January 2002

OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Upgrade of Compressed Air Control System Reduces Energy Costs at Michelin Tire Plant

Benefits

- Saves $75,000 annually
- Saves over 2 million kWh annually
- Improves efficiency
- Increases equipment life

Applications

Compressed air systems are found throughout industry and consume a significant portion of the electricity used by manufacturing plants. The efficiency of compressed air systems that use multiple compressors with individual compressor controls can be upgraded by installing an integrated multiple-compressor control system.

Summary

In 1997, Michelin North America upgraded the compressed air system controls at its tire manufacturing plant in Spartanburg, South Carolina. In response to growing energy costs and the desire to remain competitive in the tire industry, Michelin performed an internal evaluation of its compressed air system to determine how it could improve the system's efficiency and energy use. The evaluation provided the basis for a project to install a new control system. The controls upgrade project at Michelin's plant enabled multiple compressor operation without blow-off during load swings. In addition, the plant has been able to stabilize and lower pressure levels, leading to estimated annual energy savings of $75,000 and 2,143,000 kWh. The project's total cost was $120,000, giving the plant a simple payback of approximately a year and a half.

Plant Background

Michelin North America is a branch of the Compagnie Generale des Etablissements Michelin (CGEM), a tire manufacturer headquartered in Clermont-Ferrand, France, that has 18 percent of the global tire market. The company is composed of fifteen tire manufacturing plants, two products plants that are partially finished, and two textile plants.

Spartanburg Plant

The Spartanburg plant is a modern, vertically integrated facility that employs approximately 1,000 people who produce truck tires, steel belts, and bead rings on rims for large transport trucks. Compressed air directly supports the plant's production process, which includes cylinders, air motors, and conveyors. The plant's compressed air system is served by five 500-horsepower (hp) centrifugal compressors. Prior to the project, individual controls directed each of the five compressors; these individual controls were provided as standard equipment during installation in the late 1970s and 1980s. Under this configuration, the plant required all five compressors to operate at a discharge pressure of 125 psig in order to adequately supply the plant with the required air volume and pressure.

Project Overview

An internal review of energy consumption patterns at various Michelin North America facilities revealed that a similar Michelin facility in Canada had lower compressed air energy costs than the Spartanburg plant. The Spartanburg plant engineers decided to examine their plant's compressed air system to determine whether any efficiency gains were possible. The system review showed that the compressed air system had two main problems that were leading to excessive energy consumption.

The first problem was the compressor control strategy. With the existing configuration, each compressor's controls had to be manually set with its own, independent control pressure band. Since the plant's production characteristics are dynamic, the air demand varies. As the air demand increased and additional compressors were brought online, the plant pressure fluctuated widely and the pressure band between the first and the last compressor became progressively wider. This pressure differential was insufficient for a workable compressor control band, leading the compressors to enter into each other's throttling band. As a result, the plant could not sequence the compressors appropriately and had to operate all five of them continuously to ensure that the volume and pressure needed during the demand peaks would be met. All of the plant's compressors are centrifugal compressors, which need to vent air when the system demand falls below the compressors' minimum stable flow (see text box). Analysis by plant personnel revealed that approximately 1,000 scfm, or 14 percent of compressor output, was being vented into the atmosphere.

Next, plant personnel identified a significant pressure drop between the compressors and the end-use applications, which explained pressure fluctuations within the main header and inconsistent pressure at the points of use. The main cause of the plant's pressure drop was the leakage rate in the plant's distribution piping network, which caused the plant to set the compressor operating pressure higher than necessary. This leakage rate, which was almost 30 percent of the system's output, also created artificial demand. Artificial demand is the excess air required by a system's unregulated uses because the system is being operated at a pressure level in excess of actual production

Centrifugal Compressors

Centrifugal compressors blow off, or vent, compressed air into the atmosphere when the system demand falls below the compressors' minimum stable flow. This is because centrifugal compressors have a limited throttling capacity. If the system demand falls below a centrifugal compressor's minimum stable flow, it will vent excess air in order to prevent the system pressure from rising above its set-point. If the system pressure exceeds the compressor set-point, the airflow can reverse direction and come back into the impeller. This is a situation know as "surge" and it causes serious damage to the compressor.

requirements. The leakage rate required keeping all five compressors online to ensure adequate air pressure for end-use applications.

Project Implementation

The central engineers concluded that the system's control strategy was inefficient because the individual, pneumatic controls on each of the compressors did not allow them to react to the shifting demand patterns in a timely way. The engineers decided to replace the old controls with a single-loop, digitally programmable logic control (PLC) system. The new control system is capable of maintaining adequate pressure differential between the compressor pressure settings by centralizing the control of all five compressors within one single-pressure band. The new controls are sophisticated enough to respond to changes in air demand and can sequence the compressors more efficiently. In addition, the plant decided to identify and repair air leaks twice a year during normal plant maintenance shutdowns.

Project Results

The installation of new and upgraded controls has resulted in substantial energy savings and improved efficiency of the plant's compressed air system. The new controls provide a centralized control strategy that is much more responsive to changes in air demand, allowing the system to rapidly unload compressors when they are not needed. This improved control strategy has substantially reduced the compressor blow-off rate and has, along with the leak repair program, allowed the plant to stabilize its header pressure. The plant is now able to meet its air demand with four compressors instead of five, leaving one for backup use. The annual compressed air energy savings are estimated at $75,000 and 2,143,000 kWh. With a project cost of $120,000, the payback is estimated at one-and-a-half years.

THE NEW CONTROL SYSTEM

Lessons Learned

To gauge the success of a compressed air system project, operating costs before the project must be compared to operating costs after the project has been completed. In any industrial facility, it is important to benchmark the aggregate annual energy costs as well as the costs per unit of production. Once the improvements are made, the costs can be re-evaluated to accurately measure the project's impact on the plant's overall energy use as well as on its production. By benchmarking and comparing its total energy costs and its costs per unit of output, Michelin's Spartanburg plant was able to obtain a more complete picture of its project's success.

BestPractices is part of the Office of Industrial Technologies' (OIT's) Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together the best-available and emerging technologies and practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

Project Partners

Michelin North America
Spartanburg, SC

For Additional Information, Please Contact:

OIT Clearinghouse
Phone: (800) 862-2086
Fax: (360) 586-8303
clearinghouse@ee.doe.gov

Visit our home page at
www.oit.doe.gov

Please send any comments, questions, or suggestions to
webmaster.oit@ee.doe.gov

Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

DOE/GO-102002-1369
January 2002