From powder to pellets

An agglomeration equipment and systems supplier designs a new building and processing line to pelletize and package a company's powdered limestone.

Stuart M. Perry Inc. operates a limestone mine, limestone plant, and asphalt plant at its Berryville, Va., site. The company provides crushed limestone aggregate for road construction and building foundations, powdered limestone for use as an agricultural fertilizer, and asphalt for roads, parking lots, and driveways. The company's grinding facility produces the powdered limestone, which is sold in bulk for application to agricultural fields. The company recently automated the grinding operation and began producing a surplus of powdered limestone, which is dusty, difficult to handle, and relatively valueless. To reduce the dust and increase the limestone's handling ease and value, the company worked with an agglomeration equipment and systems supplier to design a new building and processing line to pelletize and package the powdered limestone. It could sell this product directly to consumers for lawn and garden applications.

Powdered limestone problems

Because the powdered limestone particles are between 45 and 150 microns in diameter (with 95 percent at 150 microns), the limestone is very dusty and difficult to handle without the proper equipment. This made it impractical to sell to consumers for home use. However, the company realized that if it could pelletize and package the powdered limestone it could produce a saleable product. To do this, the company needed to find an agglomeration equipment supplier to design a complete pelletizing and packaging line as well as a building to house the new processing line.

Working toward a solution

Joe Renner, Stuart M. Perry general superintendent, says, "We learned of Mars Mineral from reading brochures, seeing ads and articles in various magazines, searching the Internet, and talking with different people. From what we saw, they spe-

The agglomeration process begins in the continuous pin mixer as the binder solution mists over the powdered limestone.

cialized in pelletizing, and it looked like they were capable of working with us to design what we needed. That's why we approached them."

Mars Mineral, Mars, Pa., an agglomeration equipment and systems supplier, manufactures various pelletizing equipment, operates a test lab, designs systems, and provides rental equipment.

The limestone company contacted the supplier in November 1997. The supplier first collected information about the powdered limestone and the company's pelletizing requirements before testing the material in its test lab, which contains both laboratory and pilot-scale agglomeration equipment.

For the tests, limestone company representatives traveled to the supplier's test lab with about 2,000 pounds of powdered limestone. The supplier ran the powdered limestone through several types of pilot-scale agglomeration equipment to see which machine best pelletized the material. The supplier also tested various binders with the powdered limestone. After analyzing the test results, the supplier

The company needed to find an agglomeration equipment supplier to design a complete pelletizing and packaging line as well as a building to house the new processing line.

Binder solution continues to mist over the material as the disc pelletizer turns the powdered limestone into limestone pellets that range from 850 to 4,750 microns.

recommended a pin mixer and disc pelletizer that would do the job. Initial testing indicated that a lignosulfonate binder was best for this application. Later evaluation of a locally available beer-brewing by-product also performed well and was selected as the binder of choice.

Both Renner and the company's owner were pleased with the test results and decided to move forward with the next stage of the project — designing a new building and complete pelletizing and packaging line.

For this stage of the project, the supplier sent several limestone pellet samples to various manufacturers of the pelletizing and packaging line's other necessary equipment. This included feeders, conveyors, dryers, screeners, baggers, palletizers, shrink-wrappers, and others. The supplier received the manufacturers' responses and ranked them based on the equipment's ability to handle the limestone pellets. The supplier then recommended the manufacturers that could provide the best equipment for the company's requirements.

"The supplier showed us different types of each machine that would be in the pelletizing and packaging line and let us decide which to use," says Renner. "To help us make the decision, the supplier gave us literature and some of the pros and cons of each machine, which helped us better understand what we were going to be working with. We read as much as we could, and we also traveled to other plants to see some of the machines in operation to give us a better idea about how they would operate in our plant."

The supplier and company designed the building to accommodate future expansions, allowing the company to add more pelletizing equipment if product demand increased. The supplier and company also designed the pelletizing line's packaging operation to handle about twice the volume of pellets that the pelletizing equipment produces. Renner says, "If we want to expand at a later date and make more pellets, we can install another pin mixer and disc pelletizer without having to redesign the building or install more equipment in the packaging line."

Construction on the new building began in fall 1998. By summer 1999, the supplier began installing the new equipment for the pelletizing and packaging line in the new building. The supplier's technicians scheduled the equipment startups and trained the company's operators to run the pelletizing and packaging line equipment. By fall 1999, the pelletizing line was online and operating.

The pelletizing line

The company installed a 6-inch-diameter semidense-phase pneumatic conveying system from the limestone grinding facility to the new pellet plant. The system conveys about 1 ton of powdered limestone each cycle to a 100-ton-capacity feed bin located in the new pellet plant. Level indicators in the feed bin start the conveying system when the bin is near empty and stop it when the bin is full.

The powdered limestone discharges from the bin through a manual slide-gate and variable-speed rotary feeder onto a variable-speed weighbelt feeder. The rotary feeder is slaved to the weighbelt feeder so that as the weighbelt feeder weighs the material passing over its scale, both either speed up or slow down to match the feedrate setpoint. The material discharges from the weighbelt feeder into the pin mixer's top inlet at about 12 to 15 t/h. This is where the powdered limestone agglomeration process begins.

Liquid binder is stored in a holding tank and water is stored in another holding tank. Before application, the binder and water are pumped into a dilution tank at known ratios where they're mixed. From the dilution tank, the binder solution is pumped into both the pin mixer and disc pelletizer through a liquid injection system that has two spray lines, one for each machine. Each spray line has adjustable valves, gauges, control valves, and flowmeters. The amount of binder solution added to the machines depends on the material feedrate — if the feedrate increases, more binder solution is pumped into the pin mixer and disc pelletizer, and vice versa. The company can control the binder solution's dilution ratio and the amount of binder solution added to the material.

"The binder keeps the limestone pellets as pellets so a customer doesn't get a bag of powdered limestone," says Bob Hinkle, Mars Mineral director of agglomeration. "After the pellets are dried, they can be bagged, hauled, and spread out on a lawn or garden with very little dusting. Once moisture hits the pellets, they break back down and disperse as limestone fines."

The Model 30D120L continuous pin mixer is 30 inches in diameter and 120 inches long and has a rotating shaft running through its center. The shaft's mixing pins extend to the mixer's interior wall and are arranged in a double-helical pattern to hasten mixing times and move the material through the mixer to the discharge end. Binder solution is added through two liquid injection ports at the mixer's top. The ports each have a spray nozzle that mists the binder solution onto the material as it mixes, promoting microagglomeration. The company runs the mixer at about 350 rpm, creating a residence time of less than 1 minute. The material discharges from the mixer's bottom to a gravity chute that directs the material into the disc pelletizer.

The Model P120 disc pelletizer has a 12-foot-diameter continuous rotating pan that's inclined at about a 55-degree angle. The pan rotates clockwise at about 10 rpm. Material discharges from the gravity chute onto the pan at about 2 o'clock (when facing the disc pelletizer) at a point between the pan's center and outer edge. The pan's rotation continuously rolls the material as two liquid injection lines with spray nozzles mist binder solution onto the material, promoting pelletized agglomeration. As the material agglomerates in the pan, larger material is displaced by newer mate-

The pelletizing and packaging line, as viewed from the pellet plant control room, can produce 12 tons of pellets per hour and bag 21 tons of pellets per hour.

rial and pushed to the pan's outer edge. The material stays on the pan for about 5 minutes and then discharges off the outer edge at about 9 o'clock. The final limestone pellets range from 850 to 4,750 microns. The pellets discharge onto a reversing belt conveyor that discharges them onto another belt conveyor that moves them to a vibrating fluid-bed dryer.

The reversing belt conveyor functions as a reject conveyor. Renner says, "We put it in because if we test a new binder or train a new operator and we get a bunch of bad pellets, we can reverse the conveyor's direction and reject the pellets onto a reject pile so we don't have to run them through the entire plant."

The dryer's vibrating fluid bed moves the pellets through the dryer, where they're first heated and dried at about 700°F and then cooled. The pellets pass through the dryer in about 1 minute and discharge onto a belt conveyor that moves them to a screener that has two screens. The top screen removes the oversize pellets, which are gravity-fed to a hammermill for size reduction before being recycled back to the feed bin via a 4-inch-diameter dilute-phase pneumatic conveying system. The bottom screen removes the onsize pellets, discharging them to a weighbelt conveyor. The undersize pellets pass through both screens to a chute and are gravity-fed to the same 4-inch-diameter dilute-phase pneumatic conveying system, which converges with the oversize conveying line after the hammermill to form one conveying line back to the feed bin.

The weighbelt conveyor moves the onsize pellets outside the plant to a bucket elevator that lifts them and discharges them into a 200-ton-capacity pellet bin. The weighbelt conveyor also weighs the onsize pellets as they pass over its scale. By comparing the raw-material weight going into the system, as indicated by the weighbelt feeder, with the finished-product weight going out of the system, as indicated by the weighbelt conveyor, the company can calculate how much material is being fed into the pellet bin and how much is being recycled back to the feed bin. Currently, the company is getting more than 12 t/h of finished product from the pelletizing line.

The packaging line

From the pellet bin, the company can either load the onsize pellets directly into bulk trucks or convey them back into the plant for packaging. For packaging, the pellets discharge from the pellet bin onto a short conveyor belt that discharges them to a second conveyor belt. Because the pellets gravity-flow from the bin onto the conveyor, when the conveyor stops, the material flow stops. The second conveyor moves the pellets into the pellet plant and discharges them into a 1-ton-capacity storage bin that has two level indicators — one starts the conveyors when the bin is near empty and the other stops them when the bin is full. However, the company likes to keep the storage bin completely filled when the vertical form-fill-seal bagger is running, so the conveyors typically never shut off during packaging.

The storage bin's bottom has two discharge points, each with a scale that weighs the material before discharging it into 40-pound-capacity bags. When one scale is discharging, the other scale is filling so that a bag is always being filled. This allows the company to fill 17 bags per minute. After a bag is filled, it passes through a heat-sealer that seals its top. The bag is then discharged onto a conveyor that moves it through an inclined bag flattener.

The bag then travels down a roller conveyor by gravity to a semiautomatic palletizer where it's automatically positioned for palleting. The palletizer automatically dispenses a pallet, puts on a slip sheet, raises the pallet, and patterns and layers the bags until the specified number of layers have been palleted. After completing a pallet, the palletizer ejects the pallet onto a roller conveyor. From this point on, photo eyes move the pallets through the rest of the system.

The roller conveyor moves the pallet to an automatic spiral stretch-wrapper and loads it onto the stretch-wrapper's pallet platform. As the pallet platform spins the pallet, the stretch-wrapper automatically wraps the pallet from bottom to top, stops the platform, places a cover over the pallet's top for maximum weather-proofing, starts the platform, and wraps the pallet from top to bottom. The stretch-wrapper then ejects the pallet onto a powered roller conveyor with an air-clutch system that stops the pallets as they reach the conveyor's end. The conveyor can accumulate five pallets before an operator needs to remove them with a forklift. The pallets are moved outside for storage.

The company operates two 8-hour shifts a day, 5 days a week. During a shift, the company only has two operators in the pellet plant — one operator runs the pelletizing line, monitoring the pellet moisture content and size, and the other runs the packaging line, replacing materials for the bagger, palletizer, and shrink-wrapper and removing full pallets to storage. When the packaging line is running properly, the company can make a full pallet every 4 minutes, which equates to approximately 21 tons of pellets being packaged each hour. And because the pelletizing line produces 12 t/h and the packaging line handles 21 t/h, the company only operates the packaging line during the day shift, bagging in that one shift what it produces in two shifts.

The pelletizing line is controlled by a central PLC from a PC in a control room. The packaging line equipment

— two scales, vertical form-fill-seal bagger, semiautomatic palletizer, and stretch-wrapper — are each controlled independently by individual control units. There's little communication between the packaging line equipment, and the packaging line information doesn't feed back to the main PLC. However, the bagger, palletizer, and shrink-wrapper are all electrically interconnected through interlocks so that if the shrink-wrapper unexpectedly shuts down, the palletizer and bagger also shut down to prevent bottlenecks and spills.

The company also installed a dust collection system in the pellet plant at all of the discharge points along the pelletizing and packaging line. The dust collector pulls the dust from the discharge points to the main baghouse. When the dust drops off the bags, it's recycled back to the feed bin via a dense-phase pneumatic conveying line.

Pelletized limestone produces positive results

Since installing the pelletizing and packaging line, says Renner, "We've taken a material that's very dusty and turned it into a product that's fairly clean and user-friendly. And since the pelletized limestone has more value than the powdered limestone, we expect to see a return on our investment in the near future."

The pelletized limestone is cleaner to work with than the powdered limestone. "There's still a little bit of dust, but nothing like what the powdered limestone produced," says Renner. "And what little dust is produced, the dust collection system removes from the plant, creating a dust-free working environment for our operators."

There were some minor problems with the pelletizing and packaging line when the company first started it up. "We had our difficulties and we found some equipment that had to be replaced," says Hinkle. "The most noticeable thing was the wearing of the components in the pneumatic conveying line that recycles the oversize and undersize pellets, because the limestone pellets are much more abrasive than the powdered limestone. To fix this problem, we improved the construction materials in the recycle conveying line. The system has operated smoothly since."

The company has also made some improvements to the pelletizing and packaging line. "Since we've been running the operation, I've added some sensors to the packaging line," says Renner. "I put a limit switch on the bagger's bag roll so that when the bag roll gets down to about 10 bags it shuts down the bagger. And I also added a photo-electric switch just after the heat-sealer that shuts down the bagger if a bag falls over. This increased the line's efficiency and production capacity because we can stop big messes and problems from happening."

The company is very satisfied with the supplier's services. "I've worked with a lot of companies, and Mars Mineral has been a real good company to work with," says Renner. "At any time, from the day we started building the plant to today, if I have a problem I can call them up, and if it's a problem we can't figure out over the phone, they'll send someone here to fix it. They're very responsive to our needs and will travel here if things need to be fixed." **PBE**

Mars Mineral, Mars, PA
724-538-3000
www.marsmineral.com

Equipment manufacturers

Pin mixer (1), disc pelletizer (1), binder-solution system (1), bagger storage bin (1): **Mars Mineral, Mars, Pa., 724-538-3000.**

Level indicator (4): **Bindicator, Spartanburg, S.C., 800-778-9242.**

Variable-speed weighbelt feeder (1): **Milltronics, Grand Prairie, Tex., 972-522-4500.**

Reversing conveyor belt (1), conveyor belt (2), weighbelt conveyor (1): **B.W. Sinclair, Wichita Falls, Tex., 940-766-2556.**

Dryer (1): **Carrier Vibrating Equipment, Louisville, Ky., 502-969-3171.**

Hammermill (1): **Pulva, Saxonburg, Pa., 800-878-5828.**

Recycle dilute-phase pneumatic conveying system (1), recycle dense-phase pneumatic conveying system (1): **Cyclonaire, York, Nebr., 888-593-6247.**

Bucket elevator (1), 200-ton-capacity pellet bin (1), conveyor belt (2): **Nance Corp., Richmond, Va., 804-784-5266.**

Bagger scale (2): **Express Scale Parts, Shawnee, Kans., 913-441-4787.**

Vertical form-fill-seal bagger (1): **Hamer, Minneapolis, Minn., 800-927-4674.**

Semiautomatic palletizer (1): **Conveying Industries, Denver, Colo., 303-373-2035.**

Spiral stretch-wrapper (1): **Lantech, Louisville, Ky., 800-866-0322.**

Dust collection system (1): **Flex-Kleen, Itasca, Ill., 630-775-0707.**

PLC and software program (1): **Allen-Bradley, Milwaukee, Wisc., 414-382-2000.**