Sweet Success

Sugar cane-based ethanol manufacturer uses advanced control solution to improve product quality, increase throughput.

Zilor operates a sugar cane-based ethanol manufacturing facility at Quatá, SP, Brazil. The plant produces hydrated and anhydrous ethanol as well as sugar. Pavilion Technologies, a Rockwell Automation company, implemented its Model Predictive Control (MPC) Solution for Ethanol on the distillation and the molecular sieve units, which resulted in a reduction in product quality variability ranging from 30% to 50%, and increased throughput by nearly 6%.

For 60 years, Zilor has produced energy and food from sugar cane at three ethanol plants in the cities of Lençóis Paulista, Macatuba and Quatá in São Paulo. In the 2007-2008 harvest, Zilor produced 579,000 tons of sugar and 442,000 million liters of alcohol, in addition to renewable electric power from the sugar cane's bagasse. The Quatá facility was chosen as a test case for advanced control.

How the Process Works

The Quatá plant distillery has two distillation trains and one molecular sieve section consisting of three sieves. Each distillation train includes two distillation columns. The columns separate ethanol and water from the fermentation product (wine) to produce hydrated alcohol product and a water stream (vinhaça) that's pumped to the sugar cane fields as fertilizer.

The plant can swing between hydrated and anhydrous alcohol product. When making anhydrous alcohol product, a portion of the hydrated alcohol is fed to the molecular sieves for dehydration.

Variability Challenges

The technical challenges for the distillation operation include disturbances from fermentation variability, heat variation to the first distillation column, tray hydraulics of the first column, interaction between the two distillation trains, and large variability of the hydrated alcohol product quality.

Feed composition to distillation has large variability, largely because of the batch nature of fermentation as it feeds the distillation feed tank. This requires quicker response in distillation operation to correctly reject these disturbances.

The tray hydraulics of the first distillation column are a bottleneck. At times, the liquid level on the trays increases to a point that the column floods and a loss of separation occurs. The operator's challenge to increase production through the distillery is to push the feed rate to both distillation trains, and watch instruments in both trains to make sure flooding isn't occurring.

A More Stable Distillery

An advanced control solution was installed to overcome these challenges. The solution uses Pavilion's MPC technology, including nonlinear model predictive and multivariable control with dynamic optimization. The controller simultaneously controls product quality, and pushes the distillery to higher capacity while respecting process constraints.

"Industrial process like fuel ethanol, petrochemicals and oil production have multiple process units that are used to refine a feedstock to useful products," explains Maina Macharia, project manager for Ethanol Advanced Control Solutions,

Pavilion Technologies. "These process units are integrated to save on cost and energy, and so there are significant interactions that are difficult to control. MPC technology solves this problem. Pavilion's neural-network and high fidelity hybrid models are used to represent the process behavior in a controller."

Advanced control of the distillation trains and molecular sieves provided a large benefit to Zilor quickly. No additional process equipment was necessary. The project took about three months to complete.

With the controller's ability to help increase energy efficiency and alcohol recovery, reduce variability 30% to 50% depending on the distillation train, and increase production nearly 6%, the economic benefit to the company was a return on investment of more than 180% per year.

"Implementation of MPC technology is detailed engineering. It cannot be pulled out of a CD and loaded and expected to run the plant," says Macharia. "Rather, Rockwell Automation engineers with operation knowledge, plant testing and process calculations build MPC models, simulate and commission systems online. Depending on the complexity of the project, from single unit to plant-wide applications, the time varies, and MPC projects can take from a few months to more than a year to implement. Project time is a function of the number of process units, the degree of variables interactions, and the duration the variables take to settle out."

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The operation of the distillery has become much more stable. The operator acceptance of the MPC is very high, with the controller uptime close to 100%. The solution also provides greater flexibility to the customer to respond quicker to changing market conditions in hydrated and anhydrous alcohol products.

Additionally, the customer has gained invaluable knowledge about process limitations that will allow further debottlenecking in the future.

Because of these many benefits, Zilor will deploy additional applications throughout this and its other ethanol plants. □

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