Fault Diagnosis for Aluminum Electrolysis Process using Principal Component Analysis (PCA) & Partial Least Square (PLS)

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By their very nature, the aluminium smelting processes is difficult to observe” Bearne (1999).

And here we give a fault diagnosis solution for effective process monitoring in the aluminium industry.

**Issues**

In an aluminium smelter, there are hundreds of aluminium reduction cells engaged with a complex electrolysis process. Since the process is complex, it is difficult to detect and diagnose problems that occurred in the process.

**Process monitoring**

Monitoring a process using data driven approaches such as PCA/PLS is very effective in practice (Chiang et al., 2001). In this research, faults are detected by the monitoring charts based on Multiway-PCA (MPCA):

1) Hotelling’s T²
2) Squared Prediction Error (SPE). These charts are used to identify the status of a cell whether it is

**Out-of-Control**

or

**In Statistical Control**

**Purpose**

The aim of this research is to develop a new monitoring framework in order to detect and diagnose problems arising from the complexity of the aluminium electrolysis process.

**Solution**

A new framework based on data-driven approaches that considers the dynamic behaviour of the cell has been developed in order to detect and diagnose anode faults through easy-to-understand charts.

Fault diagnosis

These out-of-control signals are further diagnosed in order to identify which anode fault has occurred by using MPCA and Discriminant PLS (DPLS). There are two main steps for each fault diagnosis method.

1) Extract P from historical process data as in Phase I below:

   - Input: X (process data)
   - Phase I: *NIPALS algorithm
   - Output: P (loading vectors)
   - Phase II
   - Input: Xnew (latent variables)
   - *NIPALS algorithm
   - Output: Tnew

2) Diagnose faults by monitoring Tnew based on the pre-defined problem areas in the latent variable space.

   - (a) MPCA
   - (b) DPLS

Both methods can diagnose the detected fault as anode spike but more out-of-control signals were classified as having an anode spike by DPLS model than MPCA model.

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References:

Conclusions

Monitoring using PCA/PLS is effective in detecting and diagnosing faults in the aluminium smelting processes. This is expected to bring the smelter significant savings per year in operating and maintenance cost.