The Use Of Shewart Control Chart In Quality Assessment Of Nimafoam

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Abstract: The quality of NIMAFORM mattresses produced by Bajabure Industrial Complete (BIC) was assessed. Data were collected from the Quality Control Unit of BIC on the various densities 15 kg/m^3, 18 kg/m^3, 20 kg/m^3, 25 kg/m^3, 29 kg/m^3. The Shewart Control Chart techniques were used precisely $\bar{X}$ *and R Chart*, since the data were of the variable type. It was observed that 15kg/m^3, 18kg/m^3, 20kg/m^3 and 25kg/m^3 meet the desired and design specification.

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1. Introduction

In Industrial perspective, the changes that occur in the process of production or manufacturing of product are called variation (Ganvrial, 1996). Variation can either be due to random (chance) causes or/and assignable causes. Some stable system of chances is inherent in any particular schemes of production and inspection (Samuel and Norman, 1998), which cannot be eliminated. But for products to maintain their standards, the assignable causes due to personnel, machines or materials must be eliminated or at least reduced. Any process that is operating in the presence of assignable causes can be said to be out of control, Montgomery (1991).

Keller and Warrack (1999) defined quality control as Statistical Process Control (SPC) 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 (Amir, 1999) stated that the capability of any process is the natural behavior of the particular process after disturbances are eliminated. Gupta and Gupta, (2006) defines statistical quality control as one of the more useful and economically important applications of the theory of sampling in the industrial field. Bewerman and O' Connell, (2003) defines quality control as fitness for use or the extent to which customers feel that a product or service exceeds their needs and expectations. He also defined three types of quality: Quality of design which has to do with intentional differences between goods and services with some basic purpose. Quality of conformance is the ability of the process to meet the specifications set forth by the design and Quality performance is how well customers' needs are met and how reliable products are by conducting after sales research.

The manufacturer is concerned with quality characteristics as measurable variables that can track and used to monitor and improve the performance of the process.

A major objective of statistical quality control is to quickly detect the assignable causes in the process so that investigation of the process and corrective action may be carried out before many non-conforming units are produced. The control chart is an on-line process control techniques widely used for this purpose Ott (1975).

A typical control chart consist of a center line (CL), a lower control limit (LCL) and an upper control limit (UCL). The CL represents the average value of the quality characteristics which corresponds to the in-control state. The UCL and LCL are estimated such that a point plotted outside of the control limit is interpreted as evidence that the process is out of control. This general theory of control charts was first proposed by Shewart (1939). Hence, the control charts developed according to these principles are often called Shewart Control Charts (Montgomery, 1991).

This paper intends to determine whether the foams produced by BIC from 2001 were up to specification or not. The Shewart Control Charts techniques are used. The data used was collected from the quality control unit of the BIC, Yola, Adamawa state. This unit started operation in 2001; data on quality (measured in terms of the density Foams produced) was collected, and tabulated in order of sequence production, year, month and day. These foams are produced in blocks; a block can now be slice into many different shapes and sizes.

2. Background of study

Bajabure Industrial Complex (BIC) the producer of Nima foam mattresses served the people of Adamawa State and its environs; it is one of the most widely used foam in the area. Its quality control units come on board just in June 2001, after over 15 years of existence. This implies that the consumers of this product were not well informed and protected.

3. Statement of the Problem

Quality control and quality assessment is necessary, without it customers may receive inferior products', manufacturer waste their resources and workers waste their time. The impression of an organization in every production or manufacturing industry is that the desires of the consumers are met. When an output is perceived as excellent consumer's response is always loyalty.

4. Hypotheses

Two hypotheses were formulated for consideration in this paper, the Null (H_0) and Alternative (H_1) hypothesis.

H_0: The process was in a state of statistical control (for 15kg/m^3, 18kg/m^3, 20kg/m^3 and 25kg/m^3).

H_1: The process was not in a state of statistical control (for 15kg/m^3, 18kg/m^3, 20kg/m^3 and 25kg/m^3).

5. Methodology

Systematic Random Sampling procedure was used in this work form subgroups. The data collected were of the secondary sources from the quality control unit of the BIC. The quality control was established in June 2001 as such only data used for this work were available. For the 15 kg/m^3 densities 120 measurement were available, out of which subgroup of 20 were formed of sizes n = 5. For 18 kg/m^3 a total of 130 measurements were available, subgroup of size n = 5 were also formed using 100 observations. For 20 kg/m^3 densities 50 measurement were grouped into subgroup of size n = 5. For 25 kg/m^3 densities 170 measurement were grouped into subgroup of size n = 5 and for 29kg/m^3 densities 185 measurement were grouped into subgroup of size n = 5.

6. Analysis

The method of analysis used for this paper is the $\bar{X}$ *and* R charts techniques, two of the Shewart Control Charts Schemes.

The $\bar{X}$ Charts is given by:

$\bar{\bar{X}}$ which represents the Centre Line (CL)

$\bar{\bar{X}} + A_2\bar{R}$ which represent the Upper Control Limit (UCL)

$\bar{\bar{X}} - A_2\bar{R}$ which represents the Lower Control Limit (LCL)

The R charts is given by:

$\bar{R}$ which represent the Centre Line

$\bar{R}D_4$ which represents the Upper Control Limit (UCL)

$\bar{R}D_3$ which represents the Lower Control Limit (LCL)

Where $\bar{R}$ represents the average of subgroup range, $\bar{\bar{X}}$ represents the average of the subgroup means, A_2, D_3 *and* D_4 are constant tabulated for various values of n.

Here the charts were not particularly plotted, but the techniques was used as follows: if a point (s) is greater than either the UCL or the LCL, that point (s) is out of specification hence the process is likely to be out of control for that density.

If a process is in-control, it does mean that variation is present, due to random causes.

6.1 Data Analysis

The data collected from the factory is presented below according to their densities. The densities for which data were collected are: 15kg/m^3, 18kg/m^3, 20kg/m^3 and 25kg/m^3.

Table 1: 15kg/m^3 samples

Sample no	X_1	X_2	X_3	X_4	X_5
1	14.7	15.4	15.7	15.3	15.1
2	15.2	15.4	15.1	14.1	15
3	15	15.1	15.4	14.6	15.6
4	14.4	14.6	15.3	15.3	16.2
5	14.6	14.9	14.6	15.8	15
6	14.1	15	14.7	14.7	15.3
7	15.3	15.3	15.1	14.8	14.9

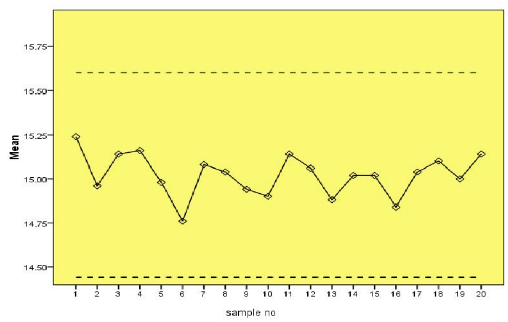
8	15.7	15.7	15	14.3	14.5
9	14.9	15	14.8	15	15
10	15	14.6	15.1	15.1	14.7
11	15.3	14.9	15	15.1	15.4
12	14.2	15	15.3	14.6	16.2
13	15.6	14.7	14.6	15	14.5
14	14.9	15	15	15	15.2
15	15.4	15	14.6	14.5	15.6
16	15.1	14.2	15.2	14.7	15
17	15	14.5	15	14.5	16.2
18	14.6	14.9	14.8	15.7	15.5
19	14.8	15.3	15.2	14.8	14.9
20	15	14.9	15.6	14.9	15.3

$\overline{X} = 15.0220 \quad \overline{R} = 1.0050$

$\overline{X}$ *Chart Control Limit*

Upper Control Limit (UCL) = $\overline{\overline{X}} + A_2\overline{R} = 15.0220 + (0.577 \times 1.0050) = 15.6017$ Centre Line (CL) = $\overline{\overline{X}} = 15.0220$

Lower Control Limit (LCL) = $\overline{\overline{X}} - A_2\overline{R} = 15.0220 - (0.577 \times 1.0050) = 14.4423$



R Chart Control Limit

Upper Control Limit (UCL) = $D_4\overline{R} = 2.115 \times 1.0050 = 2.1251$

Centre Line (CL) = $\overline{R} = 1.0050$

Lower Control Limit (LCL) = $D_3\overline{R} = 0.0000 \times 1.0050 = 0.0000$

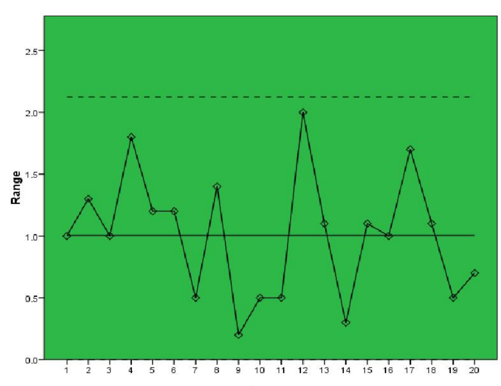


Table2: 18kg/m^3 sample

Sample no	X_1	X_2	X_3	X_4	X_5
1	18.6	18.2	17.9	19.0	17.6
2	18.0	18.7	17.9	17.7	18.4
3	17.8	18.0	18.7	18.4	17.9
4	18.2	18.7	17.9	19.3	18.1
5	17.4	19.0	17.9	18.7	18.2
6	17.5	18.7	18.1	17.9	17.6
7	18.2	17.9	18.7	18.1	17.2
8	17.8	18.2	17.2	18.5	17.2
9	18.0	18.1	17.9	17.5	17.8
10	17.4	17.7	18.0	17.5	19.2
11	18.8	18.1	17.8	18.3	17.5
12	17.8	17.4	18.2	18.0	17.9
13	18.2	18.5	18.0	18.0	17.4
14	17.1	18.4	16.7	18.9	18.2
15	18.1	17.9	17.5	18.2	17.3
16	18.3	17.7	19.1	17.2	18.0
17	17.5	17.7	18.0	18.0	18.4
18	17.7	18.2	17.5	17.2	18.7
19	18.5	18.1	18.0	17.9	17.3
20	17.8	18.4	17.5	17.9	18.2

$$\bar{\bar{X}} = 18.0110 \quad \bar{R} = 1.2700$$

$$\bar{X}\ Chart\ Control\ Limit$$

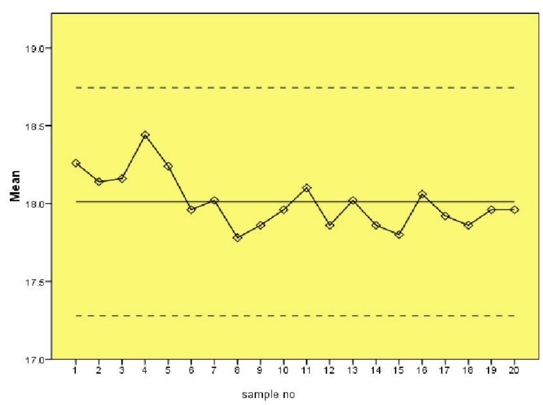
$$Upper\ Control\ Limit\ (UCL) =$$

$$\bar{\bar{X}} + A_2\bar{R} = 18.0110 + (0.577 \times 1.2700) = 18.7436$$

$$Centre\ Limit \qquad (CL) \quad = \bar{\bar{X}} = 18.0110$$

$$Lower\ Control\ Limit\ (LCL) =$$

$$\bar{\bar{X}} - A_2\bar{R} = 18.0110 - (0.577 \times 1.2700) = 17.2784$$



$$R\ Chart\ Control\ Limit$$

$$Upper\ Control\ Limit\ (UCL) = D_4\overline{R} = 2.114 \times 1.2700 = 2.6854$$

$$Centre\ Limit\ (CL) = \overline{R} = 1.2700$$

$$Lower\ Control\ Limit\ (UCL) = D_3\overline{R} = 0.0000 \times 1.2700 = 0.0000$$

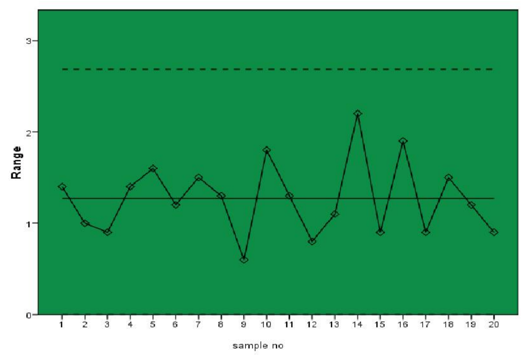


Table 3: 20kg/m^3 samples

Sample no	X_1	X_2	X_3	X_4	X_5
1	19.6	20.4	20.6	19.4	19.7
2	19.8	20.1	20.6	19.9	20.4
3	20.7	19.3	19.9	20.1	20.0
4	20.0	19.7	19.4	20.5	20.2
5	20.1	20.0	20.6	20.1	19.8
6	19.6	20.0	20.0	20.5	20.1
7	19.2	19.9	21.0	20.5	19.4
8	20.5	20.8	20.0	19.4	19.7
9	19.1	20.7	20.2	19.9	20.5
10	21.2	19.2	19.7	20.1	20.0
11	20.0	20.1	19.3	20.7	19.8
12	19.2	20.0	20.4	19.8	20.7
13	20.4	19.8	19.5	20.4	20.5
14	20.1	19.9	20.6	21.0	19.6
15	19.3	20.0	20.0	20.5	20.4
16	20.1	19.9	19.5	20.5	19.5
17	20.4	20.3	20.8	19.7	19.6
18	19.3	20.7	20.1	19.8	20.0
19	20.3	20.0	20.7	19.9	19.6
20	19.7	20.5	19.5	21.3	19.3

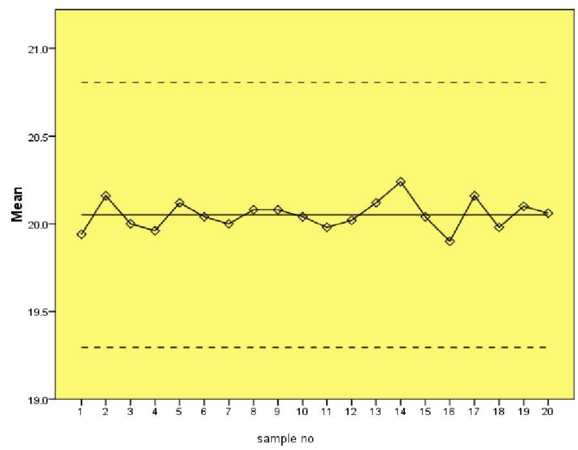
$$\bar{\bar{X}} = 20.0510 \quad \bar{R} = 1.3100$$

$\bar{X}$ *Chart Control Limit*

$$Upper\ Control\ Limit\,(UCL) = \bar{\bar{X}} + A_2\bar{R} = 20.0510 + (0.577 \times 1.3100) = 20.8069$$

$$Centre\ Limit\quad (CL) = \bar{\bar{X}} = 20.0510$$

$$Lower\ Control\ Limit\,(LCL) = \bar{\bar{X}} - A_2\bar{R} = 20.0510 - (0.577 \times 1.3100) = 19.2954$$



R Chart Control Limit

$$Upper\ Control\ Limit\,(UCL) = D_4\bar{R} = 2.114 \times 1.3100 = 2.7700$$

$$Centre\ Limit\quad (CL) = \bar{R} = 1.3100$$

$$Lower\ Control\ Limit\,(UCL) = D_3\bar{R} = 0.0000 \times 1.3100 = 0.0000$$

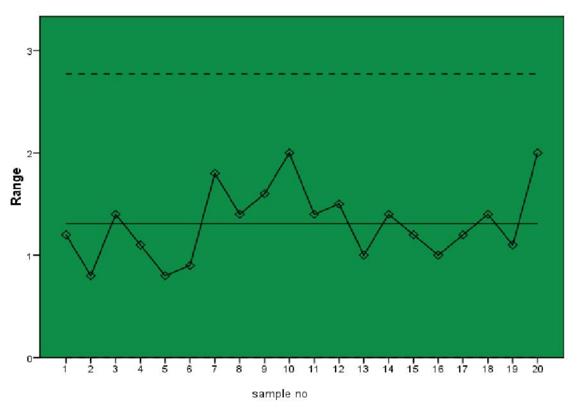


Table 4: 25kg/m^3 samples

Sample no	X_1	X_2	X_3	X_4	X_5
1	24.7	25.1	25.5	24.9	25.2
2	25.0	24.6	26.1	25.4	24.6
3	24.9	25.0	24.7	25.4	25.6
4	24.5	24.9	25.2	25.0	25.1
5	25.2	26.3	24.6	24.7	24.7
6	25.0	24.3	25.1	25.5	25.1
7	24.9	24.5	25.0	25.7	24.2
8	25.2	25.0	25.7	24.7	25.0
9	25.7	25.1	24.9	24.3	24.7
10	24.9	25.0	25.9	25.0	25.0
11	24.6	25.1	25.3	24.5	24.5
12	25.7	26.3	24.4	24.7	24.7
13	25.2	25.7	24.2	25.1	24.2
14	26.1	25.2	24.7	24.1	25.0
15	25.0	25.1	25.9	24.3	24.5
16	25.9	24.9	25.3	25.6	24.3
17	24.7	25.0	24.9	25.2	25.0
18	26.3	25.1	24.3	25.3	24.7
19	25.3	24.9	24.3	25.5	25.1
20	25.7	24.7	24.5	26.0	24.9

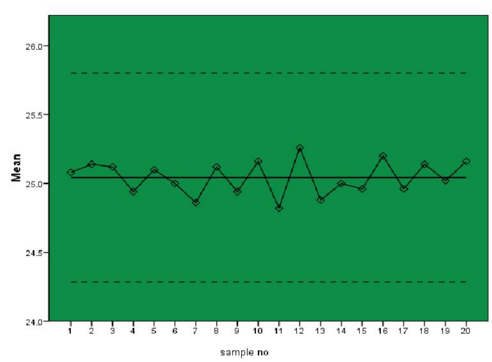
$$\bar{\bar{X}} = 25.0440 \quad \bar{R} = 1.3150$$

$$\bar{X}\ Chart\ Control\ Limit$$

$$Upper\ \ Control\ \ Limit\,(UCL) = \bar{\bar{X}} + A_2\bar{R}$$
$$= 25.0440 + (0.577 \times 1.3150) = 25.8065$$

$$Centre\ \ Limit \qquad (CL) \ = \bar{\bar{X}} = 20.0440$$

$$Lower\ \ Control\ \ Limit\,(LCL) = \bar{\bar{X}} - A_2\bar{R}$$
$$= 25.0440 - (0.577 \times 1.3150) = 24.2855$$



$$R\ Chart\ Control\ Limit$$

$$Upper\ Control\ Limit\ (UCL) = D_4\overline{R} = 2.114 \times 1.3150 = 2.7806$$

$$Centre\ Limit\ (CL) = \overline{R} = 1.3150$$

$$Lower\ Control\ Limit\ (UCL) = D_3\overline{R} = 0.0000 \times 1.3150 = 0.0000$$

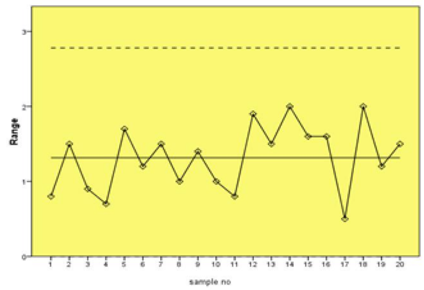


Table 5: 29kg/m^3 samples

Sample no	X_1	X_2	X_3	X_4	X_5
1	29.2	28.6	28.9	29.1	29.0
2	29.7	29.4	29.1	28.9	28.5
3	28.8	29.6	29.0	28.4	28.9
4	30.2	29.5	28.5	29.0	28.7
5	28.5	29.0	29.3	29.1	28.9
6	29.6	29.9	28.7	29.5	29.2
7	29.7	28.3	28.9	29.0	28.9
8	29.0	30.2	28.7	29.2	28.5
9	28.7	29.2	29.5	28.4	28.7
10	29.5	29.9	29.3	28.7	28.9
11	29.1	29.0	29.7	28.5	28.3
12	30.5	29.9	28.7	28.9	29.0
13	28.7	29.0	29.7	28.6	29.1
14	29.7	29.3	29.6	28.9	29.0
15	29.1	28.5	28.9	29.2	28.7
16	30.1	29.3	28.7	29.0	28.9
17	29.1	28.8	29.7	28.9	29.3
18	29.5	29.0	29.9	28.8	29.0
19	29.7	29.5	29.1	29.0	28.7
20	28.8	29.7	28.9	29.2	28.4

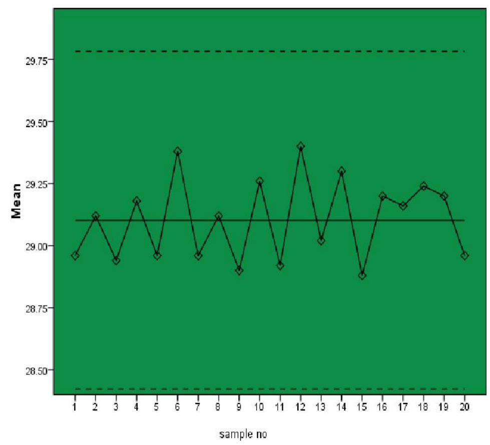
$$\bar{\bar{X}} = 29.1050 \quad \bar{R} = 1.1800$$

$$\bar{X}\ Chart\ Control\ Limit$$

$$Upper\ Control\ Limit\ (UCL) = \bar{\bar{X}} + A_2\bar{R}$$
$$= 29.1050 + (0.577 \times 1.1800) = 29.7856$$

$$Centre\ Limit\ (CL) = \bar{\bar{X}} = 29.1050$$

$$Lower\ Control\ Limit\ (LCL) = \bar{\bar{X}} - A_2\bar{R}$$
$$= 29.1050 - (0.577 \times 1.1800) = 28.4244$$

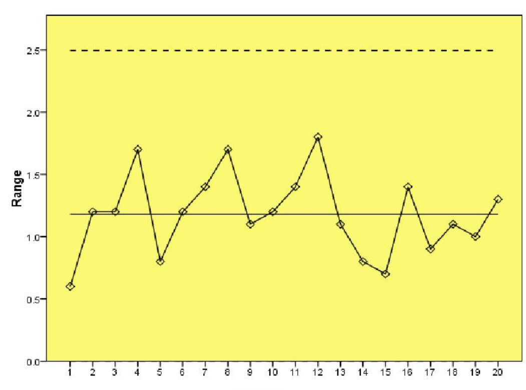


$$R\ Chart\ Control\ Limit$$

$$Upper\ Control\ Limit\ (UCL) = D_4\bar{R}$$
$$= 2.114 \times 1.1800 = 2.4951$$

$$Centre\ Limit\ (CL) = \bar{R} = 1.1800$$

$$Lower\ Control\ Limit\ (UCL = D_3\bar{R}$$
$$= 0.0000 \times 1.1800 = 0.0000$$



7. Results

The study showed that the $15kg/m^3$, $18kg/m^3$, $20kg/m^3$, $25kg/m^3$ and $29kg/m^3$ foams produced were in statistical control, this implies that the $15kg/m^3$, $18kg/m^3$, $20kg/m^3$, $25kg/m^3$ and $29kg/m^3$ foams produced within the period under study were conforming to specification. The result showed that foams produced fall between 14.44 and 15.60, 17.28 and 18.74, 19.30 and 20.81, 24.29 and 25.80 and 28.42 and 29.79 kg/m^3 respectively.

8. Conclusion

The assessment showed that all the blocks of foams produced were in statistical control. That is to say that the foams produced were up to specification. Variation observed are due to random (chance) causes, which is normal with every production process.

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