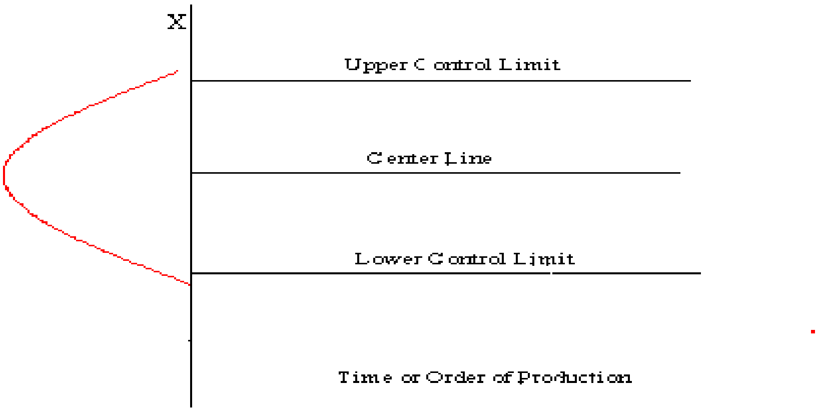
QUALITY MANAGEMENT

UNIT - 3

CONTROL CHARTS

If a single quality characteristic has been measured or computed from a sample, the control chart shows the value of the quality characteristic versus the sample number or versus time. In general, the chart contains a center line that represents the mean value for the in-control process. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL), are also shown on the chart. These control limits are chosen so that almost all of the data points will fall within these limits as long as the process remains in-control. The figure below illustrates this.

Theoretical Basis for a Control Chart



TYPES OF DATA

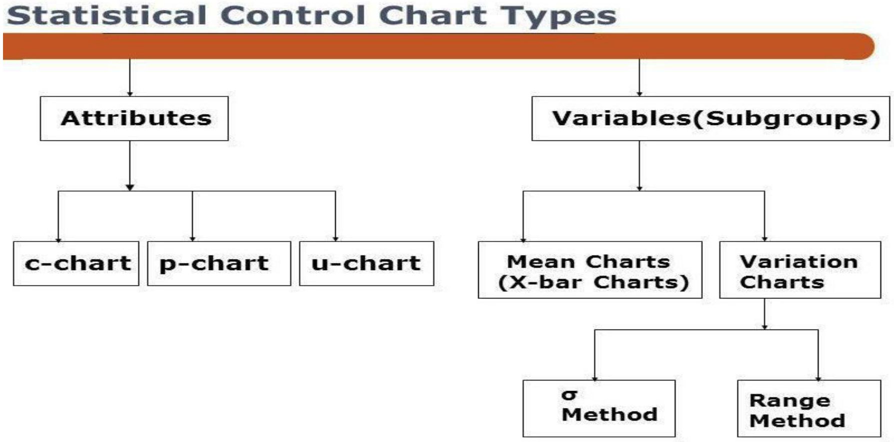
1. Variable Data

- Product characteristic that can be measured
- Length, size, weight, height, time, velocity

2. Attribute Data

- Product characteristic evaluated with a discrete choice
- Good/bad, yes/no, Colour, Look, Appearance.

Statistical Control Chart Types



Control Charts for VARIABLES

Mean chart (X-Chart)–Measures central tendency of a sample

Range chart (R-Chart)–Measures amount of dispersion in a sample

Each chart measures the process differently. Both theprocess average and process variability must be in controlfor the process to be in control.

Constructing a Control Chart for Variables

- **(1).** Define the problem
- **(2).** Select the quality characteristics to be measured
- **(3).** Choose a rational subgroup size to be sampled
- **(4).** Collect the data
- **(5).** Determine the trial centerline for the X-chart
- **(6).** Determine the trial control limits for the X-chart
- **(7).** Determine the trial control limits for the R chart
- **(8).** Examine the process: control chart interpretation
- **(9).** Revise the charts
- **(10).** Achieve the purpose

ATTRIBUTES DATA

Data that can be classified into one of several categories or classifications is known asattribute data. Classifications such as conforming and nonconforming are commonly used in qualitycontrol.

Types of attributes control chart:

1. Control chart of fraction (*p*-chart)

This chart shows the fraction of nonconforming or defective product produced by amanufacturing process.It is also called the control chart for fraction nonconforming. In this chart each item is classified as good (non-defective) or bad (defective). This chart is used to control the general quality of the component parts. In this chart

Central line = $\bar{p} = \frac{Total\ number\ of\ pieces\ found\ defective}{Total\ number\ of\ pieces\ inspected} = \frac{\Sigma d}{K}$

Where d= defective pieces

K= sample size

Upper control limit (UCL) is given by

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{K}}$$

The lower control limit (LCL) is given by

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{K}}$$

2. Control chart of defective items (*np*-chart)

This chart shows the number of nonconforming. Almost the same as the p chart.

$$n\bar{p} = \frac{Total\ number\ of\ defective\ items\ in\ all\ samples}{Total\ number\ of\ samples\ inspected} = \frac{\Sigma d}{nK}$$

$$= \frac{Total\ no.\ of\ defects}{Total\ number\ of\ samples \times\ Sample\ Size}$$

Where d= defective pieces

n= no. of samples

K= sample size

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

LCL= $\boldsymbol{n\overline{p} - 3\sqrt{n\overline{p}\,(1 - \overline{p})}}$

3. Control chart of number of defects per unit (*C*-chart):

This shows the number of defects or nonconformities produced by a manufacturing process. In this control chart numbers of defects in a place or a sample are plotted. It control number of defects observed per unit or per sample. In *C*-chart, sample size is constant.

This chart is used where average numbers of defects are much less than the number of defects which would occur.

Central line = $\boldsymbol{C = \frac{Total\ defects\ in\ all\ items\ inspected}{Total\ number\ of\ items\ inspected}}$

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

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

Calculations for Control Limits

Notation:

UCL—Upper Control Limit	x —Average of Measurements
LCL—Lower Control Limit	$\overline{\overline{x}}$ —Average of Averages
CL —Center Line	R —Range
n —Sample Size	$\overline{R}$ —Average of Ranges
PCR—Process Capability Ratio	USL—Upper Specification Limit
$\hat{\sigma}$ —Process Standard Deviation	LSL—Lower Specification Limit

Variables Data ($\overline{x}$ and R Control Charts)

$\overline{x}$ Control Chart

UCL = $\overline{\overline{x}} + A_2\overline{R}$

LCL = $\overline{\overline{x}} - A_2\overline{R}$

CL = $\overline{\overline{x}}$

R Control Chart

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

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

CL = $\overline{R}$

n	A_2	D_3	D_4	d_2
2	1.880	0.000	3.267	1.128
3	1.023	0.000	2.574	1.693
4	0.729	0.000	2.282	2.059
5	0.577	0.000	2.114	2.326
6	0.483	0.000	2.004	2.534
7	0.419	0.076	1.924	2.704
8	0.373	0.136	1.864	2.847
9	0.337	0.184	1.816	2.970
10	0.308	0.223	1.777	3.078

Capability Study

$C_p = (USL - LSL)/(6\hat{\sigma})$; where $\hat{\sigma} = \overline{R}/d_2$

Attribute Data (p, np, c, and u Control Charts)

Control Chart Formulas

	p (fraction)	np (number of nonconforming)	c (count of nonconformances)	u (count of nonconformances/unit)
CL	$\overline{p}$	$n\overline{p}$	$\overline{c}$	$\overline{u}$
UCL	$p + 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$	$n\overline{p} + 3\sqrt{n\overline{p}(1-\overline{p})}$	$\overline{c} + 3\sqrt{\overline{c}}$	$\overline{u} + 3\sqrt{\frac{\overline{u}}{n}}$
LCL	$\overline{p} - 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$	$n\overline{p} - 3\sqrt{n\overline{p}(1-\overline{p})}$	$\overline{c} - 3\sqrt{\overline{c}}$	$\overline{u} - 3\sqrt{\frac{\overline{u}}{n}}$
Notes	If n varies, use $\overline{n}$ or individual n_i	n must be a constant	n must be a constant	If n varies, use $\overline{n}$ or individual n_i