STEEL

Project Fact Sheet

A Motor Challenge Technical Case Study

Reducing BOF Hood Scrubber Energy Costs at a Steel Mill

Project Summary

To remain competitive in the rapidly changing global marketplace, Bethlehem Steel Corporation (BSC), the second largest producer of steel in the United States, was looking for opportunities to reduce energy costs, while improving overall steel-making system performance at its Burns Harbor Facility in northwest Indiana. The Basic Oxygen Furnace (BOF) #3 was identified as a key piece of equipment where significant energy savings were possible. By installing a variable frequency drive (VFD) and making associated equipment modifications to the induced draft fans that remove gases from this BOF, BSC was able to better match the fan's speeds to the BOF's varying requirements, which saved energy, reduced operational costs, and decreased system maintenance.

Plant Overview

The Burns Harbor Facility, located on about 1,700 acres on the shores of Lake Michigan, is BSC's largest and most efficient plant. Built in 1964, the plant employs 6,000 workers and is capable of producing 5.3 million tons of hot-rolled sheet, cold-rolled sheet, and steel plates. The plant is a major supplier of sheet and plate products to the automotive, machinery, and appliance markets.

Basic Oxygen Furnace No. 3

Benefits

- Reduced average monthly energy consumption by nearly 50 percent
- Payback of 2 years
- Achieved annual savings of $310,000 for BSC and GCC each
- Decreased noise levels
- Improved the system's tolerance to slight imbalances
- Reduced maintenance and downtime
- Increased production flexibility

Applications

Can be applied to any ventilation or fan system requiring variable output to meet changing demands. Other applications include climate control systems, laboratory ventilation systems, boilers and furnaces, and industrial processes. VFDs can also be used on systems like blowers, pumps, compressors, grinders, mills, and conveyors. Estimates show that the use of VFDs nationwide could result in energy savings of up to 99 billion kWh.

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Project Background

Due to stiff global competition, domestic steel producers have been forced to improve the efficiency of their steel-making operations or shut down. With daily electricity, natural gas, and potable water costs of $300,000 at its Burns Harbor Facility, BSC realized that addressing energy costs could save money and improve the plant's competitive position.

Project Team

BSC hired General Conservation Corporation (GCC) to identify and implement potential energy efficiency measures on specific operations at the Burns Harbor Facility. GCC funded the entire project in exchange for approximately 50 percent of the project's annual energy savings. Meade Industrial Services, Inc., performed the project's electrical installation and the U.S. DOE performed energy savings validation.

The Old System

An integral part of the steel-making process involves blowing gaseous oxygen into the BOF, generating high temperatures and chemical reactions that oxidize impurities in the metal and convert the iron into steel. The Burns Harbor Facility has three BOFs, each capable of making approximately 300 tons of molten steel in 30 minutes. This case study focuses on BOF #3. The gases generated when oxygen is blown into BOF #3 are removed by an induced draft fan. The synchronous fan motor, which always operates at a power factor of 1.0, is 7,000 horsepower (hp), 13,800 volts, 60 Hz, and 1,200 rpm. A 12-foot diameter duct carries the gases to a convergent region of piping where the gas is cooled and cleaned by a set of quenchers before being channeled to a scrubber where additional particulate matter is removed. The gases then travel to an induced draft fan, which has a set of dampers upstream to regulate gas flow, continue on through a silencer, and finally pass through an outlet stack and into the atmosphere.

The BOF heat cycle, which consists of six operations of varying flow requirements, takes approximately 45 minutes from start to finish. Idle periods of irregular length occur between cycles. The fans, however, were operated continuously at 1,200 rpm. Analysis of this procedure indicated that maximum flow was only needed during one-third of the BOF's cycle. To meet these widely varying ventilation requirements, the inlet dampers on the induced draft fans were modulated. This method, however, introduced unnecessary pressure drop to the system. In addition, while the ventilation system was designed to handle a flow of 40,000 SCFM of oxygen, the BOF's oxygen flow rate usually operated between 25,000 and 30,000 SCFM. As such, the induced draft fan system was considerably oversized for current plant requirements, and the fan speed of 1,200 rpm was much higher than needed.

Project Implementation

In 1987, GCC recommended that a VFD be installed to modulate the flow and that the inlet damper to the induced draft fan be kept open at all times to increase flow control efficiency. BSC, however, was hesitant to make this change, because, although the existing system was not energy efficient, it did run smoothly. BSC was wary of replacing a critical piece of equipment with one that was still unproven in projects of this magnitude. Finally, BSC did not have the necessary funds to complete such a project.

To jump start the project, GCC agreed to fund the program and assume all the risk involved. In return, GCC would receive approximately 50 percent of the project's annual energy savings. It was also agreed that after seven years, BSC could purchase the equipment for fair market value, extend the contract, or have the equipment removed. Finally, GCC agreed to provide an override capability, enabling BSC staff to bypass the VFD and return the system to its previous operating mode almost instantly.

The Systems Approach

GCC sought to optimize energy savings without increasing smokestack emissions or sacrificing plant productivity. This involved an in-depth system analysis of several aspects of BOF operation, including the complex interactions between various components. For example, since the scrubber contains a venturi and maintaining a pressure difference of 54 in. wg. was critical for effective gas cleaning, the system had to be able to generate sufficient gas flow and produce this pressure difference under varied levels of system cleanliness. In addition, an examination of the performance of each system component over the new operating range demonstrated that the radial fan in use at the time could not withstand the stresses of cyclical operation and would have to be replaced.

The New System

A study determined that the induced draft fan could operate in the range of 960 to 1075 rpm during the six BOF operations. During idling, a fan speed of only 560 rpm was required. These speeds were deduced from the requirement that the ventilation system maintain a given flow rate and pressure drop across the throat of the venturi. Speeds are subject to adjustment based on whether the rest of the system, including the primary and secondary hoods, is clean or dirty. Since the system is cleaned at regular intervals, flow requirements immediately after cleaning could often be obtained with lower speeds, especially at high ventilation rates. This aspect further illustrates the versatility of a VFD-controlled system.

The need to replace the fan yielded an opportunity to improve its energy efficiency. While the new fan had to fit in the original casing, the manufacturer was able to incorporate a redesign and obtain a five percent increase in fan efficiency.

One problem that arose was the difference between the operating voltages of the motor in use (13,800 V) and the highest operating voltages for VFDs at that time (2,400 V). To remedy this incompatibility, two transformers were installed. The first, a step-down transformer that reduced the line voltage from 13,800 V to 2,400 V, served as the input to the VFD. The second transformer enabled the output from the VFD to be stepped back up to 13,800 V. The two transformers also minimized distortions to the power grid by effectively canceling several harmonics.

Results

To quantify savings and determine how much BSC should pay GCC, monthly MWh readings were recorded at the breaker. The average monthly energy consumption for the modified BOF fell nearly 50 percent from 2,602 MWh to 1,310 MWh after the VFD was installed. As a result, based on an electricity cost of four cents per kWh, both BSC and GCC each enjoy an annual savings of approximately $310,000. For BSC, since it made no financial investment in the upgrade, its payback is immediate and the energy savings are still continuing today.

Energy and Cost Savings

Project Implementation Costs	$1,225,000
Annual Energy Costs Savings	$620,100
Simple Payback (years)	2.0
Annual Energy Savings (MWh)	15,500

Total Annual Emissions Reductions

CO_2	36,600,000 lbs
Carbon Equivalent	9,980,000 lbs
SO_x	115,000 lbs
NO_x	143,000 lbs
TSP	4,480 lbs
VOC	534 lbs
CO	4,730 lbs

Lessons Learned

The project demonstrated the importance of using subcontractors who are already familiar with the facility. Second, the project highlighted the advantage of using an independent organization to pay for the retrofit in return for a share of the subsequent savings. Finally, the operating staff learned that it is crucial to investigate the dynamics of rotating equipment when operating at speeds well below design speed.

Industry of the Future—Steel

Through OIT's Industries of the Future initiative, the Steel Association, on behalf of the steel industry, has partnered with the U.S. Department of Energy (DOE) to spur technological innovations that will reduce energy consumption, pollution, and production costs. In March 1996, the industry outlined its vision for maintaining and building its competitive position in the world market in the document, ***The Reemergent Steel Industry: Industry/ Government Partnerships for the Future****.*

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MOTOR CHALLENGE

Motor Challenge, administered by the Office of Industrial Technologies, is a voluntary partnership program with U.S. industry to promote the use of energy-efficient electric motor systems. Thousands of industrial partners have joined Motor Challenge and are improving their competitiveness and efficiency and, in turn, the Nation's.

Motor Challenge assists the steel industry and other OIT Industries of the Future by identifying near-term gains in energy efficiency these industries can achieve by adopting existing technologies.

Project Partners

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General Conservation Corporation
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