Part V

STATISTICAL PROCESS MONITORING AND QUALITY CONTROL

Contents

Chapter 1

OVERVIEW AND FUNDAMENTALS OF SPC

List of References

- **Probability Theory**

  1. Papoulis, A. *Probability, Random Variables and Stochastic Processes*, McGraw-Hill, 1991.

- **Statistical Quality / Process Control**

  1. Grant, E. L. & Leavenworth, R. S. *Statistical Quality Control*, 7th Edition, McGraw-Hill, 1996.
  2. Thompson, J. R. & Koronacki, J. *Statistical Process Control for Quality Improvement*, Chapman & Hall, 1993.
  3. Montgomery, D. C. *Introduction to Statistical Quality Control*, Wiley, 1986.

1.1 INTRODUCTION

1.1.1 MOTIVATION FOR SPC

Background:

- Chemical plants are complex arrays of large processing units and instrumentation.
- Even though designed to be steady, operations are in fact very *dynamic*. Perturbations that occur to typical plants can be categorized into two kinds.
  - Normal day-to-day disturbances (e.g., feed fluctuations, heat / mass transfer variations, pump / valve errors, etc.).
  - Abnormal events. (e.g., abnormal feedstock changes, equipment / instrumentation malfunctioning and failures, line leaks and clogs, catalyst poisoning).
- Most of the problems in the former category are handled by automatic control systems.
- Problems in the latter category are relegated to plant operators.

Useful Analogy:

- plant → patient
- automatic control systems → patient's immune system
- operator → doctor
- DCS, plant information data base → modern medical diagnosing instruments.

Key Point: Why SPC?

- Measurements often contain statistical errors / outliers + There are inherent randomness in the process. ⇒ Not easy for operators to distinguish between the normal and abnormal conditions (until the problems fully develop to produce undesirable consequences)
- SPC in the tranditional sense of the word is a diagnostic tool, an indicator of quality problems. However, it does not identify the source of the problem, nor corrective action to be taken.

Comment:
Advances in sensors / information technology made it possible to access an enormous amount of information coming from the plant. The bottleneck these days is not the amount of information, but the operator's ability to process them. We need specialists (e.g., statisticians or SPC techniques) who can pre-process these information into a form useful to the operators.

1.1.2 MAIN POINTS

Traditional SPC techniques have limited values in process industries because

- they assume time-independence of measurements during normal (*in-control*) periods of operation.
- they assume that control should be done only when unusual events occur, i.e.,
  - the costs of making adjustements are very high.
  - little incentive for quality control during normal (*in-control*) situations.

These assumptions are usually not met in the process industries.

In this lecture, we will extend the tradtional methods to remove these deficiencies. The end result will be an *integrated approach to statistical monitoring, prediction and control.*

1.2 TRADITIONAL SPC TECHINQUES

Most traditional techniques are *static*, *univariate* and *chart-based*. We briefly review some of the popular techniques.

1.2.1 Milestones / Key Players of SQC

- **Pareto's Maxim [1848-1923]:**

  > Catastrophically many failures in a system are often attributable to only a small numer of causes. General malaise is seldom the root problem.

  In order to improve the system, a skiled investigator must find Pareto's glitches and correct them.

- **Shewart's Hypothesis [1931]:** Quantitized the Pareto's qualitative observations using a mixture of distributions. Developed control charts to identify *out-of-control* epochs, which enables one to discover the systemic cause of *Pareto's glitches* by backtracking. The result is a kind of step-wise optimization of a system.

- **Deming's Implementation [1950s-1980s]:** Deming implemented the SPC concept in Japan after Second World War II (and later in North America) on a massive scale. The result was that Japan moved