ROYCE TECHNOLOGIES

APPLICATIONS BULLETIN

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WHY DISSOLVED OXYGEN INSTRUMENTS SHOULD BE CONSIDERED FOR WASTEWATER TREATMENT AERATION APPLICATIONS

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Dissolved Oxygen Control In Wastewater Treatment Plants

Energy savings for wastewater treatment plants that install dissolved oxygen (D.O.) control can be as high as 50%. Savings are site specific, and a feasibility study should be undertaken to determine potential cost savings and paybacks. Those standing to benefit most from D.O. control are large facilities approaching ultimate capacity, plants with a coarse-bubble aeration system and plants with fluctuating organic loadings.

Overview

Most treatment plants in Ontario include the following stages:

Preliminary treatment - to remove grit, rags and other large objects.

Primary treatment - to remove settleable contaminant particles.

Secondary treatment - to remove very fine particles and dissolved contaminants. It involves aeration and secondary sedimentation.

While preliminary and primary treatment involve physical removal of material from the wastewater, secondary treatment uses naturally occurring microorganisms (also referred to as biomass or activated sludge) which feed off the organic waste. These microorganisms require D.O. for reproduction and growth. Oxygen is supplied by introducing air into the tanks through an aeration process. Aeration uses more energy than any other process in wastewater treatment (Figure 1). By optimizing the amount of air supplied, significant energy savings can be achieved.

Air Requirements

The aeration process serves two purposes: to satisfy the oxygen demand of the biological activity and to mix the contents of the tank. Aeration helps dissolve the oxygen in the wastewater and transfer it to the microorganisms. Mixing ensures that contact is maintained between the microorganisms and the organic waste on which they feed.

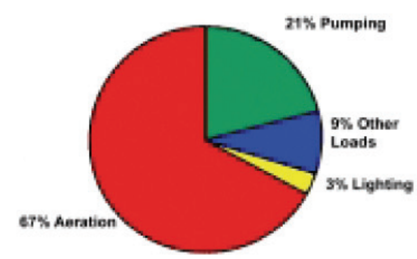

Figure 1. Electricity Use in Sewage Treatment

Biological activity fluctuates over a 24-hour period. When the amount of air supplied to the tank is optimized (matching air supply to biological activity), then the amount of energy required for aeration can be reduced. In plants not practicing D.O. control, mechanical aerators or air blowers operate full time at greater than optimum capacity, resulting in wasted energy when oxygen demand is low (see Figure 2).

Aeration Control

The basic control strategy is to continuously monitor the D.O. concentration in the aeration tanks and regulate the supply of air to match oxygen demand. In the case of mechanical

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systems, this can be achieved by reducing the number of aerators in service, or by changing

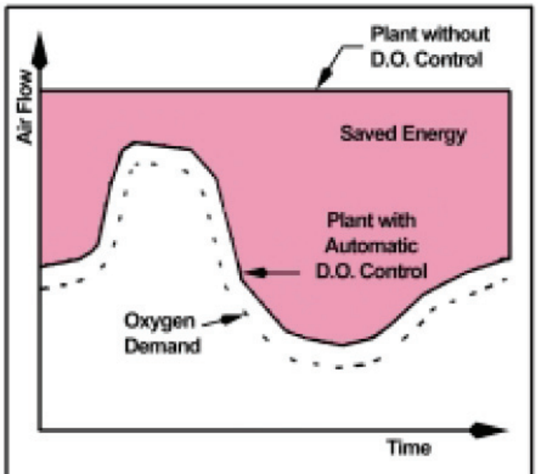

Figure 2. Potential Energy Savings using D.O. Control

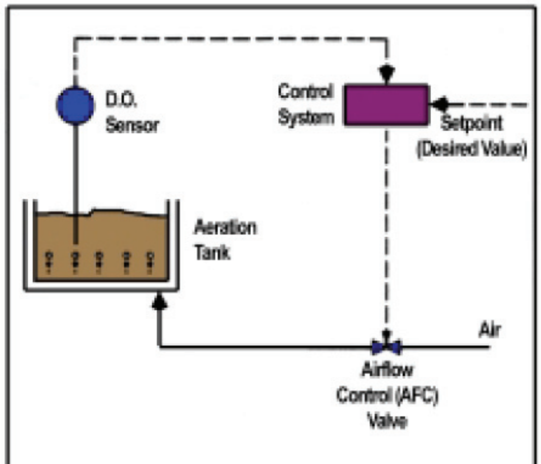

Figure 3. Simplified Dissolved Oxygen Control System

the speed or submergence level to decrease power draw. In diffused air systems, the flow of air into the tanks is regulated by airflow control valves. These valves operate continuously, opening and closing as necessary to maintain a D.O. concentration that matches the demand of the biological activity – usually 2.0 mg/l (see Figure 3).

Energy efficiency of D.O. control in a diffused air system can be improved by correlating blower output with the opening and closing of the AFC valves. If blowers continue to operate at full capacity while the AFC valves are throttling, then energy is wasted. However, if blower output is reduced in response to the drop in D.O. concentration, the AFC valves open to let more air into the tank. This minimizes energy loss.

The most common and efficient ways to regulate blower output are to throttle the inlet valve or guide vanes for centrifugal blowers, and to use variable speed drives for positive displacement blowers. In large plants, sequencing of centrifugal blowers in conjunction with inlet throttling is a commonly recommended method of control.

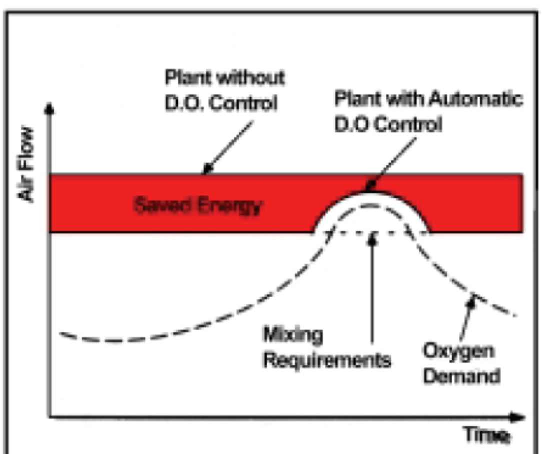

Figure 4. Energy Savings for Mixing Limited Plants

Factors Affecting Energy Savings

Plant loading, mixing limitations, plant size and type of aeration determine energy savings.

Plant loading - Hydraulic and organic loading must be examined to determine air demand fluctuations. Biological activity fluctuates over a 24-hour period as the amount of wastewater entering the treatment plant rises (typically from early morning to evening) and falls (usually between 11:00 p.m. and 6:00 a.m.). Organic loading fluctuates in treatment plants that receive high-strength wastes, for example, from dairy, poultry and food processing facilities.

Mixing limitations - In some plants, the amount of air required for mixing may exceed biological air demand for long operating periods (Figure 4). During these periods, the aeration system operates at a high level just to maintain mixing. As airflow control in such plants is limited, there is likely little potential for energy savings and implementation of a D.O. control system may not be cost effective. This is common in plants with low-strength wastewater and new or recently expanded plants where aeration tanks are oversized to accommodate increased future loadings.

Plant size - In small plants with relatively low energy consumption, the cost savings from D.O. control may not offset the installation and maintenance costs.

Aeration equipment - The type of aeration equipment being used should be taken into account when considering a D.O. control system (see Table 1). The three common methods are mechanical and coarse-bubble and fine-

TABLE 1: DISSOLVED OXYGEN CONTROL APPLICATION CHART

FACILITY	APPLICATION OF D.O. CONTROL		
	RECOMMENDED	POSSIBLE	NOT RECOMMENDED
Plants close to design loading	X	X	
Large loading variations	X		
Newly expanded facility		X	
Aeration			
- Fine bubble		X	
- Coarse bubble		X	
- Mechanical aerators			X
Mixing limited facility		X	

diffused air. Plants with coarse-bubble systems benefit most by installing a D.O. control system. Most existing mechanical aerators are not suited to D.O. control. Fine-bubble air diffusers have higher oxygen transfer efficiencies than coarse-bubble diffusers and are twice as efficient. As their operating energy costs are less, the potential saving from D.O. control is also less.

Potential Savings

The feasibility of implementing D.O. control should be studied to ensure the payback period is reasonable. For a typical 65 Ml/d (14.2-million imperial gallons/day [migd]) conventional activated sludge secondary treatment plant operating at ultimate capacity with average loading and substantial air demand fluctuations, energy savings should be compared to the capital costs of installing and maintaining a computerized D.O. control system.

Energy Cost Savings

The U.S. Environmental Protection Agency (EPA) *Design Manual on Fine Pore Aeration Systems* (EPA/625/1-89-023) states "…energy saving achievable by automatic aeration on D.O. control is 25% to40% but can be as high as 50%." Using 25% saving, Table 2 summarizes the annual energy costs and the cost saving for two typical Ontario municipal plants, one using coarse-bubble aeration and the other fine-bubble.

Capital Costs

Capital costs for installing a D.O. control system are site-specific. A new, computerized system for a five-tank plant could cost approximately $400,000 for:
~tank AFC valves (one a tank)
~airflow meters (one a tank)
~D.O. sensors (minimum of two a tank)
~blower AFC devices (valves, vanes or variable speed drives)
~control system complete with software
~miscellaneous instrumentation.

Table 2: ESTIMATED ENERGY AND COST SAVINGS FOR D.O. CONTROL 65Ml/d (14.2 migd) PLANT

AERATION TYPE	ENERGY COST ($'000)	ENERGY SAVINGS KWh (AT 25%)	ENERGY COST SAVINGS ($'000)
Coarse bubble	190.8	867,240	47.7
Fine bubble	88.6	403,000	22.2

For a retrofit, costs for piping modifications to accommodate blower AFC devices as well as the new tank AFC valves must also be included. Retrofit costs depend on the existing piping layout and aeration equipment. Existing blowers must have sufficient airflow turndown capability or they must be modified or replaced.

Maintenance Costs

D.O. sensors require periodic cleaning (usually once a week) and semiannual calibration. The annual maintenance cost for a five-tank plant is approximately $7,000, including semiannual replacement of the sensing element.

Payback Period

For a typical, new midsized plant, the payback period would be approximately 10 years for a plant using a coarse-bubble aeration system and 26 years for a plant using a fine-bubble system.
Because retrofits are governed by so many variables, a site-specific feasibility study is required to determine the actual payback period.

Summary and Conclusion

Depending on the type of facility and existing aeration equipment, potential energy cost savings for a D.O. control system can range from zero to 50%. Large facilities approaching ultimate loading with a coarse-bubble aeration system and fluctuating organic loadings have the greatest potential saving. A feasibility study should be undertaken to ascertian potential cost savings and payback period.

Additional savings may be realized by using fine-bubble-aeration variable speed drives, high efficiency motors, load shifting, and cogeneration. Again, the potential energy savings are site-specific and must be addressed individually to determine payback.

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