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STATISTICAL PROCESS CONTROL FOR VARIABLES

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Abstract: The term "statistical process control" (SPC) refers to the application of statistical methods for process or production method control. It is a quick strategy to support ongoing improvement. When regularly monitored and regulated, managers can ensure a process that operates at its best potential and produce consistent, high-quality manufacturing. The application of SPC principles and continuous improvement go hand in hand. SPC, or statistical process control, is a method that's frequently used to find production-line flaws and guarantees that the finished product falls within accepted quality limits. It is a method of using statistical analysis to control and measure quality, thereby improving the manufacturing process. Manufacturers collect quality real-time data in the form of process or product measurements taken from different instrumentation and machines. The collected data is then used to monitor, evaluate, and control the manufacturing process. It can be a very effective tool for increasing output and minimizing different types of waste. In this paper we shall discuss various methods/tools used for collecting, presenting and analyzing the data related to variables.

Index terms: Statistical Process Control, Variable, Histogram, Scatter diagram, Control charts, Run

Statistical Process Control

Introduction:

Statistical Process Control (SPC) is an industry-standard methodology for measuring and controlling quality during the manufacturing process. Quality data in the form of Product or Process measurements are obtained in real-time during manufacturing. This data is then plotted on a graph with pre-determined control limits. Control limits are determined by the capability of the process, whereas specification limits are determined by the client's needs.

Data that falls within the control limits indicates that everything is operating as expected. Any variation within the control limits is likely due to a common cause—the natural variation that is expected as part of the process. If data falls outside of the control limits, this indicates that an assignable cause is likely the source of the product variation, and something within the process should be changed to fix the issue before defects occur.

With real-time SPC you can:

- Dramatically reduce variability and scrap
- Scientifically improve productivity
- Reduce costs
- Uncover hidden process personalities
- Instantly react to process changes
- Make real-time decisions on the shop floor

The following are the most commonly used tools of SPC:

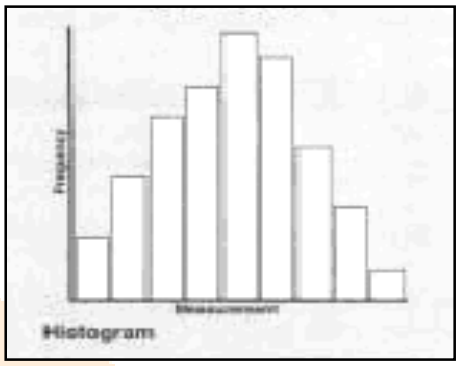
- Process flow diagrams
- Check sheets/Tally sheets
- Histograms
- Pareto diagrams
- Cause-and-effect diagrams
- Scatter or correlation diagrams
- Control charts
- Run Chart

In this paper, I will explain the tools which are related to variable data such as Histograms, Pareto diagrams, Scatter or correlation diagrams, Control charts, Run Chart

1) HISTOGRAMS:

Histograms are visual charts that depict how often each kind of variation occurs in a process. As with all SPC tools, histograms are generally used on a representative sample of output to make judgments about the process as a whole.

The height of the vertical bars on a histogram shows how common each type of variation is, with the tallest bars representing the most common outcomes.



Even if the chart is symmetrical, if the vertical bars are all similar in size, or if there are larger bars protruding toward the edges of the chart, it suggests the process is not well controlled.
The ideal histogram, for SPC purposes, has very steep bars in the center that drop off quickly to very small bars toward the outer edges.

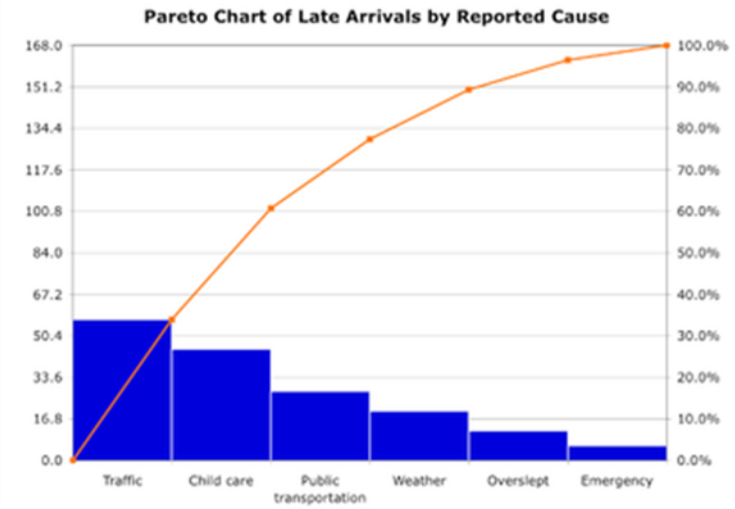
Advantages:
1. Histogram is a simple method of representing data.
2. Mere observation can tell whether the process is in control.
3. No calculations are involved.

Disadvantages:
1. It does not give the reason for the process not to be in control.
2. It does not provide the procedure to improve the process.

2) PARETO CHARTS:

A **Pareto chart**, named after Vilfredo Pareto, contains bar diagram, representing the individual values in descending order, and a line graph, representing the cumulative total.
Pareto charts highlight the most important among a (typically large) set of factors. In quality control, they often represent the most common sources of defects, the highest occurring type of defect or the most frequent reasons for customer complaints, and so on. Pareto Charts can be generated by simple spreadsheet programs

Frequency of occurrence. It can also represent cost or another important unit of measure



The cumulative percentage of the total number of occurrences, total cost, or total of the particular unit of measure.

To take the example above, in order to lower the amount of late arriving by 80%, it is sufficient to solve the first three issues.

Advantages:

1. Similar to histogram, it is a simpler method but it talks about the issues to be resolved.
2. Mere observation can talk about the process control.
3. It does not involve calculations.

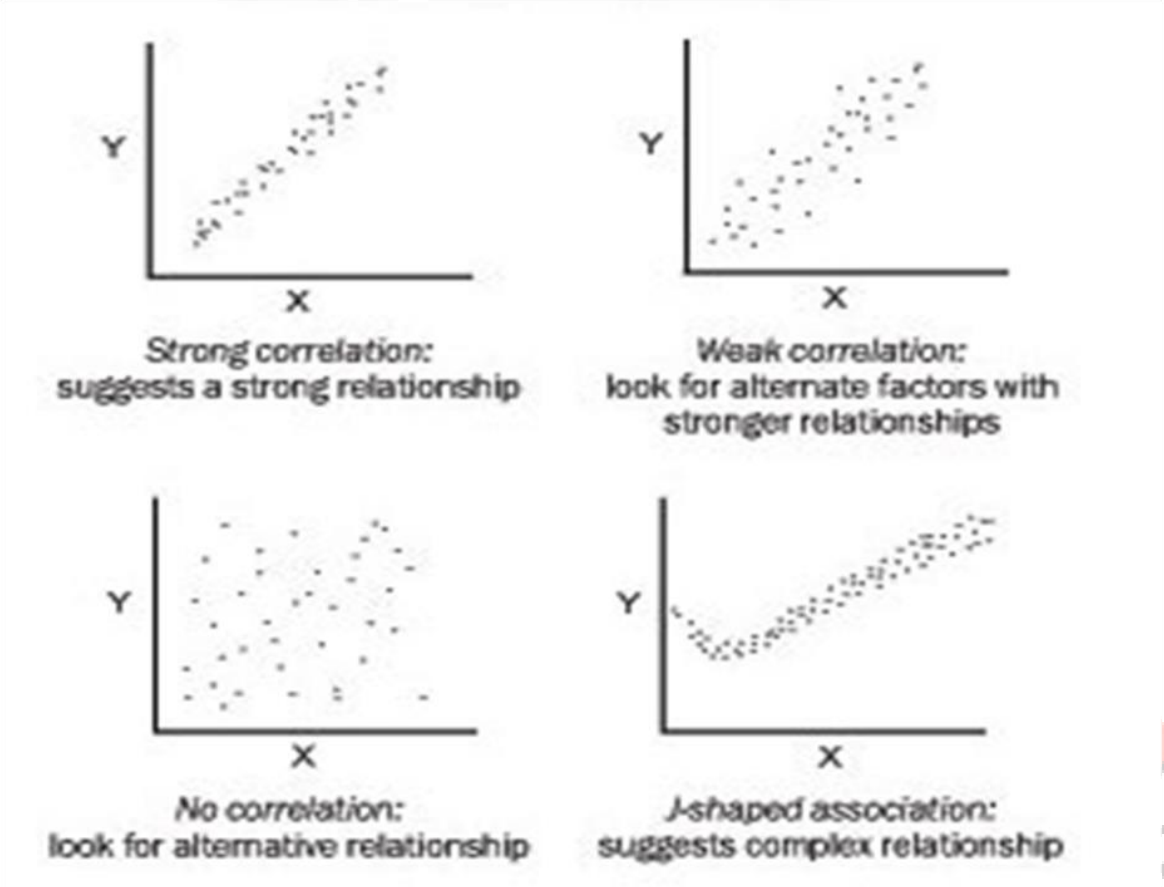
Disadvantages:

1. It does not give the reason for the process not to be in control.
2. It does not provide the procedure to improve the process.

3) <u>Scatter diagrams:</u>

Scatter diagrams are also called correlation charts. They show the graphical representation of a relationship between two variables as a series of dots. The range of possible values for each variable is represented by the X and Y axes, and the pattern of the dots, plotted from sample data involving the two variables, suggests whether or not a statistical relationship exists between X and Y and if it exists, how strong it is. The variables in scatter diagrams generally must be measurable on a numerical scale (e.g., price, distance, speed, size, age, frequency)

Scatter Diagram Interpretation



Advantages:

1. It is easy to plot and understand.
2. Mere inspection can talk about the statistical relationship between variables.
3. Remedial measure can be taken as per the plot immediately.
4. It does not require mathematical calculations.

Disadvantages:

1. The plot can be misinterpreted.
2. It does not talk about the extent of statistical relationship between the variables.
3. It does not help for further statistical analysis.

4) Control Charts:

The control charts are most successful SPC tools. They were originally developed by Walter Shewhart in the early 1920s. They help you record data and let you see when an unusual event, e.g., a very high or low observation compared with "typical" process performance, occurs.

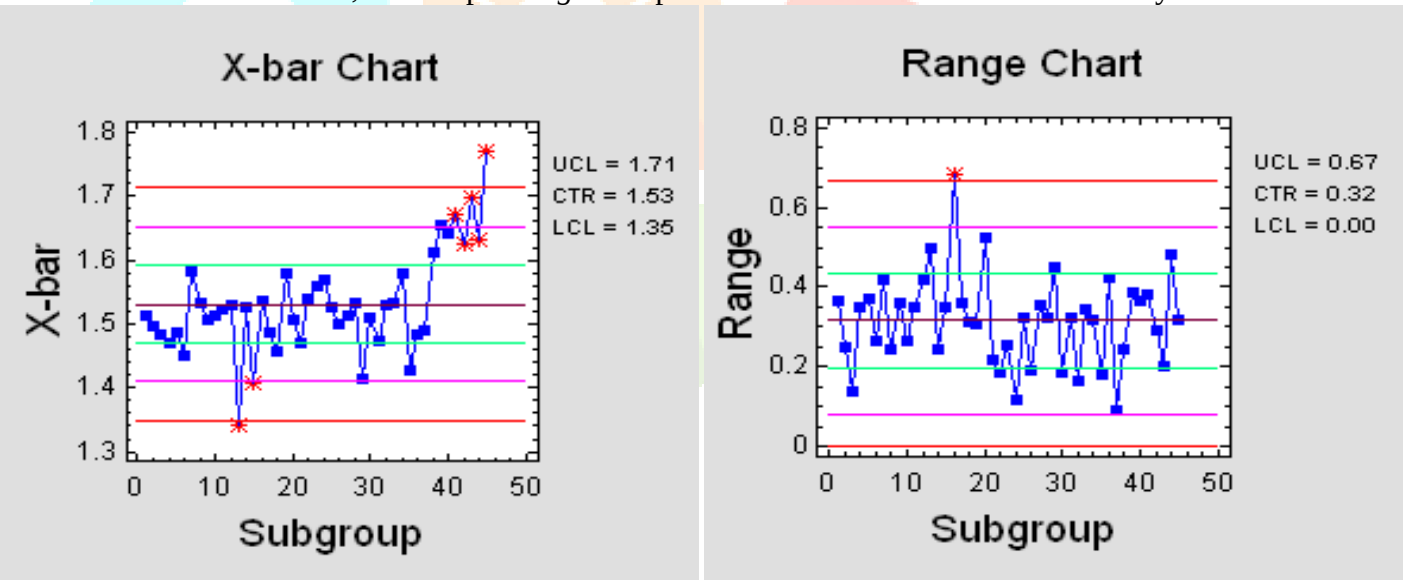
Types of Control Charts(C.C.) :

i)C.C for variables : They are used when the quality characteristic can be measured and expressed in numbers (e.g, length, time etc..)

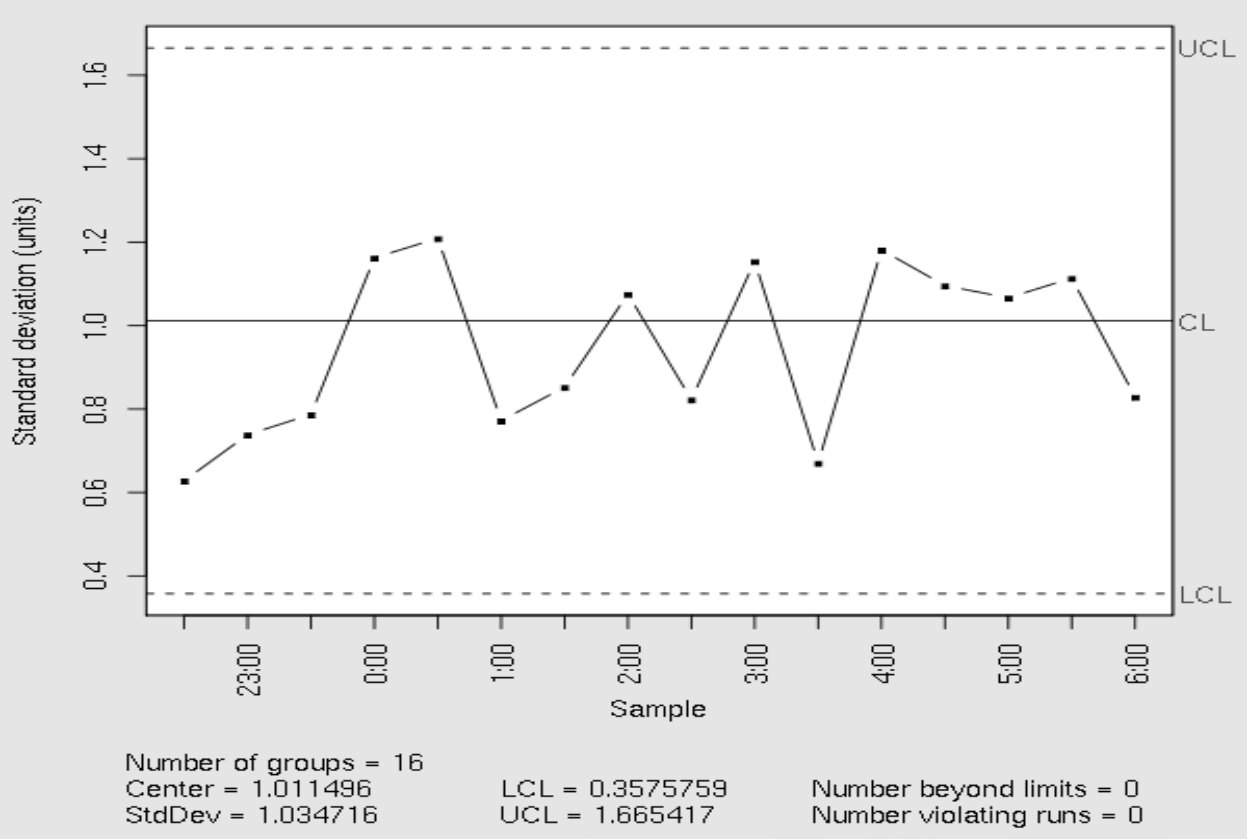
ii)C.C for attributes : They are used for product characteristic that can be evaluated with a discrete response (e.g, pass/fail, yes/no etc..)

- **C.C for Variables:**
  X-bar chart : In this chart, the sample *means* are plotted in order to control the mean value of a variable (e.g., size of piston rings, strength of materials, etc.).

  R chart : In this chart, the sample *ranges* are plotted in order to control the variability of a variable.



S chart : In this chart, the sample *standard deviations* are plotted in order to control the variability of a variable.



Advantages:

1. This method is the most useful statistical method showing all types of process control.
2. It can be used for statistical analysis as it has the strong statistical base.
3. This is the most reliable method.

Disadvantages:

1. This method requires knowledge of Mathematics and Statistics.
2. It is based on tedious mathematical calculations.

8) Run Charts:

Run charts depict process behavior against time.
Run Charts are important in investigating changes in the process over time, such as predictable cycles. They judge any changes in process stability or instability. They are also used to compare two separate variables over time to identify correlations and other relationships.

Advantages:

1. Run chart is simple to plot and easy to understand.
2. It shows predictive cycles in process.
3. Run charts are used to compare two separate variables over time.
4. Correlations and the relationships between variables can be identified using these charts.

Disadvantages:

1. This method does not help in statistical analysis.
2. It talks only about predictive cycle and relationship, but does not talk about the stage at which remedial action is required.

APPLICATIONS OF SPC:

Statistical Process Control (SPC) can be applied to software development processes.
A process has one or more outputs, as depicted in the figure below. These outputs, in turn, have measurable attributes. SPC is based on the idea that these attributes have two sources of variation: natural (also known as common) and assignable (also known as special) causes. If the observed variability of the attributes of a process is within the range of variability from natural causes, the process is said to be under statistical control. The practitioner of SPC tracks the variability of the process to be controlled. When that variability exceeds the range to be expected from
Natural causes, one then identifies and corrects assignable causes.

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