Minitab Case Study
Process Capability Analysis at a Manufacturing Company

INTRODUCTION

This case study explores a six-sigma project implemented by a production manager at a manufacturing firm, producing a pivotal automobile part. This part finds its application in vehicles manufactured by three leading automobile companies. The main aim of the project is to improve the capability of the manufacturing process.

The following are the process capability ratios:

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

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

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

$$C_{pk} = \{C_{pl}, C_{pu}\}$$

Where,

USL = Upper specification limit
LSL = Lower specification limit
µ = Process mean
σ = Process standard deviation

From the above capability ratios, if the values of e Cp and Cpk are high, then the process is better. We will be following the DMAIC approach to solve this case study and improve process capability.

DEFINE

The production manager wants to increase the process capability for the current manufacturing process. The Upper Specification Limit (USL) for the part diameter is set at 60 units and the Lower Specification Limit (LSL) for the part diameter is set at 50 units.
The core challenge is to increase the Cp and Cpk values. These metrics are pivotal in assessing the capability of a process. Higher values signify a more competent and consistent process

MEASURE

A total of 20 samples are collected, each sample containing 5 different parts. The diameters of these parts are accurately measured as shown in the table below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
52.9	54.3	49.3	55.9	54.5	60.7	57.7	54.6	52.7	55.7	53.8	54.4	55.8	56	54.1	57.2	54.3	52.1	55	53.6
55	55.7	53.4	51.9	58.8	53.2	52.6	56	54.5	55.9	55.7	55	54.8	53.3	53.4	55.6	54.4	53.2	54.4	55.4
55.5	55.9	52.7	56.2	54.4	56.2	54.6	53	51.3	52.9	51.7	56.2	53.2	53.8	54.4	56	54.1	52.4	54.5	56.9
54.1	58.1	51.1	55.1	56.1	54.2	55.7	56.4	55.7	53.9	52.1	54	57	56.7	53.7	52	52.6	54.4	57.1	53.1
55.9	55.1	56.5	53	57.3	54.9	54.8	51.4	52.5	59.1	56.8	53.7	56.7	55.7	57.4	57.8	51.8	52.3	52.7	53.4

Fig 1: Production Data before Process Improvement

Next, we check if our data is well-modeled by a normal distribution using a Normality test. That can be performed in Minitab by following the steps Stat > Basic Statistics > Normality Test. In the Normality test tab, select Anderson-Darling test and enter the title and variable accordingly. We will get the following Q-Q plot.

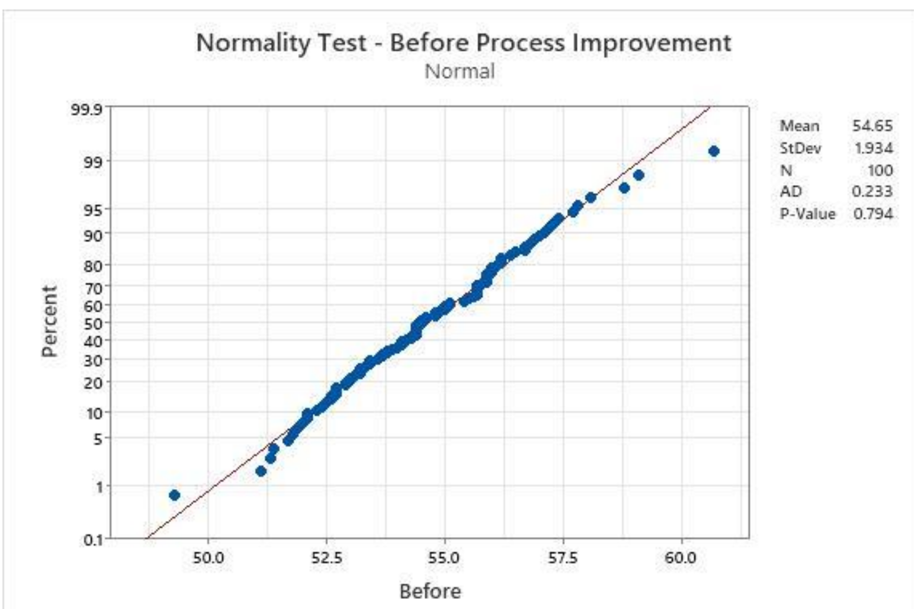

Fig 2: Normality test result before process improvement

The test indicates a P-Value of 0.794, which is >0.05, suggesting that the data does not significantly deviate from a normal distribution and that the that the process data are normally distributed.

For us to check whether the data is in statistical control, we need to transpose the data to have each sample in a single row. This is done and saved in a new worksheet. Since the data is variable with a sample size of 5, the appropriate control charts for us to construct are the X bar and R charts. To construct the R chart for data before process improvement, we will have to go to Stat > Control Charts > Variable Charts for Subgroups > R. Select "Observations for a subgroup are in one row of columns" from the drop-down menu and enter Product 1 – Product 5 to plot R Chart for all samples.

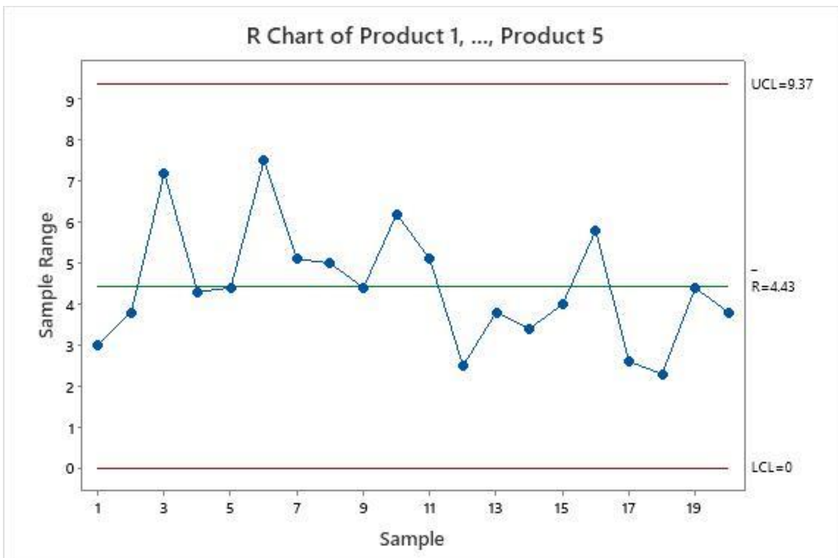

Fig 3: R chart before process improvement

Similar to constructing R charts, select Xbar to construct X Bar chart for the samples. The selections are similar to the one done for R chart. The corresponding X bar chart is given below.

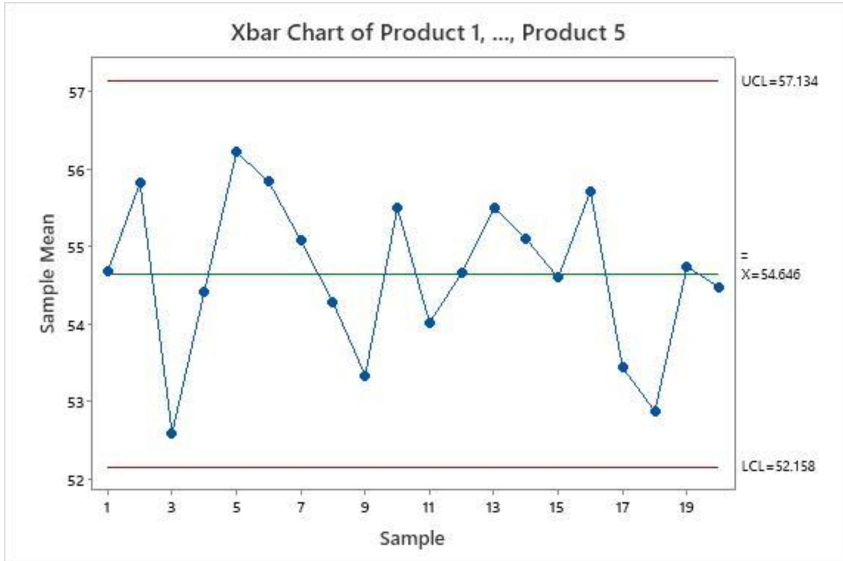

Fig 4: X bar chart before process improvement.

The sample ranges are in statistical control for the R chart. The sample means are also in statistical control. As the process data are normally distributed and are in statistical control, now we can calculate the process capability ratios. This can be done by going to Stat > Quality Tools > Capability Analysis > Normal. Select the respective rows and the Upper spec and Lower spec.

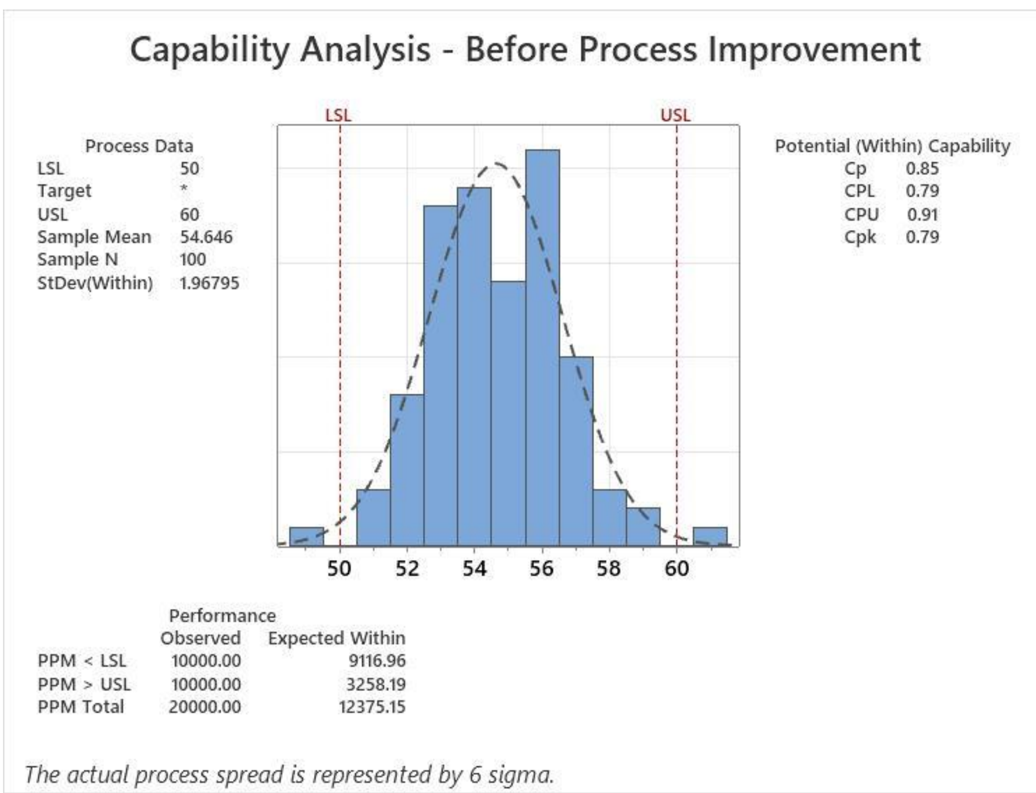

Fig 5. Capability analysis before process improvement.

We obtain the process capability graph as shown above in Fig 5. The current Cp and Cpk values are e 0.85 and 0.79, respectively.

ANALYZE

On analyzing the process, it is found that a couple of machine tools on the assembly line are not properly aligned.

IMPROVE

Upon realigning the machine tools and running the process, 5 more samples each containing 12 parts are collected.

1	2	3	4	5
56	55	54	55.9	54.5
56	51	53.4	51.9	58.8
55.5	55.9	52.7	56.2	54.4
54.1	58.1	51.1	55.1	56.1
55.9	55.1	56.5	53	57.3
53.2	55.7	56	57.7	57.7
56.2	55.9	53.3	52.6	52.6
54.2	52.9	53.8	54.6	54.6
54.9	53.9	56.7	55.7	55.7
56	59.1	55.7	54.8	54.8
56	52.4	53.1	55	58
53	54.4	53.4	54.4	57

Fig 6. Production Data after Process Improvement

In order to check whether the data are in statistical control, the data need to be transposed to have each sample in a single row. The data are variable data, and the sample size is 12, therefore the appropriate control charts to construct are the X bar and S charts.

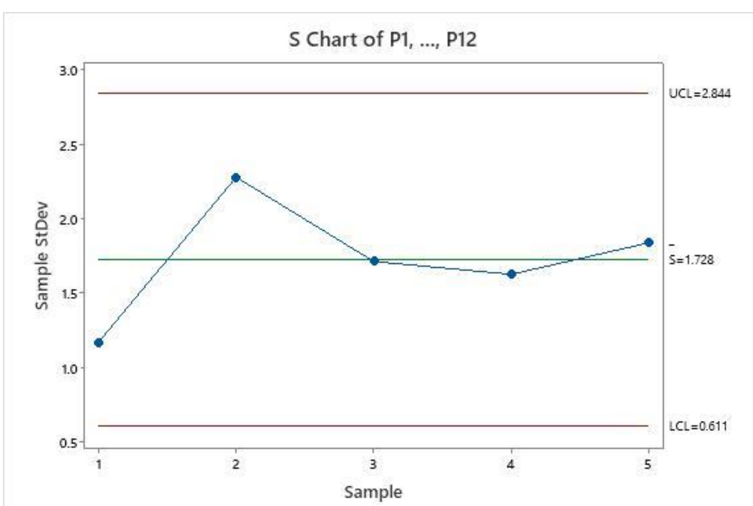

Fig 7. S chart after process improvement

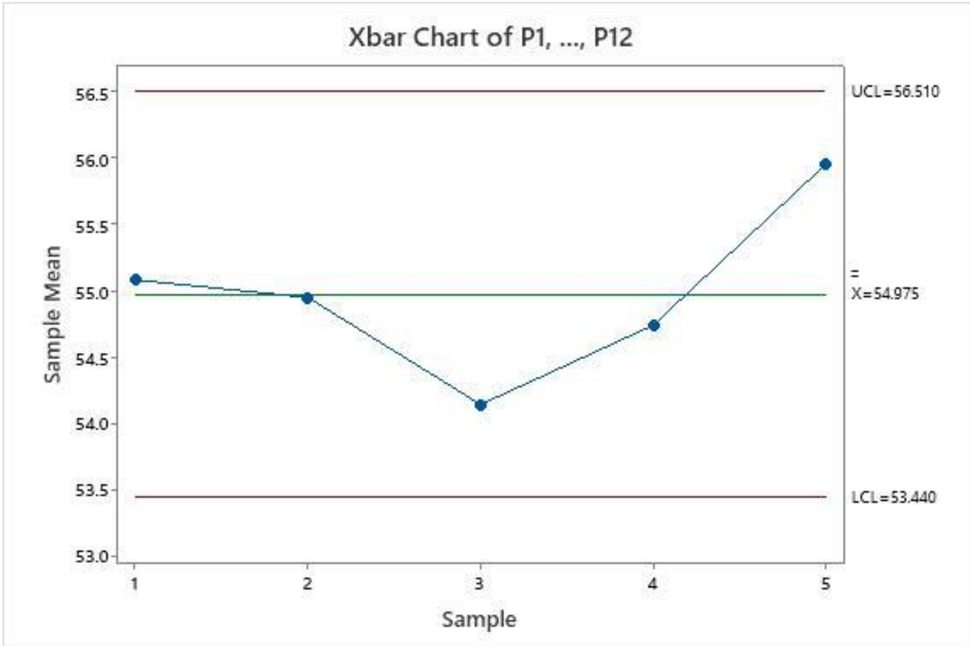

Fig 8. X bar chart after process improvement

It is clear from the X bar chart that the sample means are also in statistical control. Because the process data are normally distributed and are in statistical control, we can calculate the process capability ratios now.

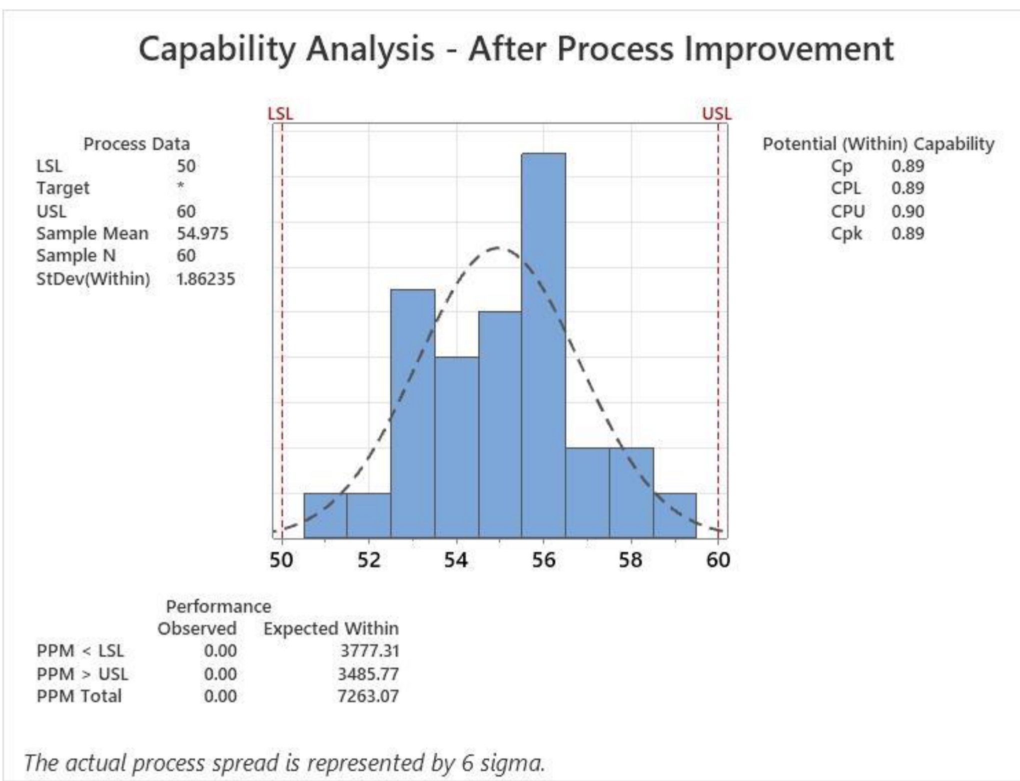

Fig 9. Capability analysis after process improvement.

The new Cp and Cpk values from the process capability analysis graph are 0.89 and 0.89, respectively. This indicates process improvement.

CONTROL

With the help of the supplier of the machines and their tools, the production manager installs a fail-safe mechanism that prevents misalignment of the two tools.