

Preface

In many industrial applications early detection and diagnosis of abnormal behavior of the plant is of great importance. For decades, model-based methods have been widely used to design fault diagnosis systems. These approaches involve rigorous development of a process model based on first principles. During the last decades, the complexity of process plants has been drastically increased, which imposes great challenges in development of model-based monitoring approaches and it sometimes becomes unrealistic for modern large-scale processes. Alternative to model-based approaches, data-driven methods have been developed, which offer powerful tools to extract useful information for design of monitoring systems based on the available process measurements. Multivariate statistical process monitoring approaches are successfully applied for fault detection and diagnosis in technical processes.

However, many industrial processes are intrinsically nonlinear and operate in different operation regimes due to different product specifications, working environments and economic considerations. Due to the nonlinearity of processes, the performance of the classical multivariate statistical process monitoring methods, which are mainly based on the linearity assumption, becomes unsatisfactory, since the process characteristics will change from one operating point to another.

The main objective of the work presented here is to study and develop efficient fault diagnosis techniques for complex industrial systems, using process historical data and considering the nonlinear behavior of the process. The nonlinear system is assumed to be linear around the operating points and therefore considered as a piecewise linear system corresponding to each operating mode. To this end, different methods are presented to solve the fault detection prob-

lem based on the overall behavior of the process and its dynamics. Moreover, a novel technique is proposed for fault isolation and determination of the root cause of the faults in the system, based on the influence of the fault on the process measurements.

After successful detection and isolation of the fault, the faulty component in the system should be repaired or replaced. Moreover, there should be the possibility to temporarily remedy the fault consequences by changing the setting of a specific component in the system. Therefore, it is necessary to have a decision support system which can help the plant engineers to determine the proper maintenance operation after detection of a faulty component in the system. To address this problem, a methodology is proposed here which makes use of the results achieved in previous steps. Economic assessment of the possible maintenance operations is integrated into this system to provide the best operation in terms of the highest impact on process performance and the lowest losses.

The performance and effectiveness of the approaches proposed in this work are studied through their application on industrial benchmarks. A laboratory set up of a continuous stirred tank heater and the dryer section of a paper making machine are considered to carry out this study.

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Nonlinear Multimode Processes

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