# Process Monitoring

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# Chapter 3b
# Multivariate Statistical Process Monitoring

# Chapter Description

- Aims
  - Analyze the process performance based on MSPM approach.
- Expected Outcomes
  - Develop a fault detection mechanism as well as perform investigation based on a specified case study by using a specialized software.
- Other related Information

# Project I

**CSTRwR System**

The schematic diagram of a simulated CSTRwR is shown in Figure A (Zhang, 2006). This system conducts an irreversible heterogeneous catalytic exothermic reaction between reactant A and product B. The process is installed with three separate control loops, which consists of tank temperature, tank level and recycling flow variables, in order to maintain the product concentration. In particular, the cold water flow is adjusted through a cascade system corresponding to the changes in the reactor temperature. The reactor level, on the other hand, is maintained by controlling the flow rate of product. Lastly, the product composition in the reactor is indirectly controlled by manipulating the recycle flow rate. There are ten on-line measured process variables and three controller outputs have been identified for monitoring as listed in Table A (Zhang, 2006).

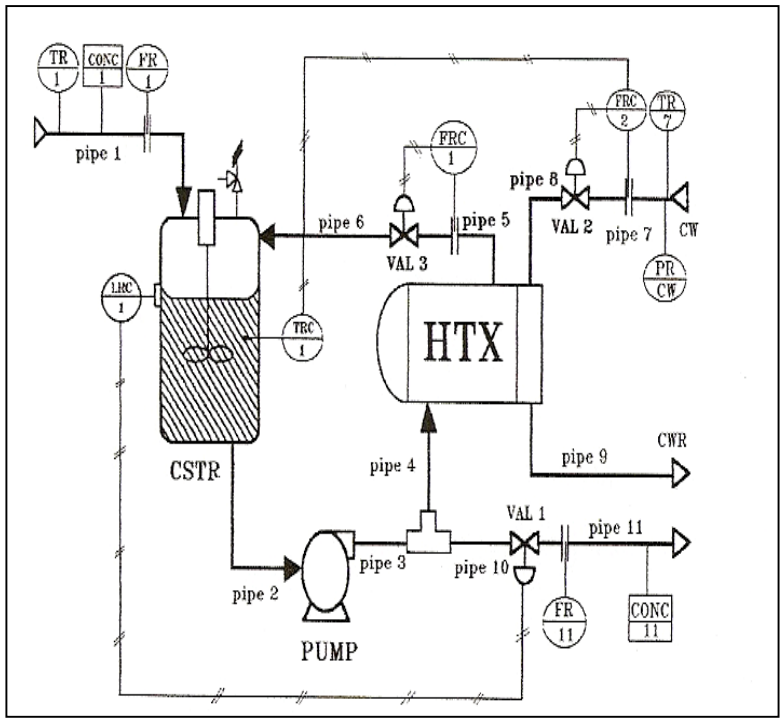


Figure A: CSTRwR system

# Project I

Table A: List of variables in the CSTRwR system for monitoring

| Process | | | Instruments | | |
|---|---|---|---|---|---|
| No. | Variables | Variable Names | No. | Variables | Variable Names |
| 1 | V1 | Tank temperature | 11 | V11 | Controller 1 |
| 2 | V2 | Tank level | 12 | V12 | Controller 3 |
| 3 | V3 | Feed temperature | 13 | V13 | Controller 2 |
| 4 | V4 | Inlet flow rate | | | |
| 5 | V5 | Recycle flow rate | | | |
| 6 | V6 | Outlet flow rate | | | |
| 7 | V7 | Cooling water flow rate | | | |
| 8 | V8 | Product concentration | | | |
| 9 | V9 | Feed concentration | | | |
| 10 | V10 | Heat exchanger entrance pressure | | | |

# Project I

Table B: List of abnormal operations in CSTRwR

| Fault Cases | Fault Causes |
|---|---|
| 1 | Pipe 1 blockage |
| 2 | External feed-reactant flow rate too high |
| 3 | Pipe 2 or 3 is blocked or pump fails |
| 4 | Pipe 10 or 11 is blocked or control valve 1 fails low |
| 5 | External feed-reactant temperature abnormal |
| 6 | Control valve 2 fails high |
| 7 | Pipe 7, 8, or 9 is blocked or control valve 2 fails low |
| 8 | Control valve 1 fails high |
| 9 | Pipe 4, 5, or 6 is blocked or control valve 3 fails low |
| 10 | Control valve 3 fails high |
| 11 | External feed-reactant concentration too low |

# Project I

For each fault presented in Table B, both abrupt and incipient faults are considered. An abrupt fault indicates a sudden change (or step change) in a process variable or parameter and typically it maintains over the operation time until the cause is completely removed. Detecting this kind of malfunctions should be easy for any multivariate monitoring system as the deviations are usually very obvious. On the other hand, an incipient fault depicts a kind of fault that gradually deviates from the normal setting. Thus, the monitoring system typically takes a while to detect these particular abnormal behaviours. In particular, all the faults were introduced at sample 2 and the sampling time was fixed at 4 seconds.

# References


- Zhang, J., (2006). Improved On-line Process Fault Diagnosis Through Information Fusion in Multiple Neural Networks. *Computers and Chemical Engineering,* 30, 558-571.

# Authors Information

## Credit to the authors: