METAL CASTING

BestPractices
Technical Case Study

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ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Compressed Air System Improvement Project Saves Foundry Energy and Increases Production

Benefits

- Saves $395,000 annually
- Saves 7,225,000 kilowatt-hours (kWh) annually
- Improves product quality
- Reduces maintenance costs
- Increases production
- Improves system reliability

Applications

Compressed air systems are widely used in industrial applications and are often among the most electricity-intensive systems in a plant. Maintaining a stable, consistent flow of clean air allows any industrial compressed air system to perform efficiently and leads to greater reliability, lower energy consumption, and better productivity.

Summary

In the late 1990s, International Truck and Engine Corporation implemented an optimization project on the compressed air system that serves their foundry, Indianapolis Casting Corporation (ICC) in Indianapolis, Indiana. Because of the project's implementation, the system's efficiency was greatly improved, which allowed the foundry to operate with less compressor capacity and to reduce its energy consumption. The project's implementation also resulted in significant maintenance savings and more reliable production. The project's total cost was $800,000.The annual compressed air energy and maintenance savings were $395,000 and more than 7.2 million kilowatt-hours (kWh), yielding a simple payback of just slightly more than 2 years.

Company/Plant Background

ICC is located next door to International Truck and Engine Corporation's engine assembly plant in Indianapolis, Indiana. The foundry employs approximately 500 people and produces engine blocks and heads for the Indianapolis engine assembly plant and for International Truck and Engine Corporation's assembly plant in Melrose Park, Illinois. A central powerhouse located in the engine assembly plant provides the foundry's compressed air.

ENTRANCE TO INDIANAPOLIS CASTING CORPORATION FOUNDRY

Before the project, the foundry and the adjacent engine plant both depended on a compressed air system that was served by four compressors. The compressors totaled 6,100 horsepower (hp) and generated 25,000 standard cubic feet per minute (scfm), 80 percent of which was needed by the foundry. Two of the compressors were 3,000-hp and 1,500-hp centrifugal units; the other two were 800-hp reciprocating compressors. The foundry requires compressed air for a number of applications, but compressed air is most critical for its molding equipment, which needs large volumes of air to perform its processes. For the foundry's production to be reliable, it was believed that a header pressure level of no less than 100 pounds per square inch gauged (psig) was necessary. Although the powerhouse frequently operated all four compressors at varying loads to try to maintain 100 psig, the header pressure was unstable and fluctuated between 81 and 104 psig.

Project Overview

In 1997, a system-level evaluation was performed on the compressed air system by independent experts during a plant-wide energy assessment. The evaluation found several factors that led to the inefficient performance of the compressed air system. The recommendations made in the evaluation formed the basis for the plant's compressed air system improvement project, which was implemented over 2 years and resulted in better system performance, reduced energy costs, and increased production.

The evaluation showed that the unstable pressure was largely caused by intermittent air demand from heavy compressed air end-uses in the foundry, particularly two large molding machines, which are in each of the two production lines. These production lines need to be operated for one hour prior to production to clear excess sand and powder from the equipment. The sudden start of the second line would cause an immediate 6,000-scfm demand in the main header and a severe loss of pressure. As more applications on the production line began to operate, the air demand increased by as much as 10,000 sfcm. The resulting loss of pressure due to excess demand caused the pneumatic applications in the foundry to fail, leading to several production shutdowns per week.

Next, the evaluation found that high levels of moisture and oil were carrying over into the main header. Three factors were causing the moisture and lubricant carryover. First, the air dryer in the powerhouse was undersized and in poor condition, which prevented it from achieving the pressure-dew-point needed by the foundry, and which allowed condensate to become entrained into the system (see text box). Second, some of the distribution piping from the powerhouse to the foundry was outdoors and not insulated. This allowed for air in the header to be exposed to temperatures that further raised the pressure dewpoint and caused more condensate to go into the foundry's production lines. Finally, the lubricant was coming into the system because of inadequate filtration equipment in the powerhouse to remove oil discharge from the reciprocating compressors.

The foundry's solution to the moisture and lubricant carryover was to open all blow off valves on the production lines upon start up to bleed lubricant out of the system, causing the system to blow off over 5,000 scfm. In addition, the foundry had seven dryers to treat the air going to its core production operations. While these dryers provided adequate air quality, their location near the end-use applications increased the pressure drop in the compressed air system. The increased pressure drop from the seven dryers, coupled with the amount of air being blown off, led the powerhouse to bring more compressors online to provide the foundry with the volume and pressure it needed.

The compressor operating scheme was another problem that surfaced. Because each compressor was controlled individually, the powerhouse personnel had to wait until a jump in air demand caused the pressure to fall before reacting by bringing more compressors online to satisfy the change in air demand. Starting and stopping the compressors was complicated by the fact that the individual compressor controls were antiquated and sometimes unreliable. This led to the inefficient operation of four compressors simultaneously, with none of them at full load.

In addition, the assessment estimated that the air leakage rate in the foundry represented up to 15 percent of its total air demand. The assessment team recommended that a leak detection and repair campaign be performed. The consultants then found that cabinet cooling was so widespread that it was responsible for up to 10 percent of the foundry's air demand. They also noted that additional data acquisition equipment was necessary because powerhouse personnel relied on flowcharts to determine when to shut off compressors. Finally, the consultants suggested that a training session be held to educate personnel from the powerhouse, maintenance, and production about the costs of compressed air and about operating a compressed air system efficiently.

Project Implementation

At the conclusion of the assessment, the staff decided to implement the recommendations incrementally to address the most critical production issues. The project's initial focus was on stabilizing and lowering the pressure to the lowest level that satisfied production requirements in the foundry. To accomplish the pressure stabilization, the plant purchased and installed two pressure/flow controllers and two 15,000-gallon dedicated storage tanks to serve the foundry. In addition, the pressure level was set at a level that was more closely aligned with the minimum operating pressure of the end-use applications. In the foundry, the pressure coming from the controller was set at 92 psig.

Foundry staff implemented additional measures to improve the compressed air system in accordance with the assessment's proposals. The staff performed an immediate leak repair campaign and decided to perform leak identification and repair operations twice per year during the plant's maintenance shut downs. Foundry personnel also decided to install individual air conditioning units to reduce the use of compressed air for cabinet cooling.

In the powerhouse, two new dryers rated for 12,500 scfm each were installed to reduce the pressure drop and lower the air treatment operating and maintenance costs. In addition, a training session was held for the powerhouse personnel to raise awareness about compressed air costs and about operating their system effectively with the new storage and control apparatus it now possessed.

Project Results

Once the project was complete, the plant witnessed a substantial improvement in the system's performance. The unstable pressure that had plagued the system was sharply reduced since the pressure/flow controllers, along with the storage capacity stabilized the system's pressure level. The compressors now deliver air to the storage receivers at 105 psig, and the controllers regulate the air going from it at 92 psig +/- 2 psig. Because the pressure is more stable—and the foundry is able to operate at a lower pressure—its air demand is lower, which requires operation of fewer compressors. The reduced need for compressors has improved the compressor operating profile. Before the project, the operating profile was as follows:

3,000-hp centrifugal compressor	90% loaded
1,500-hp centrifugal compressor	88% loaded
800-hp reciprocating compressor	65% loaded
800-hp reciprocating compressor	standby, up to 50% loaded

By the end of the project's implementation, the foundry's air demand was between 12,000 and 15,000 scfm versus more than 20,000 scfm and it can be adequately served with 3,000 to 3,800 hp. The compressor operating profile is now as follows:

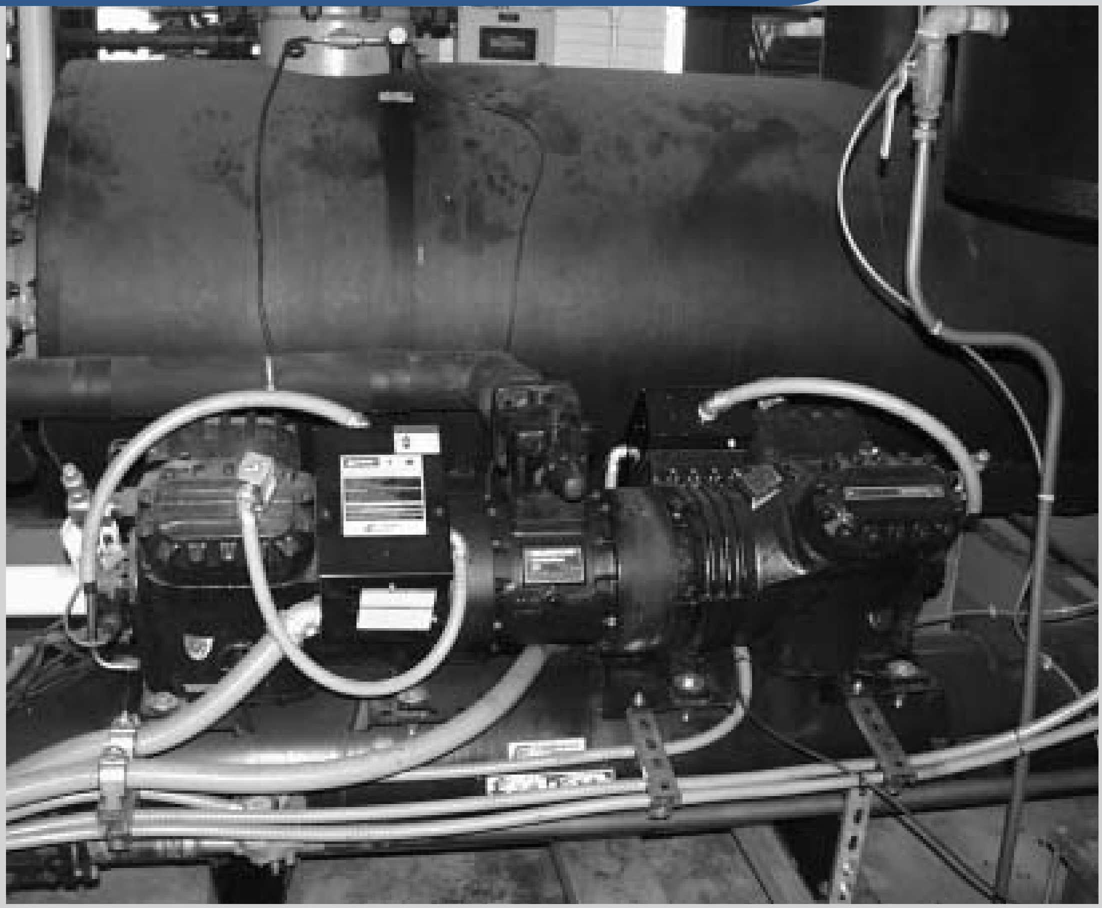
3,000-hp centrifugal compressor	100% loaded
1,500-hp centrifugal compressor	off
800-hp reciprocating compressor	off
800-hp reciprocating compressor	standby, up to 50% loaded

The implementation of the rest of the evaluation's recommendations further enhanced the efficiency of the compressed air system, leading to a reduction in required compressor capacity and better production. The leak repairs, along with the reduction in cabinet cooling, have reduced the foundry's air demand by approximately 3,000 scfm. The moisture carryover is largely eliminated because of the new dryers that are more appropriately sized for the volume of air that needs to be treated. Because the reciprocating compressors are off most of the time, there is minimal oil discharge and no more lubricant carryover.

The training session raised awareness among powerhouse personnel of the need to treat a compressed air system as a system instead of focusing on its individual components. This awareness has helped them to understand how to operate the compressors within the context of a storage and control strategy.

In addition to better system performance, the project's implementation resulted in considerable energy and maintenance savings and allowed for better production. Because compressor use is

One of the Two New Dryers, Rated at 12,500 scfm Each



substantially lower, the plant's power demand has fallen, leading to annual compressed air energy savings of $325,000 and more than 7.2 million kWh. The reduced compressor use has led to lower compressor maintenance requirements, resulting in annual maintenance savings of $70,000. With total annual savings of $395,000 and a total project cost of $800,000, the simple payback is slightly more than 2 years.

Finally, the stable pressure, coupled with reduction in moisture and lubricant carryover, has improved the operation of the foundry's compressed air applications. Because the air pressure is consistent and the system has adequate storage, the foundry no longer experiences production interruptions. The drier, lubricant-free air has led to a reduction in the amount of scrapped parts.

Lessons Learned

Converting to and maintaining a well-designed, stable, and uncontaminated supply of air is important for a compressed air system to operate efficiently, and leads to energy savings and improved production. In the case of ICC, severe fluctuations in air demand patterns and inadequate air treatment led the plant to operate more compressors than necessary, resulting in compressed air waste. Furthermore, the system's data acquisition and control strategy forced the compressor operators to wait until the system pressure fell to an unacceptably low level before bringing additional compressors online, causing production downtime. Once the facility modified its system by stabilizing and lowering the pressure, eliminating the moisture and lubricant carryover, and reducing its demand by repairing leaks and misapplied end uses, the compressed air system functioned more effectively. The system's more efficient operation resulted in substantial compressed air energy and maintenance savings and increased production for the foundry.

An Appropriate Pressure Dewpoint

Achieving the appropriate pressure dewpoint of compressed air is essential for reliable production. The pressure dewpoint is the temperature at which water vapor in the compressed air begins to condense. The lower the pressure dewpoint, the drier the compressed air. Because different types of dryers can achieve different pressure dewpoints, it is important to determine the degree of dryness required by a plant's production parameters before selecting the type and size of dryer for its compressed air system. Determining the appropriate level of dryness is also important because drying air beyond the minimum required level is very costly and wastes energy.

Most compressed air dryers are deliquescent, refrigerated, or desiccant. Deliquescent dryers tend to provide a pressure dewpoint that is 20° F lower than the dew point of the air entering it. Refrigerated dryers provide a pressure dewpoint of between 35° and 38° F, and desiccant dryers can provide a pressure dewpoint of -40° F. Once the required degree of dryness is determined, it is important to know the volume of air to be treated and its pressure before selecting a specific dryer. In addition, the temperatures of the inlet air and the air at the dryer's location must meet the manufacturer-specified levels in order for a dryer to provide its rated pressure dewpoint.

Industry of the Future—Metal Casting

The metal casting industry—represented by the American Foundrymen's Society (AFS), North American Die Casting Association (NADCA), and the Steel Founder's Society of America (SFSA), has prepared a document, ***"Beyond 2000,"*** *to define the industry's vision for the year 2020. Industrial Technologies Program Metal Casting Vision Team partners with metal casters, national laboratories, universities, and trade/environmental/technical organizations to develop and implement energy efficiency technologies that benefit both the industry and the United States. Recently, the Metal Casting Team facilitated the development of the Metal Casting Technology Roadmap, which outlines industry's near-, mid-, and long-term R&D goals.*

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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 emerging technologies and best energy management 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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Compressed Air Management, Inc.
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Compressed Air Technical Services
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