Paper ID: IE-08

Analyzing and Developing the Quality Control System of a Renowned Battery Industry, Bangladesh: A Case Study

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Abstract

This paper intends to combine Hourly Data System (HDS) and quality control charts to improve process capability and sigma values of a renowned batteries industry, Bangladesh. The main focus of this work is to find C_p , C_{pk} *and Sigma values of the process. 'Minitab 17' software were applied to calculate X bar and S chart. Then number of hourly defective product was taken. Attribute control chart (U chart) for defect was applied through the same software. Overall, it was found that few causes were responsible for lowering process capability.. However, implementation of some recommendations have been given in this paper which can significantly improve the* C_p , C_{pk} *and Sigma values of the process.*

Keywords: C_p,C_{pk}, X bar and S chart,U Chart.

1. Introduction

Statistical process control is a technique used to monitor the process stability which ensures the predictability of the process. In 1920's Shewart introduced the control chart techniques that are one of the most important techniques of quality control to detect if assignable causes exist. [7] The widely used control chart techniques are X bar S chart for variable and U chart for non-conformities. A control chart, consists of three lines namely centre line, upper and lower control limit. These limits are represented by the numerical values. The process is either "in-control" or "out of control" depending on numerical observations.

A process capability index is another one used to indicate the performance of the process relative to requirements. C_p Is one of the most commonly used capability index. The natural tolerance of the process is computed as 6σ. The index simply makes a direct comparison of the process natural tolerance to the engineering requirements. [3] Assuring the process distribution is normal and process average is exactly centered between engineering requirements.

There are so many statistical software that enables an inspector to control the quality of a product in industry. This type of in process quality inspection not only makes the entire process fast and less costly but also determine and analyse whether or not the lot of production is acceptable, provide that the company is willing to allow up to a certain known number of defective parts. Among the statistical software, 'Minitab 17' is the best and most widely used in industry, because it has built-in capacity to analyse the control chart and process capability with different graphical window.[11]

Lead-acid batteries which are mainly applied to store energy and to get uninterruptible power supply in human demand such as telecommunication, traffic, industry and medical system.[9] This paper presents the experiences in practice of quality assurance in the battery plant production and emphasizes the integration of statistical quality control (SQC) software with the process and production control methods. Quality improvements were achieved by careful security of manufacturing process details. This quality improvements resulted in more consistent battery life at lower cost.

2. Methodology

The control chart may be classified into two types namely variable and attribute control chart. In monitoring the production process, the control of process averages or quality level is usually done by X bar charts. The process variability or dispersion can be controlled by either a control chart for the range or a control chart for standard deviation. So, Variable control chart is further classified into X bar R chart and X bar S chart. X bar S chart is used when sample size n >5 [8]. In this case, sample size is six.

Lead grids for positive and negative plates are cast in mold. The grid must be rigid, free from discontinuities and have specified weight and thickness. If the grids heavier than the specified weight are functionally accepted but increase the battery cost. On the other hand, if grids less than the specified weight are functionally not acceptable and reduce the quality of the battery. [10]
In order to investigate the manner of variation of quality of gird, a specific control chart X bar S chart was introduced because quality characteristics(weight of grid) is measurable and expressed in number. [5] Weight were measured six times a day per hour from 8.00am to 6.00 pm for eight days. [6] In an X bar S chart, X bar chart shows a change in subgroup mean and S chart shows a change in the variation within the subgroup. When all points plotted in a control chart are between control limits, the process is considered to be in control stage. When an X bar S chart shows the statistically control state, process capability was grasp by a histogram of raw data.

In this paper, U chart was used to count of non-conformities per unit in an inspected battery. A non-conforming unit is one which contains at least one nonconformity. Major non-conformities were found in the battery were [10]

A. Short Molding
B. Lead Tear
C. Grid Cracking
D. Grid Lugs misshaped

The some of the factors are,

a. Spray Vanishes
b. Mold Temperatures
c. Mold Physical condition
d. Machine Physical Condition

Sample size of the U chart may be either variable or constant. Normally a constant subgroup size is preferred. This chart would help to reduce the number of nonconformities per unit. The control chart for attributes are quite similar to the control chart for variables, that is, the Centre line and control limits are set in the same manner.[4] However, it is important to note that the purpose of using these two types of control chart are quite distinct.

3. Data Analysis and Result

Table 1. The detail data of grid weight measured

Sample No		*Observations TX1.4 Grid weight(grams)*				
1	122.4	122.6	122.8	122.6	122.6	123.2
2	122.2	122.8	122.6	122.8	122.8	122.8
3	122.6	122.8	122.4	122.6	122.6	122.8
4	122.6	122.6	122.2	122.6	122.6	122.4
5	122.8	123.2	122.6	122.8	122.8	122.6
6	122.6	122.6	122.6	123.2	122.8	122.8
7	122.4	122.4	122.8	122.8	122.6	122.8
8	122.8	122.8	123.2	122.6	122.8	123.4

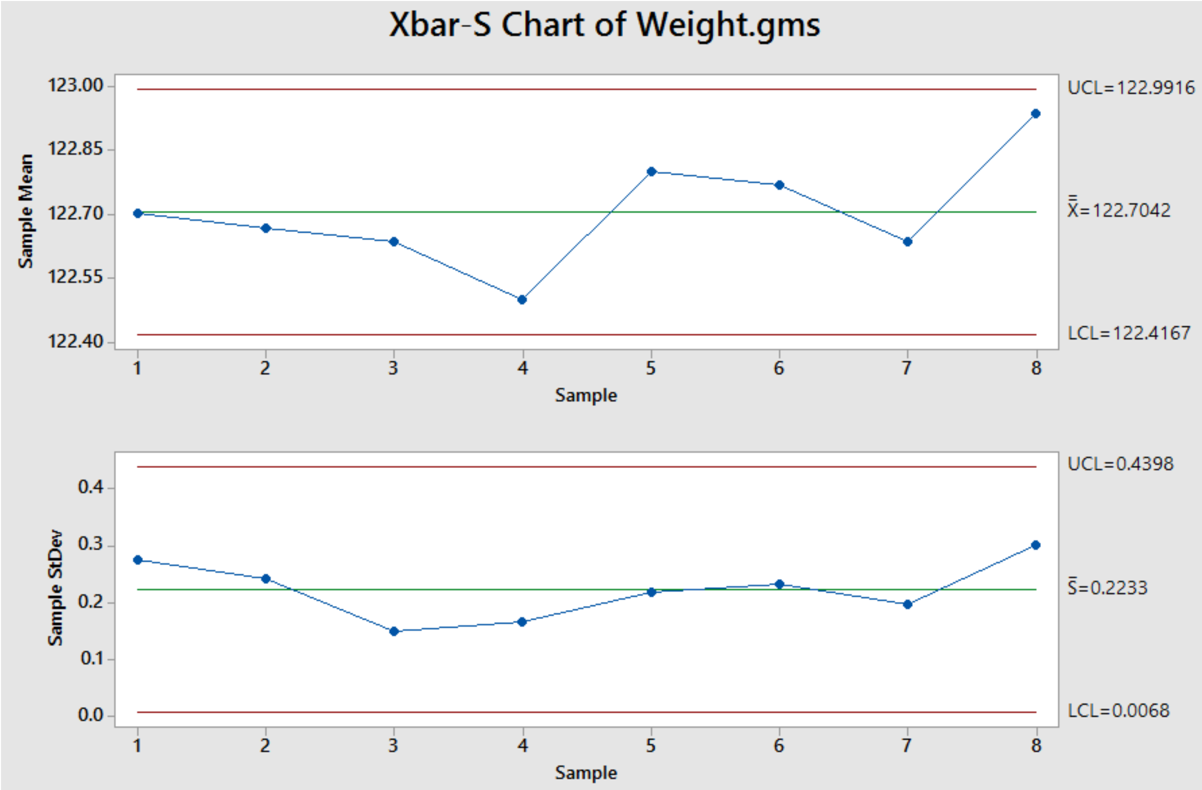

Fig. 1. X bar S chart for Grid Casting

Solid line in the centre of the chart for the X bar S chart, as shown in the figure 1, are obtained by

$$\bar{\bar{X}} = \frac{\Sigma x}{n} \text{ And } \bar{S} = \frac{\Sigma S}{n} \quad (1)$$

Assuming normal distribution for data, control limits for the charts are established at ±3σ from the central value, as follows [2]

For X bar chart,

$$\text{Upper Control Limit (UCL)} = x + A_3 S \quad (2)$$

$$\text{Lower Control Limit (LCL)} = x + A_3 S \quad (3)$$

For S chart,

$$\text{Upper Control Limit (UCL)} = B_4 S \quad (4)$$

$$\text{Lower Control Limit (LCL)} = B_3 S$$

Where the constant A_3, B3, B_4 are obtained from the standard statistical table. [1]

X bar chart is in control limit. S chart as well. No points is outside the control limits. The data was grouped into lots on each days with n=6.Thus the within-subgroup variation is composed of the daily variation including the variation both within and between lots. The variation between subgroup is the variation between days.

Table 1. The detail data for non-conformities

Sample Number	*Sample Size*	*Defects*
1	2	7
2	5	2
3	3	4
4	4	1
5	7	3

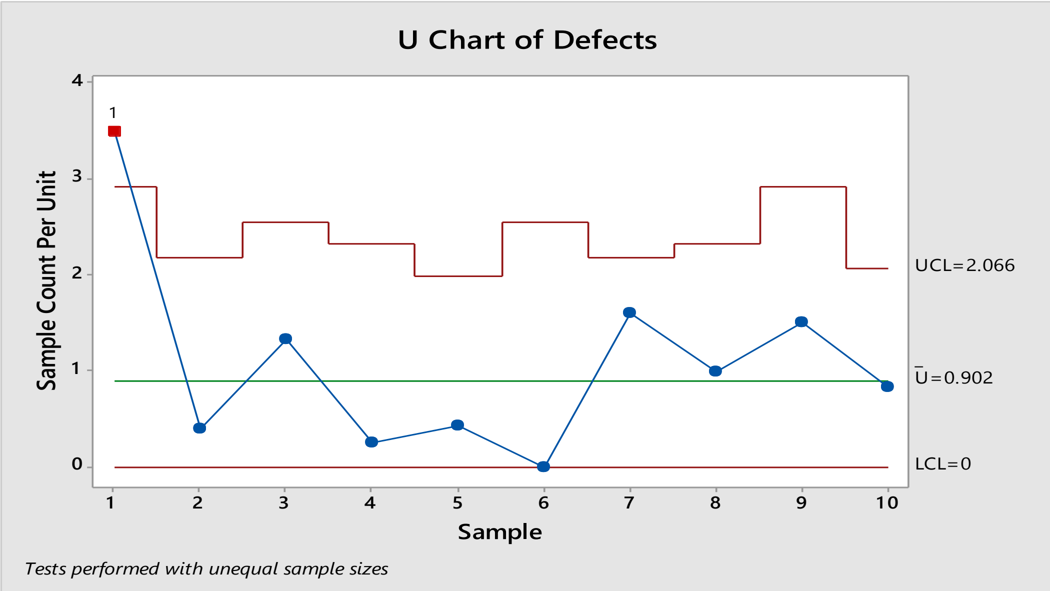

Fig. 2. U chart for defects of in grid casting

The central line is determined by,

$$\bar{u} = \frac{\bar{C}}{n}$$

(5)

Where, C=number of nonconformities in grid casting.

The figure shows approximately a normal distribution and all the point except one lies within the specified grid casting range. However, cracks, lead tear, short molding were found in samples even though most of them were in the specification limit. The standard deviation of the samples were found.

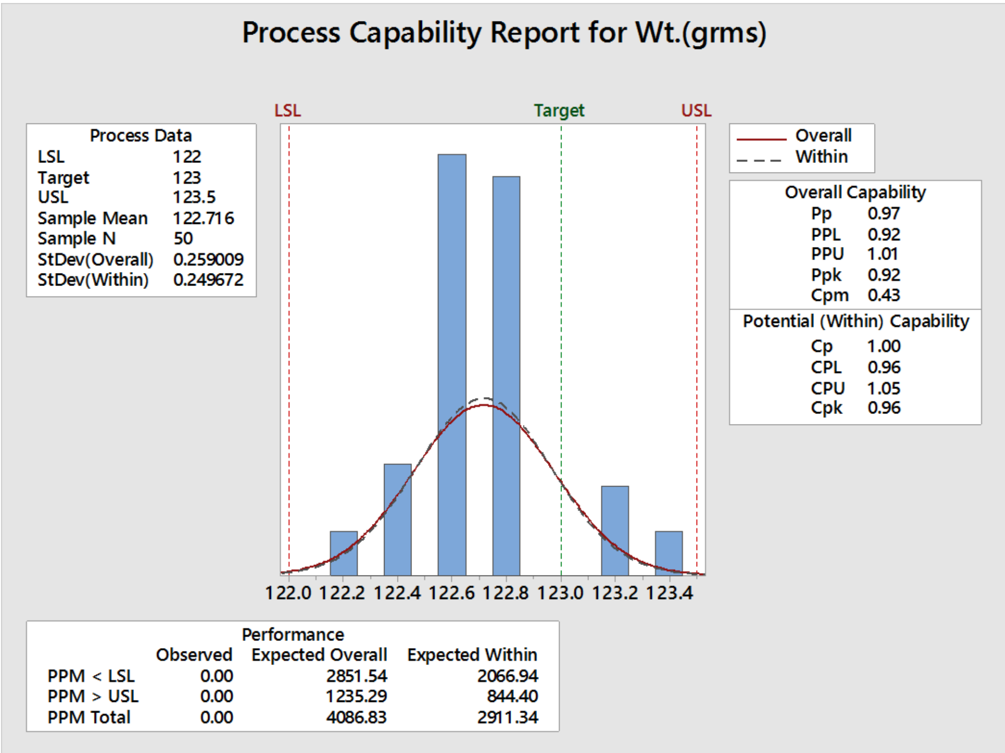

Fig. 3. Process capability of Grid Casting.

The histogram lies within the upper and lower limit of specification with margin. The process can be controlled by control lines calculated by process data. The control state is a state in which assignable causes are removed and process variation is only due to chance causes. The process is in control state and satisfying the specification. For preventing the occurrence of defectives the effort to improve the process capability. This will happen when the process has sufficient capability for the specification.

4. Conclusion

When the relation between a quality characteristics has been grasped sufficiently, next step is to control these process factors at certain level so that the target value of quality characteristics is kept in a desirable range. This step is called process control. The control chart serve as a helpful means to identify abnormal conditions of process and maintain process at a stable condition. The control chart cannot determine, if the process meets the specification or not process capability index gives a measure of it. In case of variable control X bar S chart, the limits are symmetrical about the central line and all point fall inside the $\pm 3\sigma$ limit. So process is in control. This control chart is used to improve process quality by determining the process capability index, which is found1.00 .It means that process is capable to meet the specification. In case of attribute chart, one point is way outside the specification limit. The main cause of it is temperature controlling system. Because of rough cooling in grid cracking occurs. So, proper cooling system has to be maintained to avoid the non-conformities. In case of C_{pk} which is 0.96, lower than 1, which indicates most of nonconforming units produced by the process are falling within the specification limit.

5. References

[1] A. Gupta, & S. Kant, “Development of Quality Control Systems for A Machine Tool Industry (Tractor Division) In Northern India: A Case Study”, Vol-4, No-1, 2014.

[2] M.T. Chao and S.W. Cheng, “Semicircle control chart for variables data”, Quality Engineering Vol-8, No-3, pp-441-446, 1996.

[3] R.S. Leavenworth & E.L. Grant, “Statistical quality control”, Tata McGraw-Hill Education, 2000.

[4] R. Srinivasu, G.S. Reddy & S.R. Rikkula, “Utility of quality control tools and statistical process control to improve the productivity and quality in an industry”, International Journal of Reviews in Computing, Vol-5, pp-15-20, 2011.

[5] M. Jafri & K.T. Chan, “Improving quality with basic statistical process control (SPC) tools: A case study”. Journal of Teknologi, pp-21-34, 2001.

[6] U. Heider, R. Oesten & M. Jungnitz, “Challenge in manufacturing electrolyte solutions for lithium and lithium ion batteries quality control and minimizing contamination level”, Journal of power sources, pp-119-122, 1999.

[7] D.C. Montgomery, “Introduction to statistical quality control. John Wiley & Sons,2007

[8] Montgomery, D. C., & W.H. Woodall, “Research issues and ideas in statistical process control”, Journal of Quality Technology, Vol-3, No-4, pp-376-387, 1999.

[9] D. Pavlov, “Lead-acid batteries: science and technology: science and technology. Elsevier, 2011.

[10] T.C. Hsiao, T.L. Chen, C.H. Liu, C.M. Lee, H.C. Yu & T.S. Chen, “Quality Control of Lead-Acid Battery according to Its Condition Test for UPS Supplier and Manufacturers”, Mathematical Problems in Engineering, 2014.

[11] A. Mitra, “Foundation of Quality Control”, Pearson Education, 2012.