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TECHNOLOGY SPOTLIGHT

Mass flow & density measurement saves costs, increases yield in corn ethanol plant

BY MIKE ROONEY

Margins in the corn-to-ethanol fuel industry can be pressured by costs for corn – as illustrated by the dramatic increase in Q3 of 2010, natural gas and enzymes. While distillers can't control these prices, they can do a great deal to increase productivity and minimize waste in their operations.

Technical background

The production of ethanol from corn begins with a corn mash slurry. Cornmeal (corn flour) is fed into the mash preparation tank on a weighbelt, and water, including some backset water recovered from drying the residual material at the end of the process, plus makeup water as necessary, is added in proportion to the weighbelt measurement. From the mash preparation tank, the slurry is transferred to saccharification, where enzymes are added to convert the starch to fermentable sugar.

The amount of enzyme required for complete saccharification depends on the concentration of cornmeal, starch and water, but several of these variables are difficult to measure and control. The amount of cornmeal on the weighbelt varies from minute to minute, as does its percentage of moisture, and weighbelt accuracy can be questionable — to the point that operators frequently call for emergency checks of it, resulting in high maintenance costs. All this causes the composition of the slurry to vary greatly within a short time. In a typical plant, manual sampling and laboratory analysis are used to determine the quantity of enzymes to add. But the lag time inherent in this method means that even the most recent data may be out-of-date. To reduce the risk of incomplete saccharification, most plants "over-add" enzymes, resulting in materials waste and unnecessary costs.

Looking for improvement

A Midwestern ethanol producer was faced with a couple of challenges and also wanted to improve the overall efficiency of its plant.

Feedforward system

On the front end of the process, they wanted to implement a feedforward system in which inline measurement of the percentage of fermentable material (dry solids) in the corn mash slurry as it came out of the mash preparation tank would be input to the enzyme control system. By basing enzyme addition on current data, the yield per bushel of corn could be maintained at the maximum level without over-adding enzymes. The producer asked Emerson Process Management for a way to make this measurement.

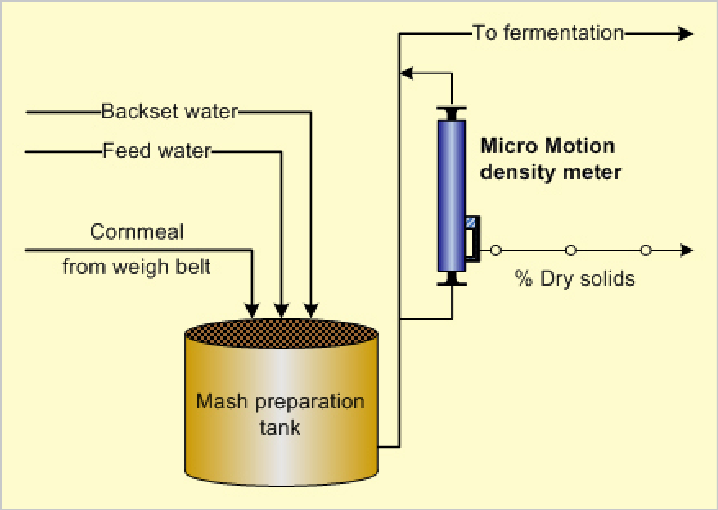

Figure 1. Measurement of slurry density coming out of the mash preparation tank allows for closer control of enzyme addition.

Two measurement solutions were proposed that would provide real-time measurement of the density of the slurry as it left the mash preparation tank on its way to saccharification.

- For line sizes below 4˝, a standard Micro Motion Coriolis mass flowmeter installed on the main line from the mash preparation tank could provide density measurement — which had a target value in the range of 32-36 percent dry solids equivalent (9-9.5 lb/gallon) with a potential accuracy of ±0.0002 g/cm^3 (±0.0017 lb/gallon)
- For larger lines, a Micro Motion densitometer installed in a slip stream could provide density measurement with a potential accuracy of ±0.00015 g/cm^3 (±0.0013 lb/gallon).

The densitometer solution was selected, and it enabled the company to control the dry solids going to saccharification to within 0.2 percent DS. In one instance the dry solids content of the slurry dropped from 32 percent to 22 percent within minutes, and the operations department was able to quickly identify the problem and regain the desired percent concentration. Without

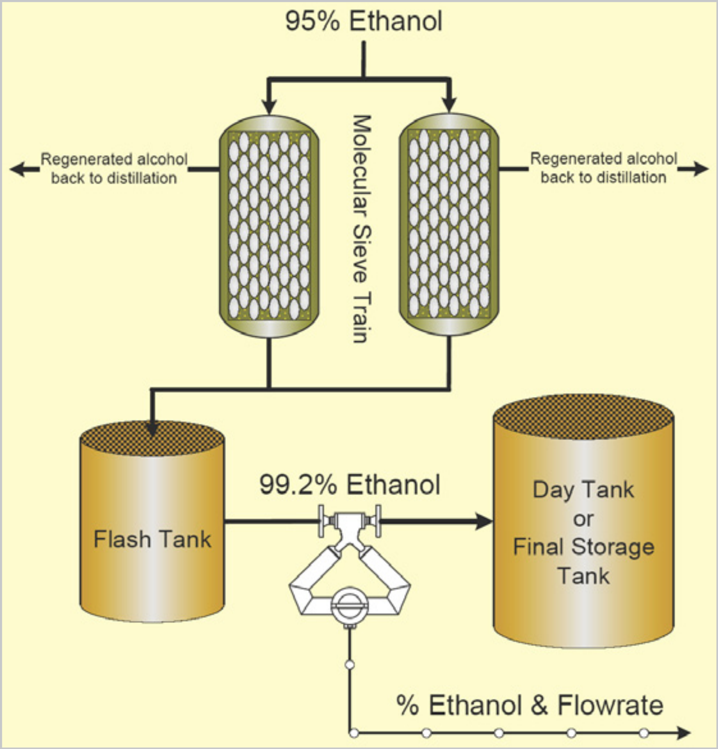

Figure 2. A Micro Motion mass flow meter delivers flow and density data for calculation of percent ethanol.

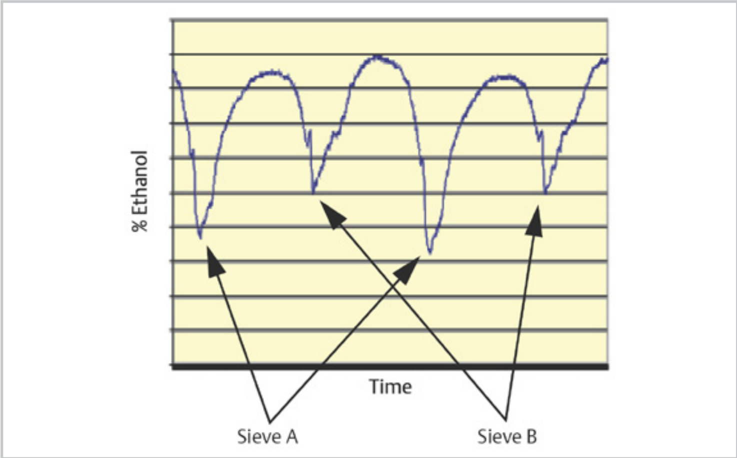

Figure 3. Density changes at sieve switchpoints indicate differences in sieve performance.

the inline density measurement, the DS of the slurry would have remained low until the next lab sample was analyzed.

As a side benefit, because the weighbelt measurement was no longer critical for product consistency, weighbelt checks were moved to the "periodic maintenance" category and maintenance costs were reduced.

Measuring ethanol proof

Another area of the operation that was open to improved efficiency was that of measuring percent ethanol value. ASTM D 4806, "Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel," specifies maximum water content by volume of 1 percent. Yet there is some variation among producer plants and delivery contracts, and different suppliers may have tolerances ranging from 0.4-1.2 percent water. Variations in water content can have a great effect on plant profitability, since it is important to avoid shipping off-spec product; but reducing moisture levels unnecessarily below the required value is costly.

The ethanol producer's process has been using molecular sieves to remove moisture from the process fluid. During the dehydration process, highly accurate measurement of percent ethanol (proof) is required. The producer has tried two different methods:

- *Day tank with manual sampling.* By taking frequent samples and adjusting the molecular sieve or the distillation column, the producer can average out the swings in ethanol content. When the product meets specifications, it is sent on to the final storage tank.
- *Slipstream densitometers.* This provides continuous measurement of percent ethanol, so that the dehydration process can be adjusted based on near-real-time data.

To avoid rework, the producer runs the system "drier" than specified, resulting in a lower return on materials. Both methods require a full stream flow measurement to determine production levels and to meet reporting requirements, and a vortex flowmeter was used for this purpose.

Manual sampling is expensive, and the producer found that it was almost impossible to take enough samples to keep up with changes in the process. Slipstream densitometers are highly accurate; however, densitometers that can measure percent ethanol are expensive. Additionally, the added piping and other slipstream complications made this solution expensive to install and to operate. Finally, vortex technology has accuracy and rangeability limitations, and it measures only flow, not density or concentration.

The producer again asked Emerson for a solution for accurate and repeatable inline measurement of flow and percent ethanol. The result was the installation of a Micro Motion Elite meter for simultaneous inline measurement of flow and density (Fig. 2), with flow accuracy of ±0.1 percent of flow rate and density accuracy of ±0.0002 g/cm3. In combination, these two measurements deliver an inline average percent ethanol measurement with an accuracy of ±0.1 percent. Because measurement is continuous, the producer can react to product variations quickly, minimize product variation and operate closer to target specifications.

The producer is now able to streamline the procedure, eliminate the costs and time needed for manual sampling, reduce instrumentation costs, increase throughput, improve product quality and consistency, and increase return on materials.

An added bonus came in the form of identifying an equipment problem. As shown in Figure 2, two molecular sieves were used to feed the production line. Because the Micro Motion device enables continuous measurement, the manufacturer was able to see that Sieve A was running "wetter" than Sieve B, as shown in Figure 3. By bringing the performance of the two sieves closer together, one major cause of product variation could be eliminated at the source, for even greater improvements in product consistency and throughput.

Finally, an additional increase in throughput could be attained by using the Micro Motion solution to monitor the percent ethanol in the regenerated stream back to distillation.

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