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IMPLEMENTATION OF STATISTICAL QUALITY CONTROL FOR SPINNING PROCESSES OF DIRE DAWA TEXTILE FACTORY

[1] R K Gera, [2] Hewan Taye, [3] Andargachew Bekele
[1] *Department of Industrial Engineering, Institute of Technology, Dire Dawa University, P.O.BOX100,635, Ethiopia*
[2] *Department of Industrial Engineering Mekelle University, Ethiopia*
[3]*Department of Industrial Engineering, Institute of Technology, Dire Dawa University, P.O.BOX100,635, Ethiopia*
[1] neemranagea@gmail.com [2] hewan_taye@yahoo.com [3] wentabekele@gmail.com

Abstract: **Statistical process control is a powerful collection of problem solving tools useful in achieving process stability and improving capability through the reduction of variability.SPC can be applied to any process. The major objective of SPC is to quickly detect the occurrence of assignable causes of process shifts so that investigation of the process and corrective action may be taken before many non conforming units are manufactured. The eventual goal of SPC is the elimination of variability in the process. It may not be possible to completely eliminate variability, but the control chart is an effective tool in reducing variability as much as possible. The main objective of this paper is to implement SPC schemes, study of control charts and comparison performance of various control charts for bottle manufacturing data. In the manufacturing environment, quality improves reliability, increases productivity and customer satisfaction. Quality in manufacturing requires the practice of quality control. This research work investigates the level of quality control in Lifespan pharmaceutical limited, makers of Lifespan Table Water. The study involves inspection of some randomly selected finished products on daily bases.**

Keywords: Statistical Process Control; Control Charts; Mean; Upper Control Limit (UCL); Center Line (CL) and Lower Control Limit (LCL)

I. INTRODUCTION

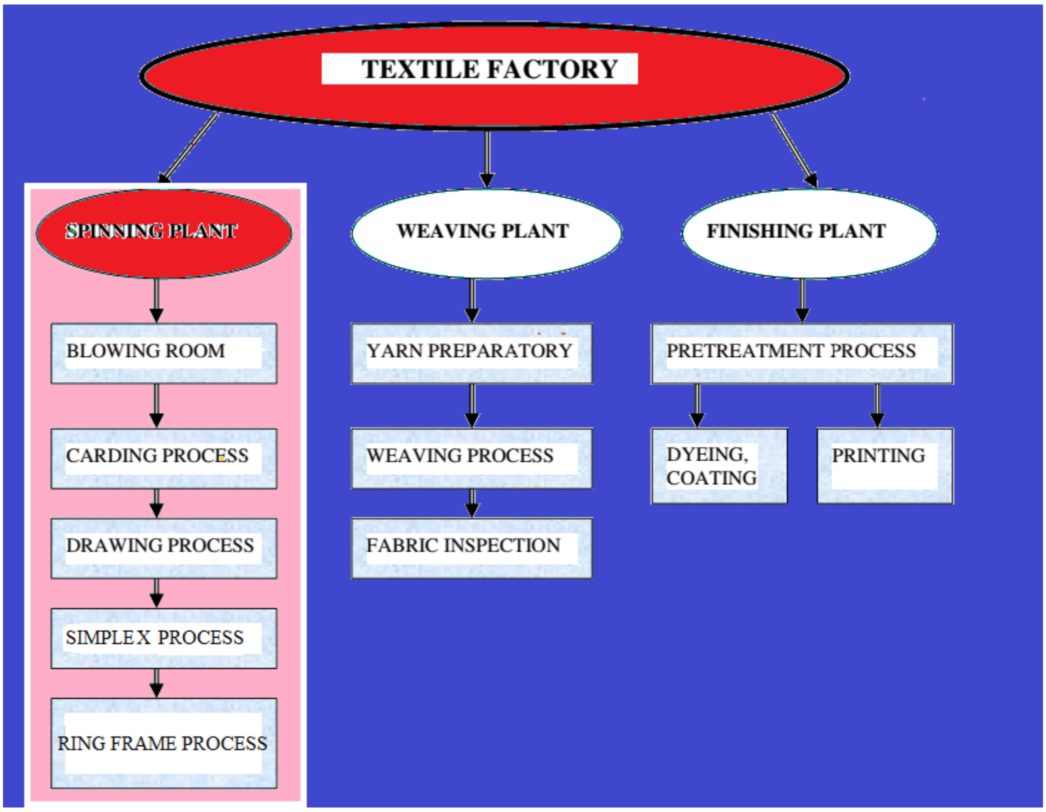
The world economy has undergone rapid changes during the past two decades with the advent of global competition to an extent that almost every company (large or small) is touched by it in some ways. Creativity and innovation are necessary to bring forth the change required to obtain competitive advantage. Quality is the most effective factor a company or organization can use in the battle for customer/clients. To be competitive, the customers must be satisfied and to satisfy the customers, we must focus on quality. Quality control provides the philosophy and driving force for designing quality in order to delight the customers by focusing on best value of a company's products and services. The basic goal of quality control is to ensure that the products, services or processes provided meet specific requirements and are dependable, satisfactory, and affordable and physically sound (Hotelling, 1947).

A control chart is a statistical tool used to distinguish between variations in a process resulting from common causes and variation resulting from special causes. Every process has variation. Some variation may be the result of causes which are not normally present in the process. This could be special cause variation. Some variation is simply the result of numerous, ever-present differences in the process. Control Charts differentiate between these two types of variation. It consists of three horizontal lines called; Upper Control Limit (UCL), Center Line (CL) and Lower Control Limit (LCL). The center line in a control chart denotes the average value of the quality characteristic under study. If a point lies within UCL and LCL, then the process is deemed to be under control. Otherwise, a point plotted outside the control limits can be regarded as evidence representing that the process is out of control and, hence preventive or corrective actions are necessary in order to find and eliminate the assignable cause or causes.

III HISTORICAL BACKGROUND OF DIRE DAWA TEXTILE FACTORY

The factory was established as an ETHIOPIAN COTTON SHARE COMPANY with initial capital of 1.5 million East African shilling which was then about 0.5 million Ethiopian Birr. The shareholders were British and Egyptian businessmen and the Ethiopian Royal family. Initially the labor force was 400 and production began with 9240 spindles and 390 looms. The annual production was 3.6 million yards of fabric and 3000 kg of yarns. In 1951 German businessmen improved the management system and also introduced new technology. The factory's capital was also raised to Birr 5 million. In 1964 Fuji International Corporation took over the management. At this time the Japanese Company and the International Finance Corporation (World Bank) made new investment in the factory and raised the capital to Birr 12 million. In 1974 D.D.T.F. was nationalized and was put under the National Textile Corporation (NTC).In 1999 DDTF was transferred to a private investor on lease sales and named Addis Izmir Dire Dawa Textile Factory. In 2002 the factory was again transferred to a public Enterprise and obtained its previous name, i.e. Dire Dawa Textile Factory At present DDTF's authorized capital is Birr 38,410,059.54 Birr. The factory is an integrated mill producing the following main products.

IV SPINNING PROCESS at DDTF



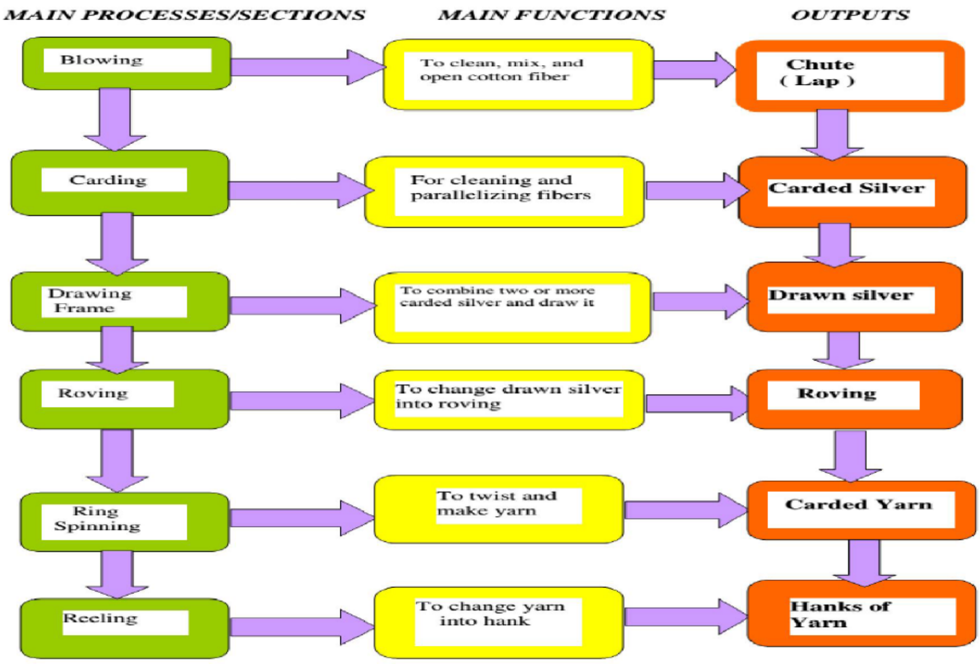


Figure 1 Main Processes and intermediate products in spinning plant

The spinning process (yarn production) has following stages:

a Inspection and acquisition of the raw material (cotton fiber)
b blending and mixing cotton
c chute forming
d carding process (pulling, separating, and orienting the fibers)
e Drafting process.
f Roving. Process
g Ring frame Process

V QUALITY CHARACTERISTICS OF COTTON FIBER

1. **Cotton color:** The color of cotton fiber is a physical characteristic and could be white, grey, spotted, tinged, reddish and yellow stand.
2. **Cotton staple length**: Staple length tests are more frequently used and are associated with not only spinning performance but also yarn properties and characteristics.
3. **Cotton fiber Maturity:** Maturity indicates ripeness or full development. Maturity of cotton fiber could influence the quality of the next product (cotton yarn). Immature cotton fiber has low strength.
4. **Micronire:** it measures the Cotton fiber fineness and maturity. Fiber fineness is the weight fineness of cotton fibers.
5. **Strength of cotton fiber**: It is a mechanical characteristic of a fiber. The importance of testing cotton fibers is for the strength. The strength of the fiber has a direct effect upon the strength of the yarn and fabric.
6. **Length uniformity:** the uniformity of the cotton Staple length

VI Pareto Chart

TABLE1 CAUSES OF POOR QUALITY PRODUCTS IN DDTF

Type of product	Unit	Designed	Attainable	Attained	Remark for Designed & Attainable
Yarn on hank form	Kg	3,764,000	3,024,000	1,829,077	Av. count 23 Ne
Yarn on cone	"	601,000	374,400	28,129	Count 20 Ne
Acrylic Yarn	"	875,000	590,000	206,825	Count 2/36 Nm
Fabrics	Yard	16,486,000	7,880,000	3,475,986	Av. Py 40 /inch

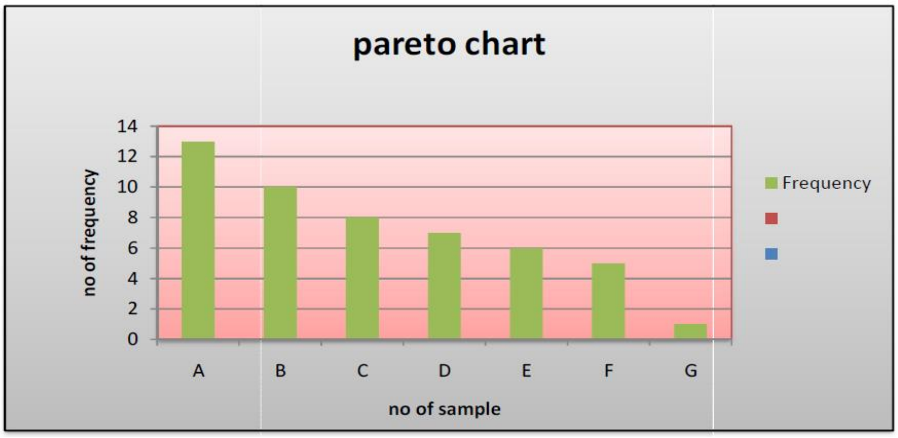


Figure 2 pareto chart for DDTF

The causes of poor quality have been assessed in the factory and the results on the pareto analysis shows About twenty six percent of the respondents have agreed that the main causes of poor quality in DDTF are due to poor maintenance of machines. Secondly, scarcity and low quality of the raw materials (mainly cotton fiber) is another core problem of the factory. By Pareto chart we identify the factors that have the greatest cumulative effect on the system and then Screen out the less significant factors in an analysis allows the company to focus attention on a few important factors in a process It is plotted by the cumulative frequencies of the relative frequency data in a descending order.

VII MATERIALS AND METHODS

Data collection method used is random sampling method. Random sampling method is the purest form of sampling, probability in the sense that each member of the population has a known non- zero probability of being selected. The reason for choosing this method is to allow each member of the population equal chance of being selected. This study used primary and secondary data. The data were obtained from both sources by getting through Primary data as well as data.

VII CAUSE AND EFFECT DIAGRAM

By cause and effect diagram we identify the potential causes for a particular spinning quality problems. the development of cause and effect diagram requires the worker to think through all possible causes of poor quality on spinning & workers can easily identify the problem of spinning quality. And another cause and effect diagram based on the grades that were given for the cotton fibre strength of the yarn lack of full development fineness

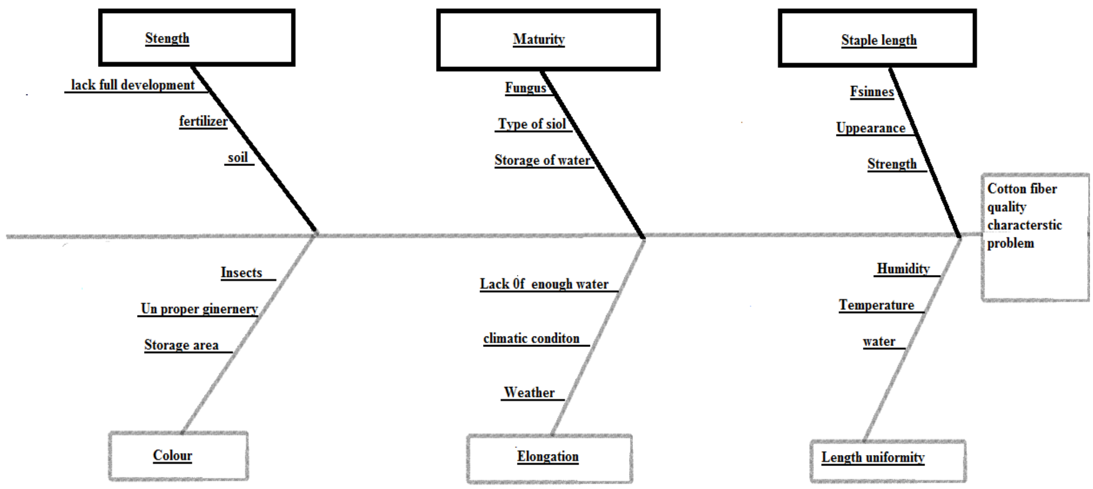


Figure 3 Cause and effect diagram for the cotton quality characteristics

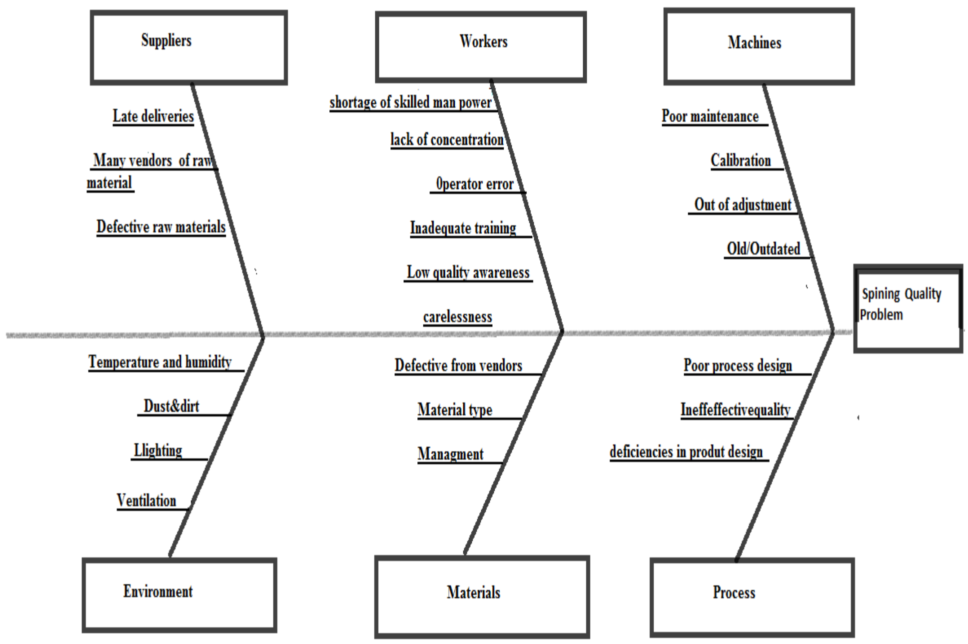


Figure 4 Cause and effect diagram for the spinning quality problem

IX R CHART FOR 21 COUNT

Control limits for $\bar{R}$-chart

Number of observations per sample=10

Number of samples25

For subgroup size of 10,from standard tables

A_2=0.31

d_2=3.078

D_3=0.22

D_4=1.78

$$\bar{R} = \frac{\sum R_i}{K}$$

$$\bar{R} = \frac{14017}{25} = 560.68$$

Control limits for $\bar{R}$-chart

$$UCL = D_4 \times \bar{R}$$

$$UCL = 1.78 \times 560.68 = 998.0104$$

$$CL = \bar{R} = 560.68$$

Due to1052 fail out of control limits we will develop another control limits by discarding the one item

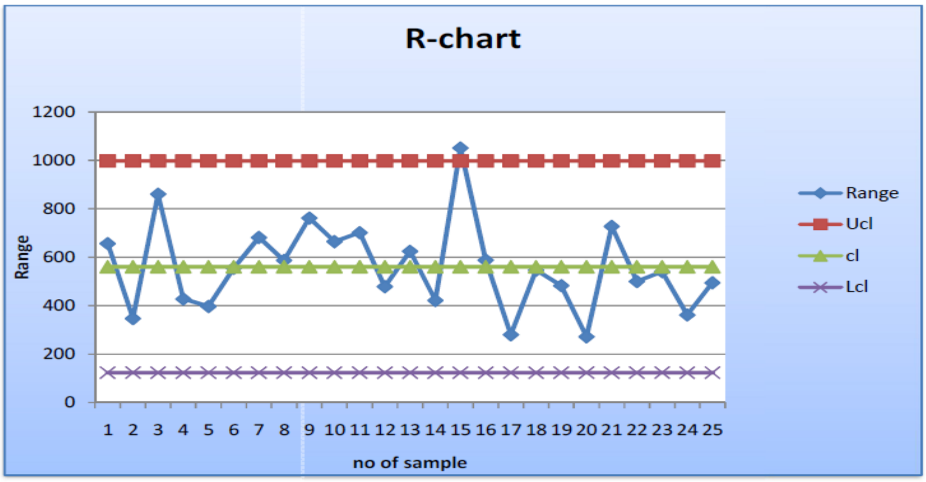


Figure 5 R- chart for 21 count

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$$\overline{R_1} = \frac{14017 - 1052}{25 - 1} = 540.20$$

Again control limits for $\bar{R}$-chart

$$UCL = D_4 \times \overline{R_1}$$

$$UCL = 1.78 \times 540.20 = 961.556$$

$$LCL = D_3 \times \overline{R_1}$$

$$LCL = 0.22 \times 540.20 = 118.844$$

CL=$\overline{R_1}$=540.20

Table2 THE REVISED RANGE CHART

Range 1	Ucl	cl	lcl
657	961.556	540.2	118.844
347	961.556	540.2	118.844
861	961.556	540.2	118.844
428	961.556	540.2	118.844
397	961.556	540.2	118.844
555	961.556	540.2	118.844
682	961.556	540.2	118.844
587	961.556	540.2	118.844
762	961.556	540.2	118.844
665	961.556	540.2	118.844
702	961.556	540.2	118.844
479	961.556	540.2	118.844
625	961.556	540.2	118.844
422	961.556	540.2	118.844
588	961.556	540.2	118.844
280	961.556	540.2	118.844
547	961.556	540.2	118.844

483	961.556	540.2	118.844
272	961.556	540.2	118.844
728	961.556	540.2	118.844
500	961.556	540.2	118.844
541	961.556	540.2	118.844
362	961.556	540.2	118.844
495	961.556	540.2	118.844

540.2

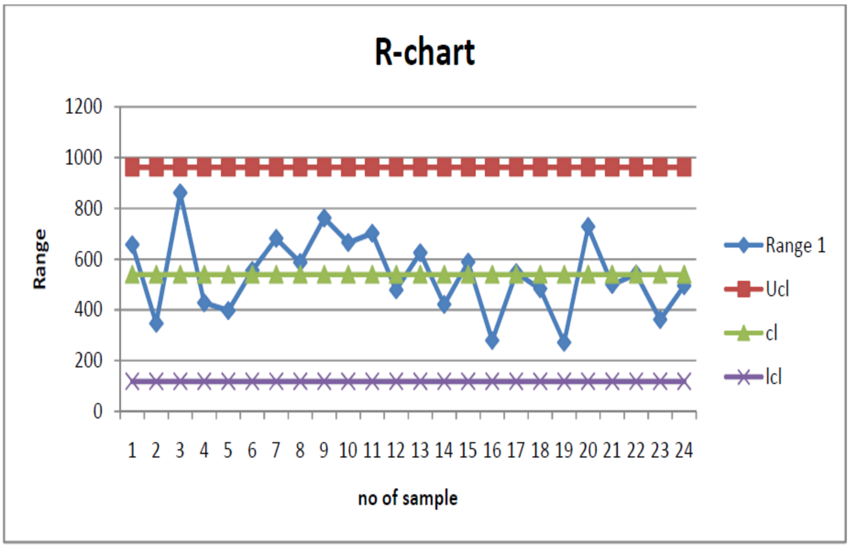


Figure 6 Revised R- chart for 21 count

Now all points are falling within the control limits. The final values are

UCL=961.556

LCL=118.844

CL=540.20

X X-CHART FOR 21 COUNT

$$\bar{\bar{X}}=\frac{\sum x_i}{K}=\frac{49002.8}{25}=1960.112$$

$$UCL=\bar{\bar{X}}+A_2\bar{R}_1$$

$$UCL=1960.112+0.31\times540.20=2127.574$$

$$LCL=\bar{\bar{X}}-A_2\bar{R}_1$$

$$LCL=1960.112-0.31\times540.20=1792.65$$

CL=1960.112

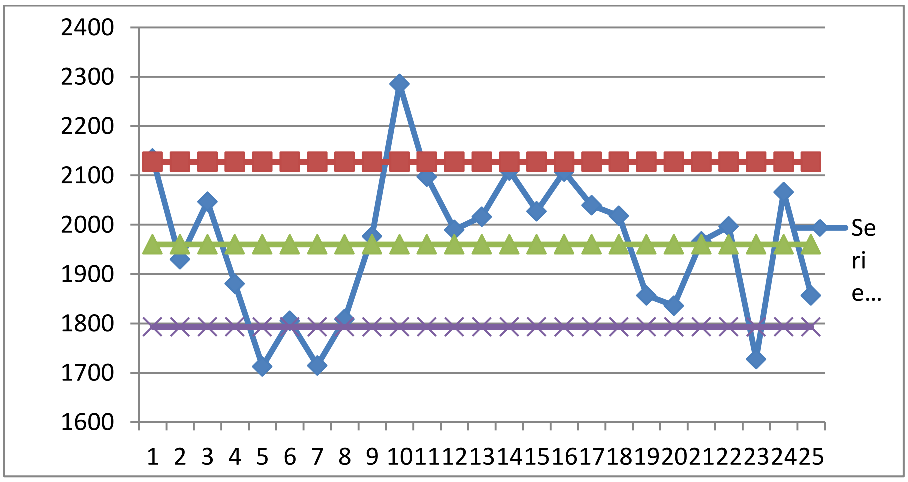


Figure 7 X- chart for 21 count

Due to 1712.6, 1714.5, 2285.3, 1727.4 fail out of control limits we will develop another control limits by discarding the 4 items.

$$\bar{\bar{X}}_1=\frac{49002.8-(1712.6+1714.5+2285.3+1727.4)}{25-4}$$

$$\bar{\bar{X}}_1=1979.19$$

$$UCL=\bar{\bar{X}}_1+A_2\bar{R}_1$$

$$UCL=1979.19+0.31\times 540.20=2146.652$$

$$LCL=\bar{\bar{X}}_1-A_2\bar{R}_1$$

$$LCL=1979.19-0.31\times 540.20=1811.728$$

$$CL=1979.19$$

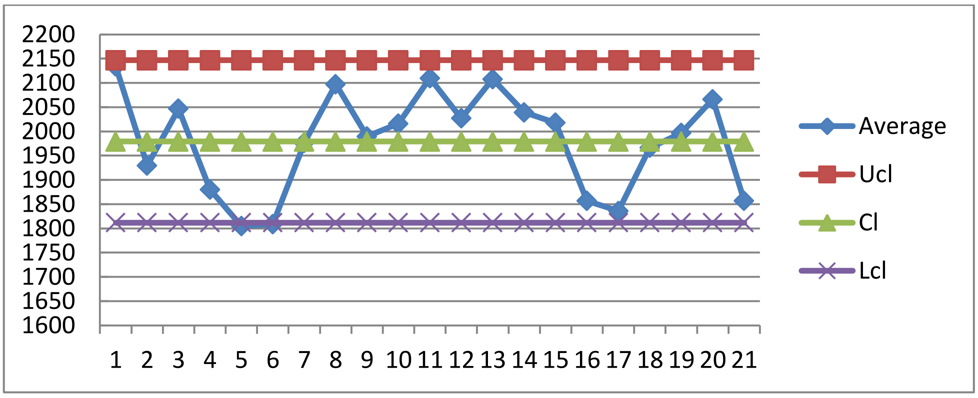


Figure 8 revised X-chart for 21 count

Now all points are falling within the control limits. The final values are

LCL=1811.728

CL=1979.19

UCL=2146.652

Interpretation R-chart is not in control, some points are crossing the upper control limits. x-chart is not in control points are crossing the control limits. So the process is not in a state of a statistical control.

$\sigma = \frac{\bar{R}_1}{d_2}=\frac{540.20}{3.078}\sigma=175.503$

The process capability $=6\sigma=6\times175.503=1053.018$

For 21 count $=2184\pm2$ specification limit

USL=2186

LSL=2182

USL-LSL=2186-2182=4

$C_p=\frac{USL-LSL}{6\sigma}=\frac{2186-2182}{1053.018}=0.0037<1$

$C_{pk}=[\frac{X-LSL}{3\delta},=\frac{USL-X}{3\delta}]$

$C_{pk}\ min=[\frac{1979.19-2182}{3*175.503},\frac{2186-1979.19}{3*175.503}]$

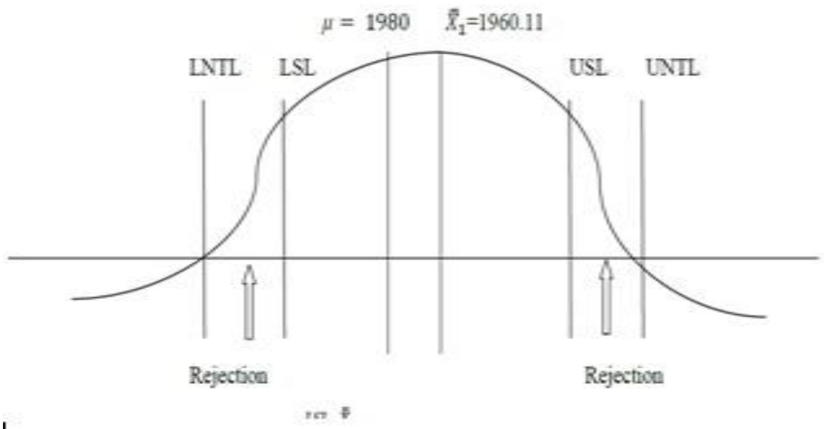
$C_{pkmin}=[-0.385,0.3927]$ Min=-0.385

The percentage of rejection

$UNTL=\bar{\bar{X}}_1+3\sigma$

$UNTL=1960.112+3\times(175.503)=2486.621$

LNTL=$\bar{\bar{X}}_1$-3 σ
LNTL=1960.112-3×(175.503)=1433.603
CL=1960.112
USL=2186
LSL=2182



Below Z=$\frac{LSL-\bar{\bar{X}}_1}{\sigma}$ = $\frac{2182-1960.11}{175.503}$=1.2643

Probability=0.8962=89.62%

Above Z=$\frac{USL-\bar{\bar{X}}_1}{\sigma}$= $\frac{2186-1960.11}{175.503}$ =1.2871

Probability=0.8997=89.97%

100%-89.97% =10.03%

Total rejection=89.62%+10.03% =99.03%

XI RING FRAME FOR 40 COUNT- CONTROL LIMITS FOR $\bar{R}$-CHART

$$\bar{R} = \frac{\sum R_i}{K}$$
$$\bar{R} = \frac{13764}{25} = 550.56$$
$$UCL = D_4 \times \bar{R}$$
$$UCL = 1.78 \times 550.56 = 979.9968$$
$$LCL = D_3 \times \bar{R} LCL = 0.22 \times 550.56 = 121.1232$$

CL=$\bar{R}$=550.56

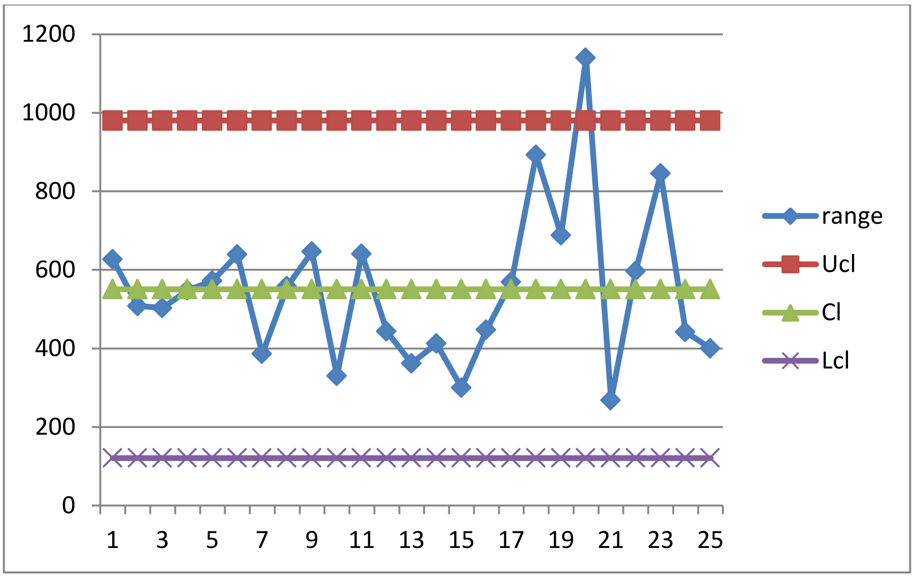


Figure 9 R-chart for 40 count

Due to1140 fail out of control limits we will develop another control limits by discarding the one item

$$\overline{R_1} = \frac{13764 - 1140}{25 - 1} = 526$$

Again control limits for $\bar{R}$-chart

$$UCL = D_4 \times \overline{R_1}$$

$$UCL = 1.78 \times 526 = 936.28$$

$$LCL = D_3 \times \overline{R_1}$$

$$LCL = 0.22 \times 526 = 115.72$$

CL=$\overline{R_1}$=526

Table 3 Revised range chart

range	Ucl	Cl	Lcl
627	936.28	526	115.72
508	936.28	526	115.72
503	936.28	526	115.72
548	936.28	526	115.72
572	936.28	526	115.72
639	936.28	526	115.72
386	936.28	526	115.72
558	936.28	526	115.72
646	936.28	526	115.72
330	936.28	526	115.72
641	936.28	526	115.72
443	936.28	526	115.72
362	936.28	526	115.72
412	936.28	526	115.72
300	936.28	526	115.72
447	936.28	526	115.72
569	936.28	526	115.72

893	936.28	526	115.72
688	936.28	526	115.72
268	936.28	526	115.72
597	936.28	526	115.72
845	936.28	526	115.72
442	936.28	526	115.72
400	936.28	526	115.72

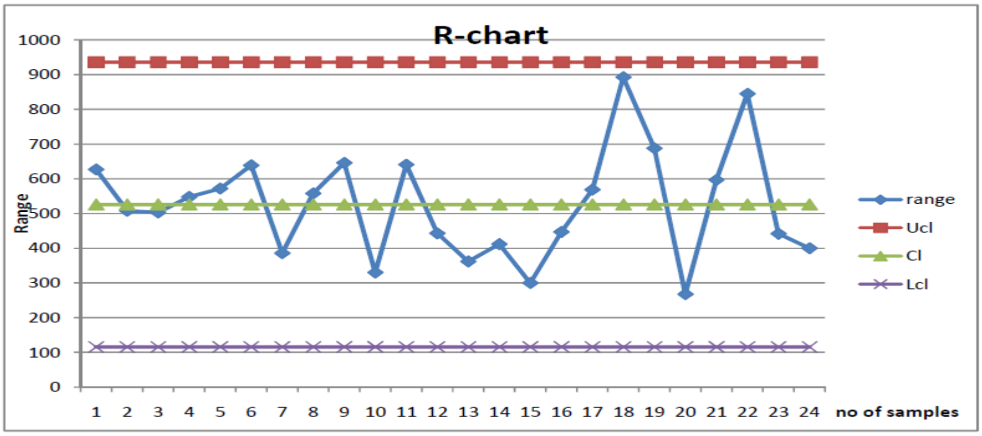


Figure 10 Revised R-chart for 40 count

Now all points are falling within the control limits. The final values are
UCL=961.556
LCL=118.844
CL=540.20

XII X-chart for 40 count

$\bar{\bar{X}}=\frac{\sum x_i}{K}$ $=\frac{49002.8}{25}$ =1929.04

UCL=$\bar{\bar{X}}+A_2\overline{R_1}$

UCL=UCL=1929.04+0.31×526=2092.1

LCL=1929.04-0.31×526=1765.98

CL=1929.04

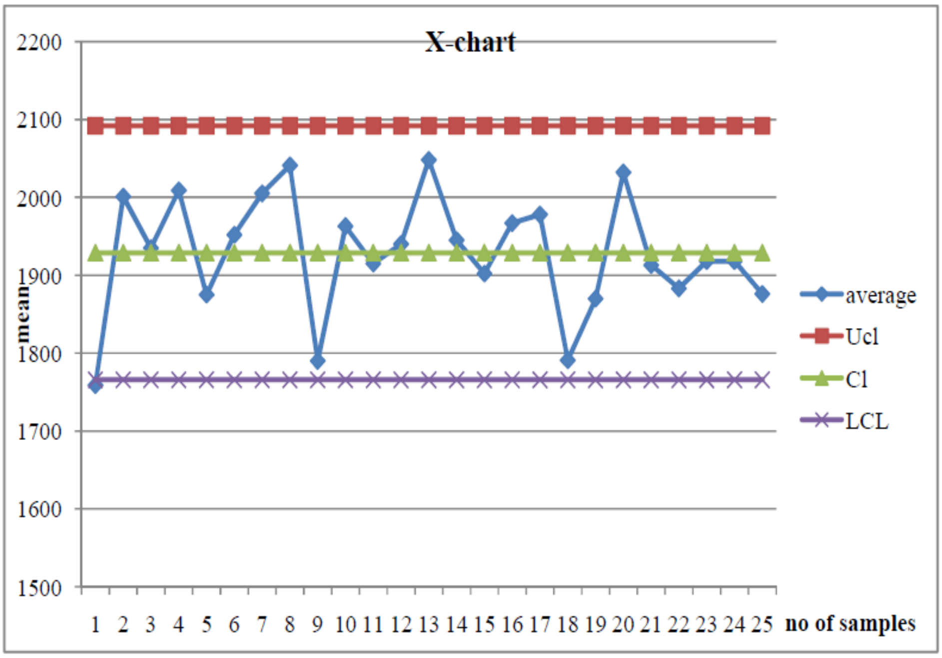


Figure 19X-chart for 40 count

Interpretation R-chart is not in control, some points are crossing the upper control limits. x-chart is in control. So the process is not in a state of a statistical control.

$$\sigma = \frac{\overline{R_1}}{d_2} = \frac{1929.04}{3.078}\ \sigma = 626.718$$

The process capability $=6\,\sigma = 6\times626.718 = 3760.3118$

For 40 count $=2080\pm2$ specification limit

USL=2082

LSL=2078

USL-LSL=2082-2078=4

Since $6\,\sigma > (USL - LSL)$ the process is not capable of meeting specification limits.

$$C_P = \frac{USL-LSL}{6\sigma} = \frac{2082-2078}{3760.3118} = 0.00106 < 1$$

Percentage of rejection

UNTL=$\bar{\bar{X}}_1$+3 σ

1929.04+3*626.718=3809.194

LNTL=$\bar{\bar{X}}_1$-3 σ

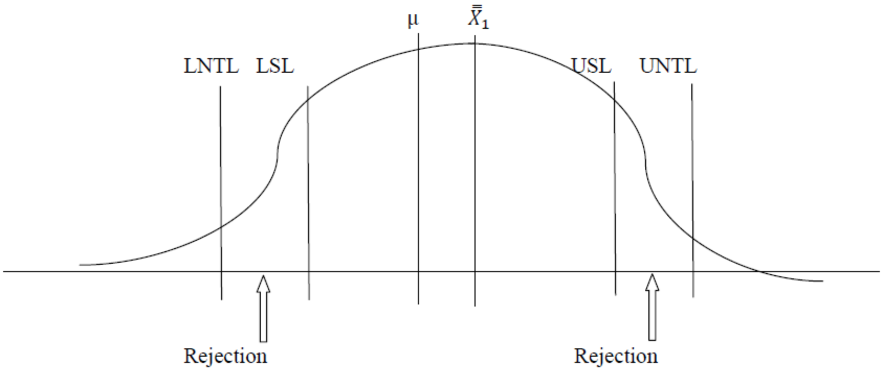
1929.04-3*626.718=48.886

CL=1929.04

USL=2082

LSL=2078

Below Z=$\frac{LSL-\bar{\bar{X}}_1}{\sigma}$



$$\frac{2078-1929.04}{626.718}=0.2376$$

Probability=0.5910=59.1%

$$\text{Above Z}=\frac{USL-\bar{\bar{X}}_1=}{\sigma}$$

$$\frac{2082-1929.04}{626.718}=0.244$$

Probability =0.5948=59.48%

100%-59.48%=40.52%

Total rejection=40.52%+59.1%=99.62%

XII CONCLUSION

R-chart is not in control in both the cases -21 and 48 counts, some points are crossing the upper control limits whereas X-chart is out of control for 21 counts and in control for 40 count. So the process is not in a state of a statically control. It can thus be concluded that the entire process at DDTF is out of control and that there are a lot of waste in input either financial or time consuming. For optimization of process output, there is a need for complete and vigorous process verification and checking so as to identify the causes of process and their elimination.

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Prof Wg Cdr R.K.Gera

Born on 4th Nov 1944. He received the B.Sc. Engg.(Electrical) degree from RIT Jamshedpur (Now NIT Jamshedpur) in 1968 and M Tech in 1980 from IIT Kharagpur. He is ex-veteran of IAF and has been trained in France on Mirage-2000 as system analyst. After his premature retirement from IAF he had a stint as consultant in telecommunication, Operations Mgr in chemical and Branch Mgr export industries before penetrating into teaching profession. He took up teaching assignments in Bahirdar University, ETHIOPIA and Ertrea Institute of Tecgnology, Asmara in ERTREA (N-W Africa) and various engineering institutions in India since 2000. He has completed various projects in IAF and Ethiopia, published papers in International journals and presently authoring a book. He has taken up PhD work at JJT University, Jhunjhnu (Raj). Presently engaged by Dire Dawa University, Ethiopia for grooming Industrial Engineers, after retiring as Professor St Margret Engineering College, Neemrana Rajasthan. His areas of interest span from the technologies for renewable energy to latest trends in in the field of Industrial Engineering and Operations Research.

Hiwan Taye

An upcoming Industrial Engineer from Department of Industrial Engineering, , Dire Dawa University, Ethiopia. Completed her B.E. (Industrial Engineering), 2006 (EC). She is an enthusiastic researcher and innovator. Presently engaged in teaching and research work Mekelle University, Ethiopia and is.

Andargachew Bekele

He is an Industrial Engineer from Department of Industrial Engineering, Institute of Technology, Dire Dawa University, graduated in 2006 (EC). A research oriented professional and an independent consultant in the field of Industrial Engineering. He is pursuing his career as an entrepreneur.