automation advantages

By Gina White

Evolution of instrumentation for sludge monitoring

Fifteen to 20 years ago, unreliable sensors accounted for most of the difficulties experienced with automatic measurement and control within the wastewater treatment processes. It was a well-known fact that wastewater treatment instruments required more maintenance than their industrial counterparts. Because most measuring devices in wastewater applications are exposed directly to raw sewage, mixed liquors or thickened sludge, these devices are subject to continued fouling from solids deposit, slime buildup and chemical precipitation. Therefore, they require more frequent cleaning and calibration. As a result, the wastewater treatment industry has turned to non-contacting devices and measurement technologies made with wear-resistant materials.

This article will discuss the evolution of some technologies designed for level and flow measurement, as well as a few specialized instruments that provide reliable bed level depth control in clarifiers and thickeners. With the advent of microprocessor technology, software for instrumentation and construction materials developed by chemical companies, the measurement of many applications within a wastewater treatment facility has come a long way to become dependable and long lived.

Sludge Bed Level Monitoring

By definition, wastewater treatment works are high energy users, and their efficient operation requires a fine balance of biological and hydraulic parameters throughout the process. Those processes require both simple and complex technologies used for measuring a variety of different parameters like level, flow, analysis and much more. Clarifiers are one of the first major steps in the wastewater treatment process. The purpose of clarifiers is two-fold: First, they thicken the solids and precipitate them out, and then produce a clear effluent from the settled solids. All waste treatment plants are designed not only for hydraulic overflow rates, but also for underflow solids rates. If a treatment plant becomes too laden with incoming waste influent, then the solids in the clarifiers begin to get out of control, and thus additional clarifiers must be brought into operation to handle the bioload. Clarifiers must be operated efficiently, and the sludge bed level of the thickened solids should be kept controlled at a specified depth. If the sludge level rises too high in a clarifier, then an upset condition will occur and biosolids will begin to flow over the launders.

Additionally, if the sludge level in the clarifier becomes too deep, the bottom rake mechanism (if present) will slow down and be hampered by the heavy sludge material. This will cause rake torque overload. If overloading of sludge bed depth continues, other parameters can change, such as the secondary clarifier effluent pH. In addition, with the presence of gaseous bubbles in the final settling tank, a septic sludge bed condition can change.

Applying a sonar instrument is a way to assist in the monitoring of sludge bed level. This measurement used to present many challenges for technologies such as submerged pressure transducers and optical devices. Even earlier ultrasonic devices had difficulty passing through the heavy suspended solids material.

When using a sonar device, it is imperative to utilize a low enough frequency, as well as a transducer that can propagate through the suspended solids material. Sonar acoustic wave technology has developed to such an advanced state that the measurement within a wastewater or mining sedimentation vessel is routine. The calibration of the bed level detector is simple, but the interface layer and picking up on the lighter flocculent layer can be tricky. Conditions within a clarifier or thickener can be difficult, especially when there is an upset in the process, and the top layer of the liquid is fouling. Technologies for optical and submersible pressure develop buildup quickly, and the fouling causes a failure in the measurement.

Many plants utilize a mechanical dip tube or "sludge judge." This device is simple in design and requires only manual labor to perform the measurement; however, dealing with hazardous waste like raw sewage can be a health hazard if it contacts human skin. Finally, the measurement itself is subjective and can be misread. The measurement is done once or twice per shift by dipping a long hollow tube with a check valve at the bottom. It is then pulled back up, hand over hand, from the raw sewage clarifier.

Process Automation

By automating the measurement process of the sludge bed within the clarifiers, a reliable and controlled signal will be provided to the local control system. This will either modulate the variable speed drive for the underflow pump or signal to a chemical dosing pump when to dispense flocculent. An electronics package is connected to a transducer with interconnecting cable. This transducer design is placed into the sedimentation vessel and submerged 2 to 3 in. Sonar acoustic waves then propagate through the liquid and reflect off the top of the sludge blanket.

The sludge bed level is measured, and the optimum depth of that sludge bed is what produces a desired underflow concentration for the solids being separated in the clarifier. Many factors play a role in the depth of the bed level in the clarifier. Influent and effluent suspended solids, influent flow rate, and under-flow concentration all are parameters that can alter the depth of the sludge. Maintaining a proper bed depth will provide improved process efficiency and allow the right density of biosolids to flow to the next process area. Too much water pumped out at the wrong time will make the downstream equipment (such as the pumps and filter presses) work harder and longer. Measuring the interface layer of the flocculent can decrease the amount of chemical floc used for settling purposes. If the sludge bed level is known and the interface layer measured, there is a good balance between how much chemical floc is added as the level or depth of the bed level changes.

Applying Sonar Acoustic Technology

It has been proven time and again that sonar acoustic technology can reduce the energy consumption of treatment works. The accurate measurement of interface levels is a complex problem in the murky, turbid settling tank environment; and without extensive sample extraction and subsequent laboratory analysis, it is difficult to obtain a clear picture of the sludge density profile. The sludge within the tank decreases in density from the bottom of the tank to the top water level.

The highest-density sludge resides on the bottom of the clarifier. In a stable tank, the sludge will gradually decrease in density to around 200 mg/L at the top of the column. Generally, waste treatment facilities are interested in high-quality biomass or sludge, which has a density greater than 2,500 mg/L. The sludge at the bottom of the tank is referred to as returned activated sludge (RAS).

Sludge at this density is heavy enough not to move hydraulically up the tank when process problems occur and also is dense enough to be termed "good-quality" biomass, which can be returned to the aeration lanes for pretreatment or diverted to waste. When a change occurs to the site loading process, problems can occur and operators need to know the dynamics of the different interfaces to assess and effectively control the continuing process.

Most sonar systems struggle to provide comprehensive and reliable information under difficult conditions, as they do not have the power or correct frequency to penetrate through the suspended solids.

In order to operate a wastewater treatment facility at its optimum efficiency, monitoring the good-quality biomass at 3,000 to 6,000 mg/L is essential. Monitoring this interface allows for control of the RAS pumps to ensure that the process is optimized. Returning good-quality biomass back to aeration, or to the thickener for wasting, is the primary goal. It is crucial in many thickeners and other sedimentation basins to monitor both the sludge bed level and the floc interface layer. If only the lighter-density floc layer interface is measured as a means of control for the RAS pump, then the floc layer will rise due to an imbalance. It automatically is assumed that the denser RAS layer also is rising. This assumption, however, cannot be made from this rise in lighter-density floc layer. If it is, then the wastewater treatment site will increase the RAS pumping rate in an attempt to bring the rising blanket back down in the tank. When this assumption is made, the higher-density sludge or biomass remains at the bottom of the tank and only the lighter floc layer will lift. After time, the lighter flocculent layer will overflow over the launders, and it could take weeks to fully rectify the situation. During this time, increased aeration may be required, which in turn increases energy consumption and costs.

The ideal practice is to apply the sonar acoustic technology to at least monitor the bed level at the optimum height and possibly conduct a second measurement on the floc layer. The transducer provides a pulsed signal through the liquid, which the software displays, whereby the lighter floc layer is picked up, along with the second sludge bed level.

This information forms the basis of improved process and control to enable a site to optimize energy consumption and site operations. Additionally, the five onboard relay contacts can be set so that, in the event of the flocculent level rising, operators can make the necessary process changes in enough time to prevent the problem from continuing and to avert a breach of consent.

Relying on instrumentation and making use of it does not mean that manual skilled labor is void from plant operations. Instrumentation, however, automates measurements and provides a sense of consistency with high repeatability. Having process automation at any plant site frees up manpower so that more improvements can be made and operations can run more efficiently. WWD

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