AN APPLICATION OF VARIABLE CONTROL CHART IN MODELLING AMERICAN HONEY SPIRIT BOTTLE IN BETA GLASS PLC, DELTA PLANT, NIGERIA

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Abstracts

Statistical quality control has become a vital tool employed in the field of quality assurance in both product and service providing industry to meet the set management standard and keep the process in control to remain in the global business. This study considered the application of variable control chart in modelling American Honey spirit bottle. The aim of the study was to applying the mean and range chart to monitor 20 samples of size 5 Mould from machine 21A export line that was subjected to a comprehensive strength test measured in psi. Data was collected secondarily from the quality assurance Department of Beta Glass PLC, Delta plant, Ughelli. Data were analyzed using Minitab 17.0 version. The mean and range chart was used to analyze the data and the runs test was also carried out to access the process randomness. It was discovered that both the range and mean chart is in statistical control. It was also observed that the process is random as revealed by the runs test; hence the null hypothesis was accepted at 5% level of significance.

Keyword: Statistical quality control, Randomness, Range Chart, Runs Test

1 Introduction

Quality refers to the perception of the degree to which the product or service meets the customer's expectation. It can also be defined as making product uniformly around the customer's target. According to Montgomery (2005), quality is the extent to which the customers or user believe the product or service surpasses their needs or expectations.
Quality can also be defined as conformance to the need, requirement and expectation of the customer. Quality can be viewed from many perspectives as given by the philosophers who include satisfying the customers' requirements, fitness for use and conformance to requirement among others.

In our society today, Quality has become one of the most important consumer decision factors in the selection of competing products and services. In fact, in the present global market, quality control is unavoidable in every day's production and service delivery routine. The phenomenon is widespread, regardless of whether the consumer is an individual, an industrial organization, a retail store, a bank or financial institution, or a military defence program and so on. The characteristics of quality are; Psychological, Technological, Time-oriented, Contractual, and Ethical. It can be classified into a different dimension which is listed below:

i. Performance (Will the product do the intended job?)
ii. Serviceability (How easy is it to repair the product?)
iii. Durability (How long does the product last?)
iv. Reliability (How often does the product fail?)
v. Aesthetics (What does the product look like?)
vi. Features (What does the product do?)
vii. Perceived Quality (What is the reputation of the company or its product?)
viii. Conformance to Standards (Is the product made exactly as the designer intended?)

The quality of a manufactured product depends on the number of factors(the raw material, machine and equipment, the expertise and skill of the persons who handle them) involved in the production process because if the factors needed for producing the product are not enough or insufficient, it could be lead to producing a less quality product. For successful marketing of the product, the end product must conform to the standard and requirement of the customer.

In recent times many products from companies are defectives, the Nigerian market is flooded with many products which have more of sub-standard goods than standard goods. What immediately comes to mind is that there must be a problem in the quality system of Nigeria manufacturers; therefore this research work is to expose manages on how variable control chart can be used to model the production of American honey bottles in Beta Glass plc. The aim of this study was the application of variable control chart in modelling American Honey bottle product in Beta Glass PLC Ughelli. The specific objectives are to Monitor the process for a process shift using the -chart; to know if the production process is in control; to expose managers on how Quality Control technique is applicable in the modelling America Honey bottles, in Beta Glass PLC Ughelli; and to carry out a runs test and check if the process is random or not.

2 Literature Review

2.1 Statistical Process Control

Statistical quality control is important to all human endeavours. It makes uses of available data to elicit the required best decision for utmost profit. The theories and methods of Statistical Process Control (SPC) have been developed from industrial statistics roots, such as quality specifications. In modern times, while quality enhancement remains a major field of applications like in healthcare monitoring (Sterner et al.,1999), detecting of genetic mutation (Krawezak et al., 1999), credit and financial fraud detecting (Bolton and Hand, 2002) to mention but a few. It has a wider range of applications. (Edopka and Ogbeide, 2013).

Process control is the practical changing of the process based on the results of process monitoring. Once the process monitoring tool has detected an out-of-control situation, the practitioner responsible for the process makes the necessary change required to bring the process back into control. Meanwhile, Statistical Process Control (SPC) is about continuous monitoring or surveillance of a process to ensure that neither the mean nor the variability of the process distribution has changed (Hawkins and Zamba, 2005; McCracken and Chakraborti, 2013). Examples of process control may include: monitoring some quality characteristics of manufactured items to ensure compliance to certain standards; detection of an increased birth

rate of infants with congenital malformations; surveillance of health data to detect an outbreak of a disease or increased rate of incidence of diseases; the observance of a natural phenomenon such as water salinity levels, or adverse drug reactions and so on (Zamba and Hawkins, 2006). The in-control process is a process that is operating at or around some target value and only under some random variation, and out-of-control (OOC) process is a process that has somehow changed from its in-control state. The quality of a manufactured product depends on the number of factors(the raw material, machine and equipment, the expertise and skill of the persons who handle them) involved in the production process because if the factors needed for producing the product are not enough or insufficient, it could be lead to producing a less quality product. For successful marketing of the product, it is important that the end product must conform to the standard and requirement of the customer.

2.2 Statistical Quality Control

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). Statistical quality control is one of the most important applications of the statistical technique in the industrial field today. As a matter of fact, it is impossible to think of an industrial field where statistical techniques are not used.

Statistical control is the branch of quality control which involves the collection, analysis and interpretation of statistical data for use in quality control activities. Statistical quality control is aimed at achieving successful marketing of the product by keeping the various steps involves in the production process of the product.

Statistical quality control is a very important technique which is used to assess the cause of variation in the quality of the manufactured product. It enables us to determine whether the quality standards are being met without inspecting every unit produced in the process. SQC basically aims at the isolation of the chance and assignable cause of variation and as a result helps in the detection, identification, and elimination of the assignable causes of erratic fluctuations whenever they are present (Badiru, 2014).

The usual control charts are often used in health engineering for evaluating hospitals performances and improvements. In addition, a number of special statistical methods have been developed for monitoring health services solely. Some quality characteristics which the researchers are recently interested in monitoring are infection rates, rates of patient falls, a number of congenital malformations in society, various sorts of waiting times as given. A good number of statistical methods have been designed based on this type of interesting quality characteristic observations (attribute or variable). (Edokpa and Odunayo, 2016).

Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer (Hawkins and Olwell, 2015). Quality control is a process by which entities review the quality of all factors involved in the production.

Controls include product inspection, where each product is examined visually and often using a stereo microscope for the finest detail before the product is sold to the external market.

Inspectors will be provided with lists and descriptions of unacceptable product defects such as cracks or surface imperfections, for example. The quality of the results is at risk if any of these three aspects are lacking in any way. Quality control emphasizes product testing to discover defects and reporting to management making the decision to allow or deny product release, while quality assurance attempts to improve and stabilize production (and associated processes) to avoid, or at least minimize, the problems that led to the defect (s) in the first place. Quality can be reviewed from different approaches of the quality experts like Montgomery (2007) and other sources gave quality definition but with a convergence (goal). The role of the Central bank of Nigeria is to put the appropriate strategy in place at reducing the inflation rates in the country whenever it is detected. Such detection can be facilitated by the use of control chart schemes.

Quality assurance methods typically collect process evidence after a production process has been completed. In contrast, statistical process control (SPC) is a dynamic monitoring method where product quality is actively measured and simultaneously charted while manufactured goods are being mass-produced. Statistical control is achieved when an index such as the average of product groups is plotted within certain limits plotted on a graph.

In addition to consistency, production efficiency is important in mass production. Therefore, a production line cannot be stopped or slowed down unless there are indications of process changes as indicated by the SPC tables. For these charts there are rules to tell technicians if a process is potentially out of statistical control. When these conditions exist, engineers must stop the manufacturing process for corrective action. Although SPC charts are designed to monitor a manufacturing process as a whole, taking product measurements on an assembly line can be costly, slow down a process or decrease product quality. Of course, companies usually don't measure all products as this could be counterproductive or economically unfeasible. As a compromise, most of the company's selected rational product subgroups often use a random sampling scheme. These subgroups are then painstakingly checked for quality and their summary measurements are plotted for quality control purposes. (Akpojaro and Orighoyega, 2020).

A process is any set of recurring steps in any services, manufacturing setting to achieve some result while the result is the output. Input refers to any process that consists of the unique combination of tools, materials, methods and engaged in producing a measurable output, such as a production line. All processes have inherent statistical variability that can be evaluated with statistical methods. Therefore understanding them and making them work at the highest possible level is the goal of statistical techniques called study of process capability in Six Sigma methodologies.

2.3 Relationship between Control Chart and Hypothesis Testing

The control chart is closely related to a statistical test of the hypothesis. The control chart is a test of the hypothesis that the process is in a state of statistical control. Every point plotted within the control limits fall within the acceptance region and leads to the acceptance of the null hypothesis. Any point plotted outside the control limits leads to the rejection of the null hypothesis the system is under control.

2.3. 1 Control Charts

A control chart is a statistical device that is used for the study and control of a repetitive process. It was originated Dr. Walter Shewhartin the Bell Laboratory in the year 1923 (Shewhart,1931). He suggested that a control chart defines a goal or standard for a process that the management might strife to attain, used as an instrument for obtaining the goal and may also serve as a means of judging whether or not the goal is reached. It is thus an instrument to be used for specification during production and inspection. The control chart is used for the following purpose.

- They are proving the technique for improving quality productivity because a successful control chart helps in reducing scraped re-work as a result of which the production capacity increases.
- They are effective in defect prevention. This is consistent with the "do it right" philosophy.
- They present unnecessary process adjustment. This is also consistent with the "if it is not broken, don't fix it" philosophy.
- They provide diagnostic value to an experienced Operator or Engineer.
- They provide information about process capability.
- They provide information on process parameter and their stability over time.

2.3.2 Types of control chart

There are two types of control chart which are;

- ❖ Control chart for Attributes
- ❖ Control chart for Variables.

2.3.3 Control Chart for Attributes

They are based on data that can be grouped and counted as conforming or non-conforming, present or not-present, defective or non-defective and so on. Attribute control chart provide useful records about a quality's history. These records may be useful in, monitoring workers, making managerial decisions about changes in process and meeting contractual obligation. Basically, this kind of control chart is used to analyze quality characteristics that cannot be represented numerically. Examples are p-chart, np-chart, c-hart and u-chart.

2.3.4 Control chart for Variables

They are Base on the data that can be measured on a continuous scale that is quality characteristics that can be expressed as numerical measures examples are $\bar{X}$and R chart, $\bar{X}$and S chart, Control chart for individual unit. In this study, we will be making use of control chart for individual unit which is categorized into control for variables.

3 Materials and Methods

3.1 Brief History of the Study area: Beta Glass PLC, Delta Plant, Ughelli

Established on June 2, 1974, Beta Glass Plc is a Nigerian industrial goods company whose business model involves the production and marketing of glass items. Specifically, the company produces glass bottles for wines, carbonated soft drinks and spirits. It also makes glass containers that are used for the packaging of cosmetics and pharmaceuticals.

The company is headquartered in Lagos but has manufacturing facilities in the Agbara industrial hub in Ogun state, as well as Ughelli which is in the Delta state of southern Nigeria. According to the Nigerian Stock Exchange (NSE), Beta Glass Plc has a market capitalization of $ 34.1 billion. Its shares were listed on the board of directors of the NSE on July 2, 1986, exactly twelve years after its establishment. Important to note is the fact that Beta Glass's share price has been one of the best performers on the Nigerian stock exchange over the past five years, having climbed from N19 in 2014 to N68 today.

3.1.1 About the company's ownership structure

Beta Glass Plc is a subsidiary of Frigoglass Industries Nigeria Limited, which holds a 61.9% stake in Beta. Frigoglass is itself a subsidiary of the Greek company, Frigoglass, which is a major player in the global Ice Cold Merchandiser (ICM) market. As a result, Athens-based Frigoglass holds the controlling stake in Beta Glass Plc in Nigeria.

Other notable shareholders include:

1. Frigoinvest Holdings B. V: 8.17%
2. Stanbic IBTC Nominees Nigeria Limited: 7.91%
3. Delta State Ministry of Finance Incorporated: 4.45%

3.2 Sources of Data Collection

The data for this research work is both primary and secondary source. Data was sourced from book, journals and several other areas from the internet. Data for the analysis was also sourced secondarily from Beta Glass PLC, Ughelli. Primarily, data was sourced via the interview method.

3.3 Method of Data Collection

The method of data collection employed for this research work is the interview method. We asked questions on how the quality assurance department measure the bottle's comprehensive pressure testing in psi and the device used from the IS production system. We went further to ask if they did employ any statistical methods in controlling their production process. Some samples of their observation were taken which will be presented in the subsequent section below. The stratified method of sampling is used for this research work. Five moulds were observed with a sample number of 20.

3.4 Quality Characteristics

The quality characteristic of interest for this research work is the comprehensive pressure strength test measured in psi (pounds per pressure inch).

3.5 CONTROL LIMITS

The computational formula for the above control charts are given below;

FOR $\bar{X}$-CHART

$$UCL = \bar{X} + A_2\bar{R} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

CL = $\bar{X}$ ……(2)

LCL = $\bar{X}$ - $A_2\bar{R}$ ……(3)

FOR **$\bar{R}$-CHART**

CL = R ……..(4)

ULC = $D_4\bar{R}$ ……..……...(5)

LCL = $D_3\bar{R}$ ……..…...(6)

WHERE;

D_3, D_4, A_2 are constant value obtained from the statistical quality control table

3.4.1 Statement of Hypothesis
H_0: the process is not in statistical control
H_1: the process is in statistical control

Decision Rule
The decision rule was to reject H_0: if the plotted point does not cluster about the control limit

3.5 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.

Test Statistics:

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

where,

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

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

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

3.5.1 Hypothesis Testing

H_0: The process is random

H_1: The process is not random

Decision Rule

Reject H_0 if p-value < $\alpha = 0.05$,
Otherwise, accept H_0.

4. Data Anaysis and Results

The result of the data analysis using Minitab, 17.0 was shown figure 1 to 3.

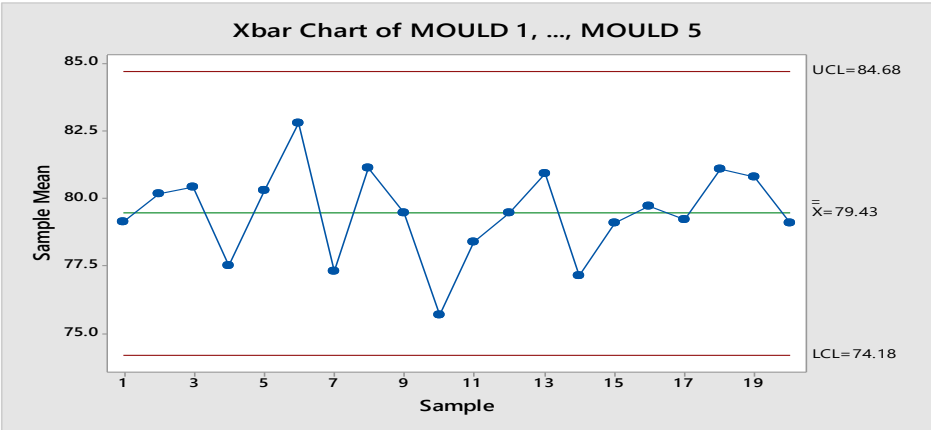

Figure 1. Shows the $\bar{X}$-chart for 5 Moulds

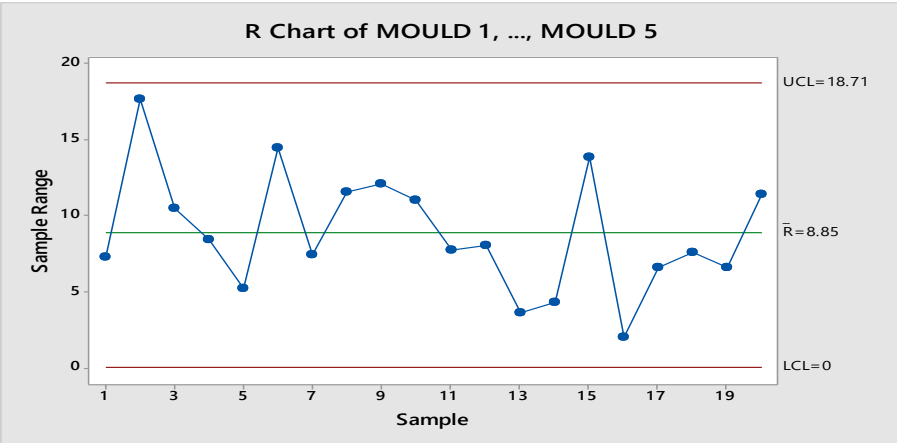

Figure 2. Shows the Range chart for 5 Moulds

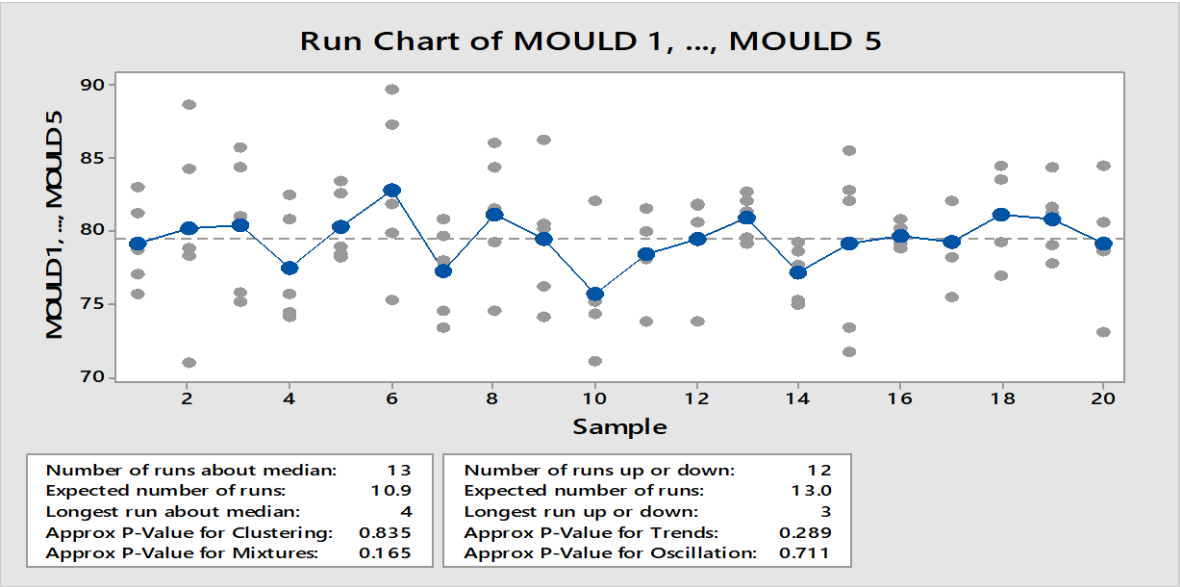

Figure 3. Showing the Runs chart for the 5 Moulds

Discussion of Result

It was observed from both charts that the 5 moulds are in statistical control and the process is said to be stable. We hereby accept the alternative hypothesis and conclude that the process is in statistical control.

The runs analysis shows that the plotted points are random and since the p-value is greater than $\alpha = 0.05$, we accept the null hypothesis and conclude that the process is random.

5 Conclusion

This study considered the application of the variable control chart in modeling the American Honey spirit bottle. The aim of the study was to applying the mean and range chart to monitor 20 samples of size 5 Mould from machine 21A export line that was subjected to a comprehensive strength test measured in psi.

The outcome of the study shows that both charts and the 5 moulds are in statistical control. Since the plotted points cluster around the control line for both the range graph and the mean graph, we accept the alternative hypothesis and conclude that the process is stable and under statistical control. Furthermore, the series analysis reveals that the points above and below are random, which leads to the acceptance of the null hypothesis and we hereby conclude that the process is random.

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