Beyond Conventional MBRs

Oxygen transfer technology revolutionizing MBR applications

By Dennis Livingston

Submerged membrane bioreactor (MBR) technology continues to gain traction on a global level as a cost-effective means for treating wastewater. Moreover, given the high effluent quality, MBR systems increasingly are being used for water recycling and as feed to reverse osmosis systems. The advantages of the technology are well documented in literature and include, among others, small footprint, superior effluent and ease of operation.

Despite the substantial upside of owning and operating an MBR, there is also a downside to consider. If an MBR system is not properly designed to run efficiently or is not operated in an energy-efficient manner—or some combination thereof—what looks sustainable on paper will not be in real life.

The perception, and in some cases reality, that MBR systems are "energy hogs" chewing up kilowatts at rates two to 20 times the theoretically achievable value of 0.32 kWh/cu meter (1,200 kWh/MG) is not specific to one membrane technology.

SDOX oxygen transfer technology is based on simple physics.

A growing body of evidence appears to support the idea that membrane geometry may have less to do with actual system energy consumption than other factors.

For example, in a recent survey of nine U.S. MBR installations—some using hollow-fiber membranes and others using flat plates—aggregate consumption numbers varied between 5,400 kWh/MG and 16,000 kWh/MG. For comparison, a typical energy estimate for a new MBR plant will be approximately 3,000 kWh/MG and conventional activated sludge plants have reported usages averaging less than 3,500 kWh/cu meter.

A more granular look at many of these plants reveals that they can and do run efficiently near design flows but become increasingly inefficient as less water is treated. The decrease in efficiency is often due to a lack of process turndown and specifically may be caused by so-called parasitic loads (e.g., mixers, blowers and pumps). Other factors such as system complexity and compounding equipment inefficiencies may contribute to the high energy usage rates and ultimately may determine the fate of MBR technology rather than the type of membrane equipment used for filtration.

New Technology

EcoBlox systems are specifically designed for ease of operation, requiring 70% less automation; the biggest advantage to end-users, however, may ultimately be reduced installation costs. Whereas recent data suggests that conventional MBR systems may cost between $7.80/gal and $13.80/gal to build, contractor estimates indicate that EcoBlox systems may cost less than $4/gal to construct due to the reduced footprint, reduced concrete and overall process simplicity.

The process can be described as taking three primary steps:

1. Saturating screened raw wastewater with oxygen under pressure (typically 80 to 100 psig);
2. Sending the oxygen-laden wastewater to the high-rate MBR for treatment running at mixed liquor suspended solids (MLSS) concentrations between 2% and 3%; and
3. Controlling the dissolved oxygen (DO) in the reactor to achieve simultaneous nitrification and denitrification (SNdN).

None of these steps is necessarily new, with the exception of the method by which oxygen is being added to the process. The oxygen transfer technology, called SDOX, is novel in the wastewater industry but is based on simple physics. The other parts, running at high mixed liquor and achieving SNdN, are well documented in literature and have many references in the U.S. and abroad.

Oxygen Delivery

Instead of trying to add oxygen to a process using gas bubbles rising through a water column (diffused air, etc.), water is aerosolized, or turned into small droplets, and contacted with pure oxygen in a small tank. Using this method eliminates the variable influence of mixed liquor and greatly simplifies maintenance.

The physics part, Henry's Law, relates gas pressure in the tank to the saturation oxygen concentration in the water. If the screened influent is pressurized to 100 psig and put in contact with pure oxygen, it will contain 300 mg/L oxygen when sent to the reactor. If the tank pressure drops, the oxygen concentration drops. If the pressure is increased, the oxygen concentration increases proportionally.

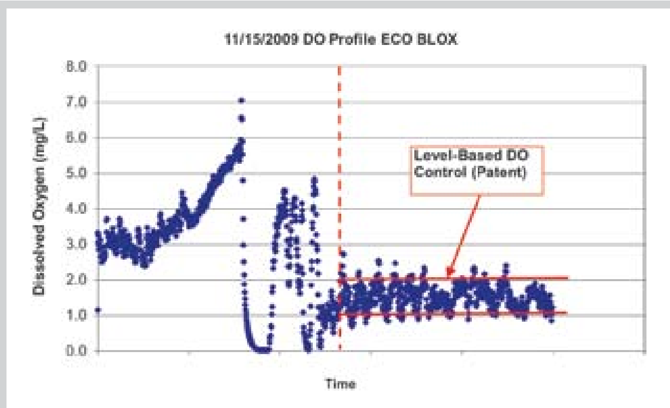
In an EcoBlox system, the oxygen delivery rate is controlled by changing the liquid level in the contact tank based on the DO measured in the permeate—not the mixed liquor. Bouncing between low DO set points can be used to promote SNdN. Supply oxygen is made up on site using a vacuum swing adsorption technology manufactured by PCI, called DOCS.

The energy demand of an EcoBlox system is primarily due to the high-pressure pump, oxygen makeup system and air scouring requirements. All of these demands combined equate to less than 4,000 kWh/MG.

DO Control

DO control in conventional MBR systems using diffused aeration is a strong function of mixed liquor conditions or properties. For example, at times MBRs are run at very high MLSS concentrations to reduce waste solids handling costs, but the increased concentration also drives down fine-bubble diffuser performance.

Figure 1. DO Control Trial



In other cases, operators may choose to run at lower or thinner solids concentrations, but that can lead to excessive, uncontrollable DO in recycle streams and inhibit denitrification.

Whatever the process conditions, submerged instruments are prone to getting out of calibration or malfunctioning. The ideal situation is to monitor permeate conditions for control purposes, eliminating some of the problems with conventional and multistage MBR processes.

The ability to control the oxygen concentration in a single-stage MBR by monitoring permeate was demonstrated in a full-scale pilot conducted earlier this year. During several trials, a sharp saw-tooth DO profile was observed bouncing between varying high and low set points in roughly 15-minute intervals. In trial DO, for example, set points were 1 mg/L and 2 mg/L (see Figure 1).

This same type of profile was observed during pilot testing conducted by BlueInGreen in cooperation with CH2M Hill-OMI at a wastewater treatment plant in Fayetteville, Ark. During the study, both mixed liquor and plant effluent where used as feed to an SDOX system in different trials to demonstrate performance. With the capability of transferring and controlling oxygen delivery to a high-rate MBR now proven, the advantages of the technology are significant. MT

Dennis Livingston, P.E., is director, MBR Systems, for Enviroquip, a Div. of Eimco Water Technologies. Livingston can be reached at dennis.livingston@glv.com.

For more information, write in 1104 on this issue's Reader Service Card or visit www.wwdmag.com/lm.cfm/mt101004.