On the Use of Extents for Process Monitoring and Fault Diagnosis

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Process monitoring and fault diagnosis are broadly used to control quality and enforce safety compliance in industrial processes. Processes are commonly monitored by online spectroscopy, with either PCA or calibration techniques such as PLS being used to predict abstract or physical process variables. By comparing these variables to historical data measured under normal operating conditions, possible faults are detected based on deviations from statistical thresholds [1]. One then tries to identify the causes of these faults, identification being easier when monitoring involves a calibration that predicts physical process variables and when fault detection uses a model to relate controlled and manipulated variables [2].

Exploiting the structure of balance equations, a transformation can separate multivariate data into decoupled variant/invariant states, which can be investigated individually to identify rate laws and reconstruct unmeasured quantities [3]. A convenient linear transformation uses the generalized concept of extents [4, 5], which coincides with a time-invariant transformation used to model rank-deficient spectroscopic data [6]. This transformation requires only limited process information, namely, the reaction stoichiometry, the species transferring between phases, the composition of inlet flows and the initial conditions. Moreover, this transformation was adapted to handle calorimetric and spectroscopic data [7, 8].

This contribution addresses the applicability of the transformation to extents for process monitoring and fault diagnosis. By comparing the extents computed from measurements of the current batch with either their prediction or the extents computed from previous batches, significant deviations can point at possible faults and provide a systematic way of identifying their causes.

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