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Case Study:
Bibby-Ste-Croix

Energy Efficiency in the Production of Cast Iron

Highlights

- Compressed air costs reduced by 30 percent
- Electricity used in the compressed air system reduced by 32 percent
- Natural gas consumption reduced by about 200 000 m^3 annually
- Greenhouse gas emissions reduced by about 300 tonnes CO_2e annually

In 2004, with support from Natural Resources Canada's Canadian Industry Program for Energy Conservation, Bibby-Ste-Croix, a cast-iron foundry, had an energy audit conducted at its Sainte-Croix, Quebec, plant. The energy efficiency measures identified in the audit focused on reducing the plant's consumption of natural gas and electricity by optimizing the compressed air system and recovering heat from the cupola's combustion exhaust. By implementing some of the recommended measures, the plant was able to reduce the cost of compressed air by 30 percent. It also reduced its space-heating costs by recovering the heat given off by the compressors.

Plant profile

Bibby-Ste-Croix designs and manufactures grey and ductile cast iron, specializing in drain, waste and vent piping for commercial and residential buildings, waterworks and street castings, and all types of Original Equipment Manufacturer (OEM) castings. The foundry also manufactures counterweights, agricultural machinery, pump and marine equipment, hog grates, wood stoves and stadium seating.

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Canada

As part of its manufacturing process, Bibby's two foundries recycle more than 57 000 metric tonnes of scrap iron per year. Foundry Ste-Croix uses cupolas and electric furnaces to melt the scrap iron that is then poured into sand moulds. When the cast iron has cooled, the mould is broken to release the piece, which can then be painted.

Electricity, natural gas and coal are used in the foundry's production processes, while natural gas is used for space heating. In 2003–2004, the plant consumed 27.6 gigawatt hours (GWh) of electricity, at a cost of approximately $1,400,000. It used 2 300 000 cubic metres (m^3) of natural gas, at a cost in excess of $1 million. The plant's coal costs reached $1 million.

Energy audit

The Bibby-Ste-Croix foundry audit, conducted by Opti-Conseil inc., included electrical and thermal components. The proposed energy efficiency measures involved optimizing the plant's network of compressed air lines and recovering heat from flue gases for space and process heating.

Compressed Air System Optimization

Two options were proposed for optimizing the compressed air system. The first option involved purchasing two new air compressors, plugging leaks and implementing smaller measures, such as changing the breathable compressed air system to reduce pressure in the air lines connected to the respiratory helmets used in specific areas throughout the plant. This energy-savings measure offered a payback period of 1.7 years.

The second option included purchasing three new air compressors, but it did not address reducing the demand for compressed air. The payback period for this project was 2.5 years. In both options, the company took into consideration recovering the heat given off by the compressors.

The plant chose to implement the second option because it did not involve making changes to the compressed air system, and it had a relatively short payback period. The calculation of the payback period took into account the financial assistance the plant received from Hydro-Québec's Industrial Initiatives Program.

Bibby-Ste-Croix uses compressed air to operate its production equipment, such as pumps and air motors, to maintain combustion air currents at the required levels and to supply respiratory helmets. The plant used eight single-speed, air-cooled, oil-injected screw compressors to meet its compressed air requirements for a total rating of 1007 kilowatts (kW) (1350 horsepower [hp]). The annual electricity bill to operate the compressed air system exceeded $275,000. This system was replaced with three new air-cooled compressors: two single-speed, 224 kW (300-hp) compressors and one variable-speed, 187 kW (250-hp) compressor.

The combination of single- and variable-speed compressors allows for running the single-speed compressors at full capacity, while using the variable-speed compressor to modulate the production of compressed air to match the demand. A single-speed compressor runs at the same speed whenever it is on, while a variable-speed compressor adjusts the speed of its drive motor so that the production of compressed air matches the demand placed on the system, which reduces energy costs. Sequential controls ensure the automatic operation of the compressors operating in parallel.

Pressure control in the compressed air system improved considerably with the addition of a new compressed air reservoir. This reservoir receives the compressed air as it is produced and acts as a buffer downstream from the compressors, cushioning fluctuations in the air flow. It also removes the water that is introduced into the distribution lines. When compressed air leaves the compressor, it is warm and contains moisture. As the air cools, the moisture condenses to form water, which can corrode the lines, valves and other system components. This situation increases maintenance and operating costs.

Because two of the compressors used in the old system could not cool the compressed air they produced, warm humid air was introduced into the compressed air lines. During the summer, up to 265 litres (L) (58 imperial gallons) of water were carried into the lines every day, and approximately 68 L (15 imperial gallons) per day during the winter. This significant volume of water in the compressed air had a detrimental effect on the performance of the air dryers, which were used to remove moisture from the air before it was introduced into the distribution lines.

The old system used individual air dryers, with heatless regeneration of the desiccant bed, to remove the moisture before the air was introduced into the distribution lines. This type of dryer uses absorbent material to remove moisture from the compressed air. It also consumes approximately 15 percent of the compressed air already treated to regenerate the desiccant saturated by the moisture collected from the compressed air. The compressors in the new system are connected to a single refrigerant air dryer, thereby reducing the quantity of compressed air used for regenerating the desiccant and eliminating the problems of moisture in the lines.

Air compressors generate a considerable amount of heat: generally 80 to 90 percent of the electrical energy supplied to a compressor is converted into heat. At Bibby-Ste-Croix, this heat is now recovered. In the winter, the air used to cool the compressor is vented into the plant and turned into supplementary space heating. In the summer, it is vented outside.

The new compressors were installed by a team of subcontractors working under the direction of plant staff. Purchase and installation costs for the replacement of the compressors were approximately $750,000, while the replacement costs of the compressed air dryer were approximately $45,000. An incentive of $335,000 from Hydro-Québec helped offset the costs of the new equipment.

Heat Recovery

The auditors evaluated several options for employing heat from the cupola's combustion exhaust. The options included the following:

- Space heating — preheating the air of the plant's supplementary air systems or supplying new unit heaters as an alternative to the natural gas furnaces, which had payback periods of 5.7 and 1.2 years, respectively
- Heating the air supplied to the paint dryers offered a payback period of 5 years
- Providing heat for a new ventilation system, which would reduce air infiltration, had a payback period of 1 year
- Heating the water used for conditioning the sand, which had a payback period of 4.8 years

In addition, the auditors proposed measures for recovering heat around the pipes' production and using it for space heating. This option had a payback period of 2.4 years.

Bibby-Ste-Croix has not yet implemented any of the thermal options proposed in the study at its Foundry Sainte-Croix, but is examining them for future implementation.

Results

By implementing several of the measures proposed in the energy audit, Bibby-Ste-Croix reduced its annual electricity consumption by 2.1 GWh, saving over $85,000, or 30 percent of the cost associated with its compressed air system. By installing a new system for drying the compressed air, the plant saved $7,000 annually. Finally, by recovering energy from the air used to cool the compressors, the plant reduced its annual consumption of natural gas by 200 000 m^3. This saved $84,000 on space heating costs and reduced its greenhouse gas emissions by nearly 300 tonnes of CO_2 equivalent (CO_2e).

The electrical energy solutions proposed were considered economically feasible, given their relatively short payback periods. In addition to the significant energy savings, the new equipment allows for enhanced air pressure control and eliminates moisture in the compressed air distribution lines, thus avoiding corrosion problems and excessive costs for maintenance.

Key to the success of Bibby-Ste-Croix's energy audit was the company's commitment and determination to improve the energy efficiency of its manufacturing operations. By upgrading its compressed air system, it achieved this goal.

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