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Modeling and forecasting fouling in multiproduct batch processes

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In the chemical process industry (CPI), it is important to properly manage process and equipment degradation as it can lead to great economic losses. The degradation dynamics are seldom included in modeling frameworks due to their complexity, time resolution and measurement difficulty. However, tackling this problem can provide new process insights and contribute to better predictive maintenance policies (Wiebe et al. 2018). In this work, we focus on a prevalent problem in CPI regarding the accumulation of fouling on equipment surfaces.

Prognostics models (Zagorowska et al. 2020) provide tools to model process degradation like fouling. The level of fouling in heat exchangers can be considered as the state of health (SoH) of the equipment, as it influences heat transfer efficiency and requires regular maintenance interventions. Fouling is a process that consists of the deposition, accumulation and aging of suspended solids or insoluble salts on the surface of heat exchangers (Sundar et al. 2020). This phenomena increases surface thickness and decreases conductivity, thus increasing heat transfer resistance (Trafczynski et al. 2021).

We study fouling in batch heat exchangers that are part of a multiproduct system. Differences in physical properties and processing conditions for products can lead to different fouling rates. Fouling is evaluated at the batch level over periods between two consecutive heat exchanger cleanings, called a campaign (Wu et al. 2019). The first step (after data preprocessing) is to perform feature engineering to find a batch fouling SoH surrogate that will be used as the target response of the model. The regressors set is also built using feature engineering with domain knowledge and functional data analysis (Ramsay et al. 2009). The second step is to build a fouling SoH machine learning prediction model. We trained and compared the performance of partial least squares (Wu et al. 2018), Gaussian process regression (Richardson et al. 2017) and support vector regression (Chaibakhsh et al. 2018). Finally, the model is used to forecast the fouling SoH at each batch and provide guidance on the number of batches that can be processed before cleaning is needed.

References:

Chaibakhsh A, Bahrevar R, Ensansefat N. Maximum allowable fouling detection in industrial fired heater furnaces. Journal of Mechanical Science and Technology. 2018;32.

Ramsay JO, Hooker G, Graves S. Functional Data Analysis with R and MATLAB. 1st edition, Springer, New York, NY, 2009.

Richardson RR, Osborne MA, Howey DA. Gaussian process regression for forecasting battery state of health. Journal of Power Sources. 2017;357.

Sundar S, Rajagopal MC, Zhao H, Kuntumalla G, Meng Y, Chang HC, Shao C, Ferreira P, Miljkovic N, Sinha S, Salapaka S. Fouling modeling and prediction approach for heat exchangers using deep learning. International Journal of Heat and Mass Transfer. 2020;159.

Trafczynski M, Markowski M, Urbaniec K, Trzcinski P, Alabrudzinski S, Suchecki W. Estimation of thermal effects of fouling growth for application in the scheduling of heat exchangers cleaning. Applied Thermal Engineering. 2021;182.

Wiebe J, Cecílio I, Misener R. Data-Driven Optimization of Processes with Degrading Equipment. Industrial & Engineering Chemistry Research. 2018;50.

Wu O, Bouaswaiga A, Schneider SM, Leira FM, Imsland L, Roth M. Data-driven degradation model for batch processes: a case study on heat exchanger fouling. Computer Aided Chemical Engineering. 2018;43.

Wu O, Bouaswaiga A, Imsland L, Schneider SM, Roth M, Leira FM. Campaign-based modeling for degradation evolution in batch processes using a multiway partial least squares approach. Computers and Chemical Engineering. 2019;128.

Zagorowska M, Wu O, Ottewill JR, Reble M, Thornhill NF. A survey of models of degradation for control applications. Annual Reviews in Control. 2020;50.

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