Process Monitoring

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Chapter 2
Statistical Process Control

Process Monitoring

Chapter Description

- Aims
  - Analyze process performance using the SPC methodology.

- Expected Outcomes

  - Apply as well as analyze the univariate monitoring performance based on the progression of the means and range charts of SPC framework.

- Other related Information

Subtopics

2.1 Process Variations

2.2 Control Charts

2.1 Process Variation

- The general objectives/benefits of process monitoring are:

1. **Routine Monitoring**. Ensure that process variables are within the specified limits.
2. **Detection and Diagnosis**. Detect abnormal process operation and diagnose the root cause.
3. **Preventive Monitoring**. Detect abnormal situations early enough so that corrective action can be taken before the process is seriously upset.

2.1 Process Variation

The aim of descriptive statistics: summarization of process data

Central tendency (magnitude of deviation from the targeted value)

Mode, median or **mean (average)**

Variability

Range: Largest – smallest.

Sample variance

2.1 Process Variation

- In statistical process control, an important distinction is made between **normal variation** and **abnormal variation**.
- Normal variation is caused by the cumulative effects of a number of largely unavoidable phenomena such as electrical measurement noise, turbulence, and random fluctuations in feedstock or catalyst preparation.
- Abnormal variation (fault operation) is referred to *special cause* or an *assignable cause* such as disturbances, equipment degradation, upsets in process condition, changing in operating modes, signal/communication failure.

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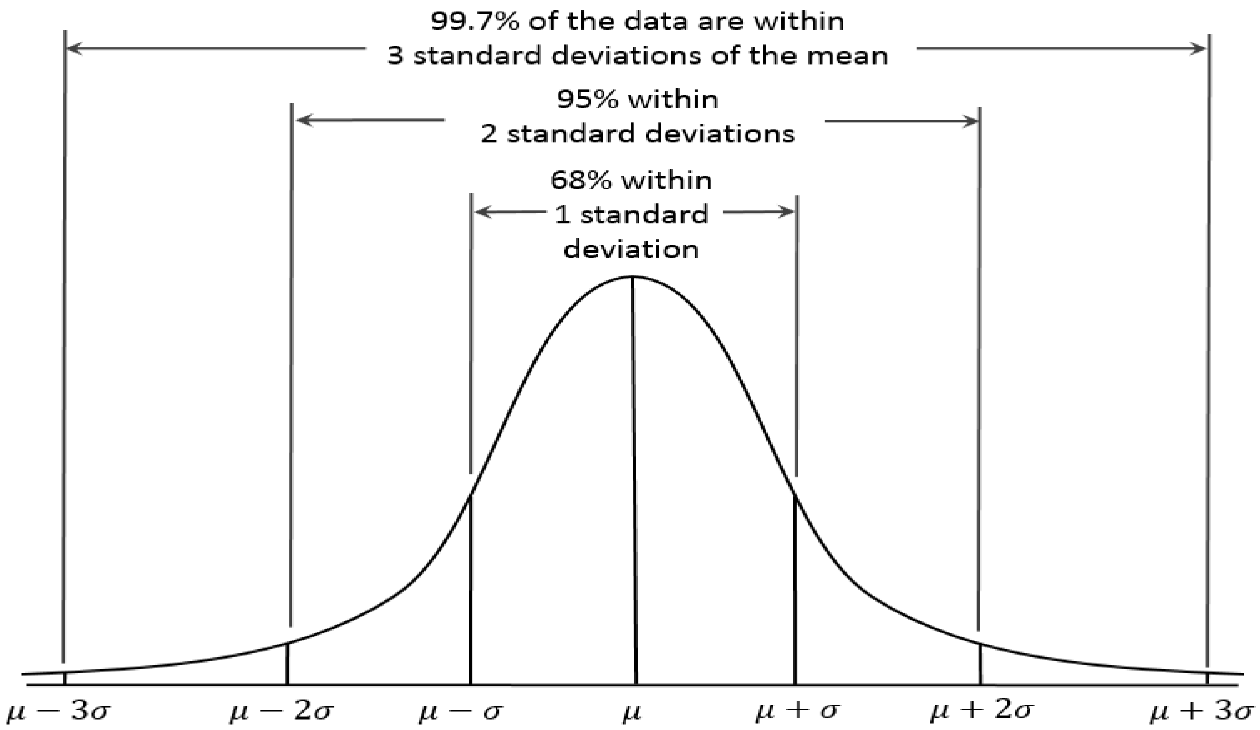
Normal Distribution



Source: https://www.flickr.com/photos/mathplourde/24125284062, Dan Kernler

2.2 Control Charts

In statistical process control, *Control Charts* (or *Quality Control Charts*) are used to determine whether the process operation is normal or not.

This type of control chart is often referred to as a Shewhart Chart, in honor of the pioneering statistician, Walter Shewhart, who first developed it in the 1920s.

2.2 Control Charts

- ☑ For variables that have continuous dimensions
  - ☑ Weight, speed, length, strength, etc.
- ☑ x-charts are to control the central tendency of the process
- ☑ R-charts are to control the dispersion of the process
- ☑ These two charts must be used together

2.2 Control Charts

Development Procedures

1. Take representative sample from output of a process over a long period of time, e.g. 10 units every hour (*k*) for 24 hours (*n*).
2. Compute means and ranges for the variables and calculate the control limits
3. Draw control limits on the control chart
4. Plot a chart for the means and another for the mean of ranges on the control chart
5. Determine state of process (in or out of control)
6. Investigate possible reasons for out of control events and take corrective action
7. Continue sampling of process output and reset the control limits when necessary.

2.2 Control Charts

For $\bar{x}$-Charts when we know σ

$$\text{Upper control limit (UCL)} = \bar{\bar{x}} + z\sigma_x$$

$$\text{Lower control limit (LCL)} = \bar{\bar{x}} - z\sigma_x$$

where

$\bar{\bar{x}}$	=	mean of the sample means or a target value set for the process
z	=	number of normal standard deviations
σ_x	=	standard deviation of the sample means
	=	$\sigma/\sqrt{l}$
σ	=	population standard deviation
l	=	sub-group size

Where typically, z = 3.

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l	=	sub-group size

Where typically, $z = 3$.

2.2 Control Charts

For $\bar{x}$-Charts when we don't know σ

$$\text{Upper control limit (UCL)} = \bar{\bar{x}} + A_2\bar{R}$$

$$\text{Lower control limit (LCL)} = \bar{\bar{x}} - A_2\bar{R}$$

where

$\bar{R}$ = average range of the samples

A_2 = control chart factor found in Table 1

$\bar{\bar{x}}$ = mean of the sample means

2.2 Control Charts

Subgroup Size k	Mean Factor A_2	Upper Range D_4	Lower Range D_3
2	1.880	3.268	0
3	1.023	2.574	0
4	.729	2.282	0
5	.577	2.115	0
6	.483	2.004	0
7	.419	1.924	0.076
8	.373	1.864	0.136
9	.337	1.816	0.184
10	.308	1.777	0.223
12	.266	1.716	0.284

Table 1

2.2 Control Charts

For R-Charts

$$\text{Upper control limit } (UCL_R) = D_4\bar{\bar{R}}$$

$$\text{Lower control limit } (LCL_R) = D_3\bar{\bar{R}}$$

where

$\bar{\bar{R}}$ = average range of the samples

D_3 and D_4 = control chart factors from Table 1

References

- http://www.statit.com/statitcustomqc/StatitCustomQC_Overview.pdf
- https://www.aidt.edu/course_documents/Manufacturing_Skills/SPC/Intro_to_SPC.pdf

Authors Information

Credit to the authors: