DOmaster^{TM} White Paper

Superior control methods for maintaining optimum dissolved oxygen (DO) levels

This paper explores problems associated with variability of dissolved oxygen (DO) concentration in aeration basins. *DOmaster*^{TM} is software that automatically maintains constant DO.

Understanding DO

Aerobic microorganisms use oxygen for oxidation of carbonaceous matter and ammonia. Oxygen is introduced into the system by pumping oxygen-containing gas (usually air or pure oxygen) into the water. The presence of oxygen in the water is quantified by DO concentration.

Effect of DO on oxidation rate and energy consumption

An increase in DO generally increases both the oxidation rate of aerobic processes and the energy needed to pump the oxygen. Maintaining DO above optimum concentration, however, causes such problems as:

- energy waste
- deterioration of phosphorus and nitrate removal

while having minimum effect on effluent BOD and ammonia.

Effect of food load fluctuation on performance of an activated sludge process

When wastewater flow and/or strength increase, it causes an increase in oxygen demand. If the oxygen supply does not satisfy this increased demand, operators may encounter one or more of the following problems:

- problems with effluent quality (TSS, BOD and ammonia)
- low DO bulking
- poor flocculation
- breakthrough of nitrite that may cause significant effluent disinfection problems
- effluent toxicity

Avoiding problems caused by non-optimum DO

To avoid the above problems, two different approaches can be taken: either correlating oxygen supply with oxygen demand *or* basing oxygen supply on the maximum oxygen demand. The latter method, while providing the required process reliability, causes excessive energy usage during non-peak hours and may cause deterioration of the nutrient removal. Maintaining constant DO concentration in the water is the most popular method of maintaining equilibrium between DO demand and DO supply at all times.

Problems with the traditional DO control method

Traditionally DO control has been implemented using cascaded methodology, utilizing multiple control loops. In this method each control loop utilizes a PID (proportional-integral-derivative) control algorithm. Despite the fact that DO control has been advocated over several dozens of years, it is rare to find a properly-operated DO control system due to the following reasons:

1. PID control works well for control of processes that can be described by linear equations (for example, control of car speed). Neither DO nor airflow dynamics, however, can be

described by a linear equation. As a result the PID algorithm cannot provide precise and stable control.

2. Traditionally, control of blower or compressor airflow is based on maintaining constant discharge pressure, assuming that an increase in airflow demand leads to changes in discharge pressure. Blower discharge pressure, however, depends mostly on water depth in an aeration basin and not on blower airflow. Even hydraulic flow and temperature often affect blower discharge pressure more than airflow. Therefore, it is not surprising that a computer modeling study showed that precise tuning of the pressure control loop is very difficult, if not impossible.
3. Interaction of the poorly-operated control loops causes system oscillation (valves and blower "hunting"), and frequent disruption of blower operation due to the initiation of the surge protection control routine; in addition, DO set points cannot be precisely maintained.
4. Undetected DO meter and actuator failures may cause deterioration of activated sludge process performance and disruption of blower operation.

DOmaster™ introduces a better control method

DOmaster™ is a software program that maintains constant DO in each part of the aeration basin, matching oxygen demand with oxygen supply in real time. Its sophisticated control algorithm prevents valve and blower "hunting," and notifies operators about unusual patterns in oxygen demand as well as about DO meter and actuator problems.

DOmaster™ solves the problems inherent in the traditional solution by using an activated sludge model-based control for the DO control loop and aerodynamic models for valve and blower controls. In addition, the blower is controlled based on airflow demand and valve positions in individual tanks rather than on blower discharge pressure. Finally, special pattern recognition algorithms are able to detect early problems with DO meters and actuators, inform operators, and switch to the "safe mode".

Daily recommendations for optimum DO set points can be provided by *OPTImaster™*.