Multi-Model Soft-Sensor Design for a Depropanizer Distillation Column

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Abstract

The enormous technological growth increases the application of machine learning in the petrochemical industry. One of these applications is a soft-sensor design. A soft sensor represents a relatively efficient way of inferring hard-to-measure industrial variables (e.g., concentration). It takes a form of a mathematical model. Consequently, the sensor is less expensive to maintain than other (physical) sensing devices and usually offers very good practical accuracy. The standard structure of a soft sensor involves a single model, but it is possible to extend this to more concurrent models with a tailored switching mechanism between them. In this contribution, the potential benefits of a multi-model soft sensor are explored using a high-fidelity mathematical model (digital twin) of a depropanizer distillation column.

The soft-sensor design is usually purely based on the data. Therefore, the size and quality of the data have a significant impact on the soft-sensor performance. In the case of industrial data, these factors are not flexible but result from the efficiency of the industrial monitoring instrumentation. On the other hand, the synthetic data from a mathematical model can provide more flexibility in studying the multi-model soft-sensor design. Therefore, we gather such data from the model simulations in gPROMS ModelBuilder.

We divide the entire dataset into the training and testing (unseen) set to provide a reliable analysis of the designed soft sensors. There are various methods suitable for the single-model soft-sensor training. We study the performance of several regression techniques, such as the principal component regression (PCR), least absolute shrinkage and selection operator (LASSO), and subset selection (SS) class of approaches. The multi-model soft sensor is designed by an advanced approach with (a) continuous

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switching between the soft-sensor models and (b) optimised a priori labelling of the training dataset to design the models effectively.

Subsequently, the performance of the soft sensors is evaluated on the testing dataset. The main aspects of the soft-sensor performance are the estimation accuracy and complexity of the model structure. We compare the performance of the designed soft sensors with a reference sensor (i.e., a soft sensor that would be used in the refinery). The results indicate that the designed soft sensors outperform the reference sensor. Moreover, the multi-model soft sensor performs better than the single-model alternative, mainly when different operating conditions are considered within the model of the depropanizer column.
Keywords: Depropanizer Column, Multi-Model Soft Sensor, Soft Sensor

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