Showcase Demonstration CASE STUDY

MOTOR CHALLENGE

a Program of the U.S. Department of Energy

THE CHALLENGE: IMPROVING DUST COLLECTION SYSTEMS AT AN ALUMINUM REFINERY

Project Profile	
Industry:	Primary Production of Aluminum
Process:	Aluminum Refining
System:	Pot Line Dust Collector
Technology:	System Optimization

Summary

Alumax, a South Carolina aluminum refiner, wanted to improve the energy efficiency of its four pot line dust collection systems. After determining that the collection systems did not require the full capacities of the four fans powering each, the Mount Holly plant analyzed several alternative methods of operation and decided to shut down one fan in each system and match existing fan capacities to each system's demand using variable inlet vane (VIV) controls. These simple modifications reduced the systems' annual energy consumption by 3,346,320 kWh, a 12 percent decrease. This, in turn, resulted in total cost savings of $103,736 per year. Furthermore, because the VIV controls were part of the fans' original design, no capital costs were incurred. This Motor Challenge Showcase Demonstration Project demonstrates that, through thorough systems analysis, significant energy and cost savings can be achieved with little or no capital outlay.

Company Background

Alumax Inc., the parent company of Alumax, is the third largest producer of aluminum in the United States and has more than 100 plants in seven different countries. The Mount Holly plant processes alumina (aluminum oxide) into custom alloyed ingots and billets for fabrication into consumer products, employs 625 people and produces 200,000 tons of aluminum annually. One of Alumax Inc.'s four reduction plants, the Mount Holly plant consumes 300 megawatts of electricity continuously at a cost of $1.7 million per week. With electricity consumption levels of 6.1 kilowatt hours (kWh) per pound of aluminum produced, compared to the industry average of 8 kWh, the Mount Holly plant is extremely energy efficient. Always concerned with minimizing pollution, Alumax Inc. has also invested more than $40 million in advanced environmental technologies.

Alumax Mount Holly Aluminum Production Facility

Project Overview

The pot line fans are responsible for the removal of dust and other airborne impurities generated during the reduction process that converts alumina to aluminum. Reduction occurs in pots of molten cryolite (sodium aluminum fluoride) when a high dc voltage is applied to the bath. The plant has 360 pots, equally divided into 8 pot lines. Each of the four pot line dust collection systems collects dust from a pair of pot lines. Main

The energy savings network

Plug into it!

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA headers are connected to individual ducts coming from each pot and direct the dust-laden air through a dry scrubber (baghouse). Once leaving the baghouse, the ducts each split into four individual ducts, channeling the air into four fans, which then deliver the air to a stack for emission. Each of the four dust collection systems has four fans for a total of 16 and each system has its own stack.

The continuously operating fans are designed to provide each system with a total airflow of 360,000 cfm, or 90,000 cfm per fan. After long periods of experience with the system, staff at Alumax determined it could be operated at lower flows and heads without affecting performance. A field performance test conducted by the Showcase Demonstration Team measured fan speed, air temperature, air flow, and static pressure to determine the aerodynamic performance of the fans and identify the optimum way to run the dust collection system at reduced rates.

ALUMAX OF SOUTH CAROLINA

SIC: 3334

Products: Custom alloyed ingots and billets

Location: Berkeley County, South Carolina

Employees: 625

Showcase Team Leader: Cecil Pulley

Company Energy Philosophy: We are not as good as we should be, can be or will be. — *Mount Holly Vision 2000*

Project Team

Joining the Alumax staff in this Showcase Demonstration Project was the firm Jacobs-Sirrine Engineers. This engineering consulting firm was involved in direct data collection, analysis of the data, and report writing.

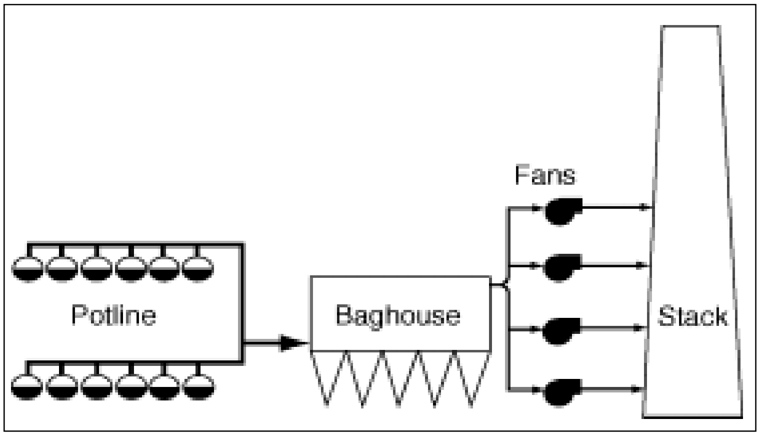
The Systems Approach

Selected as a Showcase Demonstration by the U.S. Department of Energy's (DOE) Motor Challenge program in January 1996, this project examined the plant's existing dust collection system, as well as several alternative systems, to identify and implement the most energy- and cost-efficient dust collection method available.

In the original pot line dust collection system, a total of 360,000 cfm was produced by the four fans operating on VIV control. After years of experience with the system, staff at Alumax found they could partially close the VIVs and operate the system at 325,000 cfm, which resulted in improved bag life. However, as a result of closing the VIVs, the fans were operating at an efficiency of only 68 percent even though the fans' design point efficiency rating is 87 percent. The Showcase Demonstration Team measured a variety of performance criteria in the existing system and considered alternative systems to determine the most economical and efficient mode of operation.

Project Implementation

To identify the most energy-efficient system, the Showcase Team measured fan speed, air temperature, air flow, static pressure, and fan motor power consumption. This data was used to compare four different operating scenarios: (1) operate with four fans using VIV control; (2) operate with three fans using VIV control; (3) operate four fans using variable frequency drive (VFD) control; and (4) operate three fans using VFD control. For the two VIV tests, airflow through the system was measured in the stack using stack sampling ports located midway up the stack; pressure was measured at the outlet of the baghouse and in the stack. For the VFD scenarios, fan speeds and power levels were calculated



Pot Line Dust Collector Diagram

using the performance curves provided by the fan manufacturer, measurements of the original system, and fan affinity laws.

After comparing all four methods of operation, the three-fan VIV system proved to be the most efficient and cost-effective. Based on a power consumption cost of $0.031/kWh and the total kW demand of each system, the $786,981 total annual cost of the three-fan VIV system was the lowest of the four systems. The four-fan VFD system was the second least expensive at $806,058; the four-fan VIV (original) system was third at $890,717; and the three-fan VFD, at $898,970, was the most expensive. It should be noted, however, that while the two VIV modes were tested on actual power consumption, the power consumption of the two VFD modes could only be predicted based on the fan manufacturer's performance curves. For exact figures, the systems would need to be installed and examined. The table below shows fan operating points and power consumption for each scenario.

Pot Line Dust Collector

The three-fan VIV system was the most efficient of the four systems tested because the VIVs were open wider and resulted in less pressure loss through the VIVs, resulting in a "wire-to-air" efficiency level of 84 percent; significantly higher than the 68 percent offered by the four-fan VIV system. Because airflow must be split between the ductwork to three fans—rather than four—the three-fan system had higher velocities in the ducts and a marginally higher pressure drop. With more air flow being handled by each fan, the power consumption of each fan was higher in the three-fan VIV scenario. However, because only three fans were operating, the total power consumption of this system was less than in the four-fan VIV mode. The VFD systems were not optimum solutions because they resulted in the fans operating farther away from their best efficiency points, and because of the inefficiencies inherent in the VFDs themselves.

Results

Based on the systems analysis results, Alumax decided to implement the three-fan VIV control as the optimization method. This method provided Alumax with $103,736 of gross and net savings as there were no capital costs. Payback was immediate. The resulting demand reduction of 382 kW translated into annual energy savings of approximately 3,350,000 kWh, nearly 12 percent less than the original system. Turning off one of the four fans and changing the VIV controller set points to maintain the required airflow while operating with three fans were the only activities needed to make the transition from the four-fan VIV system.

Options for System Optimization

Optimization Method	Fan Input Power (bhp)	Fan Efficiency	Motor & Drive Efficiency	Total Input Power (kW)
Four Fan VIV	253	68%	92.0%	820
Three Fan VIV	298	78%	92.0%	725
Four Fan VFD	200	86%	82.0%	728
Three Fan VFD	309	77%	86.5%	799

Partially Closed Dampers — A Good Indicator of an Energy Savings Opportunity

Many fan systems use either inlet guide vanes or outlet dampers to control flow rates. With either, energy is wasted because of the pressure drop across the vanes or dampers. Systems with variable flow requirements may benefit from the use of VFDs to control flow rates. For systems with constant flow (such as this one), opening the vanes or dampers and using a smaller fan or slowing down the existing fan will save energy. The same principals also apply to pump systems that use valves to control flow rates.

Other benefits from this Showcase Demonstration Project included:

- Spare fans, since the fourth fan in each system is no longer used in day-to-day operations;
- Reduced maintenance requirements such as bearing lubrication, bearing failure, balancing, and fan control repairs;
- Reduced noise levels as only three fans now operate; and
- Increased fan control accuracy because there is one less fan operating and the VIVs are more fully open than in the base case.

Lessons Learned

In addition to the economic and energy-saving benefits of this project, the project also demonstrated that VFD operation is not always the most energy-efficient solution. VIVs are typically efficient in the upper range of operation (where the three-fan VIV mode operated in this case). Fans operating closest to their best efficiency point (BEP) maintain the highest efficiency ratings. Therefore, matching the system demand to the appropriate fan can be more critical to the fan's performance than the type of control system used. In this case, recognizing that the three-fan VIV system operated the fans closest to their BEPs saved the time and cost associated with installing VFD control systems.

Performance Improvement Summary	
Energy and Cost Savings	
Project Implementation Costs	$0
Annual Energy Cost Savings	$103,736
Simple Payback (years)	Immediate
Demand Savings (kW)	382
Annual Energy Savings (kWh)	3,346,320
Total Annual Emissions Reductions	
CO_2	5,831,766 lbs
Carbon Equivalent	1,593,379 lbs
SO_2	9,020 lbs
NO_x	5,592 lbs
TSP	1,352 lbs
CO	793 lbs
VOC	93 lbs

About Motor Challenge

The Motor Challenge is a joint effort by the U.S. Department of Energy (DOE), industry, motor systems equipment manufacturers and distributors, and other key stakeholders to put information about energy-efficient electric motor system technology in the hands of people who can use it.

Showcase Demonstration Projects target electric motor-driven system efficiency and productivity opportunities in specific industrial applications. They show that efficiency potential can be realized in a cost-effective manner and encourage replication at other facilities.

DOE provided technical assistance and independent performance validation (IPV) of energy savings. A DOE-sponsored IPV team reviewed the test plan and provided assistance, as requested by the host site, on testing procedures, instrumentation techniques, and data acquisition. The DOE team developed a detailed IPV Report thoroughly documenting the project. The Report is available by calling the number listed below. DOE did not witness the actual test data, and the conclusions in this case study are based solely on data provided by the host site and their partners.

For more information on becoming involved in the Motor Challenge or sponsoring a Showcase Demonstration, call the Motor Challenge Information Clearinghouse at (800) 862-2086.

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