

## **570b Data-Based and Model-Based Blockage Diagnosis Systems for Stacked Micro Chemical Plants**

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In recent years, micro chemical technologies have attracted a great deal of industrial and academic attentions in various fields. Especially in the chemical industry, research and development on micro chemical plants (MCPs) have been energetically conducted for realizing the production of specialty products that have been difficult to produce in conventional macro chemical plants.

One of critical problems in operation of MCPs is blockage in microchannels. Therefore, a process monitoring system which can detect and diagnose blockage is indispensable for effective operation of MCPs. However, few researches on operation of MCPs have been reported. The present research focuses on blockage diagnosis of stacked microdevices. Two types of diagnosis systems, i.e., a data-based blockage diagnosis system (DB-BDS) and a physical-model-based blockage diagnosis system (MB-BDS), are proposed. The performance of the proposed systems is evaluated with their applications to a micro heat exchanger and a microreactor.

In DB-BDS, operation data is assumed to be obtained under complete blockage in each microdevice (plate). DB-BDS is constructed under the following policy; 1) temperature sensors are set up at regular intervals, 2) the system uses only two temperature measurements, which change the most when blockage occurs, and the system diagnoses the blockage between the two sensors. As a result, the performance of DB-BDS is not affected by the total number of stacked microdevices, and the system can be expanded to any scale of plants. It should be noted here that various degrees of blockage are expected in real plants and blockage needs to be detected and diagnosed as early as possible. To realize efficient diagnosis for various degrees of blockage, the proposed DB-BDS uses the ratio of temperature difference between normal and abnormal operating conditions at one sensor to that at the other sensor. The ratio is calculated off-line in advance by using the data obtained under complete blockage in each microdevice. DB-BDS diagnoses blockage by comparing the prepared ratio with the actual ratio when blockage is detected. It is expected that the ratio of two temperature differences remains unchanged even if the degree of blockage varies. In fact, the application results have shown that the proposed DB-BDS functions better than another method based on a linear discriminant model.

MB-BDS uses physical models of the process operated under a normal condition and under blockage occurrence in each microdevice. The inputs of the models are pressure drop and inlet temperature, and the outputs are temperatures of microdevices where sensors are set up. By using the physical models, the temperature distribution vector under normal operating condition and that under blockage occurrence in each microdevice are calculated. MB-BDS diagnoses blockage by comparing correlation coefficients between the prepared temperature distribution vector with the actual temperature distribution vector when blockage is detected. The performance of MB-BDS will not be affected by the accuracy of the physical models because calculated temperature distribution is to be similar in spite of the model accuracy.

DB-BDS and MB-BDS are applied to blockage diagnosis problems of a micro heat exchanger and a microreactor. A countercurrent micro heat exchanger with twenty plate-fin microdevices is modeled and simulated. In addition, a stacked microreactor consisting of reaction plates and cooling plates is modeled and simulated. Those modeling and simulations are conducted by using the dynamic micro process simulator developed by our group. DB-BDS and MB-BDS are applied to various types of blockage, i.e., various location and degrees. The results show that both DB-BDS and MB-BDS can diagnose the blockage location successfully.