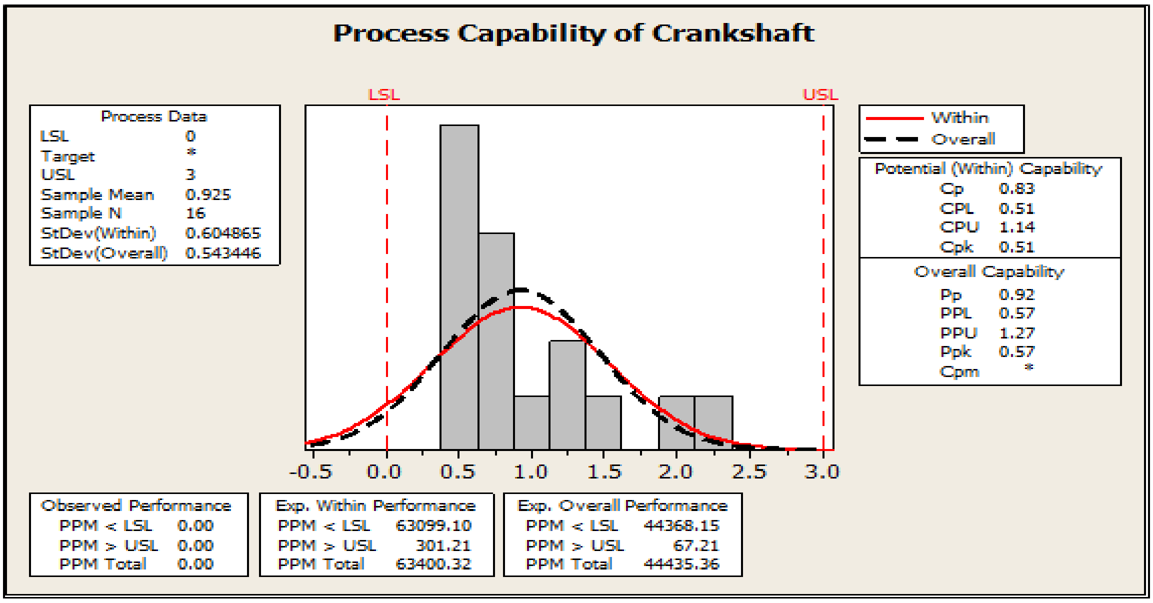

Figure 3. Process Capability of Crank Shaft After Improvement in Washing Machines

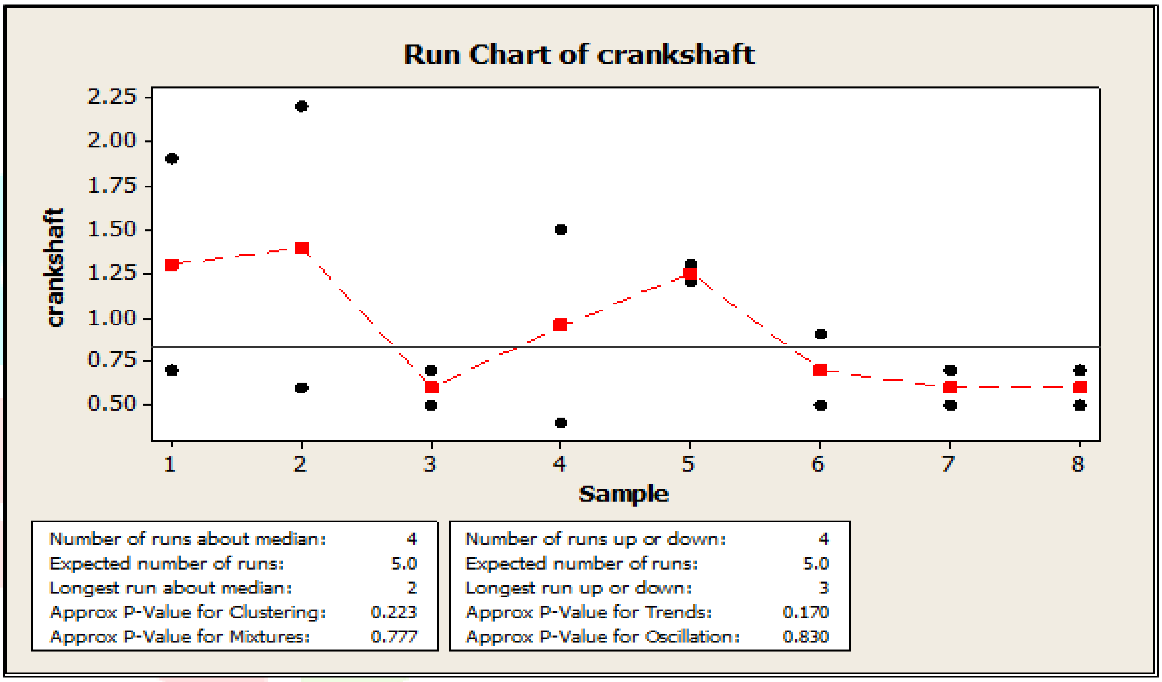

Figure 4. Run chart of Crankshaft after After Improvement in Washing Machines

4.2 Comparison of Values Before and After the Improvement in Washing Machines

The amount of dust particles of the machined part before and after the improvement inthe 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 crank shaft machined parts represents the values before and after the improvement in the washing machineprocess. The minimum values are randomly obtained as shown in **Fig 5**.

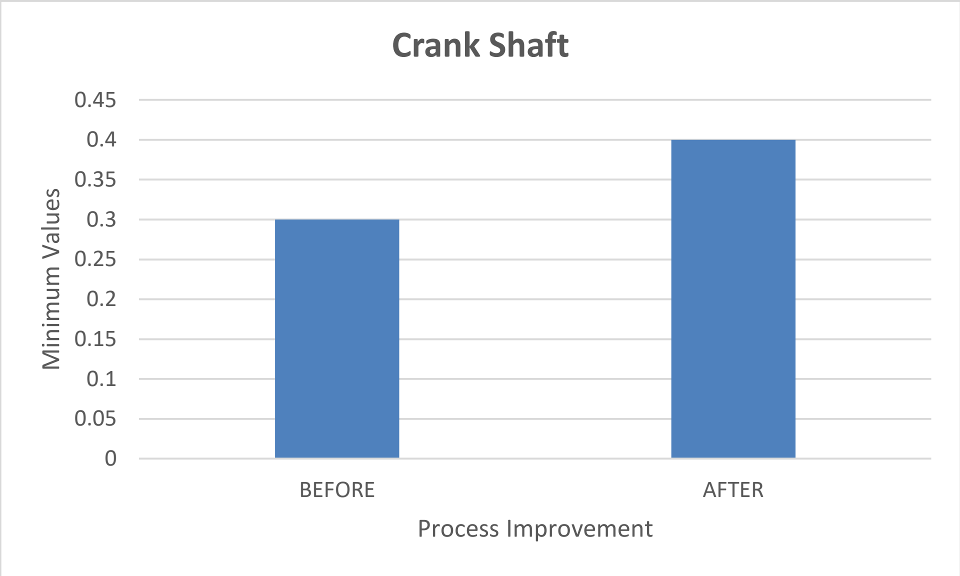

Figure 5. Minimum Values of Crank shaft Before and After Improvement in Washing Machine.

Maximum Values:

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

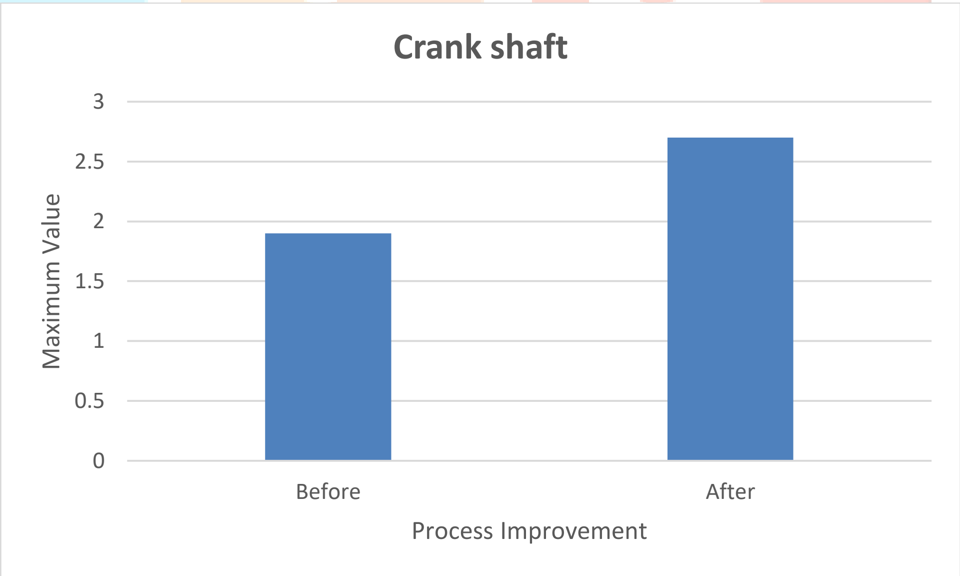

Figure 6. Maximum Values Obtained Before and After Improvement inWashing Machine.

Range Values:

The weight of dust particles of crankshaft 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 **Fig 7**.

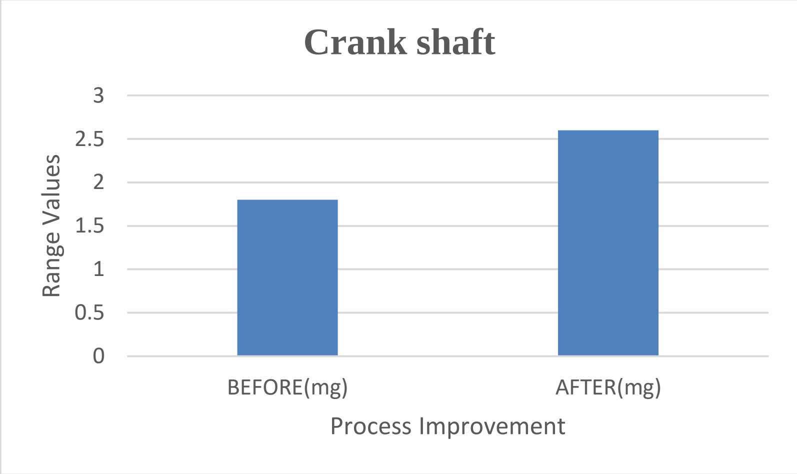

Figure. 7. Range Values of Crank shaft Before and After Improvement in Washing Machines

Cpk values:

The weight of dust particles of the crank shaft 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 **Fig 8.**

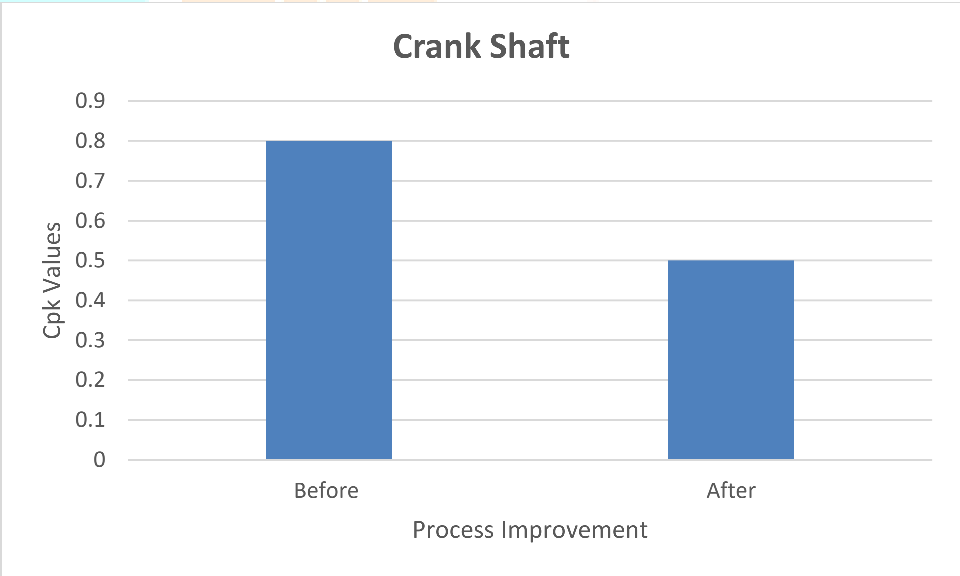

Figure. 8. CpK Values of Crank shaft Before and After Improvement in WashingMachines.

4.3 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. 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 **Fig 9**.

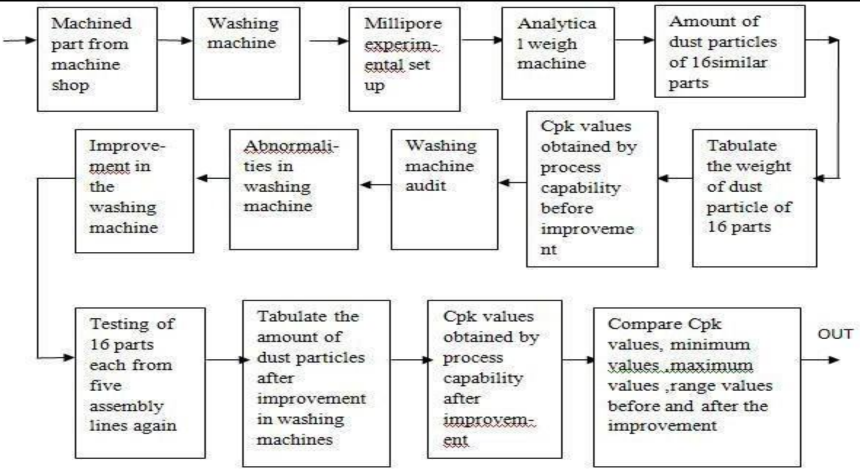

Figure. 9. The Standardized Process to reduce the amount of dust particles in the machined part.

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 Milliporetest in which Cpk value is increased than before. Thus, the continuous improvementsof washing machines are necessary to improve the washing machine performance andto increase the Cpk value up to the 1.33 to satisfy the customer.

5. CONCLUSION

The crank shaft 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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