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TenStep Supplemental Paper

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The Control Chart - A Simple Tool for Quality Management

Although quality is a subjective area, statistical techniques have always been used when making quality measurements. Quality practitioners use Statistical Process Control (SPC) to monitor, manage, analyze, and improve performance by eliminating special causes of variation.

SPC gives companies the benefits of a scientific, data-based tool to help make decisions based on facts. SPC is a powerful technique for improving process quality since it systematically eliminates all causes of variation. The simple control chart is one of the best tools when utilizing SPC.

Control Charts

A control chart is a graph with a horizontal axis that represents sample numbers or points in time, and a vertical axis that represents measurements made from these samples. A control chart has one central line denoting the process average and both upper and lower control limits representing the acceptability limits around the process average line.

A control chart relies on the data collected during the sampling process. Sufficient data must be collected and plotted on a graph. When all the points in the graph are within the control limits, the process is labeled as controlled. If there are points outside the upper and lower control limits, the process is considered uncontrolled.

Types of Control Charts

Control charts can be sorted into two types:

1. **Control charts for variables**. Variables are numerically expressed quality characteristics such as height, weight, volume, temperature, output, etc. Control charts for variables are further subdivided into:
    - X-bar Charts: An X-bar chart controls the mean quality level of the process. The vertical axis of the X-bar chart represents the mean, or average, quality level of the samples. The horizontal axis represents the number of samples.
    - R-Charts: An R-chart is constructed from the ranges of each subgroup's data. These ranges are calculated by subtracting the maximum and minimum values from each subgroup. The vertical axis of the R-chart represents the ranges of each subgroup's data, while the horizontal axis represents the number of samples.
2. **Control charts for attributes**. Charts constructed to control the quality characteristics of attributes are known as control charts for attributes. There are also several different types of control charts for attributes:
    - C-Chart: The vertical axis of the C-Chart represents the number of defectives per unit or per day, while the X-axis represents the number of samples. These charts are constructed based on the assumption that quality attribute defects are very rare.

- U-Chart: In the U-Chart, the vertical axis represents the rate of defectives (number of defectives divided by number of samples), and the X-axis is the number of samples. Unlike the C-Chart, the U-chart can be used for different size samples. U-Charts are constructed based on the assumption that the number of defectives is rare.
- Np-Chart: The Np-Chart is similar to the C-Chart, but its control limits are based on binomial distribution and therefore cannot be used for samples with very few defects (the number of defective parts must be at least 5%).
- P-Chart: In this chart, we plot the percentage of defectives (per unit, per day, per batch, etc.) in a way similar to the U-Chart. However, the control limits are not based on the distribution of rare events, but on the binomial distribution. Therefore, the chart is not applicable to situations where defectives are very rare.

Short Run Control Charts

Some processes consider dozens of measurements when constructing the control limits. It is nonetheless difficult to construct different control charts for different measurements. To overcome this difficulty, short run control charts can be developed. All the processes can be plotted in the same short run control chart, but with rescaled plot points.

Short run control charts are classified into:

- **Short run control charts for variables.** The most important short run control charts for variables are:
  - *Nominal charts and target charts*: In these charts, the measurements for each part are transformed by subtracting a part specific constant. These constants may be nominal values for each part (nominal control charts) or targeted values (target charts). The nominal charts and target charts are appropriate as long as the variability across the different points is the same.
  - *Standardized short run charts*: Standardized short run charts are used when the variability among the different parts of the operation is not the same. The plot points are first transformed, as in nominal or target charts. Later, they are divided by part-specific constants that are proportional to the variation in the parts.
- **Short run charts for attributes.** The estimate of variability for attribute control charts is a function of the process average. Therefore, only standardized short run attribute charts are possible. For example, while constructing the short run P-chart, the plot points are determined first by subtracting the average part and then dividing by the standard deviation of the average part.

Variable control charts vs. attribute control charts

Quite often, quality engineers have to choose between variable and attribute control charts.

Advantages of attribute control charts: Attribute control charts provide a quick look at the various quality aspects of a product. They make it easy to distinguish between

acceptable and unacceptable products and are less expensive and less time consuming. Moreover, even inexperienced people can easily understand them.

Advantages of variable control charts: Variable control charts are more precise than attribute charts. They will lead to the root cause of quality problems before any actual unacceptable products occur.

Summary

The control chart is a simple yet very powerful tool for total quality management. Control charts are generally used to determine whether the products are meeting the required specifications. Moreover, they can lead to the root cause of the problem long before any unacceptable products occur.