Engineering Case Studies: Analyzing the Quality of Steel and Glass Products via Statistical Process Control Charts

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Abstract and Objective

Statistical Process Control (SPC) is the collection of various problem detection and solving techniques which can be applied to any process. Statistical process control is a crucial technique in quality improvement. The major objective of SPC is to detect the root cause and frequency of issues in the processes so that corrective actions may be taken before non-conforming (defective) units are generated. The ultimate goal of SPC is to eliminate the variability in the process. The basic seven tools of SPC, i.e., Magnificent Seven are listed below:

1. Process Flowchart
2. Check Sheets / Tally Charts
3. Cause and Effect Diagram (Ishikawa)
4. Scatter Diagram
5. Histogram and Graphs
6. Pareto Chart
7. Control Charts

Background and Project Design: Data Collection and SPC

Control charts, central to SPC, are used to visualize and analyze the performance indicators over time. In this study, the appropriate control charts are applied to two different cases which are a manufacturing process in a steel components manufacturing job shop and a glass bottle manufacturing company in order to see if they are under control. Recommendations for future research are also included in the study.

Case Study 1: Measuring Process Capability of Steel Manufacturing

In this case study, we have applied the control chart approach to the data collected from a job shop. Figure 1 demonstrates the product which has a 2 cm exterior diameter with in the specified tolerance limits of +/- 0.03 cm.

Figure 1: Manufactured Component

The data set is collected for 20 different periods with subgroups of 5.

Table 1: Collected Data

PERIOD									
1	2	3	4	5	6	7	8	9	10
1.988	2.007	1.987	1.989	1.997	1.983	1.996	2.004	2.009	1.991
1.975	1.988	1.983	1.989	2.018	1.972	1.982	1.998	1.994	1.989
1.994	2.002	2.006	1.997	1.999	2.002	1.995	2.011	2.020	2.000
1.991	1.978	2.019	1.976	1.990	1.991	2.020	1.991	2.000	2.016
2.000	2.012	2.021	2.007	2.003	1.997	2.008	1.972	2.006	2.037
11	12	13	14	15	16	17	18	19	20
2.004	1.988	1.996	1.999	2.018	1.986	2.002	1.988	2.011	1.998
1.980	1.991	2.005	1.984	2.009	2.010	1.969	2.031	1.976	2.003
1.998	2.003	1.996	1.988	2.023	2.012	2.018	1.978	1.998	2.016
1.994	1.997	2.008	2.011	2.010	2.013	1.984	1.987	2.023	1.996
2.006	1.985	2.007	2.005	1.993	1.988	1.990	1.990	1.998	2.009

Case Study 1 Analysis and Results

Figure 2 exhibits the upper and lower control limits and the range of the measurements derived from the collected data.

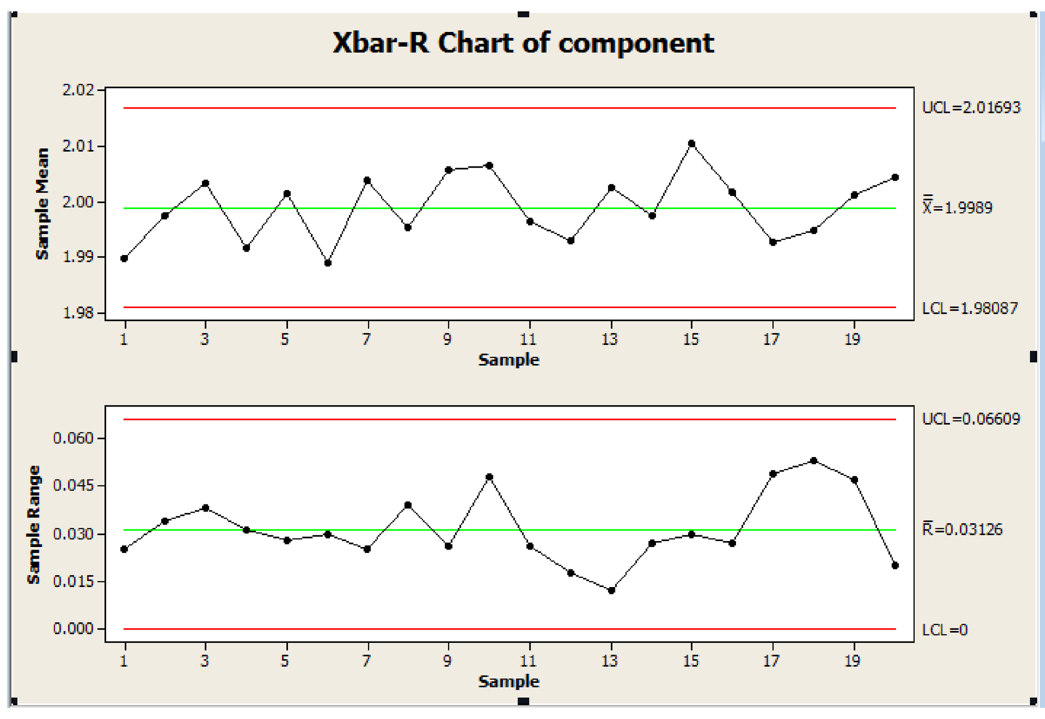

Figure 2: X-bar and R charts

In order to run the process capability test, first we need to conduct a normality test for the collected data. Figure 3 shows the applied Anderson-Darling normality test for the data.

H_0 : The data is normally distributed

H_1 : The data is not normally distributed

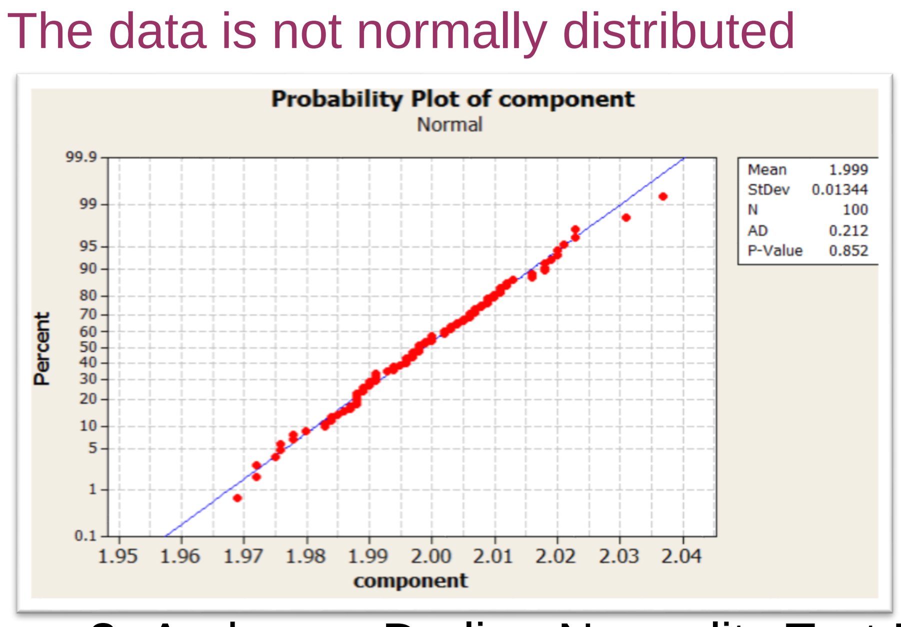

Figure 3: Anderson-Darling Normality Test Results

According to the calculated, p-value Null Hypothesis (H_0) can not be rejected at the 95% confidence level. The data is normally distributed.

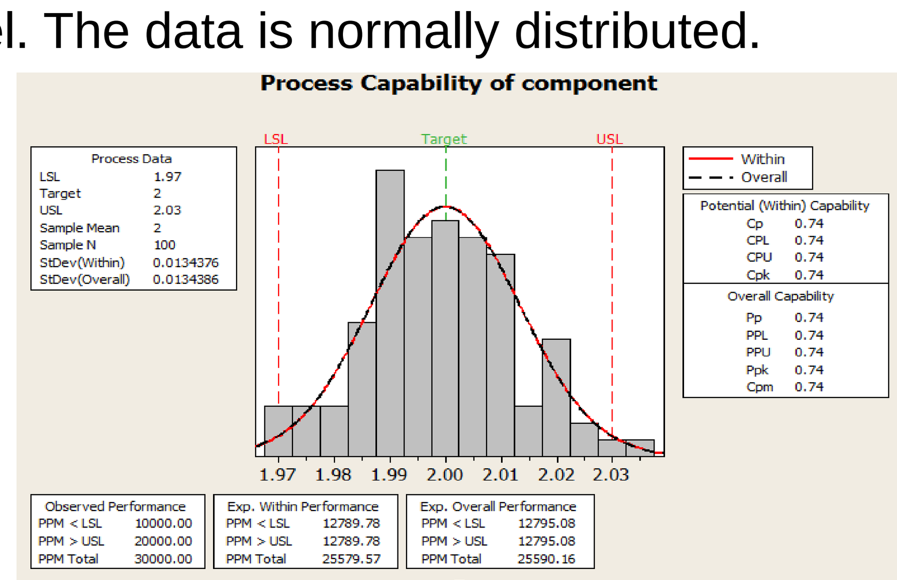

Figure 4: Results of Process Capability Test

Within the given tolerance limits, the calculated *Cp* value is less than 1 which means the process is not capable.

Case Study 2: Control Charts for Bottle Manufacturing

The second case study focuses on the control charts for defected products. A glass bottle manufacturing company measures the volume and the count of air bubbles in the glass. Bottles, having over a specific volume of air bubbles are counted as defected products.

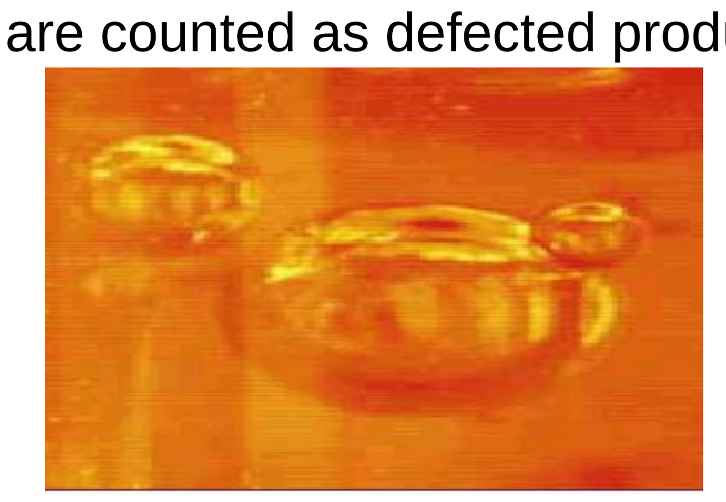

Figure 5: Air Bubble in a Glass Bottle

Case Study 2 Analysis and Results

The following data, provided from the glass bottle company, has the number of defectives over the weeks. Figure 6 (P and NP graphs) represent the proportion and number of defectives in each subgroup.

Table 2: Number of Defectives

Week	Sample Size	Number of Defectives	%	Week	Sample Size	Number of Defectives	%
1	75	1	0.0133	13	75	1	0.0133
2	75	2	0.0266	14	75	0	0
3	75	0	0	15	75	0	0
4	75	1	0.0133	16	75	1	0.0133
5	75	1	0.0133	17	75	3	0.04
6	75	0	0	18	75	1	0.0133
7	75	2	0.0266	19	75	2	0.0266
8	75	1	0.0133	20	75	1	0.0133
9	75	1	0.0133	21	75	3	0.04
10	75	0	0	22	75	0	0
11	75	0	0	23	75	3	0.04
12	75	2	0.0266	24	75	2	0.0266

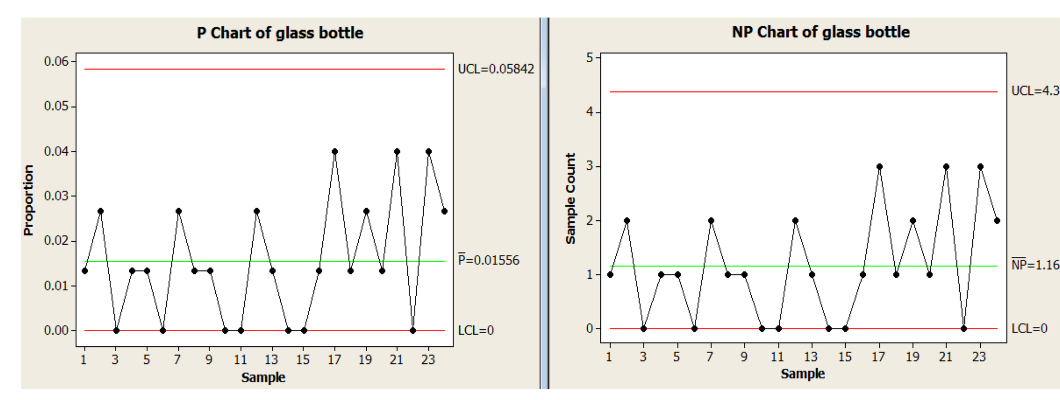

Figure 6: P and NP Charts of Defectives

Both graphs demonstrates that the process is in control limits. In order to analyze the number of detected air bubbles to gain a deeper insight, C charts are used with the following data.

Table 3: Number of Defects

Week	Number of Defects	Week	Number of Defects	Week	Number of Defects	Week	Number of Defects
1	5	7	1	13	9	19	7
2	3	8	3	14	0	20	2
3	0	9	2	15	0	21	9
4	6	10	0	16	9	22	0
5	7	11	0	17	9	23	2
6	0	12	6	18	2	24	9

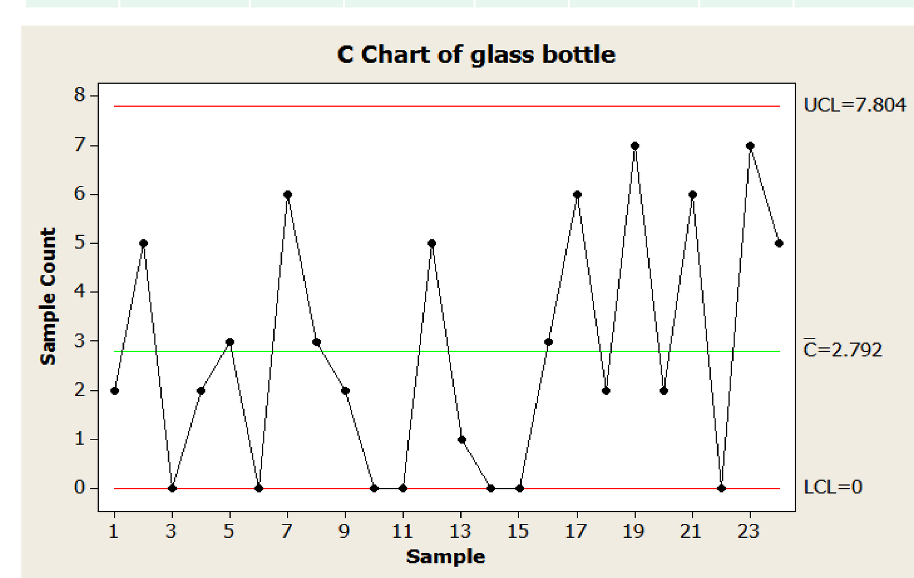

Figure 7: Counts Control Chart for Defects

As seen in the C chart, the process is in control.

Conclusions

In any industry, monitoring the key characteristics of the processes is vital for quality improvement. The control charts are well known and very useful for detecting the conformities or non-conformities in quality control. In this study, we applied the major SPC charts to the processes in a steel components manufacturing job shop and bottle glass manufacturing company.

For further analysis and research, the root causes of the detected non-conformities need to be analyzed and eliminated to improve the overall quality.

References

Montgomery,D.(2005), Introduction to statistical quality control. 5th Edition, New York: John Wiley.