FOREST PRODUCTS

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Project Case Study

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Pump System Optimization Saves Energy and Improves Productivity at Daishowa America Paper Mill

Summary

In 2000, Daishowa America implemented an improvement project on the effluent pumping system at its paper mill in Port Angeles, Washington. Because of chronic maintenance issues and rising energy costs, personnel at the Port Angeles mill decided to review the pumping system for optimization opportunities. The review led mill personnel to implement a system-level project that decreased the pumping system's energy consumption. The project involved the installation of mechanical Adjustable Speed Drives (ASDs) on two pumps in the mill's pumping system. The project allowed the system to operate more effectively, and resulted in annual energy savings of $32,000 and 700,000 kilowatt-hours (kWh). The project also eliminated many problems that led to excessive maintenance costs and resulted in annual maintenance savings of $10,000. Because the project received partial funding from the Northwest Energy Efficiency Alliance (NEEA), the total mill project cost was $60,000. With a total annual savings of $42,000, the simple payback was slightly more than 15 months.

Benefits

- Saves 700,000 kilowatt-hours (kWh) annually
- Reduces maintenance costs by $10,000 per year
- Improves equipment life
- Increases efficiency

Applications

Effluent pump systems are widespread in the paper industry and can consume a significant portion of the electricity used in paper mills. In cases where multiple pumps are used, a proper control strategy can improve efficiency and save energy by optimally matching the available pumping capacity to the system requirements.

DAISHOWA AMERICA'S PORT ANGELES PAPER MILL

Company/Plant Background

Daishowa America is the U.S. subsidiary of Daishowa Paper Manufacturing Company, Ltd., of Japan. The Port Angeles Mill in Port Angeles, Washington, is an integrated pulp and paper mill. The mill uses wood and recycled pulp to produce approximately 160,000 tons of directory papers annually. The company primarily sells the paper to publishers of telephone directories throughout the United States.

The effluent pumping system at the Port Angeles mill is vital to the mill's production process because it treats the wastewater created by the paper manufacturing process. The system has three 100-hp (horsepower) centrifugal pumps. Prior to the project, two of the pumps operated in parallel to pump all of the raw effluent from the main pump station sump to a clarifier. The third pump was used as a backup or during extreme process upsets. The mill's treatment process requires a minimum flow rate of 4,800 gallons per minute (gpm) to be reliable.

Project Overview

At the suggestion of NEEA, staff at the Port Angeles mill agreed to a review of the effluent pumping system to determine whether the system's control scheme could be improved. Although the minimum flow rate required by the treatment process was 4,800 gpm, the review showed that when both pumps operated at full load, their combined capacity was 7,000 gpm. The excess 2,200 gpm was being recirculated back to the sump.

The size of the pumps and the system's control scheme caused the excess pumping. The primary system control was a level control in which a throttling valve and a bypass valve worked in tandem to maintain a minimum level in the sump. As the level in the sump rose, the throttling valve opened and the bypass valve closed. Conversely, as the level in the sump fell, the discharge valve closed and the bypass valve opened.

Controlling the pumps this way required starting them at full load from a dead start. This created flow surges and pipe hammer that led to stress in the system's piping. In addition, starting the pumps from a dead start caused a long duration of locked rotor currents, which overheated the pump motors.

The reviewers found that cavitation and excessive vibration were present in the piping because the pumps operated at full capacity. Although the pumps were moving 2,200 gpm in excess of the process requirements, the total volume moved was still too small given the pump operating speed. This disparity led to further process-piping fatigue and shortened equipment life.

Reviewers also discovered that one of the parallel pumps drew significantly more power than the other. As a result, plant personnel took the pumps apart to inspect the impellers and discovered that the impellers were severely worn, which caused the pumps to operate less efficiently.

Project Implementation

Mill personnel decided to implement a system-level project based on the review. The project centered on installing mechanical ASDs, replacing the worn impellers on both pumps, and upgrading the pump instrumentation. The ASDs would replace the throttle and bypass valve operation and would match the system's output to the mill's requirements.

Several factors made the selected mechanical ASDs more suitable for the mill's environment and needs than electronic Variable Speed Drives (VSD). One factor that made this ASD model attractive was its easy installation. The ASD installation simply required moving the pumps back on their bases and installing spacers between the motors and the pumps. No inverter-duty motors, extensive rewiring, or reconfiguration of the pump stations were necessary. Second, ruggedness and a lack of sensitive electronic parts made these mechanical ASDs less prone to maintenance problems in an environment such as the mill's effluent treatment process. Because the mill's system is a medium-voltage application, these ASDs were less costly than comparable VSDs. Finally, these ASDs are mechanical, so there are no direct connections between the motors and pumps; this substantially reduces vibration and allows softstart capability.

An Effluent Pump with the Mechanical ASD

Project Results

The implementation of the project has improved the operation of the effluent pumping system and resulted in significant energy savings for the Port Angeles mill. With the newly configured pumping system, the mill no longer depends on bypass and throttling valves to control the pumping system. The ASDs can vary the pump speed to match the pump output capacity with the mill's required process flow rate. The new configuration allows the mill to baseload only one of the pumps while operating the other one at partial load. By not operating both pumps at full capacity, cavitation and vibration have been drastically reduced. Because they are uncoupled from the pump motors, the ASDs allow the pumps to start gradually, which eliminates water surges and pipe hammer. This, in turn, lessens stress on the system's piping and internal components, reduces maintenance needs, and prolongs equipment life.

The system's flow rate has declined by 31 percent, or 2,200 gpm from 7,000 gpm, and rarely exceeds 4,800 gpm. Power demand has declined from 142 kW to 62 kW. The reduction in the system's flow rate and power demand are due to the installation of the ASDs, the rebuilt pumps, and the operation of one pump at partial load versus two pumps at full load. The mill saves $32,000 and 700,000 kWh in annual energy costs, and $10,000 per year in maintenance costs. Because of a cost sharing arrangement in which NEEA funded a portion of the mill's project cost, the mill's total cost for the project was $60,000. The simple payback was slightly more than 15 months.

Lessons Learned

The proper control scheme is critical for the efficient operation of a pumping system. Relying on bypass and throttling valves to control a pumping system can lead to energy waste and excessive maintenance requirements. At the Port Angeles mill, the use of bypass and throttling valves led the mill to operate its pumps at a greater capacity than necessary, and in ways that created unnecessary stress on the process piping and internal system components. Operating the pumps in this manner caused the system to waste energy because it moved 2,200 gpm in excess of the process requirements. The improvement project on the Port Angeles Mill's effluent pumping system reduced the system's flow rate by 31 percent and allowed one pump to operate at variable load. These changes reduced energy consumption. In addition, the project eliminated sources of stress on the system's process piping and on the pumps' internal components, resulting in lower maintenance costs and increased equipment life.

The Mechanical ASD

The ASD installed by Daishowa America is a non-electronic, mechanical device that is usually placed between a motor and the load the motor is driving, whether it is a pump, fan, or blower. The drive consists of two independent components that have no physical contact with each other. One component, a rotor assembly containing permanent magnets, is mounted on the load shaft. The second component, a copper conductor assembly, is connected to the motor shaft. Relative motion between the magnets and the copper creates a magnetic field that transmits torque through the air gap between the components. The width of the air gap can be changed, which allows the amount of torque transmitted between the motor and load to be continuously adjusted. This allows precise speed control, including soft starts and stops. Because of the lack of a direct mechanical connection between the motor and load, the ASD also eliminates wear-and-tear caused by vibration. This ASD is well-suited for medium-voltage applications in harsh environments, and for drives in which efficiency is linear with speed, such as fluid drives.

Industry of the Future—Forest Products and Agenda 2020

*In November 1994, DOE's Secretary of Energy and the Chairman of the American Forest and Paper Association signed a compact, establishing a research partnership involving the forest products industry and DOE. A key feature of this partnership was a strategic technology plan-**Agenda 2020: A Technology Vision and Research Agenda for America's Forest, Wood, and Paper Industry**. Agenda 2020 includes goals for the research partnership and a plan to address the industry's needs in six critical areas:*

- *Energy performance*
- *Environmental performance*
- *Capital effectiveness*
- *Recycling*
- *Sensors and controls*
- *Sustainable forestry*

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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.

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