Distillation Column Flooding Predictor Will Have a Significant Impact on Energy Use in the Petrochemical Industry

The U.S. petroleum refining and chemical processing industries consume over 12 quadrillion Btu each year. Distillation is a low thermal efficiency unit operation that currently accounts for 40% of the processing energy consumed in refining and chemical processes. Despite its high energy requirements, distillation is often chosen over other separation processes because of its low, initial capital investments, flexibility, and ability to yield high purity products. This high energy consumption and widespread utilization makes improvements in distillation column operation extremely attractive for optimization.

The flooding predictor is an advanced process control strategy that utilizes a patented pattern recognition system to identify pre-flood conditions in distillation, absorption, and stripping columns. The application of a flooding predictor could greatly increase the stability and energy efficiency in distillation column operation. The flooding predictor also has the ability to maximize column throughput and allow for optimal column operation. Other advantages of the technology include low implementation and maintenance costs and the unique ability to distinguish between different flooding mechanisms within the same tower (e.g., liquid and jet flooding).

Benefits for Our Industry and Our Nation

Widespread utilization of flooding predictors could result in the following potential benefits:

- Energy savings of 9.4 trillion Btu/yr
- Carbon emission reductions of 0.11 MMTCE/yr

Applications in Our Nation’s Industry

The flooding predictor is a unique advanced process control strategy for the petrochemical industry. Validation tests at the University of Texas at Austin, concluded the Flooding Predictor works well on both trayed and packed columns. The flooding predictor controls the column very close to the true flood point where highest efficiency and capacity occur.
Project Description

The goal of this project is to develop the flooding predictor, an advanced process control strategy, into a universally usable tool that will maximize the separation yield of a distillation column.

The flooding predictor is an advanced process control strategy that utilizes a patented pattern recognition system to identify the onset of flood and pre-flood conditions in distillation and separation columns. This strategy briefly relaxes column severity at the pre-flood state, increasing the stability and energy efficiency of long-term operation. The pattern recognition system identifies transient tower instabilities, which precede flooding in trayed and packed columns. The strategy has the capability of distinguishing between a pre-flooding state and the random noise that is commonly generated from the natural frequency of the process. When column severity is relaxed briefly at the pre-flood state, the eventual flood condition is avoided, and the tower returns to a more stable state where throughput can be increased.

Barriers

The flooding predictor will predict a-priori the pre-flood alarm values for column operation based on first-principles models (equilibrium and rate-based models) using column dimensions and other column specifications (e.g. feed rates, feed composition, reflux ratio etc). These alarm values are key to predicting a pre-flood condition and currently, the plant operator determines these values by using rules of thumb or guesswork.

Pathways

The goal of this project will be accomplished using a patented pattern recognition methodology the flooding predictor, to predict the onset of hydraulic flooding. The project consists of a multi-step approach that includes an industrial-scale validation, pilot plant-scale experimentation, dynamic model development, and pattern recognition model constant generation.

Progress and Milestones

- Undertake pre-commission work on commercial-scale column (Completed)
- Compile data from commercial column test (Completed)
- Set-up column for packing test (Completed)
- Valuation of technology (Completed)
- Perform market analysis (Completed)
- Development of dynamic distillation model
- Develop algorithm to predict pattern constraints
- Evaluate flooding predictor and dynamic model based on commercial test

Commercialization

The team has completed a valuation of technology milestone and a market analysis. Current efforts include the development of cooperative research and licensing agreements and the development of a software commercialization plan. The flooding predictor is currently undergoing validation and verification tests at a refinery in California.

Project Partners

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