Statistical Techniques for Monitoring Industrial Processes

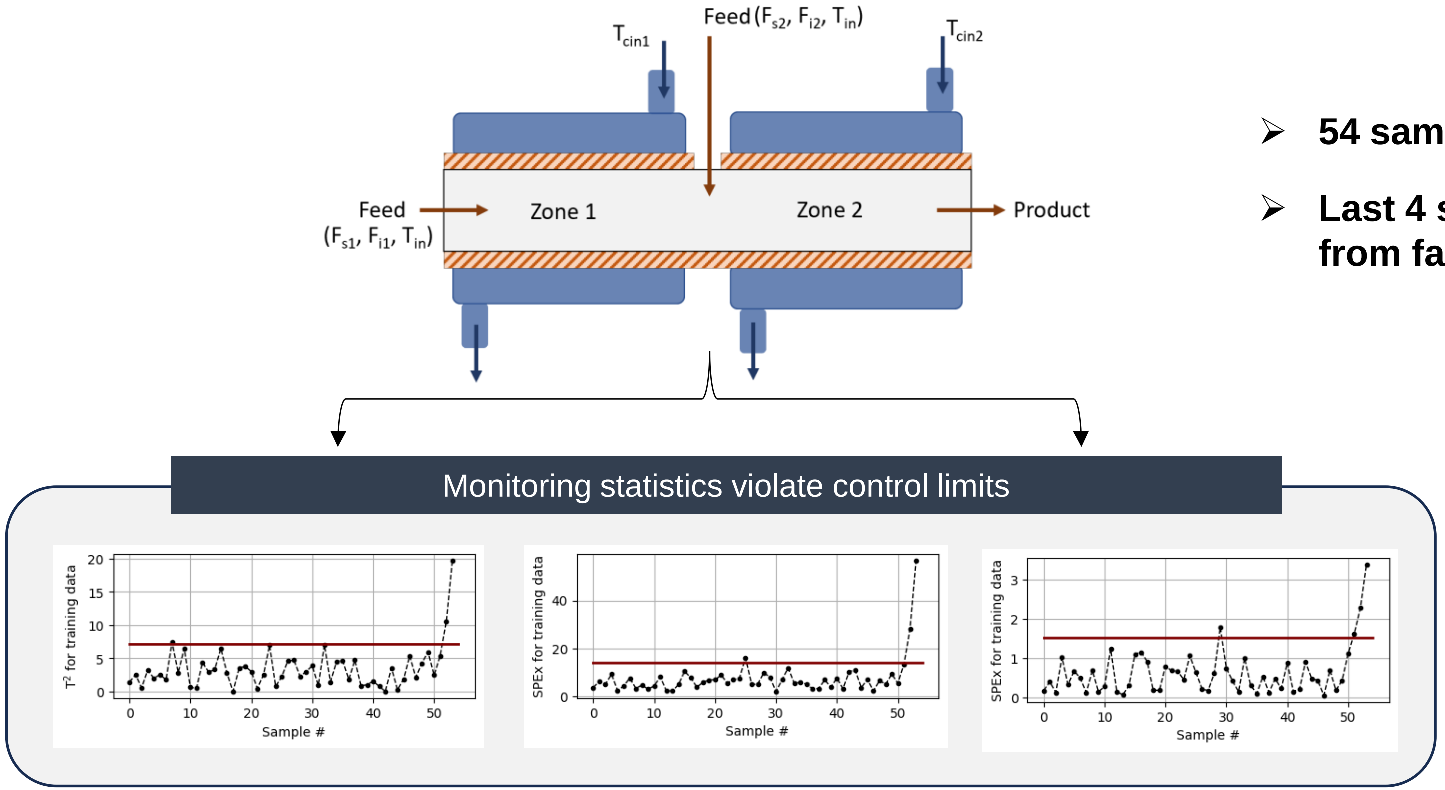
Lecture : PLS – Fault Diagnosis

Module : PLS-based MSPM

Course TOC

- ❑ Introduction to Statistical Process Monitoring (SPM)
- ❑ Python Installation and basics (optional)
- ❑ Univariate SPM & Control Charts
  - ➢ Shewhart Charts
  - ➢ CUSUM Charts
  - ➢ EWMA Charts
- ❑ Multivariate SPM
  - ➢ Principal Component Analysis (PCA)-based MSPM
  - ➢ Partial Least Squares (PLS) regression-based MSPM
    - ➢ Fault detection & diagnosis (FDD) using PLS
    - ➢ Application to a LDPE reactor monitoring
  - ➢ Strategies for handling nonlinear, dynamic, multimode systems
- ❑ Deploying SPM solutions

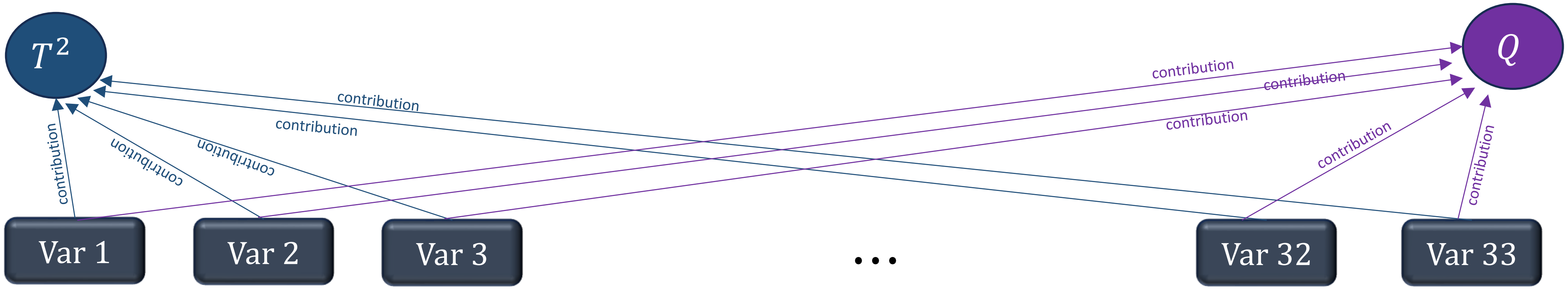
Why Fault Diagnosis?

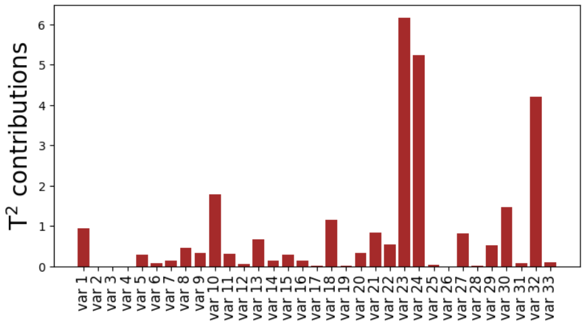


- 54 samples
- Last 4 samples known to be from faulty process

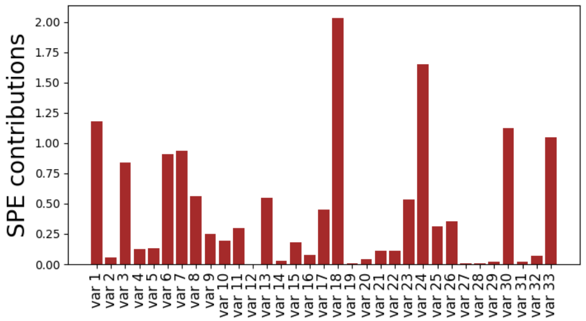
Which variables, to look at?

Fault Diagnosis via Contribution Analysis





Check variables contributing the most to the metric that violates its control limit



SPE Contributions

SPE_x

$\boldsymbol{x}_{test}$ $\hat{\boldsymbol{x}}_{test}$

$$\boldsymbol{e}_{test} = \begin{bmatrix} e_{1,test} \\ e_{2,test} \\ \vdots \\ e_{m,test} \end{bmatrix}$$

$$SPE_{x,test} = \sum_{var=1}^{m} e_{var,test}^{2}$$

$$= \sum_{var=1}^{m} Contribution_{SPEx,var,test}$$

SPE_y

$\boldsymbol{y}_{test}$ $\hat{\boldsymbol{y}}_{test}$

$$\boldsymbol{f}_{test} = \begin{bmatrix} f_{1,test} \\ f_{2,test} \\ \vdots \\ f_{m,test} \end{bmatrix}$$

$$SPE_{y,test} = \sum_{var=1}^{p} f_{var,test}^{2}$$

$$= \sum_{var=1}^{p} Contribution_{SPEy,var,test}$$

T^2 Contributions*

$\boldsymbol{x}_{test}$ $\boldsymbol{\Lambda}_k$ $\boldsymbol{R}$

$$\Gamma = \boldsymbol{\Lambda}_k^{-0.5}\boldsymbol{R}^T$$

$$Contribution_{T^2, variable\ j, test} = \|\Gamma(:, j)\boldsymbol{x}_{test}(j)\|^2$$

*Choi & Lee, Multiblock PLS-based localized process diagnosis. Journal of Process Control, 2005

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Next Lecture : Taking SPM Solutions to End-Users

Module : Deploying SPM Solutions