ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
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Fact Sheet

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Energy Efficiency at a Small Wastewater Treatment Plant

Use of Variable Frequency Drives to Control Aeration Blowers

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Abstract

This fact sheet identifies the energy savings realized at a wastewater treatment plant (WWTP) in Pana, Illinois. The Pana WWTP went on line in 1986 to process sanitary wastewater from its 5,500 residents. Its design capacity is 3.3 million gallons per day (MGD) with a daily operating load of 1.7 MGD. Wanting to cut operating costs, the plant supervisor requested ISTC's assistance in identifying energy efficiency opportunities that would not interfere with the waste treatment process. Significant energy savings were identified by the installation of variable frequency drives (VFDs) on three 75 horsepower Hoffmann Blowers.

Project Overview

ISTC made a presentation on the Illinois Conservation of Resources and Energy (ICORE) program to pollution control operators at a meeting of the Mid-Central Water Pollution Control Operators Association (MCWPCO). After the meeting, Kent Taylor, the Pana WWTP operator, asked to have an assessment of his facility to identify opportunities to reduce the electricity consumption within his plant. Previously, the city had installed VFDs on the main pumps of the water treatment plant and on the influent pumps at the wastewater treatment plant. Mike Springman of ISTC, and Tom Ellegood, of Illinois Electric Works (IEW), an ICORE vendor-stakeholder, conducted an assessment of the facility and presented to the city the recommendation to install VFDs on the blowers at the WWTP.

Variable frequency drives were installed on the three 75 HP Hoffmann centrifugal blowers which fed into a common header. A load balancer was also installed to control the blowers enabling them to work in harmony, saving additional energy.

Operations – Before the VFD Installation

The plant operated two of the three 75 HP Hoffman blowers simultaneously, 24 hours, 7 days per week. The blowers operated at 100% speed while the air flow was reduced by a mechanical valve set at 80% flow in order to achieve the desired level of dissolved oxygen within the oxidation ditch. These blowers consumed 850,423 kilowatt hours (kWh) of electricity in a nine-month period (A nine-month period was used to coincide with the nine-month period after installation).

Figure 1: Hoffmann Blowers at Pana WWTP

Operations – After the VFD Installation

The 75 HP Hoffman blowers are still operated two at a time 24/7 and still maintain the same dissolved oxygen levels within the oxidation ditch. The difference is that the mechanical valve is now fully open and a VFD controls motor speeds and air flow. The blower motors now run at 80 percent speed to produce the same volume of air. This speed reduction results in the blowers operating slower with no impediment (valve) in the distribution system. The blower motors operate at cooler temperatures that will extend the life of the motors. Motor startup will be slower and smoother, eliminating higher amperage inrush and will reduce motor and starter wear and tear. After the VFD installation, these blowers consumed 708,505 kWh in a similar nine-month period.

Results

The Hoffmann blowers operate two at a time, 24/7, with the VFD controlling them at 80 percent capacity. Nine months have passed since the VFD installation. The electric use for a nine month period prior to the VFD installation was compared to the corresponding nine-month period after the VFD installation. A comparison of the before and after nine-month scenarios identified a reduction of 141, 918 kWh, or 16.7 percent in electricity.

Figure 2: VFD Control Panel showing electricity consumption and performance after installation

Supplemental Materials

The Theory behind VFDs and Load Balancing

Affinity Laws and Variable Frequency Drives

Fan, pump and blower power consumption is equal to the cube of the speed. Two times the speed will consume eight times (23) the power. Speed is expensive. The penalty for running a motor faster than necessary is severe. Conversely, one-half the speed requires one-eighth (0.5^3) the power to drive a fan, pump or blower (see Table 1). This means significant energy savings are available by reducing motor speed.

A variable frequency drive (VFD), also known as an adjustable speed drive (ASD), is a system that controls the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor (Figure 3). It converts incoming 60Hz AC power into other desired frequencies, which allows for AC motor speed control. VFDs enhance process control and provide energy savings by matching motor speed with load requirements. Pump, fan and blower applications at water and wastewater facilities are excellent candidates for retrofits because VFDs match motor speeds to fluctuating loads at these facilities, which is more economical than running motors at a constant speed.

Figure 3: Variable Frequency Drive

Scenario 1: 100 HP motor running 24/7 at 100% speed and 75% flow with mechanical flow control.

Cost of Operating at Fixed Speed = $50,000 per year

Scenario 2: 100 HP motor running 24/7 at 75% speed, 75% Flow, and VFD at 75% speed 24/7.

Cost of Operating with a VFD = $21,094 per year

Annual Savings: $28,906

Speed	Flow	Required Power
100%	100%	100%
90%	90%	72.9%
80%	80%	51.2%
70%	70%	34.3%
60%	60%	21.6%
50%	50%	12.5%
40%	40%	6.4%
30%	30%	2.7%

Table 1: Numeric Description of the Affinity Laws

Load Balancers

Problems occur when multiple pumps or blowers are tied into a common header (Figure 4). Some of these problems include pumps and blowers that vary slightly; asymmetrical piping; impellers that wear over time; unbalanced loads; and motors that constantly cycle on and off. These problems cause uneven loads and inefficient load sharing, which wastes both energy and money.

Figure 4: Common header application

Load balancers (Figure 5) are controls that take advantage of a VFD's ability to control motor torque (load). Instead of only controlling speed, the load balancer forces the pumps or blowers to spin at the speed that produces the proper load. When tied into a common header, the pumps work evenly toshare the work. This operating efficiency also optimizes energy use and saves money. Load balancers are a sensible complement to VFDs because they offer up to 30% energy savings if the pumps are in good working order. The energy savings is even greater if the pumps are worn or operating at less than peak efficiency.

Advantages

- Energy savings
- Noise reduction
- Easy installation using existing motors and pumps
- No starting and stopping, equipment runs continuously
- Eliminate mechanical shock
- Pump the proper mass

Figure 5: Load balancer