U.S. Department of Energy - Energy Efficiency and Renewable Energy
Advanced Manufacturing Office

Case Study - The Challenge: Improving Ventilation System Energy Efficiency in a Textile Plant

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Project Profile

Industry:	Cotton Fabric
Process:	Facility Ventilation
System:	Ventilation Fans
Technology:	Variable Frequency Drives (VFDs)

Summary

In an effort to improve ventilation system performance in its Fresno, California textile plant, Nisshinbo California, Inc. (NCI) working with ADI Control Techniques Drives (ADI-CT) of Hayward, California retrofitted 15 of the system's fan motors with variable frequency drives (VFDs). This change enabled the fan control dampers to be fixed in a fully open position, and improved the system's air flow control and energy efficiency. As a result of this Motor Challenge Showcase Demonstration project - implemented under the Pacific Gas & Electric (PG&E) PowerSaving Partner (PSP) program - NCI reduced its energy consumption by approximately 1,600,000 kWh per year and achieved energy savings of 59 percent. This energy-use reduction translated to cost savings of approximately $101,000 per year, giving the project a simple payback of 1.3 years.

Company Background

Established in 1987 as a joint venture between Nisshinbo Industries, Inc., one of Japan's largest textile manufacturers, and Kanematsu Corporation, a large Japanese trading company, NCI's Fresno facility is the only spinning and weaving plant in the Western half of the United States. NCI produces approximately 60,000 yards of fabric from the 45,000 lbs of raw cotton it processes each day. The cotton, grown in the San Joaquin Valley, is processed into ten different types of cotton fabric. While its output makes it one of the smallest plants in the United States, the Fresno facility remains one of the most modern and efficient facilities of its kind. NCI, which only sells to the domestic market, has annual sales between $30 and $35 million. The company employs 300 people and operates 24 hours-per-day, 348 days-per-year.

Project Overview

A 10-step procedure is used to process bales of cotton into sheeting (fabric) and yarn at NCI's Fresno facility. The steps include: opening, carding, lapping and combing, roving, spinning, automatic winding, warping, slashing (sizing), weaving, and inspection. Because temperature and humidity levels must be closely monitored and maintained for cotton to run smoothly through the processing machines, a well-functioning ventilation system is imperative to the plant's successful operation.

NCI's ventilation system uses nine supply fans (SFs) and nine return fans (RFs) to circulate high humidity air to maintain proper ambient conditions, cool process machinery, and control suspended particulate and airborne fibers. Initially, a mixture of return air and fresh air is cleaned, cooled, and humidified by four air washers. This air is then supplied to the facility by the nine SFs and distributed to the plant through ceiling mounted ducts and diffusers, producing temperatures of 85°F to 95°F and relative humidity levels of 50 to 60 percent. The nine RFs then pull air through the processing machines into a network of underground tunnels that filter out suspended particles and fibers through rotary drum filters on the inlet of each RF.

While the psychometric qualities and volumes of air supplied and returned from each area remain relatively constant in the system, seasonal variations occasionally cause minor changes in the ventilation rates. In addition, different products result in changing heat loads in the plant due to a varying number of running motors and/or loads on the motor.

Factors that influence the pressure, volume, or resistance of the system directly impact the fan power requirements. Therefore, air density, changes to damper positions, system pressure and air filter pressure drops, supply and return air system interaction, and parallel fan operation all affect how much power the fans require and must be monitored to ensure the efficient functioning of the system. Variable inlet guide vanes (VIVs) and outlet dampers initially controlled the system's air flow, but were highly inefficient. Setting these devices was imprecise, resetting the openings could only be done manually, and the VIVs and dampers experienced corrosion problems due to the high humidity in the air.

Project Team

NCI was selected as a test site to measure the ability of VFDs to reduce energy consumption in industrial facilities. Along with ADI-CT, NCI presented PG&E's PSP program as a Showcase Demonstration for the U.S. Department of Energy (DOE) Motor Challenge Program. ADI-CT supplied the VFDs and managed this endeavor as a turnkey project. Their scope included the detailed site energy evaluation, system engineering, project management, installation, and commissioning. Tamal Energy (now a part of Planergy Services), an energy services firm, under contract with PG&E, financed the engineering and VFD procurement and installation.

Nisshinbo California, Inc.

SIC:	2211 and 2281
Products:	Ten Types of Cotton Fabrics
Location:	Fresno, California
Employees:	300
Showcase Team Leaders:	Masoud Vafaei, P.E., ADI Control Techniques Drives Bryan D. Frew, P.E., ADI Control Techniques Drives Randolph Zee, Nisshinbo California, Inc.
Company Energy Philosophy:	Nisshinbo has a strong commitment in identifying and integrating energy saving measures into its manufacturing process.

As part of PG&E's PSP program, NCI incurred no capital costs from the installation of the VFDs but benefited from the savings associated with the reduced energy consumption. Tamal Energy retains ownership of the installed equipment throughout the seven year period. When the project monitoring period ends in 2003, NCI will take over ownership of the VFDs.

The Systems Approach

To determine exactly how to improve ventilation system performance, the NCI & ADI-CT Showcase Demonstration team collected base case system data between November 6 and November 18, 1994 to measure the performance of the existing system. Motor power was electronically logged, damper positions were manually recorded based on visible inspection of the damper linkages, and power was measured on each fan at ten minute intervals. These data were analyzed along with data collected on August 22, 1994 and October 24, 1994 to provide a thorough set of conditions under which the original system operated. The latter two collection dates were added to capture a more representative study of the system, as energy demand in August and October is typically 1 to 2 percent higher than energy demand in November. The team then developed a load duty cycle to calculate energy demand, operating hours (peak, partial-peak, and off-peak periods), and annual energy consumption during these three periods for both the RFs and SFs. This data was then compared to the new system data, collected from December 1, 1995 to June 30, 1996.

Project Implementation

After determining that the ventilation system's fans were significantly oversized, ADI-CT retrofitted 15 of the 18 fans with VFDs. The remaining fans - two SFs and one RF - always ran at full flow and did not need VFDs. A power and energy measurement and verification (M&V) tool, developed by ADI-CT, was connected to each of the VFDs to gather load data for the new system. The system logged each fan's speed in 15 minute averages which were then sent hourly, via modem, to the host computers at ADI-CT and Tamal offices where various energy consumption and savings analyses reports were generated. If a fan's motor exceeded the preset value, the M&V system issued an alarm, and the system operator contacted NCI to determine the cause of the power increase. With the VFDs installed, damper control was no longer necessary so the fan control dampers were opened 100 percent.

VFDs Do More Than Save Energy

While often only regarded as energy-efficiency instruments, VFD's utility, in fact, goes far beyond reducing energy consumption. For example, by permitting more precise control over industrial processes, VFDs can improve motor reliability as well as final product quality. In addition, VFDs can increase service life and decrease maintenance costs of motors as they are automated to adjust the power draw to coincide with the system's resistance. VFD's are easily integrated with feedback and control systems, and can eliminate costly human error which often plagues other control methods. Finally, because VFDs are much quieter than valves or vanes, they can significantly reduce noise levels.

Results

Installation of the VFDs reduced the ventilation system's total electricity demand from approximately 322 kW to 133 kW, a 59 percent drop. The total annual energy consumption for the fans similarly fell 59 percent from approximately 2,700,000 kWh to 1,100,000 kWh. The energy-efficiency gains were possible because the VFDs enabled plant personnel to fully open the fan control dampers and reduced fan speed. This results in a large drop in motor power consumption and allows the system to operate efficiently. These electricity savings translated to annual energy cost savings of about $101,000. When measured against the project's $130,000 gross cost which included the cost of the feasibility study; base case evaluation; system engineering and design; VFDs and associated equipment; and installation, startup, and commissioning, the simple payback for the project was 1.3 years. It should be noted, however, that NCI did not pay for any of the costs that the project incurred.

Performance Improvement Summary

Energy and Cost Savings	
Project Implementation Costs	$130,000
Annual Energy Cost Savings	$100,950
Simple Payback (years)	1.3
Demand Savings	189
Annual Energy Savings (kWh)	1,579,400
Total Annual Emissions Reductions	
CO_2	716,500 lbs
Carbon Equivalent	195,400 lbs
SO_2	110 lbs
NO_x	730 lbs
CO	380 lbs
PM-10	24 lbs
* Note: Emissions reductions would be greater for most facilities. More than half of the electricity saved at NCI was generated by hydroelectric and geothermal plants.	

In addition to the energy savings, NCI also realized additional benefits that were difficult to financially measure. First, installation of the VFDs gave plant personnel more control over the plant's air flow. NCI estimated that 48 hours of labor per year were saved because the dampers and ceiling diffusers no longer required modulating. Second, air quality is now easier to control, as responses to minor variations in the ventilation requirements are now possible. Third, the amount of airborne lint in the plant decreased, improving product quality and reducing the number of equipment breakdowns. Finally, the VFDs slightly increased the plant's power factor, thus reducing the power factor penalty costs.

Lessons Learned

The Showcase Demonstration team learned valuable lessons that can be applied to other energy saving projects as well as various application guidelines to consider when carrying out such projects. They found that investing extra time at the beginning of a project to develop an automated, easy-to-operate, data collection and processing system, is worthwhile as it streamlines the data gathering and verification of savings. Single-source turnkey project management, provided by ADI-CT, allowed the NCI personnel to concentrate on their regular responsibilities without disruptions due to the implementation of this project. From the experience it gained in implementing and operating this system, the team determined that installing an automated control system to optimally control the fan speed based on the required air temperature and relative humidity could result in further energy savings. At present, the fan speeds are manually set.