Analysing the Process Capability of Carburettor Manufacturing

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Abstract: **Process capability is the ability of the process to meet the desired specifications. The capability analysis defines how the product specifications are compared with the inherent variability in a process. Controlling for quality is the major priority for the manufacturing companies in today's competitive world. The accuracy of machined parts is the result of properties and characteristics of the total machining system and its environment. For this purpose statistical process control (SPC) is a very effective tool. The aim of present study is to analyse the process capability of carburettor manufacturing and to find out the root cause for variability in process and machining parameters. The main function of a carburettor is to provide the air-fuel mixture to the engine. The main jets of carburettor that supply fuel to combustion chamber are the pilot jet, needle jet and main jet. The machining data is taken for the pilot jet, needle jet and needle jet clearance. Process capability analysis is done with the help of MINITAB 16 and the results are shown in the form of graphs. It was observed that the process capability indices were less than 1.33 for the measured dimensions of the carburettor which shows that the process is adequate and some improvements can be done. The possible reason for the deviation seems to be the machining parameters like over life use of tools, improper cooling. The tools use are over life and a slight delay in replacing them can cause such variation. Another important reason is the coolant used its life and filtration system of coolant.**

Keywords: Cause and Effect diagram, Control Charts, Process Capability, Process Capability Indices.

1. INTRODUCTION

Controlling and improving quality has nowadays become the most important business strategy for every organization including manufacturers, transportation companies, finance organizations, healthcare and government agencies. A business can dominate its competitors only when can give better quality to its customers. Many methods have evolved in the recent decades that help us in controlling the quality and also speed up the manufacturing process,one of which is six sigma. In the six sigma quality methodology, process performance is reported to the organization at a sigma level. The higher the sigma level, the better the process is performing [1]. Another way to report process performance is through the statistical measurements of process capability indices, i.e. Cp, Cpm, Cpk, etc. Higher the process capability indices higher will be the sigma level [2, 3]. Which was once started as quality inspection of the finished products for defective units followed by scrapping or reworking?Now it has been evolved as a quality management tool covers actions for quality improvement after production as well as before and during production[3, 4]. As industrialists started to realize the high costs direct and indirect costs of quality defects and feel the ever growing pressure of customer demand and expectations, quality improvements become crucial for survival and to keep their competitive edges [4, 5].

A steady process, in general is a process of which all the causes of variations are known and are acted upon and the process is then ruled by common causes of variations, where the output of the process is fairly expectable. Management decision requires to further increase the capability of the process [8].

In the theory of probability and statistics, the normal distribution or Gaussian distribution is a continuous probability distribution that describes data that groups around a mean. The graph of the related probability density function is normal with a peak at the mean, and is known as the “Gaussian function” or bell shapedcurve [7, 8, 9].

It is very important to note that it may be possible that data collected is not normally distributed still we are getting a bell shaped graph. For such conditions we shod concentrate on the C_p, C_{pk}, and C_{pm}. Others graphs such as X bar, R, normal probability graphs are also useful.

The main objective of this study was to analyse the process capability and find out the causes of variability in the machining process of a carburettor which were detected during its testing. Defects in the carburettor were detected during the gasoline test.

Following are the steps which were followed to complete the present work:

- Collection of machining data as well as dimensions of the product.
- Analysis of observed data and calculations of the process capability indices.
- Comparison of calculated data with the dimension provide by the product drawing.
- Formation of root cause diagram to find out the causes of defects.
- Suggestions for the improvement of the process.

2. PROCESS CAPABILITY

Process Capability is the measure of the ability of the process to meet the specified value. The capability analysis defines how the product specifications are compared with the inherent variability in a process. The inherent variability of the process is the part of process variation due to some common causes. Another reason for process variability is the special causes of variation associated with every manufacturing process. As it is very difficult to eliminate the process variation totally, variability in a process can be minimized to improve product quality. Process capability analysis is a technique used to understand the variability of a process and its effect on the product manufacturing and its performance. Process capability analysis is a significant tool in engineering decision-making and has a number of applications in different areas. For example reducing variability in a manufacturing process, as a criterion for vendor selection, specifying process requirements for new equipment or product, forecasting how well the process will hold tolerances, support product designers in choosing or modifying a process and formulating quality improvement programs. Quality of the manufactured goods has improved by the manufacturers using process capability techniques. To make inferences about the capability of processes various indices are used.Table 1 shows some of the process capability indices and their usage.

Table 1 : Process capability indices equations and their usage

Index	Estimation	EquationUsage
C_p	$C_p = \frac{\text{USL} - \text{LSL}}{6\sigma}$	It estimates that the process is capable of producing if the process mean is centered between the specification limits.
C_{pm}	$C_{pm} = \frac{C_p}{\sqrt{1 + (\frac{\bar{\bar{X}} - T}{\sigma})^2}}$	It gives estimated process capability about a target T, always greater than zero. It adoptsthat process output is normally distributed. C_{pm} is also known as the Taguchi capability index
C_{pl}	$C_{pl} = \frac{\text{LSL} - \bar{\bar{X}}}{3\sigma}$	It estimates process capability for specifications that consist of a lower limit only.
C_{pu}	$C_{pu} = \frac{\text{USL} - \bar{\bar{X}}}{3\sigma}$	It estimates process capability for specifications consisting of an upper limit only.
C_{pmk}	$C_{pmk} = \frac{C_{pk}}{\sqrt{1 + (\frac{\bar{\bar{X}} - T}{\sigma})^2}}$	It estimates process capability around a target T and accounts for an off-cantered process mean

By process capability study it is possible to establish best quality standards for the current process and further improvement will so possible. Following precautions are necessary during the process capability study [6].

- Process should be in statistical control.
- To make control charts, limits must be well defined.

3. METHODOLOGY

The adopted methodology for the present study is shown in Figure 1. A data collection sheet was used to collect the machining data during the process and the collected data was analysed using statistical software MINITAB 16.0. On the basis of calculated Process capability Indices (PCIs), capability of process was judged.

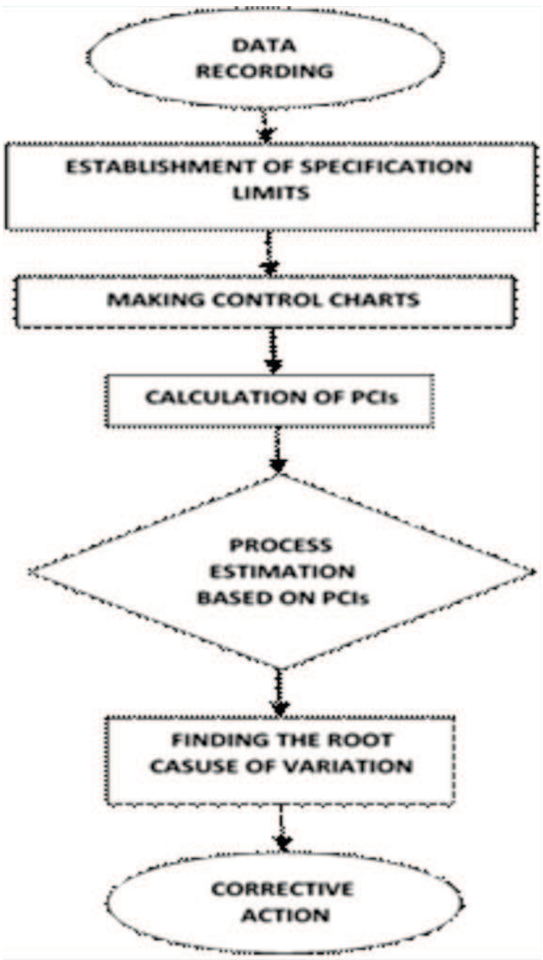

Figure 1: Research Methodology Flow Chart

Machining process data of components was collected from vertical milling machine Fanuc Sugino V8. Before the machining process the material has to pass through several processes. This is because the part which is to be machined is outsourced. At the stage of final testing, the products are fully assembled. The testing is done at two stages. In the first stage the product is checked for their dimensions. This is a stage, where the product is not fully assembled. The final test is done by conducting gasoline test which provides the performance of the product. As state earlier we have used MINITAB 16 for calculating the process capability of the product. Process capability analysis is done for gasoline test first. If the component is failed in gasoline test,(i. e. process capability indices areless than 1.33) the capability test is done for other specifications.

4. OBSERVATIONS AND CALCULATIONS

Table 2 shows the data for jet specification and BPP1. This data is further used to determine the PCIs to make inference about process capability. The data shows that there are some values beyond specification limits (shades values in Table 2).

Table 2 : Data for jet specification and BPP1

S. No	Depth of needle jet	Depth of pilot jet	Needle jet clearance	BPP1
	40.30± 0.05 mm	36.50± 0.05 mm	3.0± 0.03 mm	0.391± 0.05 mm
1	40.24	36.48	3.03	0.360
2	40.23	36.481	3.028	0.356
3	40.23	36.431	3.027	0.383
4	40.33	36.481	3.028	0.364
5	40.32	36.48	3.026	0.383
6	40.32	36.482	3.03	0.357
7	40.36	36.485	3.029	0.370
8	40.24	36.481	3.021	0.375
9	40.24	36.482	3.024	0.348
10	40.32	36.481	3.028	0.354
11	40.33	36.481	3.026	0.354
12	40.32	36.482	3.03	0.375
13	40.32	36.481	3.028	0.360
14	40.32	36.479	3.031	0.400
15	40.40	36.482	3.031	0.341
16	40.23	36.485	3.028	0.360
17	40.36	36.43	3.026	0.383
18	40.36	36.482	3.03	0.360
19	40.23	36.481	3.028	0.348
20	40.32	36.481	3.031	0.354
21	40.32	36.481	3.03	0.354
22	40.32	36.430	2.97	0.339
23	40.24	36.481	3.028	0.360
24	40.36	36.48	3.031	0.383
25	40.36	36.482	2.99	0.360

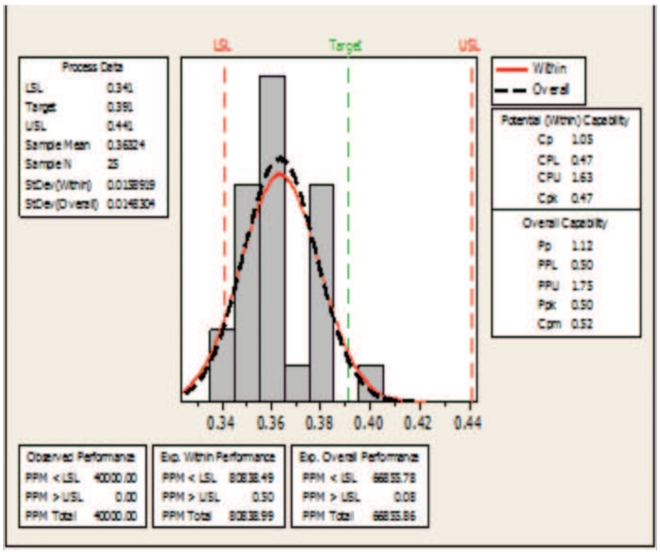

Figure 2 : Process capability for gasoline test

Figure 2 shows the process capability analysis of gasoline test. The result shows that all PCIs including C_p, C_{pk} and C_{pm} are less than 1.33. Hence the further calculation of PCIs for machining data is required.

Figure 3 shows an overall picture of process capability for BPP 1 data. Figure shows that the process is under statistical control and to make it more capable an effort must be immediately made to improve it.

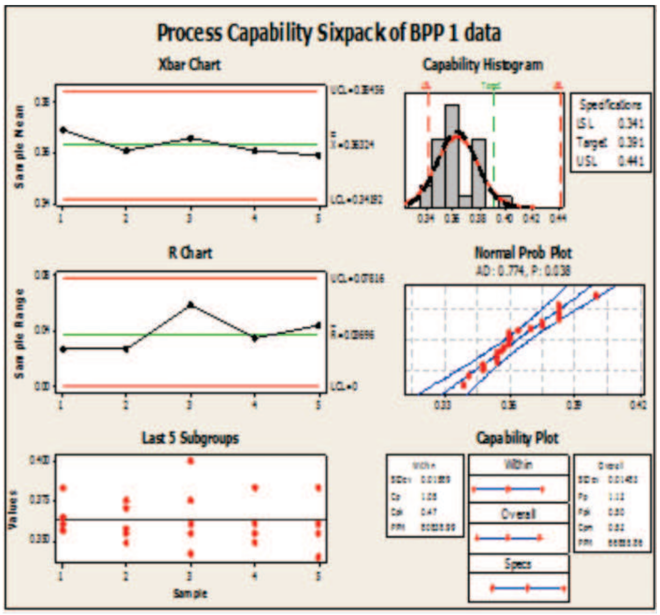

Figure 3 : Process capability six pack for BPP 1 data

Figure 4 show the process capability analysis of needle jet. As per the analysis the values of PCIsCp, Cpk and Cpm are less than 1.33.

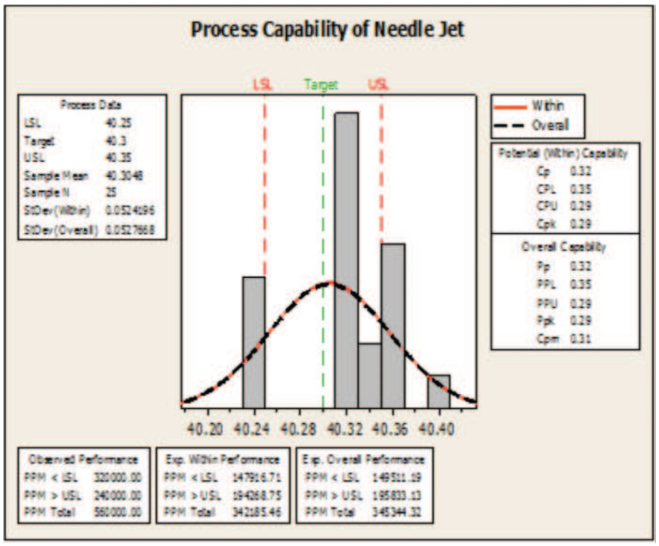

Figure 4 : Process capability for needle jet

Again the X-bar and R chart in Figure 7 show that the process is under statistical control and to make it more capable an effort must be immediately made to improve it.

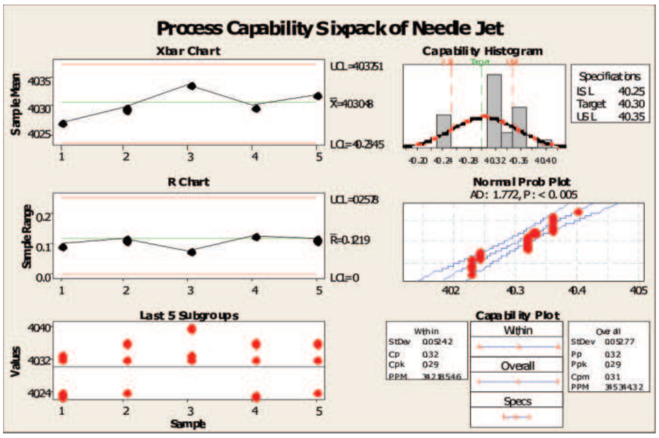

Figure 5: Process capability six pack for needle jet

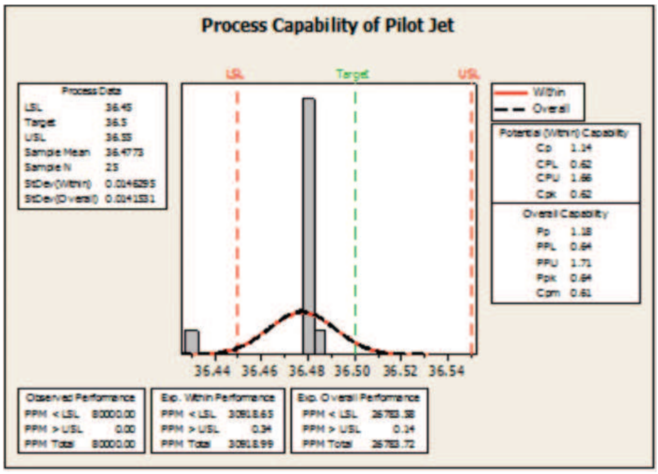

Figure 6: Process capability for pilot jet

Figure 5 and 6 shows the process capability analysis of Pilot jet and results shows that C_p, C_{pk} and C_{pm} are less than 1.33 as shown in Table 3.

Table 3: Result of process capability for pilot jet

Target	USL	LSL	C_p	C_{pk}	C_{pm}
36.5mm	36.55mm	36.45 mm	1.14	0.62	0.61

X bar and R chart in Figure 7 shows that the process is under statistical control and to make it capable an effort must be immediately made to improve it.

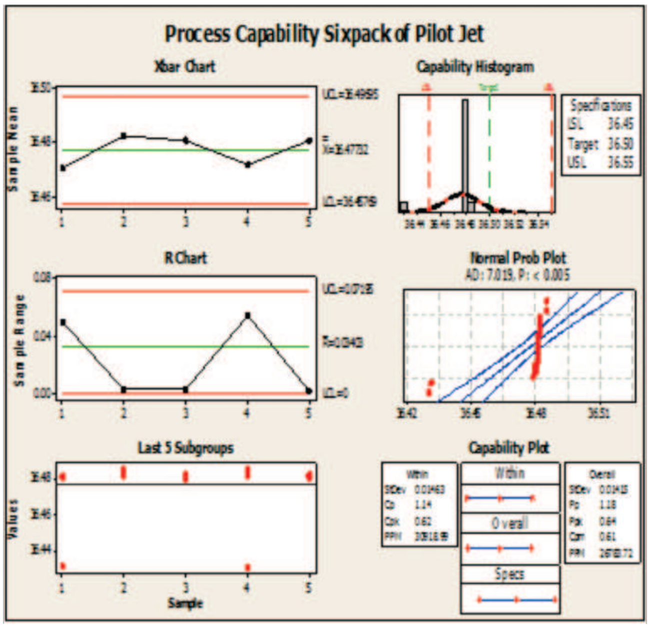

Figure 7: Process capability six pack of pilot Jet

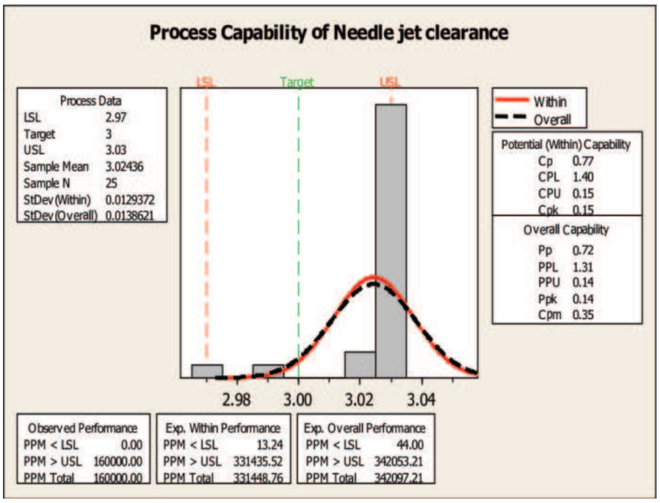

Figure 8: Process capability of needle jet clearance

Figure 8 and 9 shows the process capability analysis of Needle jet clearance and results shows results shows that C_p, C_{pk} and Cpm are less than 1.33 as shown in Table 4.

Table 4: Result of process capability of needle jet clearance

Target	USL	LSL	C_p	C_{pk}	C_{pm}
3.0 mm	3.03 mm	2.97 mm	0.77	0.15	0.35

X-bar and R chart in Figure 9 show that the process is under statistical control and to make it capable an effort must be immediately made to improve it.

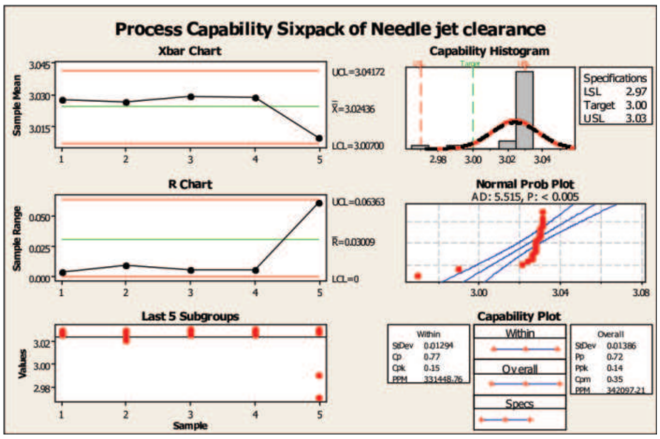

Figure 9: Process capability six pack of needle jet clearance

5. RESULT AND CONCLUSION

Capability analysis helps to determine the ability of manufacturing process between tolerance limits and engineering specifications. I the present study process is within statistical control but incapable of meeting up to specification. From the analysis it can be concluded that during the process capability indices calculation C_p, C_{pk} and C_{pm} are below 1.33 which indicates that the product is not within the specific limits. From the results it can be observed that for fuel consumption at ideal speed, process capability indices are C_p=0.51, C_{pk}=0.40, C_{pm}=0.42, for fuel consumption at 20 km/h C_p=0.83, C_{pk}=0.69, C_{pm}=0.70, for fuel consumption at 40 km/h C_p=0.64, C_{pk}=0.12, C_{pm}=0.24, for fuel consumption at 50 km/h C_p=0.91, C_{pk}=0.29, C_{pm}=0.40. Process capability indicescalculated for fuel consumption at 70 km/h (C_p=1.73, C_{pk}= 0.77 and C_{pm}=0.48) has C_p greater than 1.33, but other indices are lesser.

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