Case Study of Process Variation in a Steel Tube Manufacturing Industry

Gajendra Patidar[1] Dr. Devendra SinghVerma[2]
[1,2]Department of Mechanical Engineering
[1,2]Institute of Engineering & Technology DAVV

Abstract— This research is about to implement statistical quality control tools in tube manufacturing industries. There are various defect found in stainless steel welded tube manufacturing, due to these defects, tubes are rejected lot wise, and that is very unproductive result for each and every industries. Statistical quality control (SQC) tools, such as X-bar chart, C-chart, P-chart, R-chart and U-chart had been utilized to measure the variability in the process. We observed good result about the process, whether it is in control or not. These types of charts will also provide the fast result that will be used to take action immediately. In tube manufacturing industries, rejection reduction is possible by proper maintaining the bead process, appropriate welding line. This research helps to decide the process within the control limit or not, that would be decided by various control charts. This is also used for quality improvement. In S.Q.C, there are number of tools used such as Frequency distribution, Control charts, acceptance sampling, and analysis of the data. From all of these tools, we have to concentrate only on control charts. Ultimately it has been used for any manufacturer to solve the rejection problem, enhancing the productivity and quality of the product.

Key words: Statistical Quality Control, S.P.C, Stainless Steel tube industry, Rejection Reduction, Manufacturing Industry

I. Introduction

Statistical Quality Control (SQC) tools are the major valuable tools for performing the task of finding out the deviations and defects of finished components of each process in a statistical way. This kind of approach washed out the traditional approach, where the components are examined after the whole process accompanied with a single product, is completed. The traditional method pays a way of wasting huge amount of money invested in a product, when a defect is found on a product, because it doesn't support to observe the defects at the initial stage. Hence, a statistical method is introduced for the simple usage and rapid results regarding the deviation within the process. Statistical Quality Control methods apply statistical principles and techniques at every stage of design, manufacturing and servicing [1].

SQC tools uses the process values to determine, whether the process is in control or out of control. If the process is found out to be in control as specified by the customers or engineers, the process needs not to be disturbed. But, by theory of manufacturing, no two products manufactured in same conditions and same parameters are identical. The variations are inevitable. If the deviations are too high, i.e., if the process is out of control, then some measures are to be carried out to make the process, back into the form. For continuous improvement of the process, monitoring every process is essential in case of mass production. This can be made easy by using the Statistical tools such as Control chart and Histogram principles [9].

II. Objectives

The goal of the production is to produce output of consistent quality that meets technical specifications. When quality is consistent, both the producer and the consumer benefit. Producer benefit by having less need for inspection, less scrap and rework and higher productivity. The consumers are assured that all products have similar quality characteristics.

The objective of this paper determined. There are two objectives have been defined to be focused on and to simplify the dissertation as stated below:

1) To perform a quality control technique for a selected manufacturing process in tube manufacturing industry using statistical process control method.
2) To propose method to improve the selected manufacturing process based on the case study.

III. Literature review

In "Enhancement of quality of the processes using Statistical tools- a review by J Praveen Kumar, B Indhirajith" In the research, attempts are made for experimentation in a medium sized company on a machining process of castings and found out some deviations from the design and attained tolerance of the work piece.

It was noted that the productions process was not in normal condition before these techniques are implemented into the process. After the techniques were built into the process, the management and the employee had understood the cost wastage due to the rejection of the work piece and motivation among them were developed.

In "Implementation of statistical quality control (S.Q.C.) In welded stainless steel pipe manufacturing industry Kapil Banker, Amit Patel, Diptesh Patel" Implementation of Statistical Quality control in Stainless Steel Welded pipe manufacturing industry in KSB Pump (Apurvi industry). They use control charts to detect the process is control or not, from X bar and R chart to monitoring the process.

It is observed that in X bar and R chart, if the process is out of control, then some assignable causes are there. In Apurvi industries, there was no provision for detected and eliminated any assignable causes from the process. That was the main disadvantage in the company to increased overhead cost due to trial and error method to solve the problem [9].

In "Statistical Quality Control Approach in Typical Garments Manufacturing Industry in Bangladesh: A Case Study" by Md. Mohibul Islam and Md. Mosharraf Hossain. They focused on statistical process control method to eliminate the quality problems in garments industry. It is noted that according to lean manufacturing notion quality inspection is a necessary but non value added activity so it is needed to reduce. It may be possible to reduce this non value added activities from the manufacturing processes by applying statistical quality control system [11].

As a result of their study, the process potential index cp>1 then it is assumed that process is capable to produce the product with specification limit. From practical data analysis it is observed that the process potential index cp is always greater than 1. So the considered production process is capable to produce the product within control limit i.e. as per requirement. It is also noticed that after observing control chart for $\overline{X}$ and $\overline{R}$ for $\mu \pm 3\sigma$ control limit, all observed data points stay within the upper and lower control limit that indicate the process is in control.

IV. Methodology

Implementation of Statistical Quality control in Stainless Steel Tube manufacturing industry with the association of control charts. In this research paper we adopted the control chart method to observe and control the process along the manufacturing process line. X bar char, R chart has been suggested for this research and according to the control chart, result and discussion is presented.

A. Problem Identification and Company Profile Company Profile:

STI SANOH India Ltd, established in 1961, is one of India's leading and well-diversified engineering companies. It manufactures a wide range of Tubes for two, four wheelers brake line and refrigeration to meet the requirement of core sectors like Automobile and Refrigeration in India and abroad. Product selected for the case study is steel tube. The Diameter are critical dimension selected as it plays major role in fitting in Brakes and Refrigeration systems as company facing problems of rejection and rework.

1) Component selection: Steel tube
2) Process: Manufacturing
3) Checking parameter: Diameter
4) Thickness dimension: 4.20 mm, 4.76mm, 6.35mm
5) Tolerance: ±0.10 mm

B. Procedure for X Bar and R Chart:

The steps followed for constructing X bar and R chart in the study are given below. Step 1 - Determine the data to be collected: The data was collected for Diameter of the Tube for 20 subgroups of size 5.

Step 2 - Calculate the average of the reading by

$$X = \frac{X_1+X_2+X_3\ldots\ldots\ldots.+Xn}{n}$$

Step 3 - Calculate the range for each subgroup: The range is calculated by taking the difference between the Largest Value and the Smallest Value in each Subgroup and tabulated.

C. Range R= max (X1…Xn) - min(X1…Xn)

Control limits for X bar chart-

Upper control limit-

$$\text{UCL of } X = \overline{\overline{X}} + A_2\overline{R},$$

Lower control limit-

$$\text{LCL of } X = \overline{\overline{X}} - A_2\overline{R};$$

Control limits for R chart-

Upper control limit-

$$\text{UCL of } R = D_4\overline{R},$$

Lower control limit-

$$\text{LCL of } R = D_3\overline{R},$$

$\overline{X}$ - The average of the sample means

$\overline{\overline{X}}$ - Average $\overline{X}$

n –sample size (number of observations per sample)

N – Number of samples

A2- factor for X-bar chart

D3, D4 – factors for R-chart

V. Result and Discussion

$\sum X = 84.04 \quad \sum R = 1.1$

$\overline{\overline{X}} = \sum \overline{X} / N = 84.04/20$

$\overline{R} = \sum R / N = 1.1/20$

$\overline{\overline{X}} = 4.201 \quad \overline{R} = 0.055 \quad A2= 0.58 \quad D4= 2.11 \quad D3= 0$

UCL for X bar $= \overline{\overline{X}} + A2\,\overline{R} = 4.233$

LCL for X $= \overline{\overline{X}} - A2\,\overline{R} = 4.170$

UCL for R = D4 R = 0.116

LCL for R = D3 R = 0

Process Capability $= \sigma' = \overline{R}/d2 = 0.055/2.326$

$\sigma' = 0.024$

$6^*\sigma' = 6^*0.024 = 0.14$

X max – X min = 4.30- 4.10 = 0.20

X max – X min >6 σ'

Sub Group no.	Observation					X bar	R
	1	2	3	4	5		
1	4.18	4.2	4.21	4.18	4.24	4.2	0.06
2	4.24	4.21	4.18	4.17	4.2	4.2	0.07
3	4.16	4.2	4.22	4.19	4.17	4.19	0.06
4	4.21	4.17	4.19	4.22	4.2	4.2	0.05
5	4.17	4.19	4.2	4.21	4.24	4.2	0.07
6	4.19	4.23	4.21	4.18	4.19	4.2	0.05
7	4.18	4.19	4.23	4.21	4.22	4.21	0.05
8	4.2	4.21	4.19	4.22	4.18	4.2	0.04
9	4.18	4.21	4.17	4.22	4.2	4.2	0.05
10	4.19	4.21	4.18	4.2	4.24	4.2	0.06
11	4.22	4.19	4.21	4.24	4.2	4.21	0.05
12	4.21	4.23	4.19	4.17	4.2	4.2	0.06
13	4.23	4.21	4.19	4.22	4.18	4.21	0.05
14	4.2	4.17	4.21	4.23	4.17	4.2	0.06
15	4.18	4.21	4.24	4.22	4.19	4.21	0.06
16	4.22	4.2	4.18	4.21	4.23	4.21	0.05
17	4.2	4.23	4.19	4.17	4.18	4.19	0.06
18	4.21	4.19	4.18	4.2	4.22	4.2	0.04
19	4.24	4.2	4.21	4.23	4.19	4.21	0.05
20	4.21	4.2	4.24	4.18	4.2	4.21	0.06

Table 1: (4.20mm)

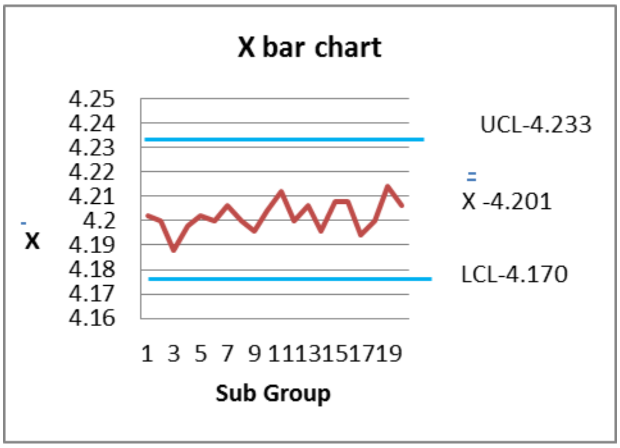

Fig. 1: X- Bar Chart for 4.20mm

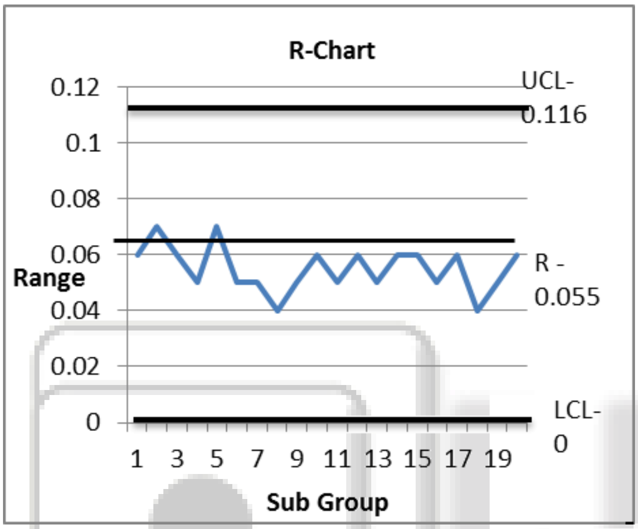

Fig. 2: R-Chart

Sub Group No.	Observation					X bar	R
	1	2	3	4	5		
1	4.75	4.77	4.74	4.76	4.79	4.76	0.05
2	4.78	4.77	4.73	4.79	4.75	4.76	0.06
3	4.76	4.74	4.75	4.78	4.77	4.76	0.04
4	4.75	4.77	4.79	4.74	4.76	4.76	0.05
5	4.72	4.75	4.78	4.76	4.79	4.76	0.07
6	4.73	4.75	4.72	4.76	4.78	4.75	0.06
7	4.76	4.78	4.74	4.79	4.75	4.76	0.04
8	4.75	4.73	4.76	4.78	4.78	4.76	0.05
9	4.77	4.74	4.72	4.78	4.76	4.75	0.06
10	4.72	4.76	4.79	4.74	4.78	4.76	0.07
11	4.76	4.74	4.77	4.78	4.75	4.76	0.04
12	4.73	4.75	4.77	4.74	4.78	4.75	0.05
13	4.79	4.76	4.78	4.79	4.75	4.77	0.04
14	4.77	4.79	4.73	4.75	4.77	4.76	0.06
15	4.74	4.76	4.72	4.78	4.79	4.76	0.07
16	4.78	4.73	4.76	4.78	4.77	4.76	0.05
17	4.73	4.77	4.75	4.78	4.76	4.76	0.05
18	4.72	4.75	4.77	4.79	4.78	4.76	0.07
19	4.74	4.77	4.79	4.75	4.78	4.77	0.05
20	4.78	4.76	4.73	4.75	4.79	4.76	0.06

Table 2: (dia. 4.76mm)

X bar = 95.204 R = 1.09

X d.bar = 4.7602 R bar = 0.054

UCL X bar = 4.790

LCL X bar =4.727

UCL R = 0.114

LCL R = 0

Process Capability $\sigma' = \bar{R} / d_2 = 0.0232$

$6^* \sigma' = 6^*0.0232 = 0.13$

X max - X min = 0.20

X max - X min > 6σ'

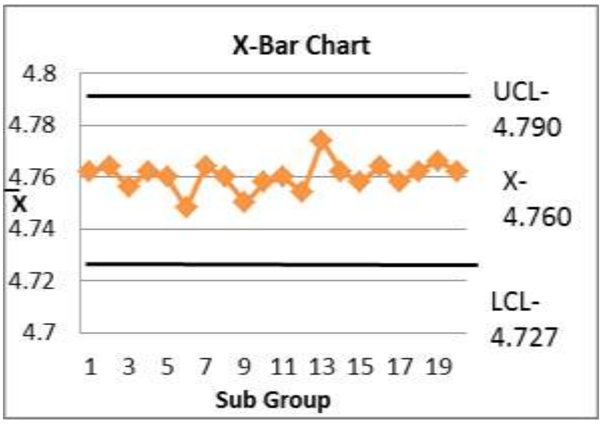

Fig. 3: X Bar Chart for 4.76mm

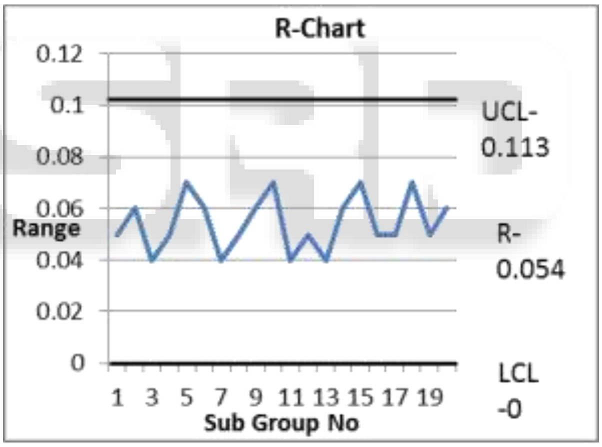

Fig. 4: R-Chart

S.G. No.	Observation					X bar	R
	1	2	3	4	5		
1	6.39	6.36	6.33	6.35	6.37	6.36	0.06
2	6.35	6.32	6.34	6.4	6.36	6.35	0.08
3	6.38	6.4	6.37	6.35	6.39	6.38	0.05
4	6.31	6.33	6.29	6.35	6.36	6.33	0.07
5	6.3	6.34	6.32	6.36	6.33	6.33	0.06
6	6.32	6.35	6.39	6.37	6.34	6.35	0.07
7	6.35	6.32	6.38	6.4	6.39	6.37	0.08
8	6.31	6.34	6.35	6.37	6.34	6.34	0.06
9	6.3	6.29	6.32	6.37	6.35	6.33	0.08
10	6.39	6.37	6.4	6.31	6.35	6.36	0.09
11	6.38	6.35	6.33	6.37	6.31	6.35	0.07
12	6.4	6.36	6.38	6.35	6.38	6.37	0.05

13	6.37	6.35	6.36	6.31	6.36	6.35	0.06
14	6.35	6.37	6.39	6.34	6.3	6.35	0.07
15	6.28	6.31	6.35	6.36	6.32	6.32	0.08
16	6.32	6.35	6.38	6.41	6.36	6.36	0.09
17	6.37	6.34	6.36	6.42	6.38	6.37	0.08
18	6.35	6.39	6.37	6.32	6.34	6.35	0.07
19	6.41	6.36	6.32	6.34	6.35	6.36	0.09
20	6.31	6.35	6.37	6.34	6.38	6.35	0.07

Table 3: (dia. 6.35mm)

X bar= 6.3524, R bar= 0.0715
UCL X bar = 6.394 LCL X bar= 6.311
UCL R = 0.150 LCL R = 0
Process Capability σ’ = R/d2
σ’ = 0.0307
6*σ’ = 0.1842
X max – X min = 0.20
X max – X min >6σ’

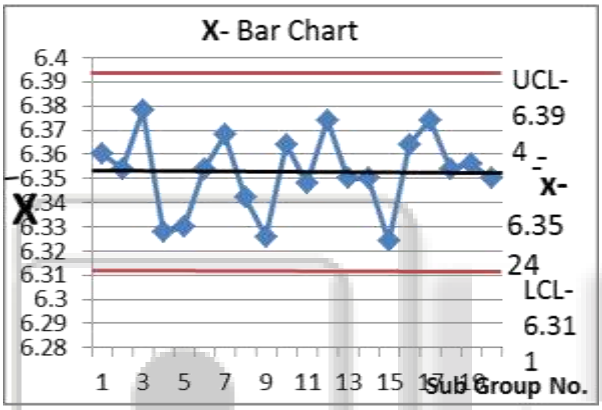

Fig. 5: X Bar Chart for 6.35mm

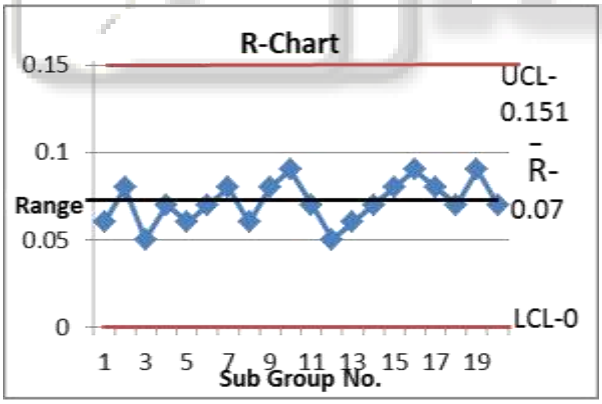

Fig. 6: R-Chart

In STI Sanoh the diameter of the tube is 4.20, 4.76, 6.35 mm with 0.10 mm tolerance. As per the result table, value of X-bar is within the specifications. The entire diameter values under the upper and lower specification limits. The X-bar and R chart result gives the clear idea that the process within the control limit.

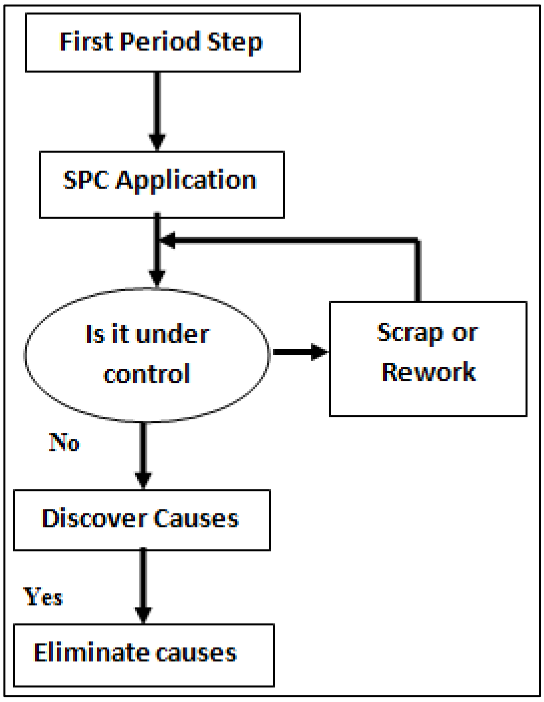

Fig. 7: Conceptual Model of SPC

VI. Conclusion

It is observed that in X bar and R chart, if the process is out of control, then some assignable causes are there. In tube industries there was no provision for detected and eliminated any assignable causes from the process. That was the main disadvantage in the company to increased overhead cost due to trial and error method to solve the problem. In STI Sanoh the main defect observed was leakage in stainless steel welded tube. The leakage occurred in steel tube at the welding bead. The leakage defect has been eliminated by adjusting the bead shape at bead cutter.

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