Application of Statistical Quality Control on the Production of Long Span Aluminum Roofing Sheet Produced by Spring Aluminum Nigeria Ltd

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Abstract:- This research is to examine some of the quality characteristics of long span aluminum roofing sheet produced by Spring Aluminum Nigeria Ltd. The quality characteristics which are Length, Weight and Thickness were examined with the use of control chart and it was observed from the control chart that the production process is in statistical control with respect to each of the quality characteristics. Furthermore, process capability analysis was carried out on the production process with respect to Length, Weight and Thickness so as to assess whether the process is able to meet specification that was set for these three quality characteristics. From the result obtained, it shows that the level of performance of this company is very good and the proportion defective obtained based on Length, Weight and Thickness is approximately zero. Hence, the production process of Long Span Aluminum Roofing Sheet in Spring Aluminum Nig. Ltd. with respect to quality characteristics that were considered is of good standard.

Keywords:- *Assignable, Performance, Process Capability, Quality Characteristics, Random Variation, Specification Limit, Statistical Quality Control.*

I. INTRODUCTION

Every product possesses a number of elements that jointly describe what user or consumer thinks of as quality. These parameters are often called quality characteristics. As a matter of fact, quality has become one of the most important consumer decision factors in the selection among competing products and services. The phenomenon is widespread regardless of whoever is the consumer. Consequently, understanding and improving quality of the factors are leading to business success, growth and enhanced competitiveness (Montgomery, 2005). In the context of the goods and services provided by business, industry and government, quality definition suggest that it is the features, properties, attributes, characteristics etc. of a good and services (Webster, 1971).

A. Statistical Process Control

In any production process, variation in quality is unavoidable. This variation could be gradual or sudden and the theory is originated by Shewart W.A (1924). As a result of his finding, variation can be categorized into two namely; Random variation and Assignable. Random variations are variations which result from the interaction of many complex causes which can neither be identified nor eliminated, except to modify the process of e.g. changes in temperature and pressure. Variation to assignable causes are certain variations in quality over which we have some degree of control in this situation, the difference in quality may be due to differences among machines, workers and raw materials.

Boot and Coxt (1995) says the application of statistical quality control to industrial and manufacturing process is known as quality control and they also said further that quality control is conceived with the collection, analysis and presentation of facts concerning quality.

David Croft (1986) in his book “Applied Statistics for management studies” says the term “quality control” should be understood to include all activities concerned with awareness in a production process.

Keller (1999) defined quality control as statistical process control which refers to one of a variety of statistical techniques used to develop and maintain a firm ability to produce high quality goods and services. Statistical process control (SPC) is an important tool used widely in manufacturing field to monitor the overall operation. SPC can be applied to all kind of manufacturing operations. The significant application of the SPC analysis to the operation will make the process more reliable and stable (Grant & Leavenworth, 1979).

Statistical process control (SPC) involves using statistical techniques to measure and analyze the variation in process. Most often used for manufacturing processes. The consistent, aggressive and committed use of SPC to bring all processes under control, recognize and eliminate special causes of variation, and identify the capability of all operations is a key requirement. SPC is defined as prevention of defects by applying statistical methods to control the process (Montgomery, 2005).

II. METHODOLOGY

Control chart for variables are used to monitor the mean and variability of process distribution. This method deals with statistical formulae and inferences used in the computation of the data collected. Various types of control charts can be used to carry out the analysis such as; $\bar{X}$-chart, R-Chart, S-chart, P-chart etc. But for this study, we adopted $\bar{X}$ and S chart.

A. *Sources of Data*

Data were collected from Spring Aluminum Nigeria Ltd.

B. *List of Symbols*

$\bar{\bar{X}}$ – Average of the subgroup average
$\bar{X}$ – Average of subgroup
n – Number of subgroups
UCL – Upper Control Limit
LCL – Lower Control Limit
σ - Population standard deviation of the subgroup averages
A_2 – Approximation factor used to calculate control limits
d_2 - Approximation factor for calculating within subgroup standard deviation.

C. *$\bar{X}$- Chart (Variable Control Chart)*

The $\bar{X}$- Chart is used to show the quality of the sample drawn from a given process. Also, it's used to control the variation in the average value of samples and monitors the process mean. The center is said to be at x i.e. the average of all data of which the limits are been defined as follows;

CL = $\bar{\bar{X}}$ control limit

UCL = $\bar{\bar{X}} + 3\sigma\bar{X}$ upper control limit

$= \bar{\bar{X}} + \frac{3\sigma}{\sqrt{n}}$

LCL = $\bar{\bar{X}} - 3\sigma\bar{X}$ lower control limit

$= \bar{\bar{X}} - \frac{3\sigma}{\sqrt{n}}$

Where $\sigma_x = \frac{\sigma}{\sqrt{n}}$ an estimator of σ

The variable (σ) which is called the standard deviation is estimated by $\frac{\bar{R}}{d_2}$ and d_2 is a constant. Hence, UCL $\bar{X} = \bar{\bar{X}} + \frac{3R}{d_{2\sqrt{n}}}$; CL $\bar{X} = \bar{\bar{X}}$; LCL $\bar{X} = \bar{\bar{X}} - \frac{3R}{d_{2\sqrt{n}}}$

Substituting $\frac{3}{d_2\sqrt{n}}$ into A_2, therefore,

UCL = $\bar{\bar{X}} + A_2\bar{R}$ while LCL = $\bar{\bar{X}} - A_2\bar{R}$

Note: The value of A_2 is contained in table and depends on the value of n while $\bar{\bar{X}}$ is the mean of all subgroup means.

D. *S- Chart (Variable Control Chart)*

In this chart, the sample standard deviations are plotted in order to control the variability of a variable. If σ^2 is the unknown variance of a probability distribution, then an unbiased estimator of σ^2 is the sample variance.

$$S^2 = \frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n-1}$$

However, the sample standard deviation S is not an unbiased estimator of σ^2. If the underlying distribution is normal, then S is actually estimates $C_4\sigma$ where C_4 is the constant that depends on the sample size n.

The statistic $\frac{\bar{S}}{C_4}$ is an unbiased estimator of σ. Therefore, the parameters of the S-chart would be UCL = $\bar{S}+3\frac{\bar{S}}{C_4}\sqrt{1-C_4^2}$

Center line = $\bar{S}$

LCL = $\bar{S}-3\frac{\bar{S}}{C_4}\sqrt{1-C_4^2}$

Usually, the constants B_3 and B_4 are defined respectively as,

$B_3 = 1 - \frac{3}{C_4}\sqrt{1-C_4^2}$ and $B_4 = 1 - \frac{3}{C_4}\sqrt{1-C_4^2}$

Consequently, we may write the parameters of S-chart as;

UCL = $B_4\bar{S}$
Center Line = $\bar{S}$
LCL = $B_3\bar{S}$

Note: $B_4 = \frac{B_6}{C_4}$ and $B_3 = \frac{B_5}{C_4}$

When $\frac{\bar{S}}{C_4}$ is used to estimate σ, we may define the control limits on the corresponding $\bar{X}$ chart as;

UCL = $\bar{\bar{X}} + \frac{3\bar{s}}{C_{4\sqrt{n}}}$

Center Line = $\bar{\bar{X}}$

LCL = $\bar{\bar{X}} - \frac{3\bar{s}}{C_{4\sqrt{n}}}$

Let the constant $A_3 = \left(\frac{3}{\sqrt{C_4\sqrt{n}}}\right)$. Then,

UCL = $\bar{\bar{X}} + A_3\bar{s}$ **Upper Control Limit**
CL = $\bar{\bar{X}}$
Control Limit
LCL = $\bar{\bar{X}} - A_3\bar{s}$ **Lower Control Limit**

E. *Process Capability*

In this process capability analysis, both attributes and variables control charts can be used. The $\bar{X}$ and $\bar{R}$ should be used whenever they are possible because of the greater power and better information they provides relatives to attributed charts. However, P-charts or U-charts are useful in analyzing process capability. If the population standard is unknown, process capability and the tolerance is combine to form capability index CP = $\frac{u-l}{6\sigma}$

Where CP = Capability Index
6σ = Process Capability
U-L = Upper specification – Lower specification

If CP = 1.00 i.e 6σ = U – L, then the process is normal, when CP>1, then it is said to be the most desirable but when the CP<1, this case represents the unique situation where the process is in control.

III. APPLICATION OF $\bar{X}$-CHART AND S-CHART

➢ *Control Chart for Length*

- *Computation of $\bar{X}$-chart (Mean Chart) for the Length:*

Upper Control Limit = $\bar{\bar{X}}$ + $A_2\bar{R}$
= 18.80+1.023(7.42)
= 26.40
Lower Control Limit = $\bar{\bar{X}}$ - $A_2\bar{R}$
= 18.80-1.023(7.42)
= 11.209

- *Computation of S-chart for the Length:*

CL = $\bar{S}$ = 3.92
UCL = $B_4\bar{S}$; B_4=2.568 (Obtained from Statistical Table); UCL=2.568(3.92) = 10.06
LCL = $B_3\bar{S}$; B_3=0 (Obtained from Statistical Table); UCL=0(3.92) = 0

- *Capability Process for the Length:*

The length specification limit is 21±10
$\sigma = \frac{\bar{R}}{d_2} = \frac{7.42}{4.358} = 1.70$
Upper Specification Limit = 31
Lower Specification Limit = 11
CP = $\frac{u-l}{6\sigma} = \frac{31-11}{6(1.70)} = 1.96$

Since CP>1, this means that the process capability is acceptable.

➢ *Control Chart for Thickness*

- *Computation of $\bar{X}$-chart (Mean Chart) for the Thickness:*

Upper Control Limit = $\bar{\bar{X}}$ + $A_2\bar{R}$
= 0.43+1.023(0.16)
= 0.594
Lower Control Limit = $\bar{\bar{X}}$ - $A_2\bar{R}$
= 0.43-1.023(0.16)
= 0.266

- *Computation of S-chart for the Thickness:*

CL = $\bar{S}$ = 0.08
UCL = $B_4\bar{S}$; B_4=2.568 (Obtained from Statistical Table); UCL=2.568(0.08) = 0.21
LCL = $B_3\bar{S}$; B_3=0 (Obtained from Statistical Table); UCL=0(0.08) = 0

- *Capability Process for the Thickness:*

A is the interval of the graph plotted for the mean (X-chart), hence, A = 0.1
$\sigma = \frac{\bar{R}}{d_2} = \frac{0.16}{4.358} = 0.04$
Upper Specification Limit = $\bar{\bar{X}}$ + A;0.43+0.1 = 0.53
Lower Specification Limit = $\bar{\bar{X}}$ - A; 0.43-0.1 = 0.33
CP = $\frac{u-l}{6\sigma} = \frac{0.53-0.33}{6(0.04)} = 0.83$

Since CP<1, this means that the process is not capable of producing since it falls out of the range of specification.

➢ *Control Chart for Weight*

- *Computation of $\bar{X}$-chart (Mean Chart) for the Weight:*

Upper Control Limit = $\bar{\bar{X}}$ + $A_2\bar{R}$
= 21.94+1.023(9.24)
= 31.39
Lower Control Limit = $\bar{\bar{X}}$ - $A_2\bar{R}$
= 21.94-1.023(9.24)
= 12.49

- *Computation of S-chart for the Weight:*

CL = $\bar{S}$ = 4.88
UCL = $B_4\bar{S}$; B_4=2.568 (Obtained from Statistical Table); UCL=2.568(4.88) = 12.53
LCL = $B_3\bar{S}$; B_3=0 (Obtained from Statistical Table); UCL=0(4.88) = 0

- *Capability Process for the Weight:*

The length specification limit is 25±10
$\sigma = \frac{\bar{R}}{d_2} = \frac{9.24}{4.358} = 2.12$
Upper Specification Limit = 35
Lower Specification Limit = 15
CP = $\frac{u-l}{6\sigma} = \frac{35-15}{6(2.12)} = 1.57$

It is obvious that the capability process here is greater than 1 and thereby we conclude that it is acceptable.

IV. SUMMARY

Statistical quality control is able to differentiate between chance cause factor which are fundamental to all process and assignable cause's factor which can be isolated and be removed from the long span aluminum roofing sheet process. By using the range of acceptability, it is possible to determine when long span aluminum roofing sheet is stable operating without an assignable causes that is to say, to know whether the long span aluminum roofing sheet is statistically control or not.

Considering the aim of this research which is to assess the quality of the product by the Spring Aluminum Nigeria Ltd, this study gives us the opportunity of having an insight into the application of shewart that is mean (x-chart) and standard deviation chart (s-chart) which was used to check the result.

From the length, it was observed that none of the samples fall out of control limit in s-chart while only one sample fall out of control limit in the x-chart. From the thickness, it was observed that none of the samples fall out of control limit in all the charts (x and s-chart). From the weight, it was observed that only one point fall out of the control limit in all the charts (x and s-chart).

V. CONCLUSION

From the result of the analysis, it can be concluded that production process of Long Span Aluminum Roofing Sheet in Spring Aluminum Nigeria Ltd is in statistical control with respect to quality characteristics been considered and their level of performance is of very good standard.

VI. RECOMMENDATION

Based on the conclusion, we will recommend that Spring Aluminum Nigeria Ltd should keep up the standard of the process at which it produces Long Span Aluminum Roofing Sheet with respect to its quality characteristics so as to have a competitive edge.

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