Process Variability Reduction of Finish Turning Operation using Statistical Process Control

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Abstract- *The study is about process capability analysis for Flange half component spigot diameter of carrier line in order to reduce non conformance of products and process variation by identifying the defects and to improvise the process using Cp and Cpk, X-bar and R charts, histogram are used using minitab V17 software for the process. (SPC) is an important tool used widely at all fields mainly in manufacturing field to monitor the overall operation.*

Keywords- Control charts, Histogram, Process capability, Process capability index, Minitab V17, Statistical process control.

I. INTRODUCTION

Process capability study (PCS) is a systematic procedure that uses control charts to detect and eliminate the unnatural causes of variation until a state of statistical control is reached. There are several capability indices, including Cp, Cpu, Cpl, and Cpk, that have been widely used in manufacturing industry to provide common quantitative measures of process potential and performance. [1]

Kane [2] described six areas of application for capability indices: the prevention of the production of nonconforming products. The process-capability indices, including Cp and Cpk, have been proposed in manufacturing industry. Pearn et al. indicated the index of capability for monitoring the accuracy of the manufacturing process. [3]

II. QUALITY CONTROL TOOLS

Statistical process control aims to produce the products in the most economic and useful way by using statistical principles and techniques at every stage of the production.

It is used to reduce the defected products as much as possible. [4]

- Check Sheet
- Pareto Chart
- Histogram
- Scatter Diagram
- Process Flow Chart
- Cause and Effect Diagram
- Control Chart

III. OBJECTIVE

The overall objectives of this project are as follows:

a) The prevention of the production of non conforming products.
b) The continuous measure of improvement.
c) The identification of directions for improvement.

IV. METHODOLOGY

Critical parameter is taken for analyzing the capability of the process. The statistical tools are used like control charts, cause and effect diagram, process capability analysis to reduce variation and non-conforming parts.

1. Select the process on which the process analysis is to be carried out.
2. Gather all the data for analysis. (120 samples).
3. Apply the principles and processes of SPC for the chosen process
4. Utilize statistical and graphical methods to represent the process conditions.
5. Calculate the capability of the process, identifying: Cp and Cpk.

V. PROCESS CAPABILITY ANALYSIS IN FINISH TURNING OPERATION

In this study the flange half component of carrier line is selected where the application of Process Capability Analysis for the betterment of process. The work piece was cast and machined on Daewoo PUMA V15 machine.

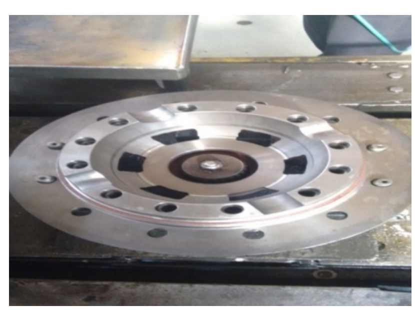


FIGURE 1: FLANGE HALF

TABLE 2: PRODUCT DESCRIPTION

Part name	Flange Half
Operation	Finish turning
Machine	DAEWOO PUMA V15
Specific Dimension	Max=250.949 mm, Min=250.879 mm
Instrument Used	Adjustable Dial Snap Gauge
Samples	120

TABLE 3: SAMPLES FOR SPIGOT DIAMETER

Sub group size	Spigot diameter					X Bar	Range
	Sample size						
	1	2	3	4	5		
1	250.903	250.906	250.911	250.915	250.922	250.911	0.019
2	250.920	250.925	250.922	250.925	250.903	250.919	0.022
3	250.915	250.921	250.920	250.900	250.920	250.915	0.021
4	250.922	250.920	250.912	250.917	250.920	250.918	0.01
5	250.917	250.919	250.920	250.915	250.920	250.918	0.005
6	250.910	250.920	250.922	250.924	250.920	250.919	0.014
7	250.922	250.926	250.921	250.920	250.917	250.921	0.009
8	250.919	250.921	250.915	250.916	250.918	250.918	0.006
9	250.920	250.922	250.924	250.921	250.919	250.921	0.005
10	250.917	250.915	250.913	250.911	250.915	250.914	0.006
11	250.907	250.910	250.912	250.920	250.917	250.913	0.013
12	250.911	250.922	250.924	250.921	250.919	250.919	0.013
13	250.917	250.916	250.914	250.912	250.916	250.915	0.005
14	250.909	250.913	250.912	250.910	250.911	250.911	0.004
15	250.913	250.920	250.915	250.923	250.919	250.918	0.01
16	250.920	250.921	250.923	250.925	250.922	250.922	0.005
17	250.916	250.923	250.920	250.919	250.917	250.919	0.007
18	250.915	250.917	250.919	250.921	250.919	250.918	0.006
19	250.915	250.920	250.911	250.915	250.920	250.916	0.009
20	250.913	250.922	250.915	250.918	250.922	250.918	0.009
21	250.920	250.921	250.920	250.922	250.915	250.920	0.007
22	250.921	250.915	250.923	250.910	250.919	250.918	0.013
23	250.917	250.923	250.918	250.912	250.910	250.916	0.013
24	250.918	250.915	250.923	250.919	250.920	250.919	0.008
Average						250.917	0.009

TABLE 4: STANDARD VALUES FROM STATISTICAL TABLE

Sample	D2	A2	D4
1	1.123	2.560	3.270
2	1.128	1.880	3.270
3	1.693	1.020	2.570
4	2.059	0.730	2.230
5	2.326	0.590	2.110

TABLE 5: TEST OF NORMALITY FOR SPIGOT DIAMETER

Tests of Normality	
	p value
Spigot diameter	0.949

* 5% level of significance

From the above table the test of normality using D'Agostino-Pearson omnibus test statistic was conducted from Minitab software V17 for spigot diameter of flange half at 5% signification level (P-value) for 120 samples and the observed values for spigot diameter is 0.949 which is greater than the p-value 0.05 which implies that the data is distributed normally.

VI. CALCULATIONS

Spigot diameter: Theoretical

Sample size n= 5

Group size N= 24

Mean $\bar{\bar{X}} = \frac{\sum \bar{X}}{N}$

$$= \frac{6022\ .02}{24} = 250.917 \text{ mm}$$

Range $\bar{R} = \frac{\sum R}{N}$

$$= \frac{0.239}{24} = 0.0099 \text{ mm}$$

Control Charts:

Computations for $\bar{X}$ Chart:

Upper control limit = $\bar{\bar{X}} + A_2 * \bar{R}$

= 250.917+0.590*0.0099 (A_2 is taken from statistical table)

= 250.923 mm

Lower control limit = $\bar{\bar{X}} - A_2 * \bar{R}$

=250.917-0.590*0.0099 = 250.911 mm

Computations for R Chart:

Upper control limit = $D_4 * \bar{R}$

= 2.11* 0.0099 (D_4 is taken from statistical table)

= 0.023 mm

Lower control limit = $D_3 * \bar{R}$

= 0*0.0099

= 0

Standard deviation (σ):

$$\sigma = \frac{\overline{R}}{d_2}$$

$$= \frac{0.0099}{2.326}$$

$$= 0.0042$$

Process Potential (C_p):

$$C_p = \frac{USL - LSL}{6 * \sigma}$$

$$= \frac{250.949 - 250.879}{6 * 0.0042}$$

$$C_p = 2.72$$

Upper Capability Index (Cpu):

$$C_{pu} = \frac{USL - \overline{\overline{X}}}{3\sigma}$$

$$= \frac{250.949 - 250.917}{3 * 0.0042}$$

$$= 2.49$$

Lower capability Index (Cpl):

$$C_{pl} = \frac{\overline{\overline{X}} - LSL}{3\sigma}$$

$$= \frac{250.917 - 250.879}{3 * 0.0042}$$

$$= 3.04$$

Process capability index (C_{pk}):

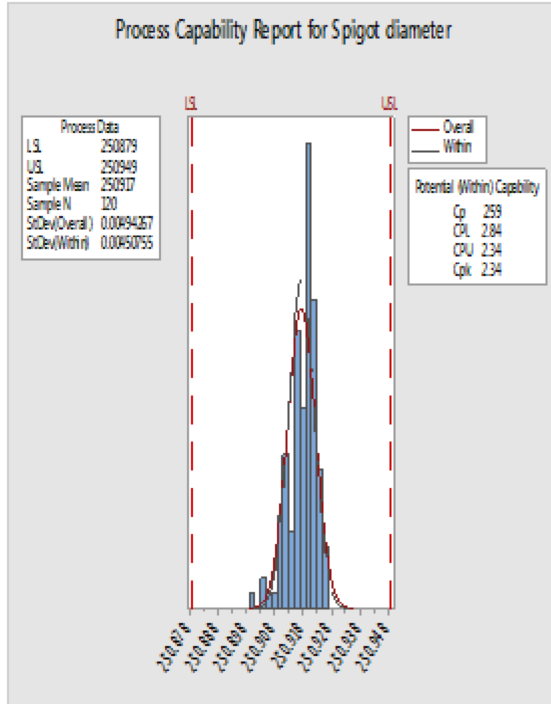
$$C_{pk} = \text{Min}\left[\frac{USL - \overline{\overline{X}}}{3 * \sigma}, \frac{\overline{\overline{X}} - LSL}{3 * \sigma}\right]$$

$$\left[\frac{250.949 - 250.917}{3 * 0.0042}, \frac{250.917 - 250.879}{3 * 0.0042}\right]$$

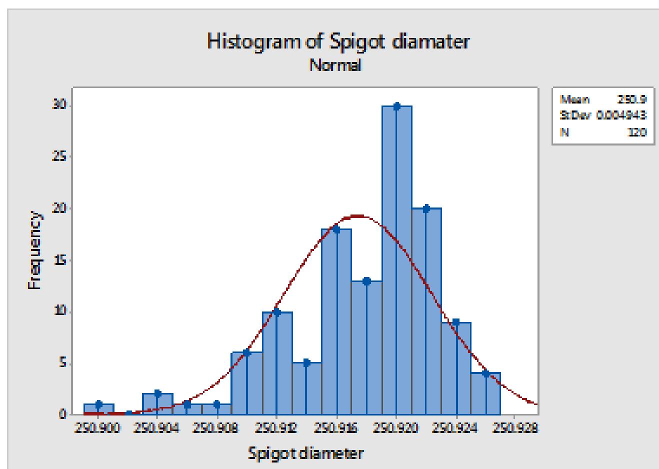
$$= \text{Min}\ [2.49, 3.04]$$

$$C_{pk} = 2.49$$

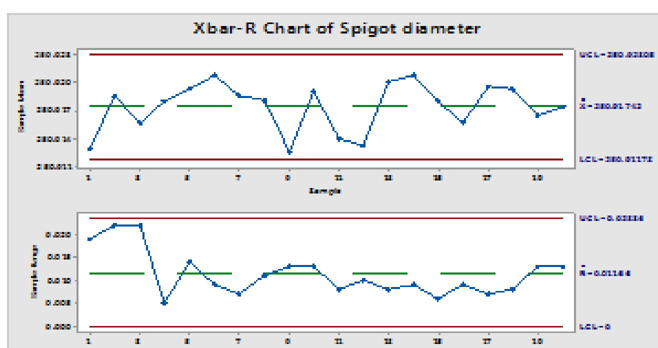
Using software MINITAB V17



GRAPH 1: PROCESS CAPABILITY OF SPIGOT DIAMETER



GRAPH 2: HISTOGRAM OF SPIGOT DIAMETER



GRAPH 3: X BAR-R CHART OF SPIGOT DIAMETER

From the histogram we see that the observations are normally distributed. By MINITAB V17 software we see that process capability report shows the value of C_{pk} = 2.34 and the theoretical value of C_{pk} = 2.49. C_{pk} Value is greater than 1.33 and the process is capable to carry the operation.

From X-bar Control charts we see the points are within control limits where upper control limit (UCL) = 250.923, control limit (CL) = 250.917 and lower control limit (LCL) = 250.911, and in R chart upper control limit (UCL) = 0.023, control limit (CL) = 0.011 and lower control limit (LCL) = 0.This indicates the process is under control to carry the operation.

VII. CONCLUSION

The process-capability analysis helps to determine the ability for manufacturing between tolerance limits and engineering specifications. In this study, X-bar and R control charts are implemented to achieve a good control over the process. SPC technique was used to evaluate machine capability (Cp) and process centering (Cpk) of manufacturing process to find whether the process is capable or not. The Cpk value for spigot diameter of Flange half component is 2.34 which is greater than 1.33 hence the process is capable to carry the operation.

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