Quality Engineering & Management

Session 8.1: Process Control & Control Charts

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Learning Objectives

• Understand what is meant by Process Control.
• Describe the purpose and the main features of a control chart.
Quality in Production - Process Control

What is a process?

What is process control?
• Parameter Selection - Designed Experiments
• Process Control
• Parameter Control - Control Charts
The Control Charts

Dr. Walter Shewhart proposed a set of procedures in early 1920's, called the **Control Charts**.

According to him, the variability in a process parameter (or a product characteristic) can be from any of the two sources:

1. “stable system of chance causes” (Common causes)
2. “assignable causes” (Special causes)

The Control Chart is the means of differentiating between the two sources of variability.
A Typical Control Chart

Samples taken at regular interval, suitable measure of quality is plotted.

- Process in control / Process not in control
- Assignable cause (special cause)

The control limits represent limits of natural variability of the measure being plotted.
## Different Measures (statistics) to Control Different Parameters

<table>
<thead>
<tr>
<th>Process Parameter to be Controlled</th>
<th>Sample Statistic Plotted</th>
<th>Name of the Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process average ($\mu$)</td>
<td>Sample average ($\bar{X}$)</td>
<td>$\bar{X}$-chart</td>
</tr>
<tr>
<td>Process variability ($\sigma$)</td>
<td>Sample range ($R$), or sample standard deviation ($S$)</td>
<td>$R$-chart, $S$-chart</td>
</tr>
<tr>
<td>Process proportion defectives ($p$)</td>
<td>Sample proportion defectives ($P$)</td>
<td>$P$-chart</td>
</tr>
<tr>
<td>Process defects per unit ($c$)</td>
<td>Sample defects per unit ($C$)</td>
<td>$C$-chart</td>
</tr>
</tbody>
</table>
Benefits from Use of Control Charts

• Avoidance of defectives by producing products right the first time
• Reduction of waste and increase in throughput
• Satisfied customers and improved customer relationships
• Better knowledge of the processes and their capabilities
• Improved worker morale because of the satisfaction they get from seeing the results of their work
• Improved image for the producer and better market share
• Improved profitability
Two Types of Control Charts

Two types of data are encountered while evaluating quality:

1. Measurement data
2. Attribute data

Need two types of control charts:

1. Measurement control charts ➔ X-bar and R-charts
2. Attribute control charts ➔ P- and C- charts
Measurement Control Charts: X-bar & R

Measurement control charts assume that the measurements follow the normal distribution.

A measurement can go off-spec if either the mean changes or the standard deviation changes.

Need two control charts:
- One to control process mean
- Another to control process variability
Measurement Control Charts: X-bar and R-Charts

- Samples of 4 or 5 observations each are taken at regular time intervals
- Sample average, X-bar, and sample range, R, are computed for each sample from the sample observations

- What is the Center Line?
- How do you calculate the Upper and Lower Control Limits?
- Need 3-sigma → what is estimate for σ?
Central Limit Theorem

If $X \sim N(\mu, \sigma^2) \Rightarrow \bar{X}_n \sim N(\mu, \frac{\sigma^2}{n})$

$\bar{X}_n \xrightarrow{n \to \infty} N(\mu, \frac{\sigma^2}{n})$
Coming Up

- Lecture 8.2: X-bar and R-Charts
Measurement Control Charts: X-bar & R

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