Papermaking Wastewater Treatment Processes Using Dynamic Multiblock Partial Least Squares

Doris Payne*

Department of Chemical and Energy Engineering, University of Warwick, Warwickshire, England, UK

Corresponding Author*
Doris Payne
Department of Chemical and Energy Engineering,
University of Warwick, Warwickshire, England, UK
E-mail: payne.d@gmail.com

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Editorial Note

The wastewater from the pulping and papermaking industry is one of the main industrial pollution sources and hard to be treated because of complex composition. Once the effluent does not meet the discharge standard, it will cause great implications for the environment. Thus, some important indicators which reflect the effluent quality of papermaking Wastewater Treatment Processes (WWTPs), such as Chemical Oxygen Demand (COD), have caught much attention of researchers and operators. . Generally, the information acquirement of these indicators just can rely on traditional manual measurements and assays, which makes a great challenge for process monitoring. In order to know the operating state of a treatment system, the sensors with high accuracy and short response time are particularly important. However, hostile operating conditions and some inevitable disturbances make the measurement accuracy of sensors decrease over time. Therefore, designing an advanced monitoring scheme to improve the detection ability of sensor faults is important for industrial processes. To this end, many traditional Multivariate Statistical Process Monitoring (MSPM) methods, such as Principal Component Analysis (PCA) and Partial Least Squares (PLS), have been successfully applied to develop an effective process model proposed a multi-scale PCA method extracting cross-correlation and auto-correlation characteristics of sensors in detecting and identifying industrial boiler process faults. Applied PCA to discover the fixed and drifting biases of sensors, while the joint angle analysis technique was used to isolate these faults in variable air volume systems. These PCA-based methods are usually based on an assumption that data follow a gaussian distribution. In practice, however, some collected variables have non-Gaussian behavior. Thus, Independent Component Analysis (ICA) and its extension methods are proposed to solve this problem. Although some PCA or ICA based methods have a better performance for process monitoring, they are unsupervised, that is, these methods neglect the relationship between key variables and process data. Therefore, to maintain the quality of effluent for the WWTP, some methods relative to evaluation indicators should be of more concern.

Small Fault Detection Scheme

The results obtained from unsupervised methods that using process data cannot judge whether the detected fault is relative to quality variables or not. Thus, the PLS, as a quality-related method, aiming to model the relationship between the input and output data, is more suitable than unsupervised methods in this case, carried out a small fault detection scheme, which took advantage of exponentially weighted moving average and PLS to improve the monitoring performance in practice. Employed orthogonal projections to latent structures as a preprocessing step before performing PLS decomposition to remove undesired variation. In addition, it also reduced the number of latent variables and decreased the complexity of computation. The extension of PLS and other quality-related monitoring methods also have been successfully applied to industrial processes. Recently, data collecting becomes easier than last few decades due to the development of advanced distributed control systems. However, by selecting all variables for modeling directly, the monitoring performance could be worse with the number of variables increasing. Besides, the interpretation of results obtained by monitoring methods becomes complicated. To solve these problems, many hierarchical or multiblock approaches were proposed adopted a variable division method based on prior knowledge partitioned process variables into several meaningful subblocks. After that, the fault diagnosis results obtained by contribution plot are more persuasive, thus have certain guiding significance for fault recovery.

Physical and Biochemical Treatment Processes

In fact, papermaking wastewater treatment is a complex process, including physical and biochemical treatment processes. The raw wastewater from different process units is firstly imported into the primary settling tank to remove large debris or suspended solid, and followed by adding chemical reagents to decrease pollution concentration. For chemical treatment processes, the reagent addition time and chemical reaction course are influenced by various conditions, such as temperature and pH, which makes the process variables present an autocorrelation feature. In addition, the collected data contain dynamic information due to unmeasurable noise disturbances and feedback regulation mechanisms. Thus, it is necessary to incorporate dynamic analysis in process modeling. Some researchers combined dynamic techniques such as just-in-time learning, augmented matrices, and recursive with multivariate statistical methods to acquire better performance