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Hybrid modelling through Latent Differential-Regression Analysis (LDRA) for predicting long-term equipment degradation in the Chemical Process Industry

Long-term equipment degradation decisively affects production cycles of chemical process industries (CPI), and has a major impact on plant safety, operation and economy. Equipment degradation is caused by underlying phenomena that evolve over time with a rate of change that depends on the operating conditions. To tackle this problem, a Latent Differential Regression Analysis (LDRA) methodology is introduced to predict and analyze long-term equipment and process degradation in CPI. As the degradation state is typically not observable, LDRA follows a hybrid modeling approach that combines knowledge-based feature engineering to infer an Equipment Health Indicator (EHI) and data-driven models to find the process variables related to EHI degradation.

The LDRA methodology was tested using real data from an industrial plant, where fouling takes place in several heat exchangers located in the reaction section. The case study illustrates how the proposed methodology unfolds in a real and challenging application and the results that it provides.

For this case study, LDRA successfully identified the concentration of a key component as being critically related to fouling. Furthermore, the models showed good prediction capabilities during both steady and unsteady operation periods, strengthening the hypothesis that fouling is caused by the accumulation of the identified component. Therefore, the results provided useful insights into the fouling phenomenon and allowed the plant personal to narrow down troubleshooting on a specific component of the process.

The methodology is general and can be applied to other long-term degradation modes commonly found in the CPI, such as catalyst deactivation, corrosion, mechanical degradation of packing beds and catalysts, coking, among others. We thus foresee that the proposed modeling approach based on LRDA and a case-dependent EHI can find wide application in CPI.

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