Fluorescent Dissolved Oxygen Sensors for Aeration Monitor & Control
By Rick Davis

When wastewater is not treated properly, nutrients such as nitrogen and phosphorous are not removed. However, Biological Nutrient Removal (BNR) can alleviate the effect of such waste in a receiving body of water. In a BNR process, a mixed population of naturally occurring microorganisms can be used to remove nitrogen, phosphorous, and biochemical oxygen demand (BOD).

Oxygen is required to sustain the microorganism population, so controlling dissolved oxygen (DO) levels is an important step in a BNR program. Essentially, the key to successful nutrient removal is the ability to control DO levels throughout various stages of the process. Reactors synchronize oxic, anoxic, and anaerobic phases to eliminate nitrogen and phosphorous from wastewater.

In the first phase of a BNR process, otherwise known as the aerobic or oxic phase, air is injected into the process and organics and nitrogen compounds are oxidized, resulting in nitrate formation. The nitrifying microbes also absorb phosphorous from the wastewater during this phase of the process.

In the next or anoxic/denitrification phase, air injection stops and, due to the absence of free oxygen, bacteria uses nitrate oxygen for respiration. This forms nitrogen that escapes from the reactor as a gas. The final phase, called the "anaerobic phase," begins when nitrate oxygen is depleted. The bacteria, oxygen-starved, are stressed to the point of releasing stored phosphorous.

Controlling dissolved oxygen

Dissolved oxygen control is fundamental to the BNR process because specific DO levels must be maintained to achieve phase efficiency. However, there are other benefits that come with DO control, such as a reduction in power required to run the blowers for aeration. This, in turn, significantly reduces plant operating costs. Up to 70% of a wastewater treatment facility's power consumption is taken up with aeration alone. The average treatment facility could save up to 30% by automating the control of aeration levels by actively and accurately measuring DO levels.

Clark cell-based DO sensors (galvanic and polaragraphic) have been the dominating technology for measuring DO in wastewater treatment facilities. Also referred to as electrochemical sensors, these sensors use an anode and a cathode contained in an electrolyte and isolated from the process medium by an oxygen-permeable membrane. Due to the delicate membrane and the contamination of the electrolyte, these sensors require regular and diligent maintenance. The maintenance level can be frustrating and, at times, has left the measurement's benefit questionable.

In early 2002 a sensor using fluorescence technology was introduced for the wastewater industry. With several thousand installations worldwide, the system has proven very reliable and also greatly reduces the level of maintenance for DO measurement.

Fluorescence technology itself is not new. It has been used to measure oxygen uptake in the medical industry for over 20 years. Within the last seven years the technology has been adapted for use in measuring DO in biological reactors. Key issues in making the technology viable for the water treatment industry included ensuring durability of the sensing element and controlling the technology's cost. In addition, the system had to be packaged so the instrument was still easy to use and required very little maintenance.

There are analyzers and sensors that have accomplished these objectives. Unlike traditional Clark cells or some other types of designs for optical probes, it is possible to obtain systems that have no consumables. The sensor has a life expectancy of up to 10 years based on accelerated wear testing and boasts no consumables, no spare parts, no recharging kits, no replacement films, and no membranes or membrane cartridges.

How it works

The system takes measurements by producing a specific energy wavelength (475 nm) within the sensor. This wavelength is then transmitted to a ruthenium compound that is immobilized in a sol-gel matrix. Ruthenium, a metal in the platinum group, is used in alloys to make electrical contacts for severe wear resistance. It absorbs the energy produced, exciting electrons in the ruthenium complex. The electron then collapses back into its original energy state, emitting energy at a wavelength of approximately 609nm.

This is the fluorescing principle. If the intensity of the transmitted wavelength is tightly controlled and the ruthenium is properly immobilized, the amount of fluorescing is both predictable and repeatable. When oxygen molecules are present, the amount of fluorescing is reduced. This is called "fluorescence quenching". By measuring the amount of quenching, it is possible to determine the oxygen concentration in contact with the sensing element.

Fluorescent benefits

Maintenance frequency is not only reduced by eliminating consumables, but so is the calibration frequency. A traditional Clark probe requires frequent calibration due to changes in the membrane/cathode geometry and the electrochemical effect. This effect is eliminated in the fluorescent probe. Due to the stability of the internal electronics and optics, the sensor will drift less than 1% per year and, therefore, calibration verification is only required once or twice a year.

In addition, the fluorescent DO probe is more tolerant of fouling than a traditional Clark cell and is unsusceptible to damage under a normal cleaning routine. All sensors come with a 1/4-inch quick-disconnect that allows an air or water line to be attached for automated cleaning. The analyzer will open or close a solenoid valve or turn an air compressor on or off at user-defined intervals.

This robust sensor is designed for the challenges of a wastewater facility. In the rare circumstance that the measuring surface is damaged, it can be replaced. The sensors are interchangeable, they are not analyzer specific, so the sensors can be moved or a replacement sensor added if required with no required configuration. Essentially, the microprocessor in the sensor "talks" to the analyzer to identify itself and enable the analyzer to adapt to operate with that sensor.

Summary

By implementing fluorescent technology in the measurement of dissolved oxygen levels, wastewater professionals will have a reliable tool that allows for the optimization of the biological processes and for a reduction in the aeration costs related to energy usage. An added benefit is the significantly reduced amount of time spent maintaining and calibrating the system.

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