# Application Perspective Discussions OnAttribute Control Charts

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## Abstract

Statistical process control (SPC) is the process to make sure the quality of the product manufactured as per the prescribed quality levels by examining, testing and analyzing them. Some statistical techniques are used to improve the quality and maintaining it to the product and also solve the quality related problems. The main purpose of the SPC is to reduce the variability and achieving process stability and capability. There are two types of variability: one is chance cause and another one is assignable cause. Chance cause is the variability happens on naturally and the assignable cause is a one having variability in the quality characteristics. SPC contains several tools; the control chart is the one of the best tool to work. Occurrence of assignable causes in process shift can be detected by using control charts. A control chart is the graphical process monitoring tool used widely for this process and also used to estimate the process parameters and its capability. The control charts have two types: one is control charts for variable and another one is control chart for attributes. Variable control charts for the data which is measurable quality characteristics and attributes control charts for the data which are countable not as measurable. Attributes are normally in the discrete nature. In this paper we discuss about the attribute control charts which are p, np, c, u charts. p-chart is used for the proportion of defectives, c-chart is used to construct the number of defects or flaws and the purpose of u chart is used to calculate the number of defects for each unit. This paper describes the attribute control charts and its application perspective way with examples. For example, illustrations the secondary data are collected from various fields and demonstrated the uses of attribute control charts in the various fields.

**Key words: -** Control charts, attribute control charts, c-chart, u-chart, p-chart

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## Introduction:

SPC is the procedure for observing the process and measuring the process variability by using the statistical techniques and it is used to control in process quality. The objective of Process control is the data collection, find out the root cause and controlling performance also managing variability. Consistency is the important one to find out the factors, which are take a part in variability. The main aim of this process is to reduce the variability. The variation is an element in similar products and it causes due to the both cause. Common causes which are known as chance causes and

Assignable causes. The variation occurs by (i) it may be happens within that product (ii) may be happens that products produced within the same process period. (iii) variations may be occurs in the products produced in the different period of time. There are many reasons for variations like tool wear, machine vibrations, etc. Chance causes of variation: There is always an unavoidable cause for variation that occurs naturally. The process with only having chance causes variation is supposed to be in control. Assignable causes of variation: The variation which takes a part in the outcome of the process like not proper material, adjustment, etc which are known as big noise and unacceptable to the process. This type of variation is supposed to be out of control. To eliminate the assignable causes there are several process steps in statistical process control.

## Control charts:

The most efficient process is the control chart. The control chart is the procedure for monitoring the process with graphical representation to find the shift or assignable causes. It is very efficient in reducing the variability and improves the quality of the any products as much as is feasible.

Control chart shows the process display of the quality characteristics. It consist Centre line which is known as average of the quality characteristics and two limiting values Upper control limits (UCL), Lower control limits (LCL). The sample points falls between the two limits there is no need to take any action. The process is said to be in control. Suppose the points falls outside the limits then we should alert, it is an alarm for the process getting out of control. Further investigation need to take action. Control chart have a close relationship with the hypothesis testing. A sample points are within the limits means accept the hypothesis, if not the points are plotting outside is to reject the hypothesis. There are two type of errors: control chart type –I error is result of the process is out of control but it is actually not out of control(in control) and type-II error is result of the process is in control but it is out actually out of control. This is used for Operation curves (OC) of control chart to describe the type errors. It contains three sigma control limits.

There are two types of control charts and they are

- control chart for variables
- control chart for attributes

## Control charts for variables:

Control charts for variable is used to the quality characteristics which are measurable. This data is said to continuous measurement variable.eg Temperature. X bar and R charts and X bar and Sigma charts S are the types of control chart for variable.



## Control charts for attributes:

Control charts for attributes used to the quality characteristics are not measurable and it may be conforming or non-conforming. The data is in the form of count eg: pass/fail, etc. The attributes control charts are p, u, np, c charts. This paper deals with the attribute control charts and their application perspective discussion only.

## Category of the data:

The control chart is also dependent on the collected data whether continuous data or attributes data.

Continuous: The data which is measurable and used in many charts.

**Ranked:** It is a value to convert the attributes control charts into variable control charts.

**Interval:** It is also like the ranked data, used to convert the attributes into variables control charts.

**Discrete:** It is a value which is countable used the data is discrete.

The continuous data have univariate data and multivariate data and the attribute data has binomial and Poisson. Continuous data can be infinite numbers but the attribute data is controlled to the discrete. Continuous is more informative than attributes. Attribute data are generally easy to collect.

## Rational subgroups:

The basic concept used in the control charts is the collection of sample data as described by Shewhart called rational subgroups. Rational subgroups are the samples or subgroups which are selected. It increases the chance of assignable causes between the subgroups and decreases the chance of assignable causes within the subgroups.

## Selection of control charts:

Check the category of the data is continuous then the sample size n= 1 we have to select individual control charts, X bar, R chart. But the sample size is greater than 10 then we have to select X bar and S chart. The control charts for attributes have two charts: charts for defectives items used p chart to find fraction of defective if

the sample size is varied. Then another attribute chart is np chart the chart is to find the number the defective when the sample is constant. The charts for defects per unit are c chart and u chart. The c chart is used when the sample size is constant. The u chart is used when the sample size is varied. In this paper we use three charts p, c,u and the secondary data are collected from the various sources like kaggle, Github, etc

## Sensitizing Rules for Shewhart Control Charts

- If one or more points lies exterior to the control limits.
- If two of the three successive points lies exterior to the two-sigma which indicates as warning limits but still inside the control limits.
- If four of five successive points outside the one-sigma limits.
- If eight consecutive points run on the one side of the center line
- If six points continuously in a row progressively increasing or decreasing
- If fifteen points in a row in zone C (both above

of npx chart with the help of x bar chart similar to the s chart and r chart. R. C. Quinino,F. R. B. Cruz and L. L. Ho(2019) proposes a new way to monitor processes mean and variance on a single chart at the same time. Although this method is control-based Chart by variable, it uses attribute validation. This study examines the possibility that the sample consists of both. Attributes and variables, and therefore attributes data, are the current work it has been replaced by variable data that makes this move toward capable. S. Chakraborti & S. W. Human(2008) have discussed expressions for a variety of chart performance characteristics, including average run length (ARL), standard deviation of run length (SDRL), and median run length (MDRL).Based on our conclusion, the estimation of the true unknown average number of non- conformities in an inspection unit c has a significant impact on the false alarm rate (FAR) and average run length (ARL) of the c-chart. DeoRaj Prajapati, Suman, and Gaurav Prajapati (2018) discussed the use of control charts in healthcare. In healthcare, errors, infections, pre- and postoperative complications, longer waiting times, length of stays, complications,

and below the center line).

etc., are always present. Human involvement

- If alternatively fourteen points in a falls up and down.
- Eight points in a row falls on the both sides of the center line with none in zone C.
- An unusual or nonrandom pattern in the data.
- If one or more points lies near a warning or control limit.

The above first four points was suggested by the Western Electric Statistical Quality Control Handbook (1956).

## Review of literature:

Silvia Joekes and Emanuel Pimentel Barbosa (2013) shows the process of low rate of non-conformities by improving the control limits of p chart for better improvement in the original data. The p chart is used to compare both charts normal and modified p chart with one term correction also new term corrections are made to improve the high quality process. The research describes the how to overcome the problems by using conventional np chart it is called as double inspection (DI). DI np chart is used for np chart for large degree and improves the performance without extra inspections. This paper also explained the attribute inspection

increases the likelihood of errors. Across the

time line, p chart, X bar chart, and run chart are also regularly used. This study has the drawback of the few studies that were included. Therefore, in the upcoming years, statistically analysis may be performed on a bigger scale to generalize the results. Rashid, Kawa M. Jamal, and Suzan S.

Haydar (2014) has discussed about the "Construction of control charts by using Fuzzy Multinomial-FM and EWMA Chart "Comparative study." A fuzzy multinomial chart is introduced in this paper that incorporates linguistic categories and variable sampling sizes (VSS), and they illustrated this approach with numerical examples. In this study, it is shown that the FM -chart gives an earlier warning regarding a shift in the specified quality level. In addition to using FM- charts with variable sample sizes, a better method to deal with deviations which lead to a change in sample sizes and a better method to control the process, FM- charts have better mathematical description than traditional quality control charts and give better results than traditional quality control charts. Consequently, the proposed method is useful to take a look at the characteristic records with linguistic categories.

Mahmood, Yasar, et al (2021) have discussed about Monitoring of three-phase variations in the mortality of COVID-19 pandemic using control charts. By monitoring variations in deaths and identifying growth phases such as pre-growth, growth, and post-growth phases, they have identified the timeline in Pakistan for the COVID-19 pandemic. It shows how these charts can be implemented in a systematic manner for government leaders and leading medical teams to enable the rapid detection of daily reported deaths due to COVID-19. It is also the public's duty to follow the prescribed standard operating procedures to ensure public safety as a temporary remedy to this pandemic while awaiting the discovery of a suitable vaccine. Inkelas, Moira (2021) discussed using control charts to describe community variation in COVID-19. Local mitigation and containment strategies have been informed by a novel method for presenting COVID-19 data that is timely and interpretable. In healthcare and other industries, statistical process control is used to study variation and disaggregate data in order to understand the behavior of processes and systems. In public health, control charts require an understanding of their value and an investment of time and resources.

## Research Methodology:

Construction of control charts:

- First, we have to select the quality characteristics.
- Second, we have to construct the quality plan.
- We have to select the type of the control chart.
- We have to choose the appropriate subgroup.
- Next collect the data, find out the trail control limits.
- Construct the control chart and use it.

## Control charts for attributes:

Attribute are countable things. Attribute control chart have appropriate types of charts to monitor the process.

conforming or non-conforming. The main purpose of p-chart is to used to measure the proportion of the items which are defective in the sample. The data for the p-chart should follows binomial distribution and the sample sizes can be different. The rational subgroup of the p-chart, n should be greater than 1 and it is used to find a defective or non-conforming of a sample. In p-chart, total sample size and the number of defectives both are evaluated.

## Assumptions of p-chart:

There are three assumptions for p-chart. (i) The p-chart should be binary (ii) every units should be independent (iii) the only one procedure for inspection is carried out for a sample and it follows the entire sample.

The upper and lower control limits are follows:

$$\text{Centre Line (CL)} = \bar{p} = \frac{\text{Total number of defectives}}{\text{Total sample observations}}$$

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

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

## c- chart:

Walter Andrew Shewhart proposed the c chart.

c-chart are used to monitor the count type data. It is used to monitor the total number of events happens in a one sample unit. c-chart follows the poisson distribution with rational subgroups more than 1. The purpose of c-chart is to count the number of defects. It is only used to determine the number of defects and doesn't determine the proposition of the defects. The defect of two samples fails in one defect each and the same two samples fails for more than 5 effects are shown. c- chart can show 10 faults.

### Assumptions of c chart:

(i) Number of non-conformities is large

(ii) Probability of non-conformities is small

(iii) Inspection procedure for each sample is same as for another sample.

### P-chart:

p-chart is one of the attribute control chart. p-chart was proposed by Walter Andrew Shewhart. It is used to measure the quality characteristic that can be classified either

The upper and lower control limits

$$\text{Centre line (CL)} = \bar{c} = \frac{\sum_{j=1}^{m} (Count)_i}{m}$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}}$$
$$LCL = \bar{c} - 3\sqrt{\bar{c}}$$

### u-chart:

When the subgroup size varies from sample to sample it is necessary to use u charts. It is proposed by Walter Andrew Shewhart. It is the total number of defects in a sample and n is the number of inspection unit in sample. u-chart follows the Poisson distribution and its rational subgroup greater than 1

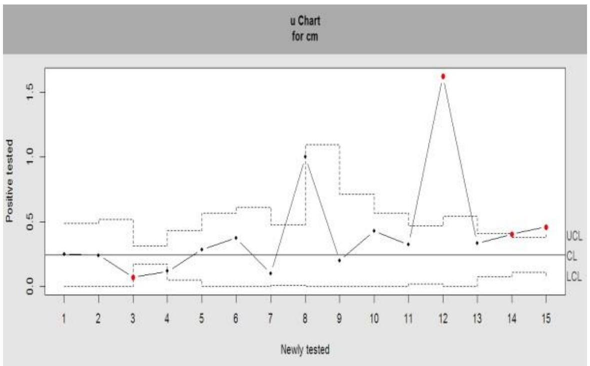
### Assumptions for u-chart:

(i) No multiple events occur at same time.
(ii)Independent event of one event does not affect the probability of the event of another one.

The upper and lower control limits

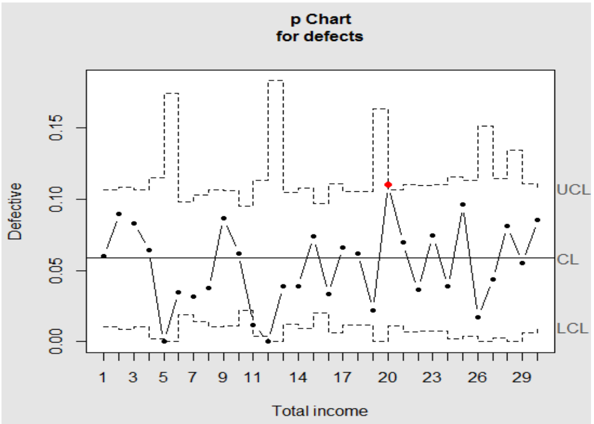
### Application of u-chart in Corona virus:

Normally, u-chart is used to measure the number of non-conformities or defectives of per items or within a group. Let us consider an example of California corona infected data. For the construction of u-chart we choose the total number of newly tested cases and the total number of newly conformed cases for 15 days. From the u-chart we found that three day falls above the UCL and one day falls below the LCL. There may be a mistake in equipment or manpower. When a point falls behind the control limits, the pre-growth phase has been moved to the growth phase.




### Result and discussions:

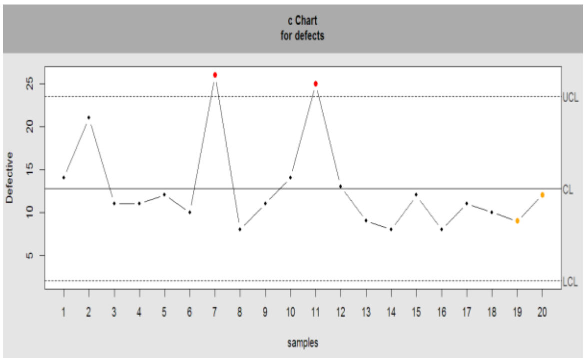
### Application of p-chart in call center




p-chart is used to measure the proposition of the defective items in the sample. Call center data is considered as an example of this p-chart. The number of defectives and the total sample size are the most appropriate for the p-chart construction. p-chart normally used for the binary data. Here the data contains abandoned call/ attained calls. For defective, abandoned calls are considered as a defective. For the construction of p chart we used the total incoming calls and the total abandoned call for 30 samples are taken. One and only one point exceeds the UCL. This signals the out of control point- a special cause of variation. There may be possible for attained call or network mistake or repaired phone, etc.

### Application of c-chart in dye product:

The data set consists of observed number of defects of a roll of 400 yards for 20 randomly selected rolls used to monitor the quality of colour during dyeing process. Here the sample size is same for 20 samples and the defects are given. So, we are going for c-chart. Using c chart, we have to plot the data in the control chart and find the special and assignable causes and element the causes. Here the two rules violations are occurred.




Therefore, when a point falls below the control limits, the possible causes machine defection,

incorrect configuration, systematic errors, process omissions, failure, power failures, and faulty equipment, etc

## Conclusion:

The control chart is mainly developed for the quality control in manufacturing. Currently attribute control charts are also used for the healthcare also. Any type of organisation can use it for a variety of monotonous tasks. Both services and products can be people, machines analyzed, as well as, costs, etc. for all the sectors. The c or u chart can be used to plot errors on engineering drawings, plans, and documents, as well as errors in computer software. Variable control charts and attribute control charts are sometimes available to quality control engineers. This enables engineers to sum up items quickly by categorizing them as suitable or undesirable in accordance with different quality criteria. Thus, attribute charts sometimes bypass the need for luxurious, accurate devices and time- consuming measurement procedures. This paper shows the applications of attribute control chart for various fields with secondary data elaborately explained. Also this paper helps to understand about attribute quality control charts construction procedure.

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