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AN APPLICATION OF P-CHART IN MODELLING NON-CONFORMING GLASS PRODUCTS THAT FAILED PREASURE TESTING

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ABSTRACT

The quality of any product can be accessed or examined by the quality characteristics of that product. These quality characteristics we wish to measure can be either quantitative or qualitative. The application of p-chart in modeling non-conforming glass products that failed pressure testingis a research work that seeks to examine how the p-chart is used to model non-conforming items and to further accessing its randomness by detecting the point it failed pressure test. A primary data was obtained from the Department of quality assurance, Beta Glass plc, Delta Plant, Ughelli of 30 samples from machine 11 using direct observation and experimentation method. The p-chart and the runs analysis were adopted. The Minitab Statistical package was used to analyze the data. It was discovered that the p-chart was out of control as 3 outliers was discovered at point 15, 21 and 23. The plotted point also appears to be randomly spread about the central line which obviously revealed that the process is random as seen via the runs analysis.

Keyword: Randomness,runs analysis, p-chart, round spirit bottle, out of control

1.0 Introduction

In Statistics, Statistical quality control is an analytical decision making tool which allows us to see when a process is working correctly and when it is not (Allen, 2006). The quality of any product can be accessed or examined by the quality characteristics of that product. These quality characteristics we wish to measure can be either quantitative or qualitative. When we are dealing with quality characteristics that are quantitative, then it is known as the variable chart. While when we are dealing with qualitative, it is known as attribute chart. Here, we can classify the attribute as good or bad, conforming or non-conforming, defective or not. In this case, we are dealing with an attribute control chart. For this research work, we will be considering the attribute control chart. (Montgomery 2005).

Attribute control charts are applied to monitor the quality characteristics, which are not possible to express in numerical scale. From the literature, first, it is concluded that there are some advantages and disadvantages for using attribute control charts like P-chart by comparing it to the variable control chart like $\bar{X}$ -R. (Ismail and Velnampy 2013).

Some advantages of using attribute control charts are as follows.

i. Attribute control charts could monitor more than one quality characteristic simultaneously.
ii. Attribute control charts need less cost and time for inspection than variable control charts.

Disadvantages of attribute control charts are as follows.

i. Attribute control charts need larger sample size than variable control charts.
ii. Attribute information could not determine the reason of being out of control, so correction action is meaningful. (Montgomery 2009).

Quality has been used as a decisive factor in choosing products and services. As a result, the search for quality control methods that may result in improved products and services has led to the development of statistical techniques applicable to the industrial and business environments. Improving the performance of control charts and developing new methods for their construction are challenges for researchers and users of statistical process control.

In response to these challenges, new control charts and monitoring strategies have been developed in recent years. (Gülbayand Kahraman 2007).

When the measurement of a specific quality characteristic is expensive and time consuming, it is reasonable to consider whether a control chart based on attribute inspection might be more appropriate for monitoring a process mean or variance.

Montgomery (2009) observed that variable-type inspection is typically significantly more expensive and time consuming on a per-unit basis than attribute inspection. Therefore, it may be more appropriate and fair to compare the effectiveness of charts based on identical inspection cost per unit time. The currently available alternatives are the p and np charts. He provided an example in his text comparing the ability of $\bar{X}$and np charts to detect the mean shift of a quality characteristic x that is normally distributed with a mean of 50 and standard deviation of two. The $\bar{X}$ chart uses three-sigma control limits and a sample size of nine items. Its power to detect a mean shift of one standard deviation is equal to 0.50. In contrast, to detect the same mean shift, the sample size of the np chart must be at least 60. The ratio between the sample sizes required for these two types of charts can be as high as 6.667. This significant difference will discourage many quality assurance practitioners from considering the use of the np chart to monitor the mean of a variable. Such findings demonstrate the need to propose other alternatives

Wu et al. (2009) proposed the use of an npx chart to monitor a process mean by attribute inspection as an alternative to the use of a chart. Motivated by the simplicity of this control chart and its good performance, the possibility of using a similar chart, an npS2 control chart, to monitor the variability of a process was explored, and the results are described in this paper. A comparison of the proposed npS2 control chart with the S2 and R control charts is presented, and a numerical example is provided to demonstrate the use of the npS2 control chart.

2.0 METHODOLOGY

Data was obtained secondarily from Beta Glass Plc, Delta Plant, Ughelli from 30 samples of export round non-conforming spirit flit bottles that failed pressure testing. The stratified method of sampling was adopted with a sample size of 30.

2.1 MODEL SPECIFICATION

Consider the binomial distribution with parameters n and p, that is,

$P\{ D = r\} = {}^{n}C_{r}p^{r} (q)^{n-r}$, r = 0, 1, …, n ……………………………(1)

Where, p is success, and q is failure and n is the number of trials. P + q must = 1. The sample fraction non-conforming is defined as the ratio of the number of non-conforming unit in the ample size n: that is,

$\hat{P}= \frac{Di}{n}$, i = 1,2, 3, …, m ……………………… ……………………..(2)

The control limits for the p-chart is giving as;

$$UCL = \bar{p} +3 \sqrt{\bar{p}(1-\bar{p})/_{n}} \quad \text{…………………………………………. (3)}$$

$$LCL = \bar{p} - 3 \sqrt{\bar{p}(1-\bar{p})/_{n}} \quad \text{………………………………… ……...(4)}$$

$$CL = \bar{p} \quad \text{……………………………………………………………… (5)}$$

And the average of these individual sample fraction non-conforming is;

$$\bar{p} = \frac{\sum_{i=1}^{m} Di}{mn} = \frac{\sum_{i=1}^{m} \widehat{pi}}{m} \quad \text{………………………………………………………… (6)}$$

2.2 Runs Test

A run is a succession of items of the same class. When the output of a process, for example is classified as defective and non-defective, a succession of defective units would be a "run" of this class of units. If plotted points in the chart fall within the upper and lower control limits, there is need to test for randomness, to ascertain if the process is actually in statistical control.

2.3 Hypothesis Testing

H_0: The process is random
H_1: The process is not random
Test Statistics:

$$Z_r = \frac{r-\mu}{\sigma_r} \quad \text{………………………………………………….. (7)}$$

where,

$$\mu_r = \frac{2n_A n_B}{n_A+n_B} + 1 \quad \text{………………………………………………… (8)}$$

$$\sigma_r = \sqrt{\frac{2n_A n_B(2n_A n_B - n_A - n_B)}{(n_A+n_B)^2(n_A+n_B-1)}} \quad \text{……………………………… (9)}$$

Where,r is the number of runs,μ_r is the test value, n_A= number of samples above the center line,

n_B = number of samples below the center line.

Decision Rule
Reject H_0if p-value < $\alpha = 0.05$,
Otherwise, accept H_0.

3.0 DATA ANALYSIS

Data was analyzed using Minitab 17.0 and the output is given below:

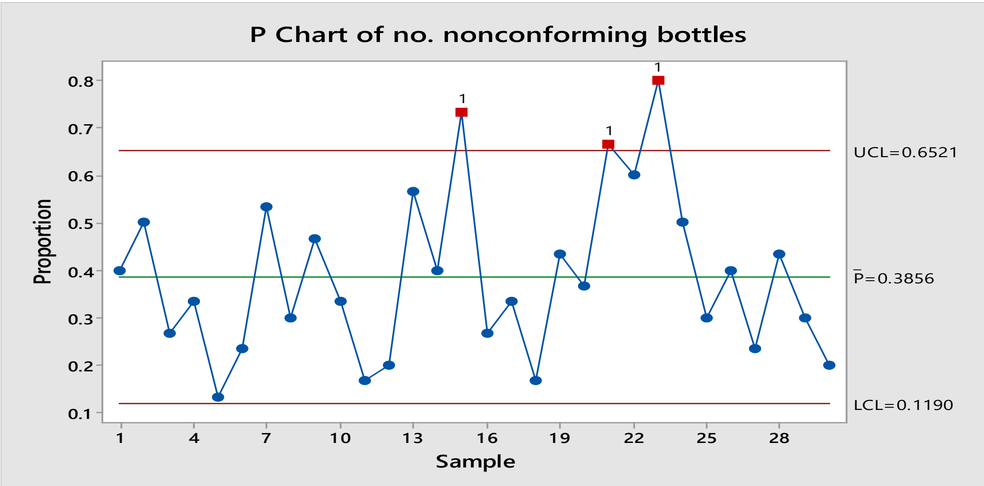

figure 1

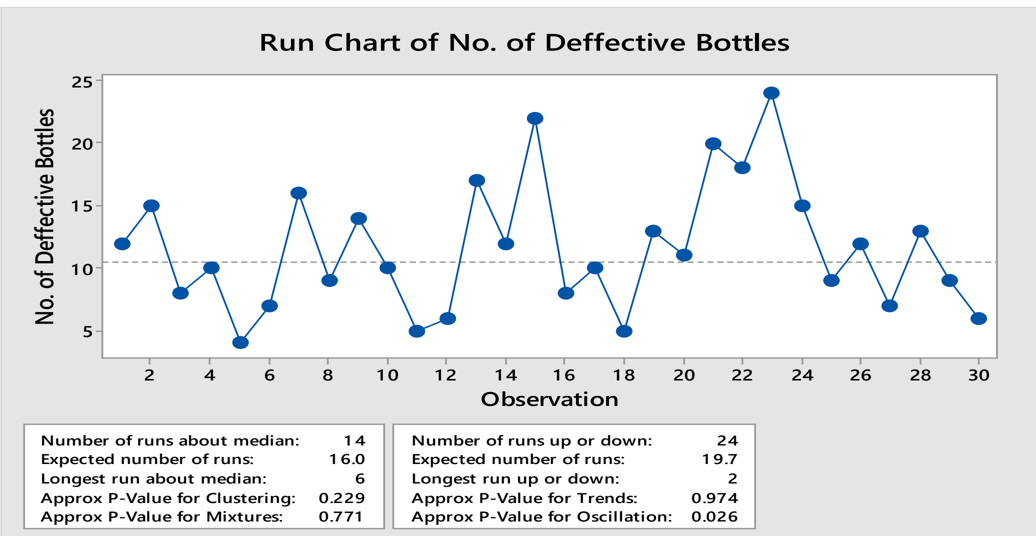

Figure 2

It is observed that the control limit is 0.3856, the Upper control Limit is 0.6521 and the Lower control limit 1s 0.1190. From the chart in Figure 1, it is observed that the process is out of control. One point more than 3.00 standard deviations from center line. Test Failed at points: 15, 21, 23, this concludes that the process is not stable and therefore is out of statistical control.
Also from figure 2, it is observed that the plotted points are random since the p-value is greater than 0.05 which lead to the acceptance of the null hypothesis.

3.1 Conclusion

It is observed that the proportion or fraction defectives chart is a veritable tool for quality assurance diagnostics. It is seen beyond doubts that from this research work that the p-chart can be used to model round spirit flint bottles that failed the pressure testing. It's revealed that the chart was out of control and the process is not stable. It was also discovered that the plotted points are random as revealed by the run chart. Therefore, a product can be out of control yet still meet randomness test.

3.2 Recommendation

1. The p-chart is good quality control tools for monitoring proportion defective item this research work has revealed it can be used to model glass product that failed pressure test.
2. The runs analysis is also recommended as it is helpful in checking the randomness or behavior of the plotted points whether they are random or not.

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