Towards an AI-improved soft sensor for the separation efficiency of a packed column

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The maximum amount of product that can be generated with a distillation column often is determined by its hydraulic limitations and the requested product quality. The throughput can be increased until the column is flooding, which means that the liquid is accumulated inside the column, on the trays or on the packing, respectively. The peak separation efficiency is reached around the flooding point.

The operation of a partially flooding column can be beneficial, on condition the desired product quality is achieved. E.g., for a batch distillation higher throughput means reduced batch times.

Pressure difference measurement is a common way of estimating the distance from the flooding point. Operators regulate the energy input, hence the vapor flow, based on the pressure drop per meter of packing. We are proposing a soft sensor approach, as an estimate for the separation efficiency of the column.

The separation efficiency of a packed column is estimated either by fully empirical concepts e.g., a fixed HETP value or semi-empirical mass-transfer calculations. The latter has a more reliable physical background, but it is computationally very expensive. This makes it difficult to use it directly in a soft sensor.

We use artificial intelligence (AI) or namely machine learning (ML) to overcome this problem. We train an ML model with results from mass-transfer calculations. We then retrain the model using data from the plant, where we will implement the soft sensor. This approach combines the plant data, which is not sufficient to train the ML model alone, and the mass-transfer model calculations, which are too slow and not accurate enough. Retraining the existing ML model, with (few) data points from the plant in operation, is called transfer learning. With transfer learning, we expect to obtain a model, which is both reliable and fast. This model can then predict the separation efficiency of packing sections in real time, based on continuously measured data like energy input, distillate flow, temperatures, and pressures.