UNIT-IV

CONTROL CHARTS

Theory of control charts – Measurement range – Construction and analysis of R charts – Process capability study – Use of control charts

ATTRIBUTES OF CONTROL CHART

Defects – Construction and analysis of charts – Improvement by control chart – Variable sample size – Construction analysis of C charts

Introduction:

In the manufacturing industry, the products produced are expected to conform to the quality prescribed. The challenge for the producers to maintain the quality of the products. It is essential that the end products possess the qualities that the consumer expect. But it is not possible to inspect every product and every aspect of the production process all the time. Thus there is necessity to design ways to maximise the ability to monitor the quality of the products being produced and eliminate defects.

Statistical Quality control (SQC):

Definition:

It refers to statistical techniques which are employed for the control and maintenance of the uniform quality of the products manufactured in process through continuous flow of production.

Classification:

Quality control covers all the factors of production. They may be broadly classified in the following way.

1) **Quality of materials:** Good quality materials will be used to produce better finished products.
2) **Quality of Manpower:** If the production personnel is trained and qualified then there will be increased efficiency and less cost of production.
3) **Quality of Machines:** If the equipment is of good quality and up-to-date, then there will be efficient work and scarcity of breakdowns.
4) **Quality of Management:** Good management will result in efficiency, harmony in relations and growth of business and markets.

Causes of Variations:

The basis of statistical quality control is the degree of variability in the size or magnitude of a given characteristic of the product.

The variations in the quality of products may be due to two causes:

i) Chance or Random Causes

ii) Assignable Causes

Chance or Random Causes: There are some variations which are natural and inherent in the manufacturing process and cannot be removed or prevented in anyway. A “Stable pattern of variation” or a “Constant cause system” is inherent in any particular scheme of production.

Assignable Causes: Variations due to specific causes like machine faults, inexperienced workmen, worn-out tools, defective raw-materials etc. are called assignable variation. The causes of such variations are called assignable causes.

Theory of Control Charts:

Types of Quality Control (or) Control charts for variable and attributes:

Techniques of SQC

- **Process Control** (By control chart device)
  - Variables
    - X-Chart
    - R-Chart
    - Chart
  - Attributes
    - c chart
    - np Chart
    - p Chart
- **Product Control** (By sampling inspection plan)
  - Variables
  - Attributes

The Control of quality of a manufactured product can be broadly classified as:
i) Process Control
ii) Product Control

The process control is achieved through control chart technique and product control is achieved through sampling inspection plans commonly there are two types of control charts.

i) Control chart for variable: Control chart for variable for variable means those quality characteristics of a product which can be measured in quantitatively. When each of these continuous variables is arranged in the form of a distribution, it will form a normal distribution.

Three commonly used control charts for variables are

1. X-Chart or mean chart
2. R-Chart
3. Standard deviation or chart

ii) Control chart for attributes: The quality characteristics like good or bad, defective or not defective are some of the attributes in nature. Thus, attributes can be measured and ascertained but cannot be measured quantatively. In Control chart for attributes, the sampled units are divided into two categories, defective and not defective.

Control charts for attributes are of three types:

1. Control chart for fraction defective (p – chart)
2. Control chart for number of defectives (np)
3. Control chart for number of defects per unit (c-chart)

Construction and analysis of R-Chart:

The sample number is taken along horizontal line and statistic range(R) is taken along vertical line. The sample points $R_1, R_2.........R_k$ are taken plotted as points against the corresponding sample number. The central line (CL) is taken as dark horizontal lines at R. UCL and LCL are plotted as dotted horizontal lines at their computed values.

Interpolation of R-Chart:

- A process is said to be in statistical control if the R charts exhibits under control i.e., all the sample points fall within the control limits.
- If one on more of the points in any, the charts go out of the control limits we say that the process is out of statistical control.

Construction and analysis of C-Chart:

In the graph paper we take the sample number along horizontal line and statistic range(c) along the vertical line. The sample points $C_1, C_2.........C_k$ are plotted against the corresponding sample numbers as a points the central line (CL) is drawn as dark horizontal line at C. The UCL and LCL are plotted as dotted horizontal lines at their computed values.

Interpolation of C-Chart:

If all the sample points fall under the 3 sigma limits then the process is said to be under statistical control if any point lay outside the 3 sigma limits then the process is said to be out of statistical control.

Measurement Range:

R-chart is used for controlling the quality dispersion or variability of the product in a process. A number of samples are drawn from the process in production at regular intervals of time and the range computed from such samples and is used in the control chart.

A range is easy to calculate and provide a very good quality measures for controlling quality dispersion or variability of the product in the process.

Methods for computing R-Chart:

Step-1: Find the range R of each sample

Step-2: Calculate the mean of the sample range R

Step-3: Calculate the standard error of range

Step-4: The control limits are

$U.C.L_R = R+3$

$L.C.L_R = R-3$

Where is the S.E. of the range R.

The value of , may be estimated by finding the standard deviation of the ranges of the samples included in a chart. However, in particle it is convenient to compute $U.C.L_R$ and $L.C.L_R$ by using D_4 and D_3 as provided i the table at the end. When the tabulated values are used, the two limits can be obtained as

$U.C.L = D_4 R$; $L.C.L = D_3 R$

Note: R chart is used only for relatively small sample sizes.

Uses of Control Charts:

A control chart is a statistical tool used to distinguish between variation in a process resulting from common causes and variation resulting from special causes. It presents a graphic display of process stability or instability over time.

One goal of using a Control Chart is to achieve and maintain process stability. Process stability is defined as a state in which a process has displayed a certain degree of consistency in the past and is expected to continue to do so in the future.

"A statistical tool used to distinguish between process variation resulting from common causes and variation resulting from special causes".

Uses of Control charts:

Control Charts help you monitor the behaviour of your process to determine whether it is stable. Like Run Charts, they display data in the time sequence in which they occurred. However, Control Charts are more efficient that Run Charts in assessing and achieving process stability.

Your team will benefit from using a Control Chart:

- Monitor process variation over time.
- Differentiate between special cause and common cause variation.
- Assess the effectiveness of changes to improve a process.
- Communicate how a process performed during a specific period.

Objectives:

1. Control charts are used as one source of information to help whether an item or items should be released to the customer.
2. Control charts are used to decide when a normal pattern of variation occurs, the process should be left alone when an unstable pattern of variable occurs which indicates the presence of assignable causes it requires an action to eliminate it.
3. Control charts can be used to establish the product specification.
4. To provide a method of instructing to the operating and supervisory personnel (employees) in the technique of quality control. Symbols or Notations

X : Mean of the sample X σ : Standard deviation of the sample X
1 : Mean of the population or universe σ1 : Standard deviation of the population.

Process Capability Study:

Definition:

Process capability refers to the ability of the process to meet the specifications set by the customer or designer.

Process Capability analysis:

- Objective is to determine how well the output from a process meets specification limits
- Compare total process variation and tolerance.

The established control charts provide information about the performance or capability of the process. The range in which the process can produce the product can be estimated using the standard deviation of the process. This quantification is the process capability which depicts the variation about a given process aim.

Process capability = 6 σ

Construction and Analysis of Control Charts:

1. There are several types of control charts. Our discussion will focus on two types:
    1) XBAR—Range Charts
    2) XBAR—Standard Deviation Charts.

These options are always used as a pair of charts. The XBAR chart monitors the process mean, and the Range or Standard Deviation chart monitors the process standard deviation.

2. There are two situations in which control charts are created:
    1) Process standard deviation known, as in a mature process.
    2) Process standard deviation unknown, as in a new process.
3. Features to be calculated for each control chart:
    1) UCL: Upper control limit
    2) CL: Centre line
    3) LCL: Lower control limit
4. Formulas for UCL, CL and LCL:
    1) For the XBAR chart the formulas place the UCL and the LCL at a distance of 3 standard deviations of the sample mean above and below the centre line. By using 3 sigma limits, a sample mean would very rarely occur which is outside these control limits when the process is operating "in control". Thus, a point outside of these limits signals an "out of control" situation.
    2) For the Range Chart or Standard Deviation Chart, the limits are established using multipliers which are meant to place the UCL and LCL so that the sample Range or sample Standard Deviation would rarely fall outside the limits when the process is "in control".

3) The formulas to be used depend on whether the process standard deviation is known or unknown. The formulas are given at the bottom of the sheet titled "Factors for Computing Central Lines and 3 sigma limits for X-BAR, S and R Charts".
4) If the process standard deviation is known, use the formulas on the left side of the page.
5) If the process standard deviation is not known, use the formulas on the right side of the page.
6) In these formulas, the desired process mean is the "target value" that is applicable for the part being produced. This is always known.
7) The constants A, A2, A3, etc. used in the formulas have values given in the table above the formulas, and the values depend on the sample size being used. The sample size must be held constant, and the interval between samples must be established by knowledge of the process variation.

Control Chart Interpretation:

There are three rules which are in general use in nearly all applications using control charts. If any one of these three rules provides an "out of control" signal, the process is to be stopped, and the problem is corrected. Often 100 % inspection of all the production since the previous OK sample is required. When the process is restarted, more frequent sampling might be done for a period of time.

1. A single point on any chart which falls outside the control limits is a signal that the process is "out of control".
2. A "run" of 9 consecutive points on the same side of the centre line on any chart is a signal that the process is "out of control".
3. A "trend" of 7 consecutive points ascending or seven consecutive points descending is a signal that the process is "out of control".