PERFORMANCE OPTIMIZATION OF A FAN SYSTEM
Overcoming Impacts of Modified Design Criteria Due to Regulatory Requirements and Changed Operating Conditions

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ABSTRACT

The Louisiana Pacific mill in Tomahawk Wisconsin manufactures oriented-strand board. Several large induced-draft fans and combustion-air blowers were operating inefficiently at this mill. This case study highlights a systems approach that was applied to address fan inefficiency. Energy savings from optimizing the system are estimated to be 338 kW, nearly half of the original measured input power of 678 kW. The project is currently being implemented and will have a payback period of less than 8 months. The opportunities here are typical of opportunities thought to exist in most industrial plants. In this case, process needs changed due to environmental regulations and change of location, but the system did not, leading to low overall system efficiency.

BACKGROUND

Optimization Opportunities for Motor Systems

According to the US Department of Energy typically 70 percent of an industrial plant's electric load is produced by motor systems. In turn about 60 percent of this motor load comes from operating fans, pumps, and blowers. Old control technologies, changing operating conditions, and varying production needs create opportunities to substantially reduce the energy use of installed motor systems. Overall system efficiency may often be below 50 percent. Sometimes systems with efficiencies as low as 20 percent are installed and operated for years without anyone even realizing the waste and enormous expense.

The case study presented here is typical of large systems found throughout industry. System efficiency was doubled, producing substantial financial and energy savings.

This project was initiated by Mark Eversman, a customer representative for the Wisconsin Public Service Corporation. He arranged for a comprehensive review of Louisiana Pacific's system through the Energy Center of Wisconsin's Responsible Power Management program, which coordinated the engineering studies and system upgrades.

Responsible Power Management program

The RPM program is a coordinated effort among Wisconsin utilities to promote energy-efficient motors and motor systems. RPM provides information to market players about the energy impacts of motor system efficiency. Currently the only major market mechanism that addresses motor system efficiency is vendor (i.e. often biased) promotion of adjustable speed drives (ASDs).

RPM's mission is to provide reliable and unbiased information that will help convince end users to embrace simple, practical optimization principles. To deliver this message to industrial end users, the RPM program sponsors motor system training and workshops, and provides technical brochures, marketing case studies, and videos. RPM also offers engineering walk-throughs to help identify and quantify optimization opportunities to qualified customers.

RPM also coordinates more detailed feasibility studies of industrial systems to identify opportunities for process improvement and provides the customer with a comprehensive costs versus benefits analysis. As documented in RPM's feasibility study for Louisiana Pacific, the financial and production benefits of improving process efficiency often far outweigh the costs.

PRODUCTION CYCLE AT LOUISIANA PACIFIC

The Louisiana Pacific plant in Tomahawk Wisconsin produces oriented-strand board (OSB) in various thicknesses and markets the product in 4' x 8' sheets for use in the construction industry. OSB provides the high shear strength desired for sheathing on exterior walls, although the product is also used extensively as an underlayment on floors and roofs. OSB is made primarily from aspen wood, which is an abundant species in the cool forests of Northern Wisconsin and has traditionally been considered a weed species by foresters. There are relatively few other commercial uses of aspen.

Aspen logs, or “sticks,” about 8 feet long and 5” to 12” in diameter are debarked and then shaved into wood “flakes” about the size of playing cards, only thicker. A 350-horsepower induced-draft (ID) fan acts as a giant vacuum cleaner, drawing the flakes through a large rotary drum dryer where the moisture is driven off and the wood is cured. After drying, the flakes go through a primary cyclone separator where the large, usable flakes are separated. A series of secondary cyclone separators collect the smaller unusable flakes and sawdust, collectively known as “fines,” which are burned to provide heat for the drum dryers. The moist air, laden with other chemicals from the wood, is drawn through an electrostatic scrubber called the E-tube by a secondary ID fan before passing through a separator and being discharged from the plant (Figures 1 and 2).

After being separated out of the air stream by the primary cyclone separator, the flakes are saturated with a resin and layered with the wood grain carefully oriented to maximize board strength. Stacks of flakes several inches high are then compressed in a hot hydraulic press that sets the resin and makes boards 1/4 to 3/4 of an inch thick, processing eight boards at once. Coming out of the press the boards are nominally 8x16 feet. The boards are trimmed, cut into four 4x8 foot sheets, and stacked.

The entire process is automated: once the logs are fed into the debarking machine the product is not handled by a person until a forklift operator unloads the bundled 4x8 stacks from the machinery. The bundled stacks are then painted and warehoused.

The process shown in Figure 1 depicts one of two identical systems that operate in parallel, each with its own ID fans and combustion-air blower. One system prepares flakes for the surface of the board, and the other prepares flakes for the core of the boards.

Process Requirements

The process equipment was originally installed at a plant in Colorado, then moved to Tomahawk, Wisconsin. It was designed to provide a high throughput of chips in the drum dryer by using high temperatures to drive the moisture out of the flakes. To operate under a Wisconsin Department of Natural Resources permit that restricts environmental emissions, the drum dryer temperature was capped. This reduction in temperature limited production rates and necessitated the use of two drum dryers instead of just one.

In addition, the fans and combustion-air blower had been specified with a high speed to compensate for the thinner air at the high altitudes in Colorado.

The lower temperature in the drum dryer required less combustion air because less wood dust and fines were being burned. To reduce the amount of combustion air, the discharge damper on the blower had been adjusted until it was mostly closed, heavily throttling the flow.

Figure 1. Existing process gas flow (process and instrumentation diagram)

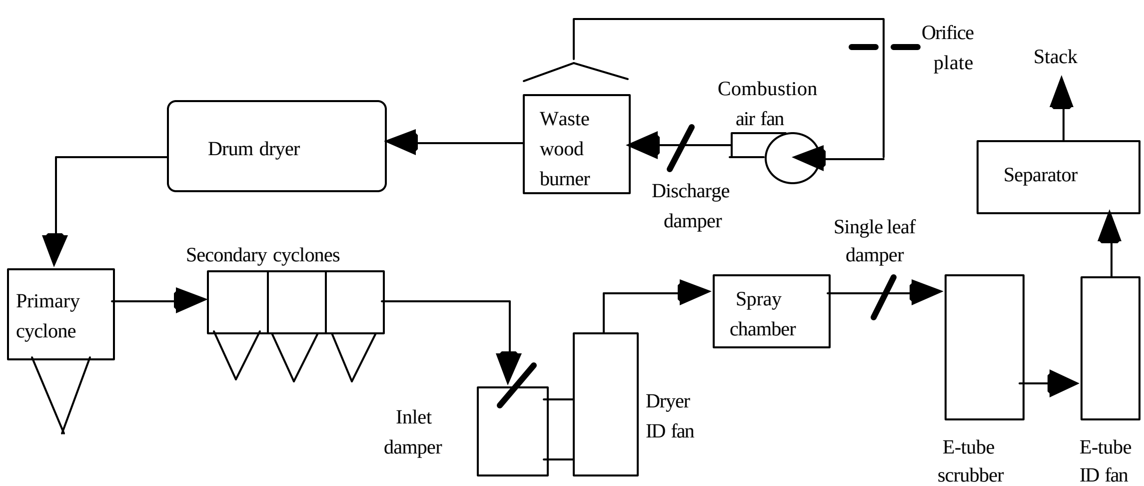
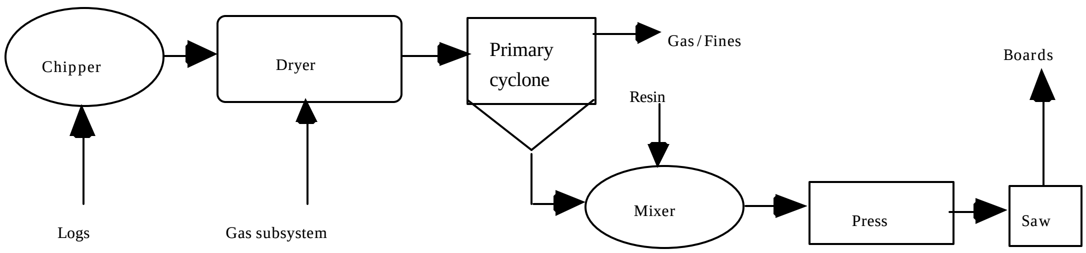


Figure 2. Process product flow diagram



On the 350-Hp dryer ID fan and on the 150-Hp scrubber ID fan, the only adjustable parts in the system were two manual dampers, one on the inlet of the 350-Hp fan, and another at the inlet of the E-tube scrubber. Adjusting the flow in the existing setup is a arduous, trial-and-error operation that requires making a small change to one damper, walking a hundred yards and climbing three flights of stairs to adjust the other damper, checking the pressure in the scrubber, and then going back and repeating the process several times to get the load properly balanced between the two fans.

Production problems with existing system

The main drawback to the current system from a production viewpoint is the lack of control. The system always pushes the same amount of air and consumes the same amount of energy regardless of outside air conditions or production rates. The higher-than-necessary airflow also boosts the plant's heating load and exacerbates a negative pressurization problem in winter.

FEASIBILITY STUDY AND FINDINGS

As part of the Responsible Power Management program's performance optimization feasibility study, fan performance tests were carried out with the system operating at the maximum production capacity of 59-percent dryer load. The parameters monitored during the tests were damper pressure loss, fan pressure rise, volume flow at the fan inlet, gas temperature and humidity, fan speed, and motor power input.

Combustion Air Fan

The combustion-air instrumentation and controls included an orifice plate mounted in the round inlet duct and a fan outlet damper.

The outlet damper is an inefficient control because it adds unusable pressure load to the fan. Under the normal operating condition, the pressure loss over the damper was 25.6" W.G., or 60 percent of the fan's static pressure output. Removing this damper, installing an inlet vane control, and lowering the operating speed could reduce this loss to less than 10 percent.

The orifice plate had a high pressure loss, and was 3.1" W.G., or 7.3 percent of the fan's static pressure output. Replacing this with a metering device such as a flow grid would result in more precise flow measurement as well as negligible pressure loss.

The performance of the flow measurement device and the fan were negatively affected by a skewed velocity distribution (a system effect) resulting from an upstream elbow. This could be eliminated by installing a new venturi elbow.

Dryer ID Fan

The Dryer ID Fan was a radial-bladed paddle wheel type operating at 37 percent efficiency including the inlet box damper control. The upstream cyclones were no more than 95 percent effective at eliminating the dust load. A more efficient fan type such as a backward-curved fan in this location was not considered because it would result in high vibration levels due to dust buildup.

The primary reason for the fan's low efficiency was the partly closed inlet box damper. This damper accounted for 14.5" W.G, or 60 percent of the fan's output. Also, the duct leading into the wet scrubber was at a positive pressure of at least 2.5". Lowering this pressure to -2.3" W.G. by opening the E-tube damper would make the more efficient E-tube ID fan generate the pressure to overcome this resistance.

These measures would reduce the fan input power by fully opening the fan inlet box damper as well as reduce the fan speed by replacing the belt drive.

E-Tube ID Fan

The E-tube ID fan was a radial-tip-bladed fan operating at 51-percent efficiency. It handled some wet dust because the upstream cyclones and scrubber were usually no more than 99 percent effective. For this reason, a more efficient fan type in this location may result in high vibration levels due to dust build-up on the blades.

The system damper at the scrubber inlet was virtually closed to maintain a negative pressure in the E-tube scrubber. The pressure loss over this damper was 4.75" W.G. Much of this loss could be recovered by opening this damper and installing a new VIV (inlet vane control) at the fan's inlet. This VIV would effortlessly maintain a negative pressure at the scrubber inlet.

Not all of the recovered 4.75" would be available to reduce the fan's power consumption—2.3" is being shifted from the dryer ID fan.

Summary Of Recommendations

Based on the engineering analysis of the existing system, the Responsible Power Management program recommended making the following changes to improve process efficiency.

Combustion Air Fan

- Replace inlet ducts.
- Install a flow-grid metering device.
- Replace the outlet damper with a variable inlet vane control.
- Reduce the fan speed by changing the belt drive.

Dryer ID Fan

- Open inlet box damper—adjust system flow with E-tube ID fan VIVs.
- Reduce the fan speed by changing the belt drive.

E-Tube ID Fan

- Open E-tube scrubber inlet damper.
- Install VIVs at E-tube ID fan inlet
- Reduce the fan speed by changing the belt drive.

The existing and new power requirements for both dryer systems are summarized in table 1.

IMPLEMENTATION

The recommendations from the performance optimization feasibility study are being implemented by Louisiana Pacific. As of this writing, modifications have been made to one of the two dryer systems, and preparations are under way for the balance of the implementation. Implementation is slow due to production demands and launching a new product line.

To avoid operating motors at 30-percent load, which gives a poor power factor and poor efficiency, a game of "musical motors" is planned. The motors on the combustion-air blowers will be replaced with new, high-efficiency 40-Hp motors. Then the existing 150-Hp motors on the combustion-air blowers will be used to replace the old, inefficient 350-Hp imported motors on the drier ID fans. The motors on the E-tube ID fans will not be subject to severe underloading in the new configuration because they will pick up some of the load from the less efficient dryer ID fans. As a result, they are being left as is for the present.

The predicted cost of the feasibility study is approximately $14,200, and the cost of the implementation is about $54,600, for a total project cost of about $68,800. The project is expected to provide energy cost savings of $107,500 per year, resulting in a payback period of less than eight months for the entire project. In this case, the payback period was even shorter because Wisconsin Public Service Corporation provided a $5000 incentive to reduce the cost of the feasibility study to $9200.

Table 1. Estimated power requirement changes as a result of efficiency improvements

	Original		Optimized		Energy savings
Equipment	Motor input power (kW)	Fan input power (Hp)	Motor input power (kW)	Fan input power (Hp)	Motor input power (kW)
Two combustion-air fans	144	188	44	56	104
Two dryer ID fans	332	402	154	186	178
Two E-tube ID fans	202	260	146	188	56
Total	678	850	344	430	338

After installation of the new motors, inlet vanes, and belt drives, a second round of measurements will be taken to verify the savings.

OTHER BENEFITS

Other benefits resulting from the project include reduced noise levels in the plant near the optimized equipment. In addition to the optimization effort on the fans, the plant has plans to monitor the stack so that flow rate, temperature, and pressure are known, and can be factored into controlling the system flow for optimal performance. It is believed that the flow can be reduced by five to 10 percent when the outside air is very dry and the flake production loading is light. The full magnitude of these production benefits are unknown because the plant operators have never been able to control the airflow in the system to see what could be done. Minimum airflow conditions will probably be dictated by the minimum velocity (about 4000 rpm) necessary to prevent flakes from settling and plugging up the system.

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