STATISTICAL ANALYSIS OF SOME QUALITY CHARACTERISTICS OF ROBUST TISSUE PAPER (A CASE STUDY OF EPESOK PAPER MILLS NIGERIA LIMITED)

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ABSTRACT: *This project is focused on the study of some quality characteristics of robust tissue paper a product of Epesok Paper Mills using statistical quality control techniques. Three important quality characteristics are Ph, Basic weight (g/m^2) and Absorbency (mm) which are all variable measures. The data used for the study is a secondary data collected from the daily laboratory records of Epesok paper Mills Company of Nigeria for a period of seven (7) months. Control chart was used to monitor the performance of each of the quality characteristics. Also correlation analysis was carried out to determine possible correlation been pairs of the quality characteristics. The results shows that each of the characteristics monitored were statistically under control. Also the results of the correlation analysis confirm significant correlations among some quality characteristics.*

KEYWORDS: *Correlation, Control chart*

1. INTRODUCTION

A major requirement in any manufacturing process is to ensure quality of manufactured product; this is necessitated by the need for products to meet the requirements of those who use them. Quality control is as old as industry itself from the time man become manufacture, there has been interest in the quality of output [5]. As far back as the middle ages the medieval guide insisted on the period of training for apprentices and required those seeking master craft men after over evidence of their ability. Such rules were fact, at the mentainance of quality [6]. According to [4], the basic problem in any production process was not the quantum of the product but the quality of the product. The producer was basically interested to see that the product was of acceptable quality that is, it conforms to certain prescribed standards of specifications. The quality of the manufactured product depends on a number of factors, starting with its design and specifications, the production process, the raw materials, machines and equipment, the expertise and skill of the persons who handle them and the inspection of the final product [9]. In 1930, Shewhart published a book titled Economic Control of Quality of Manufactured Product. The book set the pattern from sequence application of statistical method to process control. Two other Bell system men, H. F. Dodge and H. G. Roming took the leadership in developing the application of statistical theory in sampling inspections, the culmination of their work being the new well known Dodge-Roming sampling inspections table [1][2]. The work of these three men namely Shewhart, Dodge and Roming constitutes much of what today comprise theory of Statistical Quality Control (SQC). [8], statistical quality control is divided into three (3) broad categories namely; Descriptive statistics, statistical process control and acceptance sampling. Statistical quality control refers to statistical tools that can be used by quality professionals in monitoring quality characteristics of a product to ensure that it conform to specification standard.

Epesok Paper Mill Limited, like any other manufacturers only produced and market their products whether the production process are in state of control and the products are of the standard of quality needed by the customers. Thus, the research use statistical quality control to examine products produce with the aims of satisfying the customers, by studying some characteristics of robust tissue paper produced [3].

2. METHODOLOGY

2.1 Source of Data

The data used for this project is a secondary data collected from the daily laboratory records of Epesok paper Mills Company of Nigeria which is a member of the Onward Group of Companies situated at Plot Y Mobolaji Johnson Avenue, Alausa, Ikeja, Lagos. The information was collected for a period of seven (7) months.

2.2 Method of data analysis

Parameters for Individual Chart

CL=$\bar{X}$

UCL=$\bar{X} + 3\,\bar{R}/d_2$ (1)
LCL=$\bar{X} - 3\,\bar{R}/d_2$
Where: Upper control limit=UCL
Central line=CL
Lower control limit=LCL

Parameters for Moving Range Chart

UCL=$D_4\bar{R}$
CL=$\bar{R}$ (2)
LCL=$D_3\bar{R}$
where
$\bar{X}$ Is the average of all the individuals and $\bar{R}$ is the average of all the moving ranges of two observations. d_2, D_4, D_3 are values obtained from statistical quality control table with n=2

2.3 Test for Randomness

Random selection is mostly used in the whole process of industrial statistics. There is therefore the need to do a test on the randomness on the selection itself using runs. A run is a succession of identical symbols which are followed and preceded by different symbols or by no symbols. The number of runs in a sample is an indication of whether or not a sample is random.

Runs Test

The runs test can be used to test the randomness of samples consisting of numerical data by counting runs above and below the medium. This is use to check whether there might be a trend in the data so that it is possible to adjust a machine setting or some other process variable.

Hypothesis

H_0 : Arrangement of sample value is random

Test statistics

Z=$\frac{R-\mu_r}{\delta_r}$. (3)
where
$\mu_r=\frac{2n_1n_2}{n_1+n_2}+1.$
$\delta_r=\sqrt{\frac{2n_1n_2(2n_1n_2-n_1-n_2)}{(n_1+n_2)^2(n_1+n_2-1)}}.$
n_1 = Observation exceeding the mean of the samples
n_2 = Observation less than or equals the mean of the samples
z = Number of runs

Decision rule: reject H_0 if $Z_{cal} > Z_{tab}$ if otherwise we fail to reject H_0 or reject H_0 if level of significance (α) >p-value and if otherwise we fail to reject H_0

2.4 Correlation Analysis

Correlation

Correlation coefficient measures the degree of association among given characteristics of interest. The correlation coefficient r between two variables of interest X and Y is given as

$r_{xy} = \frac{cov(x,y)}{\sqrt{var(x)*var(y)}}$ (4)

Significance of correlation coefficient

To test the significance of correlation coefficient between two variables, the hypothesis is set as follows:

Hypothesis

H_o: ρ= 0

Test Statistic

t= $\frac{r_{xy}\sqrt{n-2}}{\sqrt{1-r_{xy}^2}}$. (5)

Where r_{xy}= the correlation between variable x and variable y
$cov(x,y)$ = covariance between variable x and variable y

Decision Rule

Reject H_o if p-value is less than α at 0.05 level of significance otherwise do not reject.

3. RESULT AND DISCUSSION

3.1 Analysis on PH

Table 1: Showing the Descriptive Statistics of PH

Variable	Mean	Skewness	Kurtosis	Actual spread	Allowable spread
PH	6.65	0.454	0.232	0.99	0.5

Ph as a distribution as shown in the table above with the actual spread wider than the allowable spread which implies that the process has too much variability. The process may be producing products that do not conform to specification limits.

Monitoring Ph Data

In order to monitor the Ph of robust tissue paper, the individual and moving range (MR) charts are used. The IND/MR charts are plotted below in fig. 1 and fig 2. respectively with the aid of SPSS.

Control Chart for Individuals

X- Chart

The control limits are calculated below:
CL=$\bar{X} = \frac{\sum X}{n}$ =6.6307
UCL=$\bar{X} + 3\,\bar{R}/d_2$= 6.8756
LCL=$\bar{X} - 3\,\bar{R}/d_2$=6.3857

Moving range chart

The control limits are calculated below
CL=$\bar{R} = \frac{\sum MR}{n} = 0.0921$
UCL=$D_4\bar{R} = 0.3010$
LCL=$D_3\bar{R} = 0.0000$

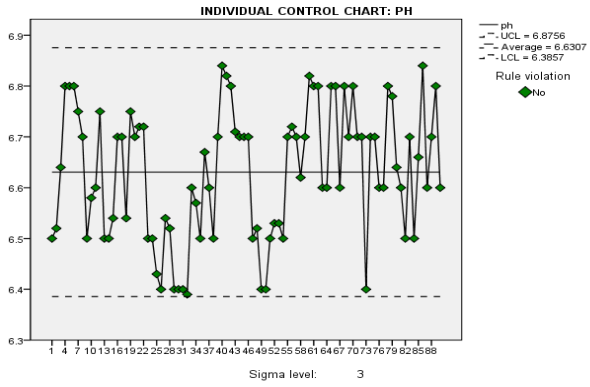

Fig 1. Variation in the process

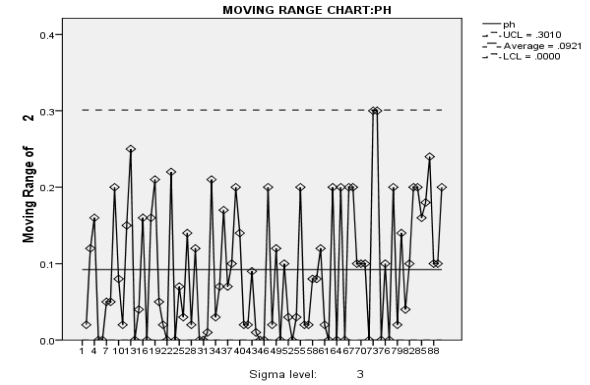

Fig 2. Variation in the process

From the control charts in fig 1. and fig 2. none of the point falls out of the control limits indicating that the variation in the process is due to random cause only. That is, the process is under statistical control.

Test of Randomness on ph

Runs test

Hypothesis

H_0 : Arrangement of sample value is random

Test statistics

Z=$\frac{R-\mu_r}{\delta_r}$= -3.177

P-VALUE=0.001

Since level of significance (α)=0.05 > p-value=0.001, we reject the null hypothesis that is H_0 and conclude that the samples are not random at 0.05 level of significance.

3.2 Analysis on Basic Weight

Distribution of Basic Weight

Table 2: showing the descriptive statistics of basic weight

Variable	Mean	Skewness	Kurtosis	Actual spread	Allowable spread
Basic weight	17.49	-0.440	-0.516	3.00	4

Basic weight as a distribution as shown in the table above with the actual spread is narrower than the allowable spread which is an indication of small variability in the process.

Monitoring Basic Weight

In order to monitor the basic weight of robust tissue paper, the individual and moving range (MR) charts are used. The IND/MR charts are plotted below in fig 3 and fig 4. respectively with the aid of SPSS.

The control limits are calculated below:

Individual chart

CL=17.5244

UCL=18.9165

LCL=16.1324

Moving range chart

CL=0.5236

UCL=1.7023

LCL=0.000

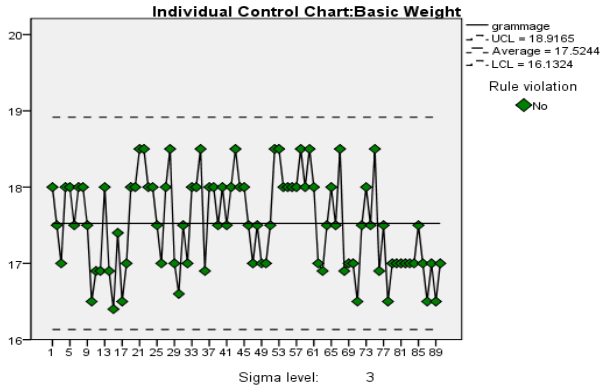

Fig 3. Variation in the process

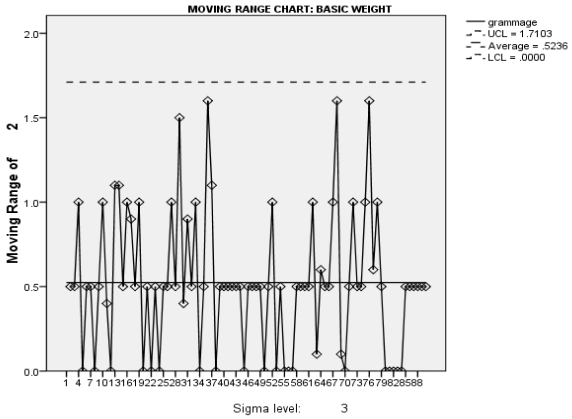

Fig 4. Variation in the process

From the control charts in fig 3. and fig 4., none of the point falls out of the control limits indicating that the variation in the process is due to random cause only. That is, the process is under statistical control.

Test of Randomness for Basic Weight

Runs Test

Hypothesis

H_0 : Arrangement of sample value is random

Test statistics

Z=$\frac{R-\mu_r}{\delta_r}$= -3.579

P-VALUE= <0.001

Decision

Since level of significance (α) =0.05 > p-value=0.001, we reject the null hypothesis that is H_0 and conclude that the samples are not random at 0.05 level of significance.

3.3 Analysis on Absorbency

Table 3: shows the distribution of absorbency

Variable	Mean	Skewness	Kurtosis	Actual spread	Allowable spread
Absorbency	15.61	-0.509	-0.758	4	6

Absorbency as a distribution as shown in the table above with the actual spread narrower than the allowable spread which is an indication of small variability in the process.

Monitoring Absorbency

In order to monitor the Absorbency of robust tissue paper, the individual and moving range (MR) charts are used. The IND/MR charts are plotted below in fig 5 and fig 6 respectively with the aid of SPSS.

The control limits are calculated below:

Individual chart

CL=15.8300

UCL=17.7060

LCL=13.9594

Moving range chart

CL=0.7056

UCL=2.3049

LCL=0.000

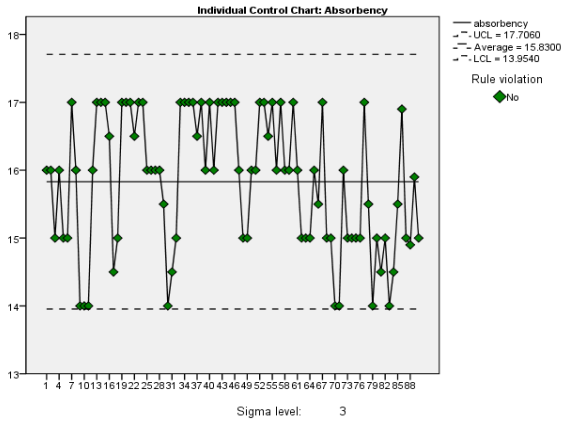

Fig 5. Variation in the process

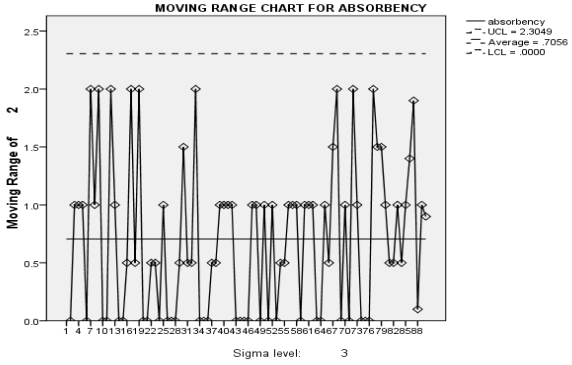

Fig 6. Variation in the process

From the control charts in fig 5 and fig 6, none of the point falls out of the control limits indicating that the variation in the process is due to random cause only.

Test of Randomness for Absorbency

Runs Test

Hypothesis

H_0 : Arrangement of sample value is random

H_1: Not H_0

Test statistics

Z=$\frac{R-\mu_r}{\delta_r}$= - 4.545

P-VALUE= <0.001

Decision

Since level of significance (α) =0.05 > p-value=0.001, we reject the null hypothesis that is H_0 and conclude that the samples are not random at 0.05 level of significance.

3.4 Correlation analysis

Measuring the degree of association between the pair of quality characteristics under consideration

Possible pairs are

Ph vs. basic weight

Ph vs. absorbency

Basic weight vs. absorbency

Hypothesis

H_o: ρ= 0 that is, there is no relationship between the variables

Test Statistic

t= $\frac{r_{xy}\sqrt{n-2}}{\sqrt{1-r_{xy}^2}}$

P-value =pr ($\rho \geq t_{88,0.975}$)

Decision Rule

Reject H_o if p-value is less than α at 0.05 level of significance otherwise do not reject.

Table 4 below gives the correlation between each of the quality characteristics under consideration.

Table 4: Correlation between each of the quality characteristics under consideration

Variables	Ph	Basic weight(g/m²)	Absorbency (mm)
Ph p-value	1	0.084 0.432	0.084 0.432
Basic weight(g/m²) p-value	0.084 0.432	1	0.601 <0.001
Absorbency(mm) p-value	0.084 0.432	0.601 <0.001	1

From the result obtain from table 4.

Ph vs. Basic weight

The correlation coefficient shows that there is a weak positive relationship between ph and basic weight.

T-test was use to test for the significance of the correlation coefficient and it was discovered that p-

value (0.432) is greater than α(0.05). Therefore H_o is not rejected at 0.05level of significance and conclude that there is no relationship between ph and basic weight.

Ph vs. Absorbency

The correlation coefficient shows that there is a weak positive relationship between ph and absorbency.

T-test was use to test for the significance of the correlation coefficient and it was discovered that p-value (0.432) is greater than α (0.05). Therefore H_o is not rejected at 0.05level of significance and conclude that there is no relationship between ph and absorbency.

Basic weight vs. absorbency

The correlation coefficient shows that there is a strong positive relationship between basic weight and absorbency.

T-test was use to test for the significance of the correlation coefficient and it was discovered that p-value (<0.001) is less than α (0.05). Therefore H_o is rejected at 0.05 level of significance and conclude that relationship exist between basic weight and absorbency.

CONCLUSION

Based on the available data and the results of the analysis as a whole, it can be concluded that the production process of robust tissue paper is statistically under control with respect to the quality characteristics studied.

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