International Journal of Research in Business, Management & Accounting
ISSN (Online): 2455-6114
Volume 02 Issue 01 January 2016
Available on-line at: https://gnpublication.org/index.php/bma
DOI: *https://doi.org/10.53555/bma.v2i3.16988* Received: *02-Jan-2016* | Accepted: *12-Jan-2016*

A STATISTICAL ANALYSIS OF QUALITY CONTROL PROCESS ON PAPER PRODUCTION: A Case Study of Bel Papyrus Limited, Ogba, Lagos State

Ali, Hassana Oseiwu
Science Education Department, Kogi State University, Anyigbal Kogi State – Nigeria
+234-08035424304 hassanaali53@yahoo.com/hassana.ali304@gmail.com
Orumbe, Seth Obafemi
Mathematical Science Department Kogi State University, Anyigba

Abstract:

This research is an analysis of quality control process on paper production on the soft roll production process of Bel Papyrus Ltd located in Ogba, Lagos State, Nigeria. The research was done with the aim of determining the conformity of the industry's product to quality standard, identifying and eliminating the possible causes of variation in their production process, with reference to Percentage Elongation. The researchers used primary data in form of periodic laboratory test result done on soft rolls.Data presentations were made using simple statistical tools like Mean, Ranges, Standard Deviations, and Tables reflecting the primary data obtained at equal interval of production. The researchers made use of variable control charts for the purpose of analysis. The $\bar{x}$ *Chart, R Chart and* σ *Chart analyses done on soft roll produced considering the percentage elongation property all revealed an in-control situation. The study recommended that further investigation through the use of attribute control chart and acceptance sampling should be done amongst others, and the agency responsible for the regulation of quality control in Nigeria should employ the services of statisticians to conduct quality control process test on production companies in Nigeria.*

Keywords:

Quality Control Process, Conformity, Assurance, production, charts.

*Correspondence Author:
Email: GreenJ@gmail.com (Dr. Anil K. Bhatt)

INTRODUCTION

The emphasis on quality, quality control is an important part of production process which provides the foremost application of statistics in production cannot be neglected. A variety of statistical quality control techniques are available for monitoring the output of production processes, and properly interpreted control charts can help determine when adjustments are necessary to correct errors in these processes.

Anderson, Sweeney, and Williams: 2003 defines ***quality*** as "the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs." In other words, quality measures how well a product or service meets customer's needs. It will be interesting to know that the characteristics of quality includes but not limited to the following;

- Physical – Length, Weight, Voltage, Viscosity etc.
- Sensory – Taste, Appearance, Colour etc.
- Time Orientation – Reliability, Durability, Serviceability etc.

Organizations recognize that to be competitive in today's global economy, they must strive for high levels of quality. As a result, they have increased the emphasis on methods for monitoring and maintaining quality, which invariably entails quality improvement. Quality Assurance one would then say is the entire system of policies, procedures, and guidelines established by an organization to achieve and maintain quality. Quality assurance consists of two principal functions: quality engineering and quality control.

Muhammed (2012) in his research work on Cashew Plant of Kogi State University quoted Edward W Demings as saying that ˝statistical control of quality is application of statistical principles and techniques in all stages of design, production maintenance and services directed towards the economic satisfaction of demand"; which suffices us to say that the main objective of quality control is basically an economic, i.e. The profit and loss statement of an organization (be it manufacturing or otherwise) is affected by the degree at which its product and services satisfies the consumers.

The quality of a product (article or service) is in its ability to satisfy the needs and expectations of the customers [Klefsjö: 2001]. Quality is an on-going process that has to be so persuasive throughout a system (an organization), that it becomes the philosophy and culture of the whole system. It is therefore necessary that all arms of that organization adopts the same strategy, to serve the customer with even better quality, lower cost, quicker response and greater flexibility.

The concepts of some terms in quality control processes; **conformance to specifications** measures how well the product or service meets the targets and tolerances determined by its designers, while **fitness for use** focus on how well the product performs its intended function or use [Reid and Nada: 2010]. Furthermore, they defined **Value for price paid** as the quality that consumers often use for product or service usefulness. This is the only definition that combines economics with consumer criteria; it assumes that the definition of quality is price sensitive. Quality does not apply only to the product or service itself; it also applies to the people, processes, and organizational environment associated with it [Reid and Nada: 2010]. **Statistical Process Control** is an effective method of monitoring a process through the use of control chart. It is done to reduce waste as well as the likelihood that problem will be passed on to the consumer [Ali: 2012]. **Psychological criteria** is a subjective definition that focuses on the judgmental evaluation of what constitutes product or service quality. Different factors contribute to the evaluation, such as the atmosphere of the environment or the perceived prestige of the product. [Reid and Nada: 2010].

VARIATIONS IN PRODUCTS

Variation in product is the reason while quality control process is on conducted on product based on pre – determine criteria. Olukotun (2002) in his research work cited Edwards Deming (1950) thus, all processes are vulnerable to loss of quality through variation: if levels of variation are managed, they can be decreased and quality raised. Every process is subject to variability; therefore it is not possible to put exactly the same amount of jam in each jar or to make every car door of exactly the same width.

The variability present when a process is running well is called the short term or inherent variability. It is usually measured by the standard deviation. If all important sources of variations are under control in a production process, then the slight variations among the quality measurements usually cause no serious problems.

Variations in any production process are always due to both or either of the following;

CHANCE VARIATION

Chance variation results from intrinsic variability in the process. It is the inherent variability of the system which is random in nature; a natural variability or "background noise" that is a cumulative effect of many small, essentially unavoidable causes, e.g. Human variations from cycle to cycle, temperature.

ASSIGNABLE VARIATION

Assignable variations indicate an exception from normal operating conditions. It is event related and as such this variability is generally large when compared to the background noise, and it usually represents an unacceptable level of process performance.

STATISTICAL PROCESS CONTROL

A study done by Olukotun (2002) reveals that the use of statistical process control methods went along way in help the management of Global Soap and Detergent Company, Ilorin to produce quality products from their line of Soap and Detergent production. The application of quality tools like R Charts, $\bar{x}$ Chart etc, helped in monitoring production process, thereby creating a window for reducing production error and reducing waste. It was observed that the production was in in-control though some measures of correction are still needed for subsequent process.

The statistical procedures for process control are based on the hypothesis testing methodology. The null hypothesis H0 if formulated in terms of the production process being in control. The alternative hypothesis Ha is formulated in terms of the production process being out of control.

AIMS AND OBJECTIVES

The aims and objectives of this work include:

i. To determine if the production process of the Soft Roll Production Industry with particular reference to percentage elongation is in-control.

ii. To identify possible causes of variations in the production outputs with reference to percentage elongation.

RESEARCH QUESTION

The following constitute the research questions:

1. Is the production process (percentage elongation) an in-control situation?

2. What are the possible causes of variations in percentage elongation of the products?

HYPOTHESIS

Based on the above stated specific objectives, the following hypotheses were tasted

i. The null hypothesis H0: the production process (percentage elongation) is In-Control

ii. The alternative hypothesis Ha: the production process (percentage elongation) is Out-of- Control.

RESEARCH DESIGN

The research design used for this study is descriptive, as it involves observing and describing the production process of Soft Rolls produced, in order to ascertain whether the production process is in-control or out-of-control.

SOURCE OF DATA COLLECTED

The data used for this study were whole collected internally from existing records.

METHOD OF DATA COLLECTION

In order to satisfy the data requirements for this study, secondary data were obtained. Secondary data refers to data collected by someone other than the user. And in this case, periodic laboratory test results done on soft rolls were released from the company for the purpose of this research work.

DESIGN OF MEAN CHART ($\bar{x}$ – CHART)

The mean chart is use to monitor changes in the mean of a production process. In constructing a mean chart we need to first construct the centre line of the chart; this is done by obtaining the overall mean ($\bar{\bar{x}}$) otherwise called mean of means obtained from taking the mean of means ($\bar{x}$) of each subgroup i.e. each sample has its own mean ($\bar{x}$). Usually these samples are small with about four to five observation. Therefore;

Mean ($\bar{x}$) of each subgroup is

$$\bar{x} = \frac{\sum x_n}{n} \qquad \text{Where } n = 1, 2, 3, \ldots n$$

i.e. dividing the sum of the values in a sample subgroup by the number of items in the each sample subgroup.

Overall Mean ($\bar{\bar{x}}$) is

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{N} \qquad \text{Where } N = 1, 2, 3 \ldots N$$

i.e. dividing the sum of the sample subgroup means by the number of samples to be included in the chart.

The control limits are obtained thus;

Upper Control Limit: $UCL = \bar{\bar{x}} + 3\frac{\bar{\sigma}}{\sqrt{n}}$

Lower Control Limit: $LCL = \bar{\bar{x}} - 3\frac{\bar{\sigma}}{\sqrt{n}}$

Where; $\sigma = \frac{\bar{R}}{d_2}$

Note: σ is the Process Standard Deviation, $\bar{R}$ is the Average Range, $d_2$is a constant that depends on the sample size, obtained from control chart constant table.

DESIGN OF RANGE CHART (R- CHART)

The Range chart monitors the dispersion or variability of the process. The method for developing and using R-chart is the same as that of the $\bar{x}$-bar chart. The range chart is designed from the ranges of sample subgroups, which is obtained by subtracting the extreme values i.e. R = Highest Value – Lowest Value (for each sample subgroup); thereafter the centre line for this control chart is the average range.

Hence,

Average Range,

$$\bar{R} = \frac{\sum R}{N}$$

Where, R = range for each subgroup in the sample, N = 1, 2, 3 … N

The control limits are as follows;

Upper Control Limit: $UCL = \bar{R} + 3\frac{d_3}{d_2}.\bar{R}$

Lower Control Limit: $LCL = \bar{R} - 3\frac{d_3}{d_2}.\bar{R}$

$d_2$andd_3 are constants, obtained from control chart constant table.

DESIGN OF STANDARD DEVIATION (S) CHART (σ – CHART)

Setting up and operating control charts for σrequires about the same sequence of steps as those for $\bar{x}$ and R charts, except that for each sample we must calculate the sample standard

deviation σ. i.e. $S^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$

Suppose that m preliminary samples are available, each of size n and let S_i be the standard deviation of the ith sample. The average of the m standard deviations is

$\bar{\sigma} = \frac{1}{m}\sum_{1} S_i$, which is the center line for the control chart.

The control limits are:

Upper Control Limit: $UCL = \bar{s} + 3\frac{\bar{S}}{c_4}\sqrt{1 - c_4^2}$

Lower Control Limit: $LCL = \bar{s} - 3\frac{\bar{S}}{c_4}\sqrt{1 - c_4^2}$

Note that, $1 - 3\frac{\bar{S}}{c_4}\sqrt{1 - c_4^2} = B3$ and $1 + 3\frac{\bar{S}}{c_4}\sqrt{1 - c_4^2} = B4$

PRESENTATION OF DATA

The data contained in Table 1 represents results from laboratory analysis done on Soft Rolls after every 30 minutes of production. The test done includes Grammage (DS, M, TS), Tensile Strength (MD, CD), Percentage Elongation, Thickness, ISO R457, Colour (L, a, b) but this work is limited to Percentage Elongation measured in Percentage with standard method ISO 1924-2, DIN EN 1924-2, T494.Stretch is the amount of distortion which paper undergoes under tensile stress. Stretch elongation is usually expressed, as percent stretch to rupture; the tensile strain developed in a test sample at maximum tensile strength before rupture, measure as the % increase in the length of the sample to the original length. Stretch can be related to the paper's ability to conform and maintain conformance to a particular contour. Stretch is higher in cross direction than machine direction.

Table 1

% ELONGATION								
SAMPLE SUBGROUP	X1	X2	X3	X4	X5	$\bar{x}_i$	***Ri***	σ_i
1	36	42	40	34	40	38.40	8	3.2863
2	32	36	38	42	36	36.80	10	3.6332
3	44	38	46	40	38	41.20	8	3.6332
4	40	42	36	32	34	36.80	10	4.1473
5	32	36	28	34	32	32.40	8	2.9665
6	36	42	42	36	38	38.80	6	3.0332
7	38	32	36	34	40	36.00	8	3.1623
8	40	38	30	30	36	34.80	10	4.6043
9	36	30	34	30	32	32.40	6	2.6077
10	34	30	32	28	38	32.40	10	3.8471
11	36	26	38	28	36	32.80	12	5.4037
12	34	42	44	42	42	40.80	10	3.8987
13	40	34	38	34	36	36.40	6	2.6077

14	38	38	38	34	40	37.60	6	2.1909
15	32	30	36	42	34	34.80	12	4.6043
16	40	40	34	32	26	34.40	14	5.8992
17	44	38	38	34	36	38.00	10	3.7417
18	38	38	38	34	36	36.80	4	1.7889
19	50	40	40	34	38	40.40	16	5.8992
20	38	40	32	34	36	36.00	8	3.1623
21	38	40	42	28	32	36.00	14	5.8310
22	32	34	30	38	28	32.40	10	3.8471
23	40	30	32	40	41	36.60	11	5.1769
24	40	42	42	38	36	39.60	6	2.6077
25	38	32	32	36	34	34.40	6	2.6077
26	36	38	34	34	38	36.00	4	2.0000
27	38	36	38	36	44	38.40	8	3.2863
28	34	36	38	42	38	37.60	8	2.9665
29	38	40	40	40	34	38.40	6	2.6077
30	38	40	38	36	34	37.20	6	2.2804
31	40	36	40	38	38	38.40	4	1.6733
32	40	40	34	40	42	39.20	8	3.0332
33	40	38	36	32	36	36.40	8	2.9665
34	38	32	40	36	38	36.80	8	3.0332
35	36	42	34	36	42	38.00	8	3.7417
36	36	36	40	46	36	38.80	10	4.3818
37	42	40	38	40	40	40.00	4	1.4142
38	42	44	40	40	38	40.80	6	2.2804
39	30	40	34	40	40	36.80	10	4.6043
40	36	38	42	42	36	38.80	6	3.0332
41	38	38	40	38	38	38.40	2	0.8944
42	34	40	46	42	38	40.00	12	4.4721
43	32	36	34	34	50	37.20	18	7.2938
44	40	36	28	40	36	36.00	12	4.8990
45	36	30	38	38	38	36.00	8	3.4641
46	34	32	38	42	32	35.60	10	4.3359
47	44	32	32	26	32	33.20	18	6.5727
48	30	42	40	34	34	36.00	12	4.8990
49	38	32	32	30	30	32.40	8	3.2863
50	34	32	28	36	36	33.20	8	3.3466
51	38	40	40	36	30	36.80	10	4.1473
52	36	34	32	34	36	34.40	4	1.6733
53	30	30	36	38	32	33.20	8	3.6332
54	40	38	44	42	42	41.20	6	2.2804

55	44	46	32	46	40	41.60	14	5.8992
56	46	36	38	36	36	38.40	10	4.3359
57	36	38	46	38	44	40.40	10	4.3359
58	38	40	38	38	38	38.40	2	0.8944
59	34	34	36	36	30	34.00	6	2.4495
60	34	36	28	34	36	33.60	8	3.2863
Total						**2208.60**	**519**	**213.8895**
Average						**36.81**	**8.65**	**3.5648**

CONSTRUCTION OF VARIABLE CHARTS FOR ELONGATION

$\bar{x}$ CHART

Center line

Using data in Appendix 1.3, we find the center line as

$n = 60$ and $\sum_{i=1}^{60} \bar{x_i} = 2208.60$

$\bar{\bar{x}} = \frac{\sum_{i=1}^{n} \bar{x}_i}{n} = \frac{2208.60}{60} = 36.81$

Lower Control Limit

From data in Appendix 1.3 we calculate the LCL thus;

LCL = $\bar{\bar{x}} - A_2\bar{R}$

Where $\bar{\bar{x}} = 36.81$, $\bar{R} = 8.65$, $A_2 = 0.5770$ as obtained from Control Charts Constants' corresponding to size of 5. Hence,

LCL = $36.81 - (0.5770)(8.65) = 36.81 - 4.99105$

$= 31.81895 \cong 31.82$

Upper Control Limit

The UCL is calculated using data in Appendix 1.3 thus:

UCL = $\bar{\bar{x}} + A_2\bar{R}$

Where $\bar{\bar{x}} = 36.81$, $\bar{R} = 8.65$, $A_2 = 0.5770$ as obtained from Control Charts Constants' corresponding to size of 5. Hence,

UCL = $36.81 + (0.5770)(8.65) = 36.81 + 4.99105$

$= 41.80105 \cong 41.80$

RCHART

Center Line

From Appendix 1.3 the center line obtained thus;

$n = 60$and$\sum_{i=1}^{60} R_i = 519$

$\bar{R} = \frac{\sum_{i=1}^{n} R_i}{n} = \frac{\sum_{i=1}^{60} R_i}{60} = \frac{519}{60} = 8.65$

Lower Control Limit

Using data from Appendix 1.3 the LCL is obtained as follows

$LCL = \bar{R}D_3 = 8.65(0) = 0$

Where $D_3 = 0$ as obtained from Control Charts Constants' corresponding to subgroup size of 5.

Upper Control Limit

Using data from Appendix 1.3 the UCL is obtained thus

$UCL = \bar{R}D_4 = 8.65(2.115) = 18.29475 \cong 18.29$

Where $D_4 = 2.115$ as obtained from Control Charts Constants' Table corresponding to subgroup size of 5.

σCHART

Center Line

The CL is calculated thus, using Appendix 1.3

$n = 60$and$\sum_{i=1}^{60} \sigma_i = 213.8895$

$\bar{\sigma} = \frac{\sum_{i=1}^{n} \sigma_i}{n} = \frac{\sum_{i=1}^{60} \sigma_i}{60} = \frac{213.8895}{60} = 3.564825 \cong 3.565$

Lower Control Limit

Using data from Appendix 1.3 the LCL is obtained as follows

$LCL = \bar{\sigma}B_3 = 3.565(0) = 0$

Where $B_3 = 0$ as obtained from Control Charts Constants' Table corresponding to subgroup size of 5.

Upper Control Limit

Using data from Appendix 1.3 the UCL is obtained thus

$UCL = \bar{\sigma}B_4 = 3.565(2.089) = 7.447285 \cong 7.447$

Where $D_4 = 2.089$ as obtained from Control Charts Constants' Table corresponding to subgroup size of 5.

CONCLUSION

Conclusively, the analysis of the graphs on the data obtained from Bel Papyrus Limited shows in percentage elongation are all in – control process, this signify conformity to laid quality or standard of production.

RECOMMENDATION

Further investigation through the use of attribute control chart and acceptance sampling should be employed as to further sieve out non-conforming products due to presence of few outliers.

Continuous training of staff should be done to ensure they are up to date with current trends of the operation techniques both mechanically and statistically.

REFERENCES

Anderson, D., Sweeney, D. and Williams, T. (2003).Modern Business Statistics with Microsoft Excel (1st Edition). Cincinnati (USA): South-Western Thomson Learning.

Ali, H.O (2012). Statistical Quality Control. Department of Mathematical Sciences, Kogi State University: Unpublished Lecture Notes.

AS/NZS ISO 8402. (1994). Quality Management and Quality Assurance—Vocabulary.Australia: Standard Australia.

Klefsjö, B. (2001). Six Sigma seen as a methodology for Total Quality Management. Measuring Business Excellence. Vol.5.

Muhammad Y. (2012). Statistical Quality Control Techniques on Production Process: A Case Study of Kogi State University Cashew Plant.Kogi State University, Anyigba (Kogi State): An unpublished 1st Degree Project Work.

Olukotun, A. (2002). Statistical Quality Control on Detergent: A Case Study of Global Soap and Detergent. Federal PolythecnicIdah (Kogi State): An unpublished1st Degree Project Work.

Reid, R., and Nada, R. (2010). Operations Management (4th Edition). USA: Wiley Press.