Control Chart: A Tool for Cause of Repetitive Process Variations

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***Abstract:*-In nature two similar things are difficult to obtain. If at all we come across exactly similar things, it must be only by chance. This fact holds good for production process as well. No Production process is good enough to produce all items of products exactly alike. Every production process is subjected to some degree of natural variability for which chance/normal and assignable causes are there .A control chart is a graphical representation of the collected information. It detects the variation in processing and warns if there is any departure from the specified tolerance limits. The control limits disclose the variability causes i.e. Chance/Normal and Assignable. In this paper we are discussing about need, types & procedure of implementation and to find out the cause of variation.**

***Keywords*:- UCL, LCL, σ, X, R**

I. INTRODUCTION

Need:

Almost every production process is subjected to variability. Innumerable small causes contribute to overall chances of variation in the quality of output. The individual/normal causes are so slight that no major portion of the variation can be traced to as single cause. These deviations are a function of the accuracy .Another type of process variation is produced by assignable causes. As opposed to natural variations, these causes produce a relatively large variation traceable to a specific reason. Most commonly, these causes are owed to differences in materials, and differences causes by the interaction of materials, workers and machines.

Control charts:

Control chart is a graphic aid to detect quality variation in output from a production process. As opposed to the aim of acceptance sampling (to accept or reject products), control chart help produce a better product. Control charts have three main applications: (1) to determine the actual capability of production process (2) to guide modifications for improving the output quality of process, and (3) to monitor the output. The monitoring function shows the current status of output quality and provides an early warning of deviation from quality goals.
Control Charts are the tool for differentiation of the causes of variation in quality.

Control charts – Purposes and Advantages

1. A control chart indicates whether the process is in control or out of control.
2. It determines process variability and detects unusual variations taking place in the process.
3. It ensures product quality level.
4. It warns in time, and if the process is rectified at that time, scrap or percentage rejection can be reduced.
5. It provides information about the selection of process and setting of tolerance limits.
6. Control charts build up the reputation of the organization through customer's satisfaction.

Applications of Control Charts:

Control charts find applications in controlling the quality characteristics of the following: -

1. Final assemblies.
2. Manufactured components (shafts, spindles, balls, pins, holes, slots, etc.).
3. Bullets and shells.
4. Soldered joints.
5. Castings and cloth lengths.
6. Defects in components made of glass.

7. For studying tool wear.
8. Punch press works, forming, spot welding, etc.
9. Incoming material.
10. Large and complex products like bomber engines, turbines, etc.

Types:

Control charts have two principle divisions: attributes and variables.
The Control charts may be classified:

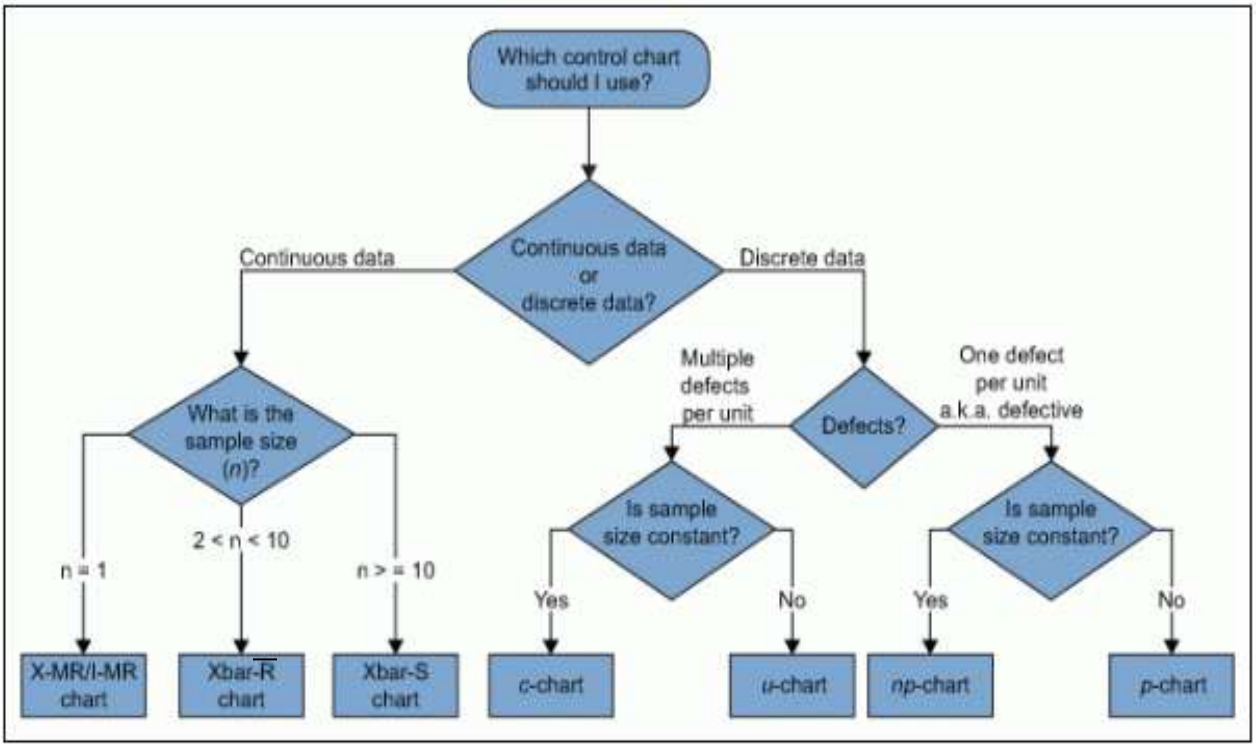
(i) Control charts for variables and
(ii) Control charts for attribute.

The control charts based on variable/continuous data that can be measured on a continuous scale i.e. weight, volume, temperature etc. are known as control charts for variables.
The control charts based on discrete data i.e. counted as "present" or "not" are called control charts for attributes.

When constructing attribute control charts, a subgroup is the group of units that are inspected to obtain the number of defects or the number of defective items. Attribute control can be further divided into charts for percentage defectives and chart for the number of defects per unit.

The main interest in the variables is control over changes in the average and the range of measurements. Control chart for all these considerations follows the same basic format of mean value bounded by upper and lower control limits. It is the calculation of the control limits that distinguishes the type of chart.

Selection of control chart:



II. CONTROL CHART PROCEDURE:

The procedure to plot or for making the control charts mentioned above is same for all the charts so we are discussing the procedure to plot or making the chart for variable/continuous data. The chart most commonly used for variable data are the $\overline{X}$ chart, and the R chart (range chart). The $\overline{X}$ charts are used to monitor the centering of process, and the R chart is used to monitor the variation in process. These charts are used together for the analysis of variable data. The range is used as a measure of variation simply for convenience, particularly when the workers on the factory floor perform control chart calculations by hand.

$\overline{X}$ and $\overline{R}$ CHART (mean and range chart)

These types of charts are based on group readings or for readings of different lots taken at different time on a single machine. These are used to find out the capability of the process and the control limits. For variable data the chart combined with it is the moving range that is based on the difference between two consecutive measurements. The readings are taken at regular interval for individual data

Values of constants:

$$\sigma' = \overline{R}/d2$$

$$UCL\ \overline{X} = \overline{X} + A2 * \overline{R}$$

$$LCL\ \overline{X} = \overline{X} - A2 * \overline{R}$$

$$UCLr = D3 * \overline{R}$$

$$LCLr = D4 * \overline{R}$$

σ' = estimated standard deviation

$\overline{R}$ = Mean of ranges = Sum of ranges/no. of sub group

$\overline{X}$ = Mean of means of individuals

A2 = 3 σ'/square root of no. of observation

UCL $\overline{X}$ = Upper control limit for means

LCL $\overline{X}$ = Lower control limit for means

UCL r = Upper control limit for ranges

LCL r = Lower control limit for ranges

Steps followed to plor $\overline{X}$ & $\overline{R}$ chart

The following procedure is adopted for finding out the process variation and machine producing the parts of proper specification & within the control variation, reduce the scrap work, lessen readjustment & on the time adjustment of the machine & achievement of the objective.

1. Take samples as per plan for taking samples for process capability study.
2. Record measurements along with date, time and process changes occurred during the study in the format for data collection.
3. Calculate the sum of each sub group and then average ($\overline{X}$) of each sub group.
   $\overline{X}$ = (X1 + X2+ X3 + X4 + X5)/5
4. Calculate the range (R) of each sub group, where
   R = X (highest) – X (lowest)
5. Calculate the average range ($\overline{R}$)
   $\overline{R}$ = (R1 + R2 + R3 + ---------------R25) /25
6. Estimate the process standard deviation (σ) by the following method
   $\sigma = R/d_2$
   where $d_2 = 2.33$ for n = 5
   where R is the average of sub group ranges.
7. Calculate the control limit for $\overline{X}$ chart i.e. UCLx and LCLx as given below:
   UCLx = $\overline{X}$ + A2 * $\overline{R}$
   LCLx = $\overline{X}$ – A2 * $\overline{R}$
   Where A2 = 0.58 for n = 5
   A2 = 1.02 for n = 3
8. Draw the average (X), UCLx and LCLx as solid lines on the "control chart". Compare all the sub group averages (X Bar) against the UCLx and LCLx.
9. Calculate the control limit for range chart i.e. UCL_r (Upper Control Limit) and LCL_r (Lower Control Limit) to show the extent by which the sub group ranges would vary.
   $UCL_r = D_4 * \overline{R}$ $LCL_r = D_3 * \overline{R}$
   Value of D_4 and D_3

For n = 5	For n = 3
$D_4 = 2.11$	$D_4 = 2.57$
$D_3 = 0$	$D_3 = 0$

10. Draw the average ($\overline{R}$), UCL_r and LCL_r as solid line on the "control chart" on range chart. Compare all the sub groups against the UCL_r and LCL_r.
11. If no sub groups go out of control accept ranges forming a homogeneous group.

12. If any sub group goes out of control limits, then it is sign of presence of special causes.
13. Initially for establishing the control limits and carrying out capability study, calculate the control limits to exclude the effect of out control periods. Exclude all sub groups affected by the special cause, examine the remaining sub group for homogeneity by repeating steps 6- 11 till range chart shows control, but there should not be too many exclusions.
14. Estimate the process standard deviation (σ) by the following method
    i. $\sigma = R/d_2$
    ii. where $d_2 = 2.33$ for n = 5
    iii. where R is the average of sub group ranges.

Table 1 :- Shows values of Constants A2, d2, D3, D4

	X bar and R Charts			
	Chart for Averages	Chart for Ranges (R)		
	Control Limits Factor	Divisors to Estimate σ_x	Factors for Control Limits	
Subgroup size (n)	A_2	d_2	D_3	D_4
2	1.880	1.128	-	3.267
3	1.023	1.693	-	2.574
4	0.729	2.059	-	2.282
5	0.577	2.326	-	2.114
6	0.483	2.534	-	2.004
7	0.419	2.704	0.076	1.924
8	0.373	2.847	0.136	1.864
9	0.337	2.970	0.184	1.816
10	0.308	3.078	0.223	1.777
15	0.223	3.472	0.347	1.653
25	0.153	3.931	0.459	1.541

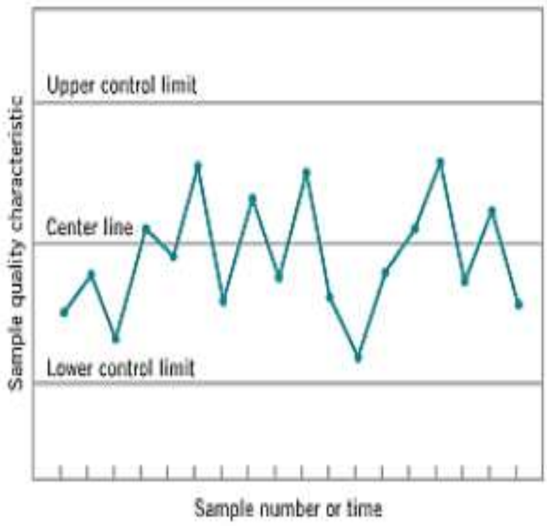


Fig.1 Control Chart

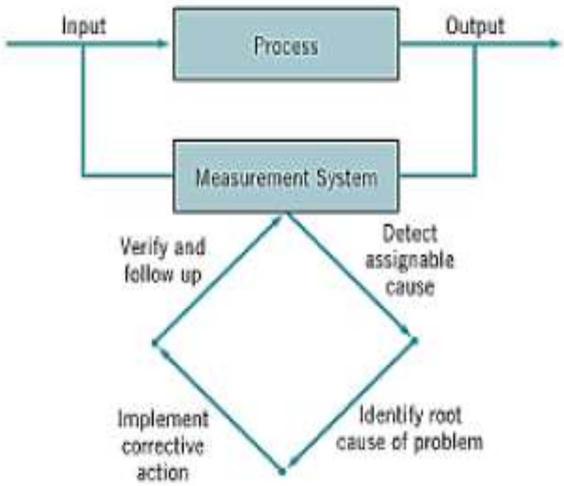


Fig. 2 Process improvement Procedure

III. CONCLUSION

From the above someone is able to how to implement the control chart on the data collected to find out the causes of variation in the process whether it is by chance or it has some assignable cause. Control charts are easy to implement and needs little involvement of employee. It also confirms the when a worker leave the process alone and prevent unnecessarily frequent adjustment. With taking this as raw data one can find the process capability and assure that which manufacturing process is better for a particular product.

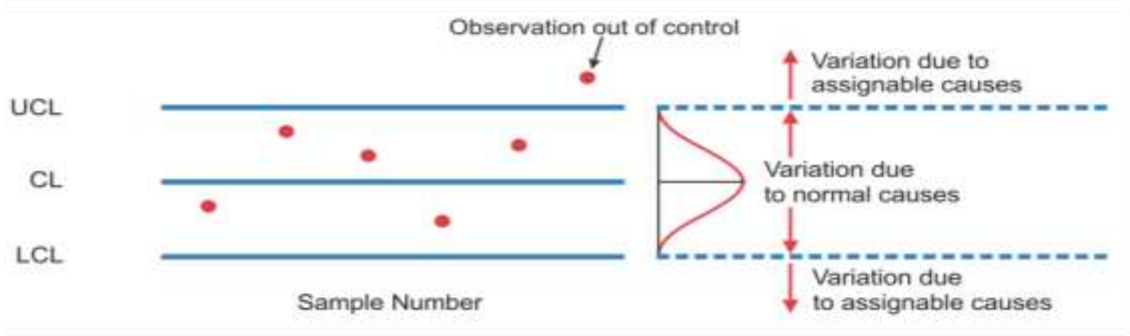


Fig. 3 Shows the Cause of variations with reference to data on the Control Chart

REFERENCES:

[1] Gupta P.K.(2006),"*Operations Management*" ,S Chand & Company Ltd. ,New Delhi.
[2] Mahajan M.(2008), " Statistical Quality Control : Dhanpat Rai & Co, Delhi.
[3] Hira D.S , (2004), "*Operations Research*", S Chand & Company Ltd. , Ram Nagar New Delhi110055
[4] Anna Satanová and Lukás Figuli, "Optimization of Production Process through Selected Statistical Methods", 2nd GLOBAL CONFERENCE on BUSINESS, ECONOMICS, MANAGEMENT and TOURISM, 3 0-31 October 2014, Prague, Czech Republic, pp 959-963
[5] Pranay S. Parmar, (2014) , "Implementation of statistical process control in industry" , *Journal of Emerging Technologies and Innovative Research (JETIR)* , Vol 1, pp 583-587
[6] Prajapati D. R., (2012) , "Implementation of SPC Techniques in Automotive Industry: A Case Study" , *Journal of Emerging Technologies and Advanced Engineering* , Vol 2, Issue3, pp 227-241
[7] Mishra Bimal and Dangayach G.S. , (2009) , "Performance improvement through statistical process control: a longitudinal study" , *International Journal of Globalisation and Small Business* , Vol 3 **,** pp 55-72
[8] Bharatendra K. Rai , (2008) , "Implementation of statistical process control in an Indian tea packaging company" , *International Journal of Business Excellence* , Vol 1, pp 160-174
[9] Grewal Chandandeep and Gupta A.D. , (2005) , "Quality Improvement Using Statistical Process Control in Automotive Ancillary: A Case Study", 11th International Conference on Productivity and Quality Research
[10] Jaju, S. B., et al (2002), "Process Capability Study of Bought-out Components for Tractor ManufacturingIndustry," Industrial Engineering Journal, Vol. XXXI, No. 4, pp 13-19.