Ethanol research center toasts new production line equipment

An ethanol research center installs feeding and conveying equipment to ensure accurate and reproducible production results.

The National Corn-to-Ethanol Research Center (NCERC), Edwardsville, Ill., operates a full-scale ethanol pilot plant facility on the campus of Southern Illinois University Edwardsville. Ethanol producers, corn-seed-trait producers, equipment manufacturers, and other clients use the NCERC facility to research and test their ideas, products, and equipment that could potentially improve ethanol production. The facility's clients use the data generated during the ethanol production process to make their own processes more efficient and productive. Because of this, when designing the facility, the NCERC specified feeding and conveying equipment for the ethanol production line that's not only accurate and reliable, but can collect the material feedrates and other relevant operational data.

The NCERC's 36,000-square-foot facility is designed to emulate both wet-mill and dry-grind commercial ethanol production processes and to validate new technologies for use in each process. The facility's research lab allows ideas to be tested and perfected on a small scale before being scaled up for use in the pilot plant. The facility also conducts investigative research on the ethanol production and its co-product, distiller's dried grains. Thus far, the NCERC facility has only served clients from the dry-grind industry because most existing ethanol plants and those currently being built use the dry-grind process.

Making ethanol using the dry-grind production line

The corn used in the ethanol production process arrives at the facility as whole kernels or cornmeal powder. The corn kernels arrive at the facility in bulk trucks and are stored in large silos located inside the facility. The cornmeal arrives at the facility in bulk bags that are stored inside the facility.

To make ethanol using the corn kernels and dry-grind process, the kernels are first conveyed from a silo to the kernel-cleaning process, then to a loss-in-weight (LIW) feeder that me-

The weighbelt feeder (left) and portable LIW feeder (right) each meter cornmeal into the vacuum conveying system.

ters them into a hammermill at a constant feedrate. The hammermill reduces the kernels to a powder that has the consistency of cornmeal. This discharges directly from the hammermill into a vacuum conveying system that transfers the powder (cornmeal) to a cyclone. From the cyclone's bottom hopper, the cornmeal discharges to a LIW feeder, which meters the cornmeal into another vacuum conveying system. This conveying system moves the cornmeal to the starch-conversion area.

In the starch-conversion area, 200°F water is added to the cornmeal to form a corn slurry (called *mash*), which is jet-cooked to break down the starch into sugar. The cooled mash is pumped into a fermenter, where an enzyme and yeast are added. The enzyme helps continue breaking down the starch into sugar, and the yeast consumes the sugar to produce ethanol and carbon dioxide. The fermented mash is conveyed into a distillation unit that separates the liquid from the mash and the water from the ethanol to produce 199-proof fuel-grade ethanol. The NCERC sells the ethanol to fuel companies that blend it with gasoline. It further processes the residual mash and water into animal feed (distiller's dried grain) that's sold to area farms and feed lots.

To make ethanol using the pre-ground cornmeal and dry-grind process, an operator uses a bulk bag discharger to discharge the cornmeal from a bulk bag onto a portable weighbelt feeder. The

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Terry Lash programs the LIW feeder that feeds corn kernels to the hammermill.

weighbelt feeder discharges the cornmeal into a pick-up shoe that directs it into a vacuum conveying system. Because the rate at which the cornmeal discharges from the bulk bag varies depending on its bulk density, the weighbelt feeder is designed to either speed up or slow down to ensure that the appropriate volume of cornmeal is delivered to the conveying system at a constant feedrate. The vacuum conveying system conveys the cornmeal to the starch-conversion area. Once the cornmeal is in the starch-conversion area, the ethanol production process proceeds as previously described.

"The vacuum conveying system can move the cornmeal to the starch-conversion area from the cyclone or the bulk bag discharger," says Terry Lash, NCERC research engineer. "An operator just has to turn a valve that's located in the starch-conversion area to activate the appropriate conveying line."

Specifying the production line's equipment

When the NCERC was designing the facility, it needed to install feeding and conveying equipment in the dry-grind production line that was accurate and reliable and could provide the operational data necessary to meet its clients' needs. This equipment included two stationary LIW feeders, one portable LIW feeder, a vacuum conveying system with two material pick-up points, and a portable weighbelt feeder for use with the bulk bag discharger. The equipment had to be able to handle materials with varying particle sizes and be easily cleaned between production runs.

To find the necessary equipment, the NCERC contacted various feeder and conveying system suppliers to bid on the job. The supplier that bid the lowest would be awarded the contract.

One of the bidders was K-Tron, Pitman, N.J., a supplier of a wide range of versatile mechanical feeding and pneumatic conveying equipment. Lash and Ethan Trepp, another research engineer at the NCERC, both had experience working with K-Tron's equipment in the past and knew that the supplier's LIW feeders were accurate, reliable, and capable of producing usage records for each production run. Fortunately for the NCERC, K-Tron bid the lowest and was awarded the contract.

"Besides having the lowest bid, the supplier also had the best equipment for the facility's needs," says Lash. "Additionally, they have excellent technical support and service, which helps us keep the dry-grind production line up and running."

The feeding and conveying equipment

The NCERC worked with the supplier's rep, TSA Sales Associates LLC, Bridgeton, Mo., when specifying the equipment for the dry-grind production line. After learning about the application, John Schroeder, TSA sales engineer, specified three model K2MLS60 LIW feeders (two stationary, one portable), one model P100 vacuum receiver with two conveying lines and pick-up points, and one model SWB300 portable weighbelt feeder.

Each LIW feeder can feed material with an accuracy of ±0.25 percent at the set rate with 19 out of 20 samples (95 percent) being within this range.

A LIW feeder consists of a hopper and a metering device (mechanical screw) mounted on a load-cell scale. The material feedrate from a LIW feeder is determined by the weight change in the hopper with respect to time. Other factors, such as the feeder's screw diameter and flighting, can also affect the feedrate. Each of the NCERC's LIW feeders has a hopper capacity of 6.5 cubic feet. And each LIW feeder can feed material with an accuracy of ±0.25 percent at the set rate with 19 out of 20 samples (95 percent) being within this range.

The LIW feeder mounted below the cyclone meters cornmeal into the vacuum conveying system at a constant rate, preventing surges and line plugs.

A LIW feeder's hopper needs to be refilled during operation to maintain a constant material supply to downstream equipment. When the material in the hopper reaches a preset low weight, the upstream equipment is signaled and material fills into the hopper. When the material in the hopper reaches a preset high weight, the upstream equipment is signaled and the material flow is stopped.

To avoid feedrate changes caused by a rapid weight increase in the hopper during the refill process, the supplier's LIW feeder uses a statistical filtering program. The feeder's scale continuously samples the material weight in the hopper up to 112 times per second, and the statistical filtering program creates a bell-shaped curve in which the curve's top portion matches the set rate.

"If there's an upset condition in the hopper, the supplier's statistical filtering program discounts the condition because it's off the curve," says

Schroeder. "During refill, the program basically ignores the weight changes that are outside the statistical center of the bell-shaped curve so that the feeder can continue discharging the material at the set feedrate. Without the program, the feeder would increase the material discharge rate because of the rapid increase in material weight in the hopper. After the material in the hopper settles, the program adjusts the feedrate, if necessary, to account for changes in the material's bulk density."

One LIW feeder is installed just before the hammermill and is used to feed the corn kernels into the hammermill at a steady rate. The other is installed just below the cyclone and is used as a surge-control device to evenly meter the cornmeal into the vacuum conveying system. Both stationary LIW feeders have extended, 30-inch-long, fixed-diameter, fixed-flight screws. Each feeder's screw diameter and flighting are different since each is set up for a specific application.

The portable LIW feeder is mounted on a stand with castors and can be rolled anywhere in the facility. The NCERC uses this feeder to add special corn kernels, cornmeal, and other products to the dry-grind process. Materials handled are typically GMO (genetically modified organism) products that can't be stored in the facility's silos and must be closely monitored to avoid cross-contamination. Because this feeder handles a diverse range of products, the facility has more than 20 different screws at its disposal. Each 18-inch-long screw has a different screw diameter and flighting arrangement, making it possible for the facility to feed virtually any kind of material at any feedrate.

The vacuum conveying system consists of one vacuum receiver, one vacuum generator, and two 2-inch-diameter conveying lines. The vacuum receiver and vacuum generator are installed in the starch-conversion area. One conveying line connects the vacuum receiver to the hammermill, and the other line connects the receiver to the pick-up shoe near the bulk bag discharger. The conveying system operates continuously when the dry-grind production line is in use. An operator activates a conveying line by turning a valve to pull cornmeal from either the hammermill or the bulk bag discharger, depending on the application.

The cornmeal is pulled through a conveying line to the vacuum receiver, where it separates from the air and falls to the receiver's hopper. The cornmeal discharges from the vacuum receiver to the starch-conversion area, and the air is pulled through several cartridge filters to the vacuum generator before being exhausted, particle-free, to the atmosphere. The cartridge filters' filter media is coated with Teflon, and a reverse air-pulse system keeps the filters clean.

Since installing the supplier's equipment, the NCERC can now record all of the data output from the supplier's equipment in the dry-grind production line.

The portable weighbelt feeder has a 12-inch-wide belt and moves the cornmeal about 60 inches from the bulk bag discharger to the vacuum conveying system's pick-up shoe. The weighbelt feeder can move the cornmeal at rates as high as 20,000 lb/h with an accuracy of ±0.25 to ±0.50 percent of the set rate with 19 out of 20 samples (95 percent) being within this range.

The bulk bag discharger's slide gate controls the amount of cornmeal that discharges from the bulk bag, and the weighbelt feeder only operates when the slide gate is open. The weighbelt feeder is programmed to move a preset amount of cornmeal to the pick-up shoe at a constant gravimetric rate. The weighbelt feeder's control program accommodates changes that occur in the cornmeal's bulk density by adjusting the belt speed. If the cornmeal's bulk density decreases (less lb/ft), the belt speed will increase to feed the same material volume into the pick-up shoe at a constant rate, and vice versa.

The supplier's weighbelt feeder has a unique double weighbridge assembly with a self-taring feature. One weighbridge is mounted under the belt just in front of the material-discharge point. This weighbridge weighs the cornmeal that discharges from the bulk bag as the cornmeal passes over it. A second weighbridge is mounted under the belt just behind the material-discharge point. This weighbridge weighs the empty belt as the belt passes over it. By weighing the empty belt, the weighbelt feeder's program can account for any material buildup on the belt and re-tare the feeder's scale to maintain feeding accuracy to the pick-up shoe.

Experiencing 199-proof positive results

Since installing the supplier's equipment, the NCERC can now record all of the data output from the supplier's equipment in the dry-grind production line. "The accuracy, reliability, dependability, and reproducibility of the feeding and conveying equipment has improved the facility's overall research capabilities," says Lash. "The data collected during a production run allows us or our clients to accurately reproduce a run to verify results. We also monitor the equipment alarms remotely so if something would prevent a feeder from operating we can send someone over to fix it immediately."

Because the NCERC works with GMO and other specialty products, it has to clean the dry-grind production line between product runs to prevent cross-contamination. "One of the unique benefits of our pilot plant is that we can break down the production line and thoroughly clean all of the feeding and conveying equipment and other components between production runs," says Lash. "A LIW feeder easily unsnaps so our operators can have one apart in five minutes. And all of the supplier's equipment is easy to clean because it's constructed of either stainless steel or electro-polished steel."

"One of the main benefits of working with the supplier has been their quality of technical service, and that's one of the main reasons that we'll stay with them," says Lash. "We really haven't had any problems with the feeding and conveying equipment. The main problems that we've had stem from the interns accidentally dropping a component. But every time, John Schroeder has immediately driven out to the facility to the rescue, even at night. One night when an intern broke off a LIW feeder's motor, John showed up from home with a new motor and had us up and running in less than two hours. We're lucky that he lives close to the facility. The supplier's technical service has been excellent, far beyond expectations." **PBE**

Note: To find other articles on this topic, look under "Feeders," "Mechanical conveying," and "Pneumatic conveying" in *Powder and Bulk Engineering*'s Article Index at www.powderbulk.com or in this issue.

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