Achieving energy optimization and operational excellence in cement production

Lehigh Cement Company's complete modernization of its cement manufacturing facility in Union Bridge, Maryland has helped them conserve energy and improve production processes. The integration of innovative process control technologies has allowed the company to optimize energy management and improve process efficiencies throughout the facility. By modernizing the facility, Lehigh was able to reduce power consumption per ton, decrease labor, and increase cement production to over 1,800,000 metric tons.

by

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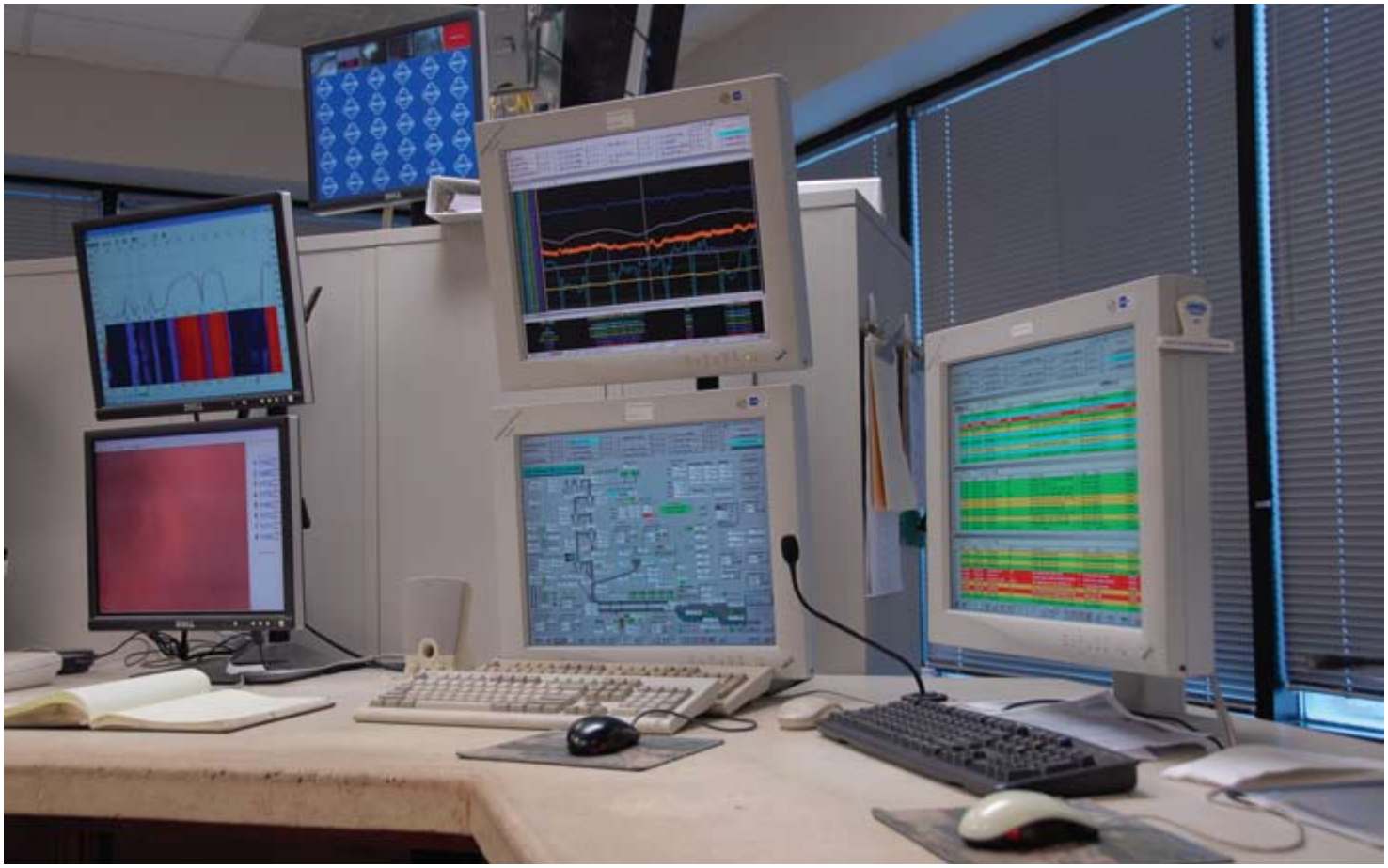
Over the years, Lehigh Cement's innovative thinking has helped it optimize energy consumption and improve operational efficiency. From eliminating islands of automation and integrating its software platform under one centralized location to transferring production data into SAP, Lehigh Cement has reduced energy consumption and improved productivity. This approach challenges the notion that PLC/HMI-based controls are the only cost-effective method for cement producers to improve the efficiency of their operation. Integrated process automation systems are being designed to meet, and many times exceed, the specific requirements of the cement industry, particularly for those with an objective to optimize energy consumption, improve control system longevity, and ultimately reduce the total cost of operation over the life of the system. Lehigh Cement shows what an integrated automation system can achieve.

Lehigh Cement Company is a division of the Heidelberg Cement Group based in Germany. Heidelberg Cement Group is the third largest cement producer in the world. In the first quarter of 2008, the company employed more than 65,000 people globally and produced 19.6 million ton of clinker and cement. The company also produced 61 million ton of aggregates and 10 million tons of ready-mixed concrete from its manufacturing operations.



Lehigh Cement Union Bridge main control room

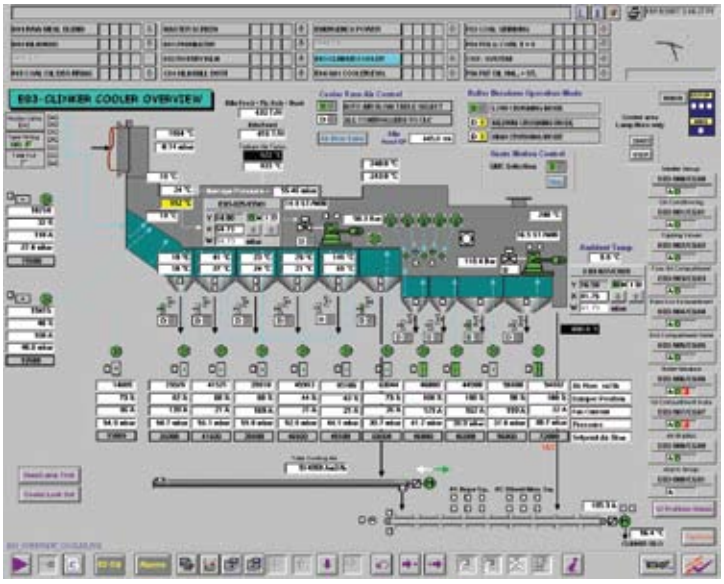
Bridging islands of automation

By modernizing the plant, Lehigh was able to eliminate the islands of automation that existed in the form of different PLC/HMI-based systems found throughout the facility, and subsequently increase productivity and efficiency.

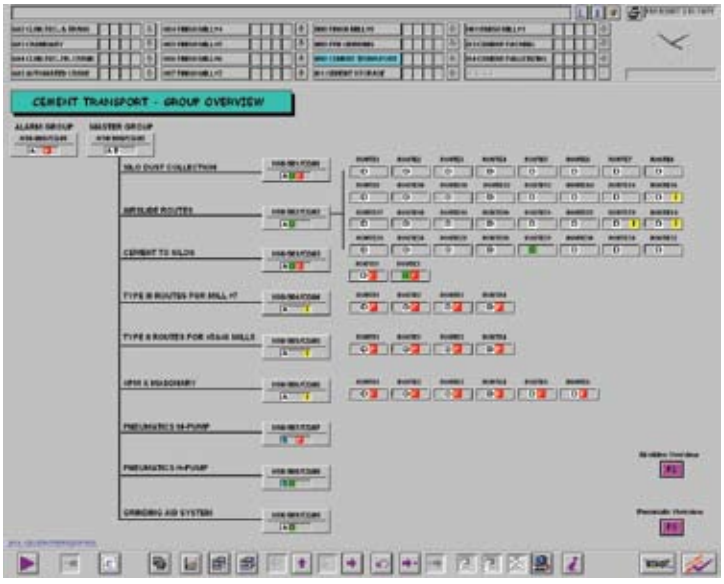
Lehigh knew it needed a process control system that could control and monitor everything from a centralized location. Meeting this complex requirement was no small task. The company sought to lower labor and operational costs by moving to a platform that could allow its process control specialists to view and manage the cement production equipment and processes from a single location.

Plant-wide integrated controls

As a result of the success Heidelberg Cement Group has seen globally, the company chose to standardize its automation platform at the Union Bridge facility with SIMATIC® PCS 7 and the CEMAT® application library from Siemens. One of the key benefits of this automation platform is found in the flexibility and functionality of the system. The diagnostics provided by the individual objects such as motors, valves, and dampers are consistently applied across the whole plant. An operator trained on one section of the plant can easily learn the operations of a new plant area or even the operations in a different plant across the Lehigh organization. This advantage allows managers to redeploy operators to the areas that need the most attention within the plant or to other Lehigh manufacturing facilities.



Clinker cooler with start-up group sequence on the right



Cement transport start-up sequence

Flexibility of an open system

With 17,600 I/Os currently active in the plant, and 3,000 more I/Os becoming active soon, the new system controls all sections of the cement plant. This includes everything from raw material mining, crushing, grinding, and blending; to the preheating tower and kiln temperature controls to produce clinker; to the roll press, grinding mill, packaging and bagging facility, and storage silos.

The CEMAT application library consists of pre-engineered function blocks, faceplates, and operator graphics designed for full operation of a cement plant. It delivers a uniform flow of data from mining of raw materials through the cement process with a high level of transparency. Integrating process optimization software packages from various vendors allows the system to easily add on controls for processes like a Mill Optimization System, a Kiln Shell Scanner, a Quality Control System, and a KCS (Kiln Control System) database to optimize kiln operations.

The application library provides clear direction to the operator on how to best operate a cement plant because many of the plant operations are built into the system. These operations include how to make a diagnosis to reduce downtime to a minimum in the event of a plant problem and how to interlock the drives, dampers, belt conveyors, and analog measurements throughout the plant. This also allows best operating practices at the plant to be shared across Lehigh's organization without making operators re-learn the basic operation philosophy or the functionality of the individual objects such as motors and dampers.

The functionality embedded in the function block is based on years of on-site experience, so engineering is simplified and reliable. This allows operators to focus on process interlocking that is unique to the particular process that is being assigned. Fault-finding is fast because of detailed fault messages that are grouped together in operational-specific areas or groups.

Central room for all controllers and engineering stations

Power monitoring

Lehigh's integration of power monitoring information into the PCS 7 system has proven to be extremely beneficial. According to the U.S. Department of Energy, 64 percent of the energy consumed in a process plant today is used to operate motors.* This fact highlights that the use of high-performance motors, the adoption of "Smart" MCC technology and the tight integration of motors and drives into a process automation system can have a significant impact on a company's bottom line. It cuts energy costs and enables more effective maintenance techniques.

Lehigh Cement uses this integration capability to lower energy consumption and cost throughout their manufacturing operations. The plant has a power monitoring system implemented by a dedicated PCS 7 controller, with 218 power monitoring devices connected via PROFIBUS. These devices have been installed on each of the motor control centers and drives, providing real-time information about the energy usage.

The power monitoring devices provide the operator with the power consumption, amps, voltage and the power factor sequencing in total numbers for each phase and current. With this capability, power consumption calculations and measurement for each area of the plant, even for each drive and motor, can be presented to the operator via the HMI screen. This enables the operator to have tight control over the plant's power usage. If an area is not running efficiently, operators will be able to see where the inefficiency is located and make adjustments accordingly. For example, if the power consumption spikes or the plant's per ton power consumption increases, supervisors can now take immediate action so that the performance of the entire process is optimized.

In the past, Lehigh Cement placed power monitoring devices in only a few key areas throughout its processes. Plant personnel had to go around and record measurements manually in those locations. It would not be until the end of the month, after the data was calculated, that they would discover the plant had an energy consumption problem. With the new system, there is no manual collection of data, and the plant operators can act immediately to fix the situation based on the real-time data.

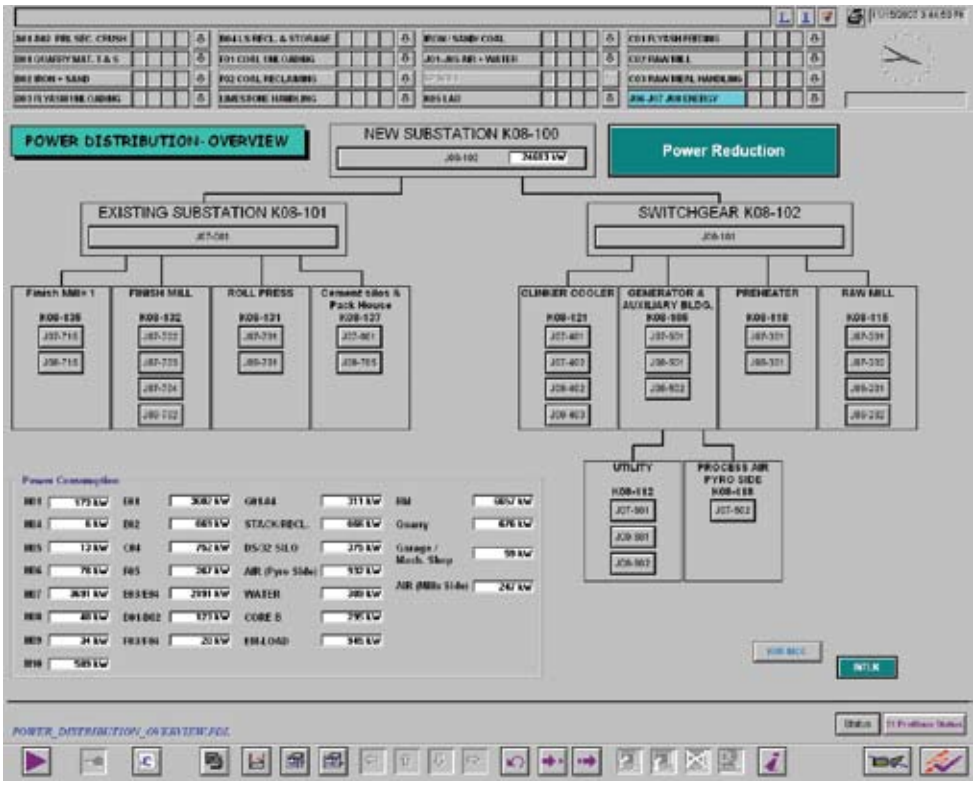
Medium-voltage substation with power monitoring device connected via PROFIBUS

Variable-speed drive connected to the main control via PROFIBUS

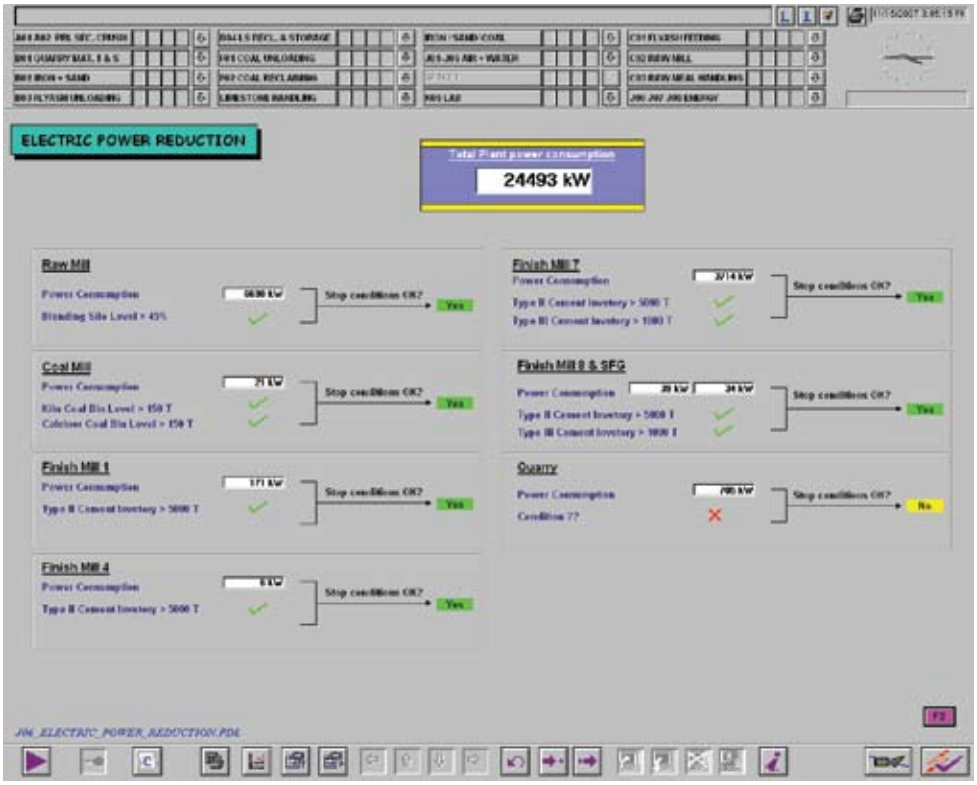
Load shedding for profit

Because the system provides real-time information about power consumption in different sections of the plant, Lehigh can sell power back to the utility if it does not completely utilize the power quota required for the entire operation of the plant.

Many manufacturing plants buy power in bulk per month at a fixed price. Market prices for power change about every five minutes. If market consumption goes high at any time and the prevailing prices are higher than what Lehigh paid at the beginning of the month, Lehigh has the option to sell some of its pre-purchased power back onto the open market at a rate higher than what it paid. By having the ability to precisely monitor its overall power consumption, Lehigh knows exactly where it has "excess" load that it can shed and sell back power to the utility at a higher rate to offset its energy costs.



Main incoming substation and power monitoring



Screens allow operators to make quick decisions on power reductions

The plant can also shed its power load selectively to avoid a complete plant shutdown in the event something happens on the grid in which the power company calls requesting the plant curtail its load immediately. Lehigh can, in real time, look at its power system and see what areas the plant can accommodate for the load reduction. With the PCS 7 system and power monitoring devices, this is very quick and easy for the operators. In emergencies, the utilities require the plant to cut the load within ten minutes. Almost immediately plant operators can view its system and decide what sections of the plant can be shut down to meet the power reduction in such a way that it has minimal impact on its production targets.

Lehigh Cement plant at Union Bridge

Results

The modernization of the manufacturing processes and implementation of fully-integrated process controls into the plant has been critical in increasing production, while reducing energy consumption and labor hours.

In 2007, the plant produced in excess of 1.8 Million metric tons of cement, a dramatic increase over its pre-modernization cement production. Similarly, plant clinker production has increased over the same period. Meanwhile, the energy consumption per ton has dropped.

The islands of automation that existed in several areas throughout the site are now integrated into the PCS 7/CEMAT software platform under one centralized location. The plant's 40,000 square-foot core building houses all activities supporting the manufacturing process, which can be controlled through 12 consoles by just one operator if necessary. The modernization project resulted in18 percent reduction in labor hours.

The integration of its new process control system has allowed Lehigh to optimize its energy management and improve process efficiencies throughout its facility. The functionality and diagnostics are now consistently applied across the whole plant, increasing operability and streamlining plant cost of operation.

Embracing plant-wide process controls

Clearly, reducing the total operating costs of a cement plant can be achieved by streamlining its process controls, and most efficiently by switching from a PLC/HMI-based format to one based on fully-integrated plant automation.

It is not a question of whether or not cement plants will embrace this technology; it is inevitable that plant economics will prove that this is the way to go. Those facilities that do will be in a better position to accelerate market share and increase profit margins.

High-speed process control functionality

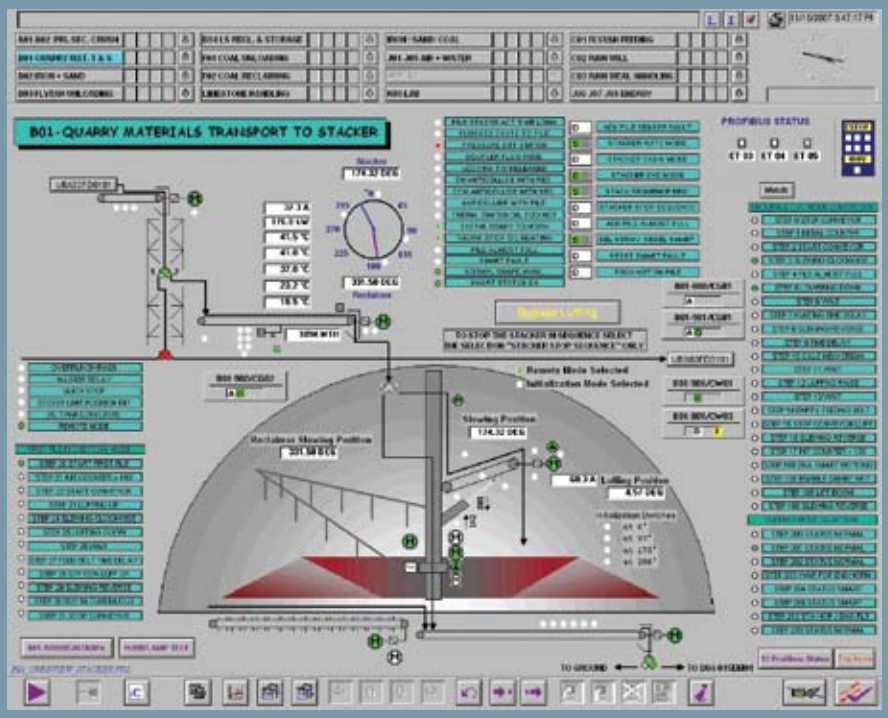
Cement plants are a combination of several process sub-sections combined to form continuous processes. OEMs supply mechanical equipment packages with sub-controls that perform specific functions within the sub-sections. The sub-controls are an integral part of the process, which take commands from the main plant control system and report status and messages. The sub-controls are normally implemented using high-speed, dedicated PLCs.

Lehigh Cement chose a different approach, as it found that PCS 7/CEMAT not only provided main process control, but was also capable of executing high-speed logic, which is the main requirement of OEM equipment. This approach allowed Lehigh to gain several benefits, including requiring a single engineering tool to program and maintain its control system. Operators no longer have to learn multiple tools to maintain and diagnose the equipment. Another advantage is that the communication of messages and control information reside in one system, allowing the operator consistent and clear information about the sub-controls. This makes the system easier to support, operate, configure and maintain long term.

One example of this is the logic for the clinker cooler grate hydraulic control, which is implemented in the clinker cooler controller, operating in a 5msec cycle. Another example is the logic control for the circular stacker, the reclaimer for the limestone and longitudinal stackers and the reclaimer for the other raw materials – all of which are implemented in the system.

In most cases with existing cement plants, the above equipment is controlled by a dedicated PLC supplied by the equipment suppliers. Since the amount of data exchanged with the main control system is limited, the operators have difficulty understanding if any problems exist. Troubleshooting is difficult because programmers and technical support have to be sent locally to fix any issues.

With this new, integrated approach, the PCS 7/CEMAT system provides a universal set of clear diagnostics and operation information to the operator on one screen for all process functions in the plant, including high-speed functions.



Circular stacker and reclaimer in the plant control center

Improving operational efficiency

Lehigh's system allows for a diverse range of applications to be integrated. A very interesting function, which has been built into the facility by the Lehigh engineering team, is an Automatic Load Positioning system at the plant's day silos for loading cement into trucks. The operation allows Lehigh to provide 24-hour/7 days a week bulk cement loading at its plant with only minimum intervention by the operator and truck driver.

The driver simply parks the bulk cement truck on a scale located under one of the six company loading lanes, then walks over to a card-scanning terminal and scans a pre-authorized magnetic card on a control panel to start the automated process. Since this self-serve operation is directly linked to the cement plant's SAP system, which is integrated with PCS 7, the driver does not have to do anything but open the loading hatch and wait for the system to approve his order. Once the driver's card and order is approved, a vision system, using a Siemens VS 10 camera, scans the top of the truck, finds the top hatch, extends a bellows over the opening, and begins loading the cement automatically.

Because the bulk cement hauler is on a scale during the loading process, an exact weight can be measured and recorded into the system. When the truck is full, typically with 25 tons of cement, the bellows retracts automatically and the driver receives an invoice and is ready to proceed to the delivery point.

The entire loading process takes only seven minutes, half the time it took before installing the system, and without the intervention of any plant personnel. The success of the Automatic Load Positioning system for the cement trucks has been so successful that Lehigh decided to adapt the system for its rail car loading operations.

* Ref.: U.S. Department of Energy Website, "Improve Motor System Efficiency with Motor Master," http://www.eere.energy.gov/industry/bestpractices, October 2005

Day silo – Automatic truck loading operation

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