Case history

Slow-motion conveying systems rapidly deliver positive results

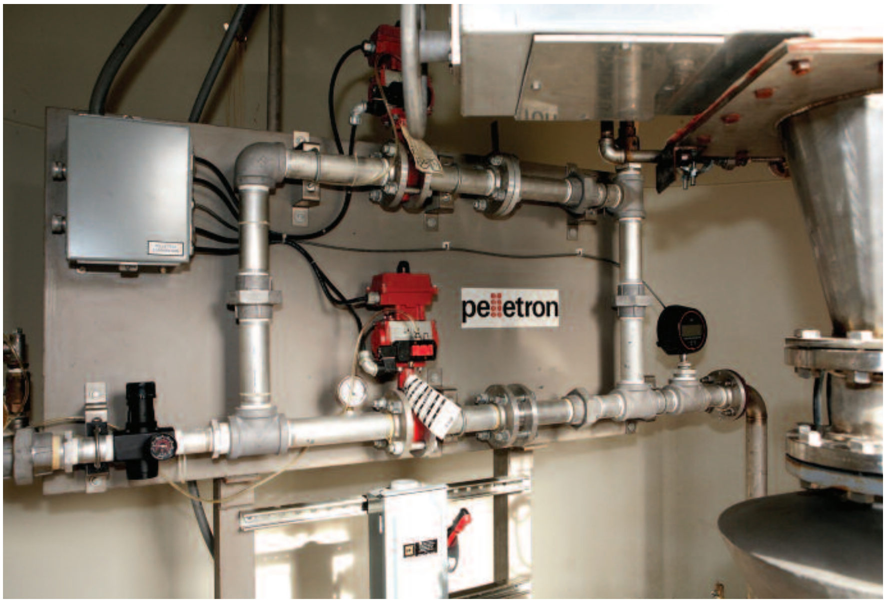
A synthetic-yarn manufacturer installs two new conveying systems to improve its resin pellet delivery operation.

Pharr Yarns, headquartered in McAdenville, N.C., operates several US production plants that produce high-performance synthetic fibers and yarns for use by fabric, clothing, carpet, and other textile companies. In 2006, the company commissioned a new plant in McAdenville to produce a range of synthetic yarns for carpet and rug manufacturing. To move ⅛-inch resin pellets from a large storage silo to a downstream extrusion process, the plant installed a high-pressure dense-phase pulse-conveying system. However, the dense-phase system's substantial air requirements led to high operating costs, and its high conveying velocity damaged the pellets, creating fines that increased maintenance costs. When the plant expanded its production operation and needed to install two more conveying systems, it decided to look for a better way to deliver the pellets to the extrusion process.

Feeding the extrusion process

The company's McAdenville plant operates continuously, 24 hours a day, 7 days a week. Its synthetic yarns are made by extruding resin pellets, primarily various polyesters and some nylon. When the new plant was commissioned, it installed three storage silos, five desiccant dryer-hoppers, five extruders, and 3-inch-diameter conveying lines to connect the silos to the dryer-hoppers and extruders. Since the plant was going to produce only one product at this point, it installed just one high-pressure dense-phase pulse-conveying system beneath one silo to convey 50,000 pounds of pellets per day to the extrusion process. Diverter valves in the conveying line direct the pellets to the appropriate dryer-hopper, which then feeds a dedicated extruder.

The dense-phase conveying system operates in cycles, moving pellets through the conveying line in slugs. First, pellets from the silo enter the conveying system pressure vessel through its top inlet. When the pellets reach a high-level sensor, the vessel's inlet closes and compressed air surges into the vessel to pressurize it and push the pellets out of the bottom dis-



The air-regulation station uses a Laval nozzle to generate an airflow of about 110 scfm and a conveying pressure of about 20 psig to continuously move the pellets in mass flow through the conveying line at a constant low velocity.

charge into the conveying line. For a predetermined time, the high-pressure air pushes the slug through the conveying line at a high velocity. The vessel's discharge then closes and its top inlet opens again to allow more pellets in.

The system repeats this cycle until all of the pellets have filled into the dryer-hopper, ending with an air-purge cycle to ensure that the conveying line is clear. The dryer-hopper continuously circulates hot, dry air through the pellets so they enter the extruder at the proper moisture content to ensure a top-quality finished product.

Pulse-conveying system has problems

During 2006, the plant added two additional dryer-hoppers and extruders and increased production, delivering 75,000 pounds of pellets per day to the extrusion process. By this time, the plant had found that the dense-phase system had some problems. "The system was taxed," says Russ Dirks, McAdenville plant's director of fiber extrusion. "The farthest distance that we convey pellets from silo to dryer is three hundred twenty feet, and we have to run the system at maximum pressure all the time to convey the pellets that distance. However, without a massive expense, we can't regulate the

The original dense-phase pulse-conveying system's high conveying velocity damages the pellets, creating fines that keep the plant's maintenance costs high.

The conveyor station's high-pressure rotary valve, which can be started and stopped with full head pressure on it, meters pellets from the silo into the conveying line at a constant rate.

system to have different pressures based on line distance — less pressure for short runs and more pressure for long runs. Because of this, the system consumes too much air, and the more air we use, the higher our utility costs."

The dense-phase system's high conveying velocity also damages the pellets, creating fines that keep the plant's maintenance costs high. "We have to shut down the dryer-hoppers to clean or replace their filters more often," says Dirks. "Also, if we don't use an air-purge cycle to clear the conveying line after a hopper is filled, the pellets get backed up and block the diverter valves, causing them to fail."

Another problem is that the system is set to convey the pellets the longest distance, so air continues to blow into the dryer-hoppers located nearest the silo long after the pellets have been delivered and cleared from the line. This introduces extra air and moisture into the drying system, increasing drying time and energy costs.

At the end of 2006, the company decided to activate the other two silos and produce two more products, so it needed to install a conveying system under each silo. "We took a close look at the dense-phase conveying system and the amount of air it required to convey the pellets," says Dirks, "and realized that if we wanted to keep operating and maintenance costs low, we needed to find a different conveying method."

Looking at the alternatives

Dirks and the plant's engineers contacted various conveying system suppliers and researched several different conveying methods, including mechanical systems, continuous dense-phase systems, and other pulse dense-phase systems. "We reviewed and compared several suppliers' operating specifications and parameters," says Dirks, "and one supplier's system really looked promising. It uses a rotary airlock to meter pellets into a pressurized conveying line and doesn't require as much air as our dense-phase system."

Dirks called the supplier, Pelletron, Lancaster, Pa., which supplies pneumatic conveying systems and components and other bulk material handling equipment for the plastics, chemical, pharmaceutical, mineral, food, automotive, and other industries. He talked with vice president of sales Paul Wagner.

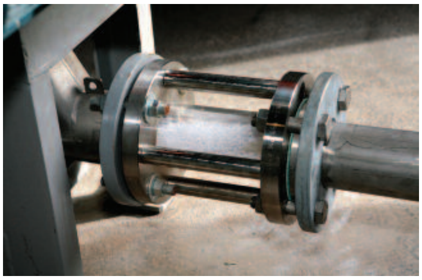
"Paul told me that they could design a conveying system specifically for our production process to meet every one of our operating parameters," says Dirks. "The system would be able to convey the pellets to our farthest dryer-hopper at the required rate using less air than our dense-phase system, which is something that would keep utility costs low and improve the dryer-hoppers' operating efficiency. And since the system's low conveying velocity doesn't create fines during conveyance, we'd see a reduction in maintenance costs."

Pharr Yarns purchased two systems, one for each silo. To keep costs low, the plant required that the systems be designed to connect with the existing conveying lines and fit in the existing space beneath the silos.

The continuous dense-phase slow-motion conveying system

In January 2007, the McAdenville plant received the two conveying systems, and plant engineers installed them beneath the silos. Each system consists of two stainless steel components: a Pelletron Air-Regulation (PAR) station and a high-pressure rotary valve conveyor station. The system is designed for use with ⅛-inch pellets or similar-sized granules with bulk densities ranging from 35 to 60 lb/ft^3. Since the system gently conveys material at a low velocity, it can be used with fragile or heat-sensitive materials.

The PAR station uses a Laval nozzle to control the airflow through the conveying line at a constant rate. A Laval nozzle (or convergent-divergent nozzle) accelerates air passing through it and creates constant mass flow.



A sight glass installed in the conveying line at the conveying station's discharge allows operators to monitor material flow through the system.

The conveyor station, which is installed directly below the silo, uses a high-pressure rotary valve to continuously meter pellets at a controlled rate into the conveying line. The rotary valve's inlet has an anti-shear device, which allows the valve to be started with full head pressure on it and pellets already in its pockets. The valve's tight clearances and a specially designed vent hopper prevent leakage air from going up through the silo discharge and disturbing the material flow to the valve.

During operation, the PAR station provides a constant airflow through the conveying line as the rotary valve meters the pellets into the line. In a feed shoe underneath the rotary valve, the constant pellet flow into the conveying line meets with the constant airflow, which gently pushes the pellets at a very low velocity to the dryer-hoppers.

"The system doesn't cycle and move the pellets in slugs, and there's no pressure surge at the conveying line's beginning near the silo," says Wagner. "We call it continuous dense-phase slow-motion conveying, because the system continuously moves the pellets at a controlled and constant low velocity through the entire conveying line."

The system's low conveying velocity prevents fines and angel hair generation during conveyance. The PAR station produces an airflow of about 110 scfm and a conveying pressure of about 20 psig, and the pellets move through the conveying line at about

600 to 800 fpm. The system can move about 4,000 pounds of pellets per hour.

The system's controller is much less complicated than the McAdenville plant's original dense-phase system's controller, because there are fewer components to monitor and run. "With our system, the valve is either open or closed," says Wagner. "There's no fill cycle, pressurization cycle, conveying cycle, or depressurization cycle. This, along with low conveying velocities, makes our system much quieter during operation."

Using the new conveying systems

Since installing the two new conveying systems, the plant has added three more dryer-hoppers and extruders and increased production to more than 100,000 pounds of pellets per day. Currently, each of the plant's three silos holds a different type of resin pellet so the plant can make a variety of finished products.

"Each silo has its own conveying line with a diverter valve at its end," says Dirks. "The diverter valve directs the pellets into a header that's also connected to the conveying lines from the other two silos, bringing all three lines together into one single conveying line that connects to the dryer-hoppers. So we have a pellet delivery system in which each silo can service any of the ten dryer-hoppers."

The pellet delivery system's controller monitors and maintains pellet levels in the dryer-hoppers, ensuring that the extrusion process operates smoothly. The dryer-hoppers have high- and low-level sensors, so when a hopper's pellet level gets low, the low-level sensor signals the system's controller to convey pellets to the hopper. When this occurs, the controller activates the appropriate diverter valve to direct the pellets into the hopper and then simultaneously starts up the rotary valve to feed pellets into the conveying line and the PAR station to convey them to the hopper. When the pellets reach the high-level sensor, it signals the controller to shut off the PAR station and rotary valve. The controller is also programmed to alert the operator if the conveying pressure increases (caused by a line plug) or decreases (caused by a leakage in the line).

"With this system, we don't have to purge the line every time a hopper has been filled," says Dirks. "The pellets can stay in the line and we can restart the conveying system without any problems. However, if we need to clean out the line between product runs to prevent cross-contamination, we can activate the PAR station's bypass valve to increase the airflow to about two hundred scfm for about twenty seconds."

Improving the resin pellet delivery operation

The plant's original dense-phase conveying system can move more pounds of pellets per hour, but it costs a lot more to do so and causes more pellet damage than the newer conveying systems, which are a little slower but cost much less to operate. "The supplier's system uses half the air pressure that the other dense-phase system requires," says Dirks. "Its air consumption is probably a little more over time, just because it blows for longer periods, but because it's at a much lower pressure, it costs less to generate. The lower pressure demand also means we could downsize the compressor, which also saves us because it uses less electricity than the original dense-phase system's compressor."

The supplier's conveying systems have been much more reliable than the original dense-phase conveying system. "We haven't had any failures with the supplier's conveying systems," says Dirks. "Whereas with the original system, we have line blockage problems every two to three weeks caused by the high conveying pressure. We never get a line blockage using the supplier's system since the pellets aren't as compacted in the line because of the low pressure."

The supplier's conveying system requires minimal maintenance because there are few moving parts. "But if we ever have a mechanical problem, the components are generic," says Dirks. "For example, if a regulator ever fails, I can replace it with any regulator — I'd just call my local parts guy and get a replacement. Also, it's a lot easier making repairs to the system, because the parts are easy to get at, whereas with the original dense-phase system, if something goes bad I have to take the whole unit apart to get at it. Some of the other things we really like about the supplier's system are that it's a complete, well-made system from one supplier, it's simple to operate and didn't require any custom operating program, and it was easy to install — all we had to do was plug it in, plug in the air, hook up the electrical contacts to the existing control system, and, boom, we were in business."

PBE

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