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Combined Heat & Power for Wallboard Manufacturer

By Jeffrey D. Celuch

Lafarge Gypsum Division, the world's third largest producer of gypsum wallboard, wanted to increase its U.S. production to accommodate the growing demand for drywall in a service area that covers 14 states. Lafarge chose Silver Grove, Ky., for its new manufacturing facility.

The design team partnered to create innovative solutions for the new plant. First, due to high volume of natural gas use, it was decided to bypass the local gas distribution company (LDC), Union Light, Heat and Power (UHL&P), a Cinergy subsidiary, and connect directly to the KO Gas Transmission Line.

This required extending a 12-in. (0.3 m) natural gas pipeline capable of carrying 2.1 million cfh of natural gas to Silver Grove, a small community of mostly residential sites. One of the design partners designed and installed the gas main to serve Lafarge and the residents of Silver Grove. ULH&P and Lafarge shared in the cost of the installation.

The benefits were threefold. Bypassing the LDC allowed Lafarge to save on distribution charges from ULH&P. The utility benefited by serving customers that had been looking for access to natural gas. And, the residents of Silver Grove benefited from their new neighbor by being served natural gas from a gas pipeline

A new 138 kV substation was designed and constructed to serve Lafarge's electrical needs. The substation consists of two 138 kV transmission feeds and is designed for importing or exporting power from the transmission grid. Based on plant operating load, the cogeneration plant can export excess power to the transmission grid, import power from the grid or, in the event of a loss of the transmission system, operate in island mode completely disconnected from the transmission system.

The biggest challenge facing the design team was to find a thermal source that would match the process requirements of the gypsum cage mill dryer. The original gypsum-drying concept was based on providing natural gas-fired burners. This is typical for many similar industrial drying applications. Additionally, the new plant would require just under 5 MW, which would be purchased from the transmission grid.

A 5 MW natural gas-fired turbine generator (GTG) was chosen as the optimal solution of meeting the cage mill dryer's thermal requirements. Detailed analysis and equipment selections were performed to ensure that the thermal output of the GTG matched the thermal requirements

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of the cage mill heater. Sensitivities were performed varying multiple factors such as gypsum moisture content, temperature, and humidity, which fluctuate in this part of the country. The final system selected is capable of producing 5 MW of power and 44 MMBtu/h of heat to the plant. Since the plant was completed prior to the installation of the GTG, the cage mill dryer was installed with the natural gas burner so that the plant could remain in production when the GTG was down for service.

As ambient conditions changed, the output of the gas turbine would not satisfy the process requirements once the outdoor temperature was above 60°F (16°C). To overcome this constraint, a 200-ton (703 kW) air-cooled chiller was installed to produce chilled water to feed a cooling coil in the inlet ductwork. The chiller is capable of lowering the inlet air temperature from 95°F (35°C) to approximately 55°F (13°C). This allows the cage mill dryer to maintain process requirements because the cogeneration plant heat output increases as the inlet air is lowered. In addition, at full-load, the chiller consumes approximately 200 kW of electricity, while boosting generator output by almost 600 kW, creating a net increase in output of 400 kW.

Turbine generator for gypsum wallboard manufacturer.

The cogeneration plant is very efficient. For every MMBtu of energy that goes into the cogeneration plant, almost 96% is supplied as input to the process. The 4% loss in energy comes from inefficiencies in the gas turbine, gearbox and generator. All the remaining MMBtu's are either converted to heat that is transferred to the process for drying of gypsum, or is converted into electrical energy in the generator. The gas turbine requires, on average, 71 MMBtu's per hour and provides 44 MMBtu's per hour to the cage mill. The GTG exhaust is supplied to Lafarge at approximately 1,100°F (600°C).

In addition to the chiller and GTG, other auxiliary equipment includes a gas compressor, self-cleaning inlet air filtration system, chilled water distribution pumps and accessories, complete programmable logic controller (PLC) control system and a 15 kV isolation transformer and transfer switch. The natural gas compressor boosts the natural gas supply pressure to the GTG from 100 psig to 300 psig (690 kPa to 2070 kPa).

A 150 ft (46 m) tall stainless steel exhaust stack also was included in the design. The 6 ft (18 m) diameter exhaust duct from the GTG passes up the stack and is either sent up the stack for simple-cycle operation, or is diverted to the process through a 6 ft (1.8 m) diameter damper to the process for combined heat and power application. The stainless steel exhaust stack design eliminated the need for refractory, insulation or painting.

Lastly, the controls for the cogeneration plant use state-of-the-art programmable logic controllers (PLC) to operate the facility. The controls monitor the status of the equipment and a digital paging system alerts operators of critical alarms. The operators can monitor and control the system from remote locations. This has allowed for safe and reliable operations while minimizing dedicated staff resources and costs.

One last hurdle overcome by the design team was to minimize noise because of the cogeneration plant's close proximity to private residences. Techniques to mitigate noise from the plant include: installation of sound walls with acoustic baffles, inlet and exhaust silencers, and the addition of acoustic blanketing on the inlet ductwork. After these upgrades, the cogeneration plant is virtually undetectable from the residents' homes.

This system is efficient and effective. The Lafarge facility is the largest single-line production facility in the United States operating at 500 board feet per minute.

Raw material input to the manufacturing process comes from the Zimmer generating station. At the Zimmer station, the exhaust gases from a coal-fired boiler are scrubbed using a lime-based process. The chemical reaction between the lime and the sulfur in the exhaust gases produces calcium sulfite. An oxidation process is used to converts the calcium sulfite into calcium sulfate, or synthetically produced gypsum.

Prior to signing an agreement with Lafarge to supply the facility with synthetic gypsum material, Zimmer's flue gas desulphurization (FGD) process required the land filling of more than 1.7 million tons (1.5 million Mg) of calcium sulfite per year. Now, instead of being placed in a landfill, the calcium sulfate is sent to Lafarge to be converted into drywall. Zimmer Station supplies Lafarge with approximately 850,000 tons (765 000 Mg) of raw material per year.

As the gypsum enters Lafarge's process, it's moisture content is about 10% to 12%. As the gypsum is fed into the cage mill dryer, the free moisture in the gypsum is immediately flashed to steam and evaporated away into the atmosphere by the GTG exhaust. The GTG supplies Lafarge's cage mill dryer with exhaust at approximately 900°F to 1,000°F (480°C to 540°C). The GTG exhaust dries the gypsum from 10% to 12% moisture content, down to less than 1% moisture content for further processing before being converted into drywall.

This innovative design has reduced the amount of fuel consumed to produce heat and power on site when compared to purchasing electricity directly from the grid and firing independent gas heaters dedicated to each piece of equipment. This feat has not gone unrecognized.

Recently, the U.S. Environmental Protection Agency Combined Heat and Power Partnership and Department of Energy have recognized Lafarge and its partners when they presented the partners with the 2004 Energy Star® CHP Award.

What is most impressive about the facility is what it is not. It is no longer an abandoned rail yard, nor does it rely on a distant mining operation. The facility in Silver Grove was chosen due to its accessibility to the existing rail line and the Ohio River and the proximity to the Zimmer plant.

The Zimmer coal-fired power station uses barges on the river to transport the synthetic gypsum. Therefore, truck transportation and associated vehicle emissions are reduced significantly since natural gypsum is not transported from distant mines. This in turn allows the plant to produce nearly 900 million ft^2 (83.6 million of wallboard annually with 100% of its raw materials being recycled products.

The GTG system also results in lower NO_x, SO_2, particulate matter, mercury, HCl, and selected metals emissions compared to facilities that have power only generated from utility coal-fired plants. Estimates include an annual reduction of carbon dioxide emissions by almost 15,000 tons (13 500 Mg).

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