CHAPTER-10

Statistical Quality Control

When a number of products is on large scale or mass production then the sale/profit depends upon the quality of the product. So it is necessary to control the quality of the product. So statistical quality control refers to statistical techniques which are employed for the control and maintenance of the uniform quality of the product manufactured in a factory through contineous flow of production.

Control Charts : It is most important tool for statistical quality control. There are three horizontal lines in a control chart known as control lines.

1. Central Line (C.L.) Passess through the middle of the chart and represents prescribed standard quality of the product.
2. Upper control Line : Shown in the chart by a dotted line and passes through the chart above and represents the upper limit of tolerance.
3. Lower control Line (L.C.L.) Shown in the chart by a dotted line and passes through the chart below and represents the lower limit of tolerance.

Determination of control limits :

If a variable x is normaly distributed then the probability lies between $\mu \pm 3\sigma (0.997)$, which is very high. μ is mean and σ is standard deviation.

If a sample point falls out side the three sigma limits it may be assumed that it happens due to the presence of some assignable causes in the process of production that the said point indicates to some factor contributing to the quality variation in the process.

Types of Control Chart :

(1) Control charts for variables (variables are those quantitites which can be measured such as weight)

There are three control chart in this

1. $\bar{x}$ -chart or mean chart.
2. R-chart or Range chart
3. σ -chart or standard deviation chart.

(2) Control Charts for attributes.

(i) P-chart (ii) np-chart and (iii) $\subset$-chart

Mean Chart : ($\bar{x}$ -chart) Mean chart is used for controlling averae quality of the procuct.

Working Rule :

Step-I. Samples, x_1, x_2 …… are drawn from the process.

Step-II. Find the mean of each samples. $\bar{x} = \frac{\sum x}{n}$

Step-III. Find the mean of sample means

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{\text{No. of Samples}}$$

Step-IV Find the standard error of means.

$$\sigma\bar{x} = \frac{\bar{\sigma}}{\sqrt{n}}$$

Step-V : The limits are

$$U.C.L. = \bar{x} + 3\sigma_{\bar{x}}$$

$$L.C.L. = \bar{x} - 3\sigma_{\bar{x}}$$

The control limits are

$$U.C.L. = \bar{\bar{x}} + A_2\bar{R}$$
$$L.C.L. = \bar{\bar{x}} - A_2\bar{R}$$

Where $\bar{R}$ is a biased estimator of σ and value of A_2 are given in the table.

Problem: If the number of samples = 20, size of each sample = 5, $\bar{R}$ =2.32 $\bar{\sigma}$, $\bar{\bar{x}}$=99.6, $\bar{R}$=7.0.

Find the value of control limits for drawing a mean chart.

[n = 5, mean range = 2.32 (population standard deviation)

Solution: $\bar{\bar{x}}$=99.6, $\bar{R}$=7.0, $\bar{R}$=2.32 $\bar{\sigma}$,

$$\Rightarrow \bar{\sigma} = \frac{\bar{R}}{2.32} = \frac{7}{2.32} = 3.0172$$

N = 5

$$U.C.L. = \bar{x} + 3\left(\frac{\bar{\sigma}}{\sqrt{n}}\right) = 99.6 + \left(3 \times \frac{3.0172}{\sqrt{5}}\right)$$

$$= 99.6 + \frac{9.0516}{2.2361} = 99.6 + 4.0479 = 103.6479$$

$$L.C.L. = \bar{x} - 3\left(\frac{\bar{\sigma}}{\sqrt{n}}\right) = 99.6 - 4.0479 = 95.5521$$

$$C.L. = 99.6$$

R-chart: (Construction of control chart for Range).

Step-I : Sample numbers are taken along x-axis and range values along y-axis.

Step-II : Draw the control limits. U.C.L. and L.C.L.

Step-III. Plot the points to represent the range values.

Problems: Control on measurements of pitch diameter of thread in aircraft fitting is checked with 5 samples each containing 5 times at equal intervals of time. The measurements are given below. Construct $\bar{x}$ and R-chart and state your infrence from the chart.

$$LCR = D_3\bar{R} = 0$$

$$CLR = \bar{R} = 3.4$$

All the sample points lie between control limits. Hence the variability is under control. But process is out of control due to $\bar{x}$ -chart.

Fraction defective chart (p-chart) (Attributes)

p-chart is designed to control proportion (p) percentage (100p) or defectives per cell

$$\text{Fraction defective p} = \frac{\text{Number of defective articles}}{\text{Size of the sample}}$$

$$\Rightarrow p = \frac{\sum d}{N}$$

Working Rule to Construct p-chart.

Step-I. Calculate the average fraction defective $\overline{p}$

Step-II. Compute σ the standard error of $\overline{p}$

$$\sigma = \text{standard error of } \overline{p} = \sqrt{\frac{pq}{n}} = \sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$

Step-III. Calculate the upper control limit UC_P and the lower control limit LCL_P.

$$VCL_P = \overline{p} + 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}, \quad \text{C.L.p} = \overline{p}$$

$$LCL_P = \overline{p} - 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$

where p=mean defective of population or Average fraction defective.

Step-IV. Draw the control line of p and UCL_P & LCL_P.

Step-V. Plot the individual points p (or 100p).

Step-VI. (1) If all the points lie between two dotted lines then the process is in statistical control.

(2) If any point is above UCL_P or below LCL_P the the process is out of statistical control.

Problem: Construct a p-chart for the following data.

Number of samples (each of 100 items)	1	2	3	4	5	6	7	8	9	10
Number of defectives	12	10	6	8	9	9	7	10	11	8

Samples No.	**1**	**2**	**3**	**4**	**5**
Measurement (*x*)	46 45 44 43 42	41 41 44 42 40	40 40 42 40 42	42 43 43 42 45	43 44 47 47 45

Solution: We have

Samples No.	**1**	**2**	**3**	**4**	**5**

	46	41	40	42	43
Measurement (*x*)	45	41	40	43	44
	44	44	42	43	47
	43	42	40	42	47
	42	40	42	45	45
$\sum x =$	**220**	**208**	**204**	**215**	**226**

$$\bar{x} = \frac{\sum x}{n} = \frac{220}{5} = 44, \frac{208}{5} = 41.6, \quad \frac{204}{5} = 41.8, \frac{215}{5} = 43 \quad \frac{226}{5} = 45.2$$

	Max - Min				
R	46 - 42	44 - 40	42 - 40	45 - 42	47 - 43
	= 4	= 4	= 2	= 3	= 4

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{n} = \frac{44 + 41.6 + 40.8 + 43.0 + 45.2}{5} = 42.92$$

$$\bar{R} = \frac{\sum R}{5} = \frac{17}{5} = 3.4$$

From table, for sample size of 5 items $A_2 = 0.577$

Limits for $\bar{x}$ chart

$$U.C.L.\bar{x} = \bar{x} + A_2\bar{R} = 42.92 + 0.577 \times 3.4 = 44.88$$
$$L.C.L.\bar{x} = \bar{x} + A_2\bar{R} = 42.92 - 0.577 \times 3.4 = 40.96$$

$$\bar{x}_5 = 45.2 > UCL = 44.88$$

All the sample points do not lie between control limits. Hence the process is out of control.

From the table D_3=0, D_4=2.115

Limits for R-chart

$$UCL_R = D_4\bar{R} = 2.115 \times 3.4 = 7.141$$

No. of samples	No. of units in sample (n)	Number of defectives	fraction defective $p = \frac{d}{n}$
1	100	12	0.12
2	100	10	0.10

3	100	6	0.06
4	100	8	0.08
5	100	9	0.09
6	100	9	0.09
7	100	7	0.07
8	100	10	0.10
9	100	11	0.11
10	100	8	0.08
	N=1000	$\sum d = 90$	

Average fraction defective

$$\bar{p} = \frac{\text{Total number of defective in all sample combined}}{\text{Total Number of items in all samples}}$$

$$= \frac{\sum d}{N} = \frac{90}{1000} = 0.09$$

Standard Limits

Upper Control Line $UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$$= 0.09 + 3\sqrt{\frac{(0.09)(1-0.09)}{100}}$$

$$= 0.09 + 3\sqrt{0.000819}$$

$$= 0.09 + 3 \times 0.0286 = 0.09 + 0.0858 = 0.1758$$

Lower Contorl Line $LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$$= 0.09 - 0.0858$$

$$= 0.0042$$

All the values lie between control limits, hence the variability is under control.

np-chart : For equal size use p or np-chart but for variable size use p-chart.

Working Rule :

Step-I. Obtain $\bar{p} = \frac{\sum d}{N}$

Step-II. Calculate σ the standard error or d by the formula

$$\sigma = S.E.(d) = \sqrt{n\bar{p} - \frac{1}{\bar{p}}}$$

Step-III. Calculate central limit CL = $n\overline{p}$

$$UCL = n\overline{p} + 3\sqrt{n\overline{p}q}$$
$$LCL = n\overline{p} - 3\sqrt{n\overline{p}q}$$

Remark. If LCL is -ve take it = 0

Step-IV. Plot the defective item points.

Step-V. If all the points lie within UCL and LCL then the process is under control otherwise process is out of statistical control.

Problem: Distinguish between np-chart and p-chart.

The following is data of defective of 10 sample of size 100 each. Construct np-chart and give your comments.

Samples Number	1	2	3	4	5	6	7	8	9	10
Number of defectives	6	9	12	5	12	8	8	16	13	7

Solution : Number of samples = 10

Size of sample = 100

$$\overline{p} = \frac{\text{Total number of defectives of all sample combined}}{\text{Total Number of items of all the samples combined}}$$

$$= \frac{6+9+12+5+12+8+8+16+13+7}{10\times100}$$

$$= \frac{96}{1000} = 0.096$$

Central control line $CL = n\overline{p} = 100\times0.096 = 9.6$

$$UCL = n\overline{p} + 3\sqrt{n\overline{p}q} = 9.6 + 3\sqrt{9.6\times0.904}$$

$$= n\overline{p} + 3\sqrt{n\overline{p}(1-\overline{p})} = 9.6 + 8.84 = 18.44$$

$$LCL = 9.6 - 8.84 = 0.72$$

Since all the sample points are inside inside the control limit so the process is under statistical control.

C-chart. The c-chart is used when the number of defects per unit (are counted). If C follows poisson distribution with mean m and standard deviation $\sqrt{m}$.

Mean of $C = \overline{c}$

1. When the standard are specified.

Control limit line = $\bar{c}$

Upper control limit line $UCL = \bar{c} + 3\sqrt{\bar{c}}$

Lower control limit line $LCL = \bar{c} - 3\sqrt{\bar{c}}$

Remark. Size of samples should be equal and If size of each sample is not equal use p-chart.

2. When the standards are specified.

Here the central line is at $c_2\sigma, c_2$ is taken from the table.

Standard error for $\sigma = \frac{\sigma}{\sqrt{2n}}$

UCL for C-chart = $c_2\sigma + 3\frac{\sigma}{\sqrt{2n}}$

LCL = $c_2\sigma - 3\frac{\sigma}{\sqrt{2n}}$

Second method $LCL = B_1\sigma$, $UCL = B_2\sigma$,

where B_1 & B_2 are taken from table.

C-chart is very useful for Attributes.

Problem : The number of defects in 500 blades are given as

Days	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Number of defects days	1	1	2	3	1	2	1

are these data under taken out from a controlled process.

Solution : The number of defects C = 1+1+2+3+1+2+1

$$\bar{c} = \frac{\text{Total number of defects of all the sample contained}}{\text{Total Number of days}}$$

$$= \frac{1+1+2+3+1+2+1}{7} = \frac{11}{7} = 1.57$$

Standard error = $\sqrt{\bar{c}} = 1.25$

$UCL = \bar{c} + 3\sqrt{\bar{c}} = 1.57 + 3(1.25) = 1.57 + 3.75 = 5.32$

$LCL = \bar{c} - 3\sqrt{\bar{c}} = 1.57 - 3.75 = -ve$ so=0

C.L.=$\bar{c} = 1.57$

Since all the points are within the control limit, so the process is in statistical control.

Example Suppose we are given the following information:

$n = 20$, $\bar{\bar{x}} = 75$, $d_2 = 3.735$ and $\bar{R} = 15$. We are asked to find the CL, UCL and LCL for a $\bar{x}$ control chart.

Solution. It is obvious that CL is the grand mean, that is, 75.

$$\text{UCL} = \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$$

$$= 75 + \frac{3(15)}{3.735\times\sqrt{20}}$$

$$= 75 + \frac{45}{16.70}$$

$$= 77.69$$

$$\text{UCL} = \bar{\bar{x}} - \frac{3\bar{R}}{d_2\sqrt{n}}$$

$$= 75 - \frac{3(15)}{3.735\times\sqrt{20}}$$

$$= 75 - \frac{45}{16.70}$$

$$= 72.31$$

Example A company manufactures tyres. A quality control engineer is responsible to ensure that the tyres turned out are fit for use up to 40,000 km. He monitors the life of the output from the production process. From each of the 10 batches of 900 tyres, he has tested 5 tyres and recorded the following data, with $\bar{x}$ and $\bar{R}$ measured in thousands of km.

Batch	1	2	3	4	5	6	7	8	9	10
$\bar{x}$	40.2	43.1	42.4	39.8	43.1	41.5	40.7	39.2	38.9	41.9
$\bar{R}$	1.3	1.5	1.8	0.6	2.1	1.4	1.6	1.1	1.3	1.5

Construct an $\bar{x}$-chart using the above data. Do you think that the production process is in control? Explain. (Value of $d_2 = 2.326$)

Solution.

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{k} = \frac{410.8}{10} = 41.08$$

$$\bar{R} = \frac{\sum R}{k} = \frac{14.2}{10} = 1.42$$

$$\text{CL} = 41.08$$

$$\text{UCL} = \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$$

$$= 41.08 + \frac{3(1.42)}{2.326\times\sqrt{5}}$$

$$= 41.08 + \frac{4.26}{2.326\times 2.24}$$

$$= 41.08 + 0.82 = 41.9$$

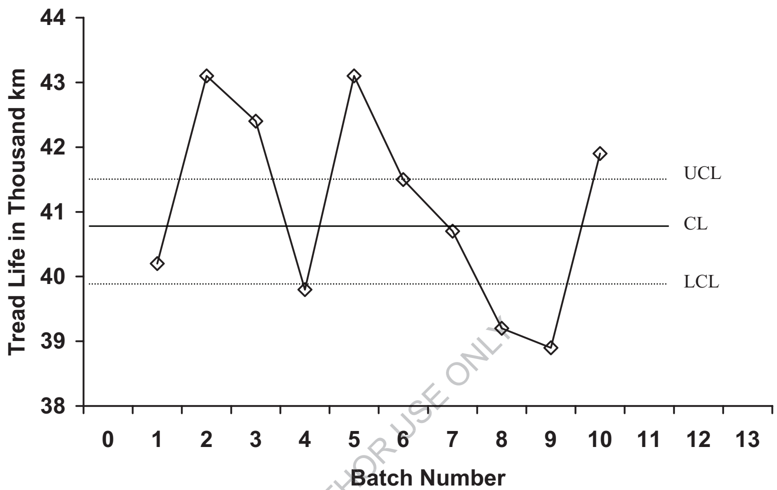
$$\text{LCL} = \bar{\bar{x}} - \frac{3\bar{R}}{d_2\sqrt{n}}$$

$$= \quad 41.08 - \frac{3(1.42)}{2.326 \times \sqrt{5}}$$

$$= \quad 41.08 - \frac{4.26}{2.326 \times 2.24}$$

$$= \quad 41.08 - 0.82 = 40.26$$

The production process is in control in respect of only 3 batches as is indicated in Fig. 16.3. The production process is in respect of batches 1, 4, 8 and 9 has gone out of control so also batch numbers 2, 3 and 5.



$\bar{x}$**-Chart for the data**

R-Charts: Control charts for process variability

In this chart, the value of the sample range for each of the samples is plotted. The central line for R-charts is placed at $\bar{R}$. Now, we have to decide the control limits for which we need some additional information regarding the sampling distribution of R, in particular its standard deviation σ_R. For this purpose, the following formula is used.

$\sigma R = d_3\sigma$

where

σ = population standard deviation

d_3 = another factor depending on n

The values of d_3 are given in question.

Control Limits for an R-Chart

$$\text{UCL} = \quad \bar{R} + \frac{3d_3\bar{R}}{d_2} = \bar{R}\left(1 + \frac{3d_3}{d_2}\right)$$

$$\text{LCL} = \quad \bar{R} - \frac{3d_3\bar{R}}{d_2} = \bar{R}\left(1 - \frac{3d_3}{d_2}\right)$$

It may be noted that these limits are often calculated as:

UCL = $\bar{R}\,D_4$, where $D_4 = 1 + \dfrac{3d_3}{d_2}$

LCL = $\overline{R}\,D_3$, where $D_3 = 1 - \dfrac{3d_3}{d_2}$

The values of D_3 and D_4 can also be found from Table of control charts.

Example We have to determine the UCL and the LCL by applying the above formulae to the data given in Example 16.3.

Solution. The UCL and the LCL are calculated as follows:

$$\begin{aligned}
\text{UCL} &= \overline{R}\left(1+\frac{3d_3}{d_2}\right)\\
&= 1.42\left(1+\frac{3(0.864)}{2.326}\right)\\
&= 1.42\ (1 + 1.11) = 2.996 \text{ or 3 approx.}\\
\text{LCL} &= \overline{R}\left(1-\frac{3d_3}{d_2}\right)\\
&= 1.42\left(1-\frac{3(0.864)}{2.326}\right)\\
&= 1.42 \times -0.11 = -0.156 \text{ (to be taken as zero)}
\end{aligned}$$

Some explanation is needed for the zero value of LCL. A sample range is always a non-negative number (because it is the difference between the largest and smallest observations in the sample). However, when $n \le 6$, the LCL computed by the above equation will be negative. Although in this case n is 10, yet the calculation shows a negative value. As such, we set the value of LCL at zero.

A major limitation of R-chart arises from the characteristic of range itself. As we know that the range considers only the highest and the lowest values in a distribution, it may ignore the nature of variation in the remaining observations. Further, it is influenced by extreme values, which may significantly differ from one sample to the other. In view of these limitations, R-chart is only a convenient device for examining variability of the process.

Control chart for C (Number of defects per unit)

So far we have consider the control charts for attributes in those cases wherein a random sample of definite size is selected and examined in some way. However, there are certain situations where the number of events, defects, errors can be counted, but there is no information about the number of events, defects or errors that are not present. Each item is classified in one of the two categories- defective or non-defective. In such cases, we know the number of defects, say, number of holes in a fabric but we do not know the number of non-defects present. In such cases, the Poisson distribution is to be applied.

The central lines of the control chart for C is $\overline{C}$ and the 3-sigma control limits are

$$\text{UCL} = \overline{C} + 3\sqrt{\overline{C}}$$

$$\text{LCL} = \overline{C} - 3\sqrt{\overline{C}}$$

This formula is based on a normal curve approximation to the Poisson distribution. The use of the C-chart is appropriate if the occasions for a defect in each production unit are infinite, but the probability of a defect at any point is very small and is constant.

Example Fifteen pieces of cloth from different rolls contained respectively 1, 5, 3, 2, 7, 6, 3, 2, 6, 5, 4, 3, 5, 6, and 3 imperfections. Draw a control chart using these data and state whether the process is in a state of statistical control.

Solution.

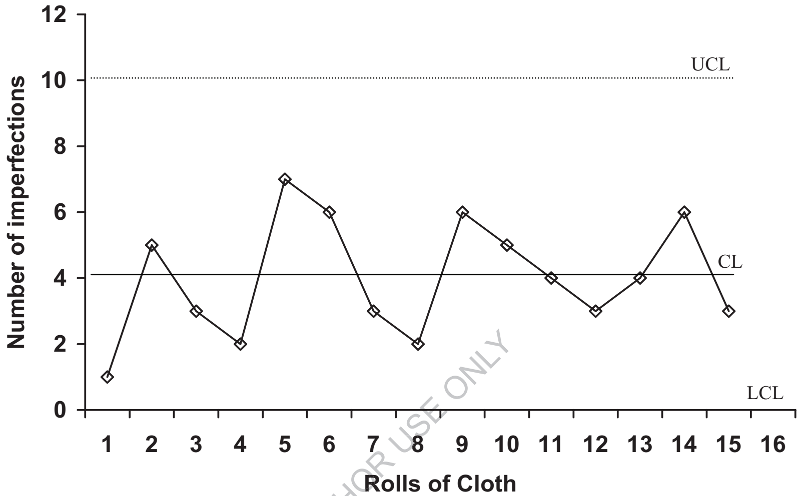
$$\begin{aligned}
\overline{C} &= (1 + 5 + 3 + 2 + 7 + 6 + 3 + 2 + 6 + 5 + 4 + 3 + 4 + 6 + 3)/15\\
&= 60/15 = 4\\
\text{UCL} &= \overline{C} + 3\sqrt{\overline{C}}
\end{aligned}$$

$= 4 + 3\sqrt{4} = 4 + 6 = 10$

$LCL = \bar{C} - 3\sqrt{\bar{C}}$

$= 4 - 3\sqrt{4} = 4 - 6 = -2$

Since the number of defectives cannot be negative, the lower control limit will be taken as zero. Figure 16.4 shows both the control limits. The chart clearly shows that all the imperfections in cloth are within the control limits, that is, no point lies outside the control limits. This suggests that the process is in a state of statistical control.



Control chart for C

<u>*p*-charts: Control charts for attributes</u>

The control chart for attributes is known as the *p*-chart. Such a chart is used to control the proportion or percentage of defectives per sample. It may be noted that there is an assumption that the items are produced by Bernoulli process, which implies the following three assumptions: (i) There are only two outcomes– acceptable or defective. (ii) The outcomes occur randomly. (iii) There is no change in the probability of either outcome for each trial. As we have seen earlier that the C-chart is concerned with the number of defectives, it can be easily converted into proportion by dividing the number of defectives by the sample size. Thus, we can use the *p*-chart in place of the C-chart. In order to draw the *p*-chart, we have to follow the following procedure:

Calculate the average fraction defective ($\bar{p}$) by dividing the number of defective units by the total number of units inspected.

The value of $\bar{p}$ is now used to draw a horizontal line.

The upper and lower control limits are to be obtained by using the following formulas:

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}\,\bar{q}}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}\,\bar{q}}{n}} \qquad \text{where } \bar{q} = (1 - \bar{p})$$

Any sample point falling outside the UCL and the LCL indicates that the process is not in control. It is preferable to set up the chart to express 'percent defective' to 'fraction defective'.

Example The following figures give the number of defects in 10 samples, each containing 200 items: 40, 44, 22, 34, 24, 32, 28, 32, 34 and 30. Calculate the values for central line and the upper and lower control limits of *p*-chart. Draw the *p*-chart and comment if the process can be regarded in control.

Solution.

Table 1. Worksheet for calculating the values for *p*-chart

Sample No.	No. of defectives	Fraction defectives
1	40	0.20
2	44	0.22
3	22	0.11
4	34	0.17
5	24	0.12
6	32	0.16
7	28	0.14
8	32	0.16
9	34	0.17
10	30	0.15
Total	320	

$$\bar{p} = \frac{\text{No. of units defective}}{\text{Total no. of units inspected}} = \frac{320}{2000} = 0.16$$

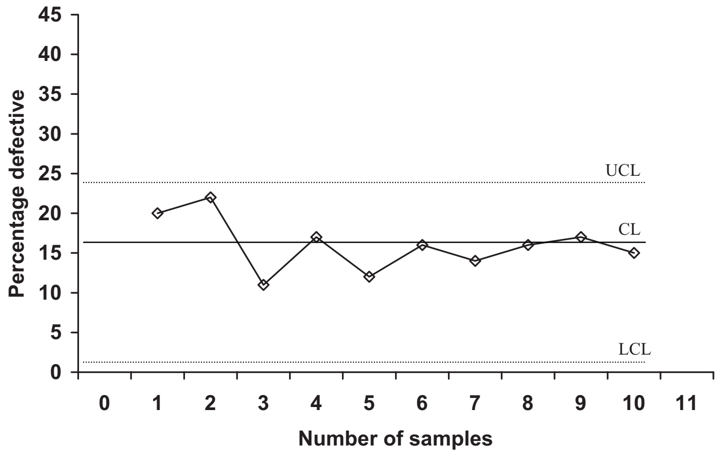
$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.16 + 3\sqrt{\frac{0.16(1-0.16)}{200}}$$

$$= 0.16 + 0.07776 = 0.2378$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.16 - 3\sqrt{\frac{0.16(1-0.16)}{200}}$$

$$= 0.16 - 0.07776 = 0.0822$$

It will be seen from Fig. 16.6 that all the units fall within the upper and lower control limits. On the basis of this chart, we can say that the process is well under control. It may be noted that we have plotted the percentage defective instead of fraction defective in the above chart.



***p*-Chart for data**

Benefits of Statistical Quality Control

There are several benefits of SQC approach and these include:

SQC can be applied to any type of problem selected and process originally tackled will result into improvement.

This approach eliminates the 'emotion' factor and the decisions are based on facts rather than on opinions.

As the workers are directly involved in the improvement process, their 'quality awareness' increases.

The knowledge and experience potential of those involved in the process is released in a systematic way through the investigative approach. They increasingly realise that their role in problem solving is collecting and communicating the relevant facts on which decisions are made.

Managers and supervisors solve problems methodically instead of in a haphazard manner. Thus, the approach to the problem becomes unified in place of an individual approach earlier.

Exercise

1. What is statistical quality control? How is it useful to industry?

2. What is a control chart? Describe how it is constructed and used?

3. Describe briefly the working of the p-chart.

4. Write a detailed note on ‘Acceptance Sampling’.

References

[1] Mathematical Statistics by – J. N. Kapur & H. C. Saxena
[2] Mathematical Statistics by – M. Ray & H. S. Sharma
[3] Mathematical Statistics by – M. Ray, H. S. Sharma & S. Chaudhary
[4] Statistical Methods by – G. C. Sharma & S. S. Choudhary
[5] Statistical Methods by – H. K. Pathak & D. C. Agrawal

[6] Business Statistics by Shenoy and Shenoy.
[7] Statistical Methods by S.P. Gupta.
[8] Statistics for Business and Economics by R.P. Hooda.

[9]Spiegel, Murray R.: Theory and Practical of Statistics., London McGraw Hill Book Company.
[10]. Yamane, T.: Statistics: An Introductory Analysis, New York, Harpered Row Publication
[11]. G.C. Beri: Statistics for Mgt., TMH.
[12] J.K. Sharma: Business Statistics, Pearson Education.
[13] Elhance, D. N. and V. lhance, 1988, *Fundamentals of Statistics,* Kitab Mahal, Allahabad.
[14] Nagar, A. L. and R. K. Dass, 1983, *Basic Statistics,* Oxford University Press, DeIhi .
[15] Mansfield, E., 199 1, *Statistics for Business and Economics: Methods and Applications, W.W.* Norton and Co.
[16] Yule, G U. and M. G Kendall, 1991, *An Introduction to the Theov of Statistics,* Universal Books, Delhi.