BestPractices Case Study

Industrial Technologies Program—Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

American Water Heater Company: Compressed Air System Optimization Project Saves Energy and Improves Production at Water Heater Plant

Benefits

- Saves $160,000 annually
- Saves 2,345,000 kWh annually
- Improves product quality
- Reduces maintenance costs
- Increases production by 12% annually
- Achieves a simple payback of 17 months

Applications

Compressed air systems are found throughout industry and consume a significant portion of the electricity used by manufacturing plants. Maintaining a stable, consistent flow of clean air improves system performance and reliability, lowers energy consumption, and improves productivity. The compressed air optimization project described here, along with its accompanying benefits, can be replicated throughout industry.

Summary

In 2001, American Water Heater Company (AWHC) implemented a system-level project on the compressed air system that serves its manufacturing plant in Johnson City, Tennessee. The project involved a total system reconfiguration that stabilized the system pressure and improved its air treatment capability. The project's implementation enabled the system to support the plant's production processes more effectively, which significantly improved product quality and allowed for greater production. The plant can now operate with less compressor capacity, which has reduced its energy consumption and maintenance needs. The project's total cost was $228,000; the annual compressed air energy savings (2,345,000 kWh) and maintenance savings total $160,000, yielding a simple payback of 17 months.

Company/Plant Background

Located in Johnson City, Tennessee, AWHC is a leading manufacturer of high-quality residential and commercial water heaters. It employs more than 1,000 people in modern manufacturing and warehouse facilities and produces thousands of water heaters each day.

The plant's compressed air system is served by four 350-hp and one 250-hp lubricated rotary screw compressors that total 1,650 hp. The plant requires compressed air for various industrial applications in four separate production centers. Each of the four production areas has different pressure and/or air quality level requirements. Before the project was implemented, the plant operated all five compressors during normal production to maintain a desired pressure level of 90 psig. However, the main header pressure fluctuated between 83 and 111 psig and was beset with poor air quality that negatively affected production.

Project Overview

In early 2000, plant personnel commissioned a U.S. Department of Energy Allied Partner, Compressed Air Management of Louisville, Kentucky, to evaluate the system. A compressed air system audit by Compressed Air Management revealed the causes of the system's problems and provided a system-level strategy to improve its performance (see text box).

The evaluation showed that two factors led to the system's unstable pressure:

- Inadequate storage and shifting air demand patterns produced large swings in pressure. Plant personnel responded to the pressure swings by bringing all of the compressors online.
- The plant's production is divided into four separate zones, one of which is at the far north end of the plant. That zone's location requires the air to travel a long way to serve its applications. Also, the compressors were located in two separate rooms, which effectively meant that the plant had two compressed air systems operating independently of each other.

Front Entrance to American Water Heater Plant

Next, the evaluation found that the air in the plant was contaminated because of poorly functioning air treatment equipment. The system was served by deliquescent air dryers, which were both undersized and unable to provide the suitable pressure-dew-point (PDP) for the plant's applications. As a result, the dryers allowed excess condensate to pass into the air stream. In addition, the condensate drains in the dryers were equipped with unreliable ball valves. When the dryers discharged their waste, these ball valves allowed the waste to pass into the air. The greatest impact of the poor air quality was felt in the powder coating area that requires a PDP of -40°F for reliable production. Even had they been properly sized, the deliquescent dryers could not have achieved this PDP level.

In addition, a poor control scheme, a convoluted distribution piping network, leaks, and excess heat in the compressor rooms during the summer decreased system efficiency. The controls were manually operated start/stop controls and plant personnel had to either operate all compressors simultaneously or wait until an increase in air demand caused the pressure to fall before bringing more units online. This led to the inefficient compressor operation and large pressure excursions.

Project Implementation

Per the evaluation findings, plant personnel applied a systems approach to optimize the compressed air system. The company implemented the project in two phases to address the most critical issues and mitigate the production impact.

In phase 1, the system pressure was stabilized and reduced to the lowest level that satisfied production requirements. Although two of the plant's four production zones share the same pressure requirement, their air quality needs differ. A pressure/flow controller was installed for each zone to partition the system into four zones. Two 3,750-gallon storage tanks were added and the largest leaks in the system were repaired. Once the pressure/flow controllers were installed, the pressure in each zone was set at the lowest level that satisfied that zone's end uses.

In the second phase, plant personnel replaced the deliquescent dryers with a combination of refrigerated and desiccant dryers. Refrigerated dryers were installed in the three production zones whose applications could operate well with air having a PDP of 39°F and a desiccant dryer was installed in the zone that requires very dry air (PDP -40°F). Next, plant personnel reconfigured some system piping, changed the cooling system from an air-cooled to a closed-loop system, replaced the condensate drains and upgraded the controls by installing a compressor sequencer with a data acquisition system.

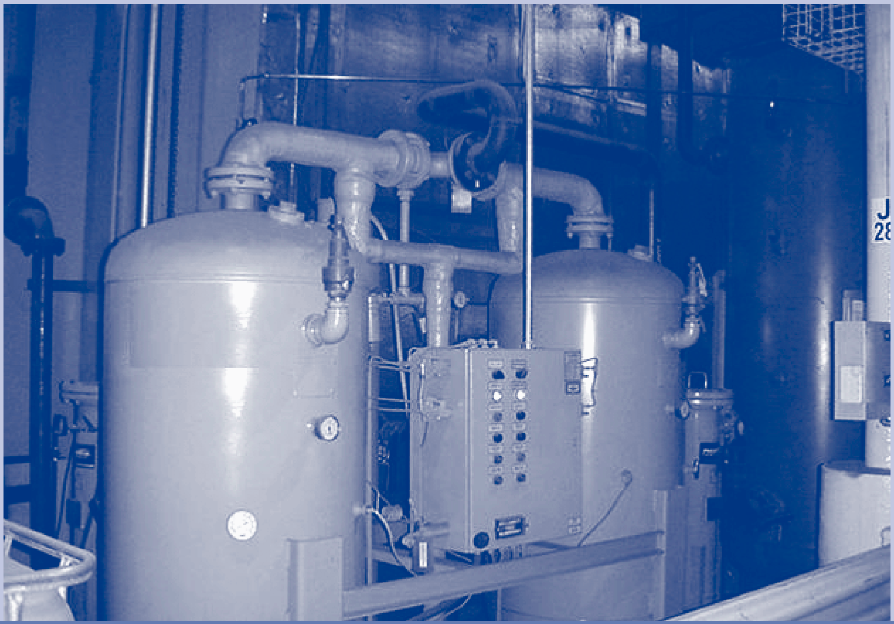
Finally, plant personnel consolidated the compressors into one compressor room. Part of the plant is located over an underground cave containing cool (70°F) air. To maintain cool intake air, the compressors were placed in a room that straddles the cave so the cool air could be piped into it. Placing the compressors in this room eliminated the need to cool the intake air artificially.

Project Results

The project substantially improved the compressed air system's performance, yielding significant savings and better production. Each production zone now enjoys stable pressure. The compressors deliver air to the storage receivers at 96 psig, and the pressure/flow controllers release air going from them to within +/- 2 psig. Because of the lower and stable pressure, and the reduced air demand resulting from the leak repair effort, the system requires less compressor capacity. The plant now needs to operate only two 350-hp compressors and a 250-hp unit in trim mode. As a result, plant personnel can rotate the 350-hp units to avoid excess wear of either compressor. The more optimal size and type of dryers substantially improved the air quality and eliminated the moisture contamination. As a result, the air is now dry enough for the compressed air applications to function well.

The project also yielded substantial energy and maintenance savings and improved production. Because of reduced compressor use, the plant achieves annual compressed air energy savings of $129,000 and 2,345,000 kWh. By using fewer compressors and converting to closed-loop cooling, the plant also saves $31,000 annually in maintenance and cooling process costs. With total annual savings of $160,000 and a total project cost of $228,000, the simple payback is 17 months. Finally, the stable pressure coupled with the elimination of contaminated air has improved production. The plant's production has increased by 12% and product quality has improved as evidenced by a 22% reduction in warranty claims.

Creek that Supplies Cool Intake Air to Compressors



Desiccant Dryer

Lessons Learned

Configuring a compressed air system to deliver stable, clean air is important for optimal performance, energy efficiency, and reliable production. At the Johnson City plant, fluctuating pressure levels caused the system to waste energy because they led plant personnel to use excess compressor capacity. At the same time, inappropriate and inadequate air treatment inhibited production by preventing the end use applications from operating properly. The project saved energy and improved production because it stabilized and lowered system pressure, and eliminated the contaminants in the air. However, the project's significance lay in its approach toward treating and stabilizing the air. Instead of installing desiccant dryers for the whole plant, which would have been more expensive, one desiccant dryer was dedicated for the applications that needed very dry air, and refrigerated air dryers were installed for the rest of the plant. The project thus achieved the most cost-effective level of air treatment and pressure that supports reliable production.

Levels of Analysis

The Compressed Air Challenge has developed guidelines to define three levels of compressed air system analysis services, independent of the type of firm offering these services. These three levels of service include a walk-through evaluation, a system assessment, and a fully instrumented system audit. A **walk-through evaluation** is an overview of a plant's compressed air system that identifies the types, needs, and appropriateness of end uses, pressure levels, and air quality requirements. A **system assessment** is more detailed than a walk-through evaluation and a written report of findings and recommendations is submitted at its conclusion. Readings are taken to identify the system dynamics, and generate a block diagram along with a pressure and demand profile. A **system audit** is similar to a system assessment, but is more in-depth and detailed. A comprehensive written report of all findings, recommendations, and results is provided at its conclusion. Auditors install data loggers to measure all important parameters to establish a baseline against which any proposed changes can be measured. For more information, see ***www.compressedairchallenge.org***.

BestPractices is part of the Industrial Technologies Program, and it supports the Industries of the Future strategy. This strategy helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and energy-management best 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

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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