DECOUPLING AERATION FROM MIXING ACHIEVES 70% ENERGY SAVINGS IN AEROBIC DIGESTION

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The City of Benton, IL, a 1.65 MGD WWTP, is utilizing a system of decoupled aeration and mixing in its aerobic digesters to realize over $40,000 in annual energy cost savings. That amounts to roughly 70% savings versus conventional aerobic digestion without any sacrifice to the digestion process – in fact, the process is improved versus diffused aeration alone.

The process called "BioCycle – D" incorporates compressed gas mixing with diffused aeration, versus diffused aeration alone in order to oxygenate and mix the basin contents at a fraction of the operating cost. The energy-efficient mixing approach referred to as "compressed gas mixing" utilizes large bubbles created from short bursts of compressed air released through nozzles mounted to the basin floor. When used in conjunction with a right-sized diffused aeration system, the Benton, IL WWTP and others are realizing significant benefits including process improvements, energy savings, and automated operation through instrumentation feedback.

TRADITIONAL AEROBIC DIGESTION VS. THE ALTERNATIVE

Traditional aerobic digestion uses diffused aeration to both deliver oxygen and mix; a seemingly simple approach to achieve Class B Solids (per EPA 40 CFR Part 503) using a single technology. However, aerobic digesters are almost always mixing limited, especially when the digesters receive waste activated sludge from long sludge age or extended aeration processes. Mixing limited conditions mean that more energy is required to mix than to satisfy the oxygen demand. The industry standard for mixing sludge with diffused aeration is 30 SCFM/1000 ft^3 of tank volume, which will provide adequate mixing up to about 2% solids. Using blowers and diffused aeration alone, Benton would have required 1,320 SCFM per digester or two 100 HP blowers running continuously with one common standby.

Decoupling the process separates the function of mixing and oxygen delivery. The compressed gas mixing system can mix both digesters from a common 15 HP compressor, which allows for the aeration requirement to be based on oxygen demand alone. The typical industry standard for the Actual Oxygen Requirement, AOR, for complete digestion of waste activated sludge is 2.3 lb. O_2/lb. VSS destroyed. To satisfy the oxygen demand of the sludge at the Benton WWTP, the aeration system requires just 425 SCFM per digester, or two 30 HP blowers operating sixteen hours per day. The other eight hours of each day are reserved for dedicated anoxic time, settling, and decanting. A summary of the power savings offered through the use of a decoupled system is shown below:

	Traditional Approach	BioCycle-D
Air Requirement	1,320 SCFM/digester 24 hours per day	425 SCFM/digester 16 hours per day
	2 blowers @ 100 HP ea.	*2 blowers @ 30 HP ea. 1 compressor @ 15 HP*
Operating Power (BHP)*	24 hours @ 180 HP	16 hours @ 54 HP + 24 hours @ 13.5 HP
Daily Power Consumption (kWh/day)	3221	886
BioCycle-D Power Savings	**72%**	

**Calculated power at 90% of nameplate horsepower*

Incorporating dedicated anoxic mixing into the aerobic digestion process facilitates denitrification to recover alkalinity and mitigate the suppression of pH that would otherwise occur due to uncontrolled nitrification that occurs under continuous aeration. Thus, reducing the need for alkalinity dosing to adjust pH or excessive polymer use prior to dewatering. Optimal oxygen delivery will also reduce process foaming in the digester and improve sludge dewaterability. But process benefits are not limited to sludge treatment alone. When digesters are aerated excessively, the digested sludge begins to break down and release nitrogen and phosphorus that is returned to the head of the plant during decanting. For plants facing permit pressures to remove nutrients, this recycle stream is a disruption to the secondary process. Adequate aerobic and anoxic time creates an environment that keeps nitrogen and phosphorus in the sludge so it is not recycled back into the plant. As more municipalities face nutrient removal requirements, this benefit will become ever more important.

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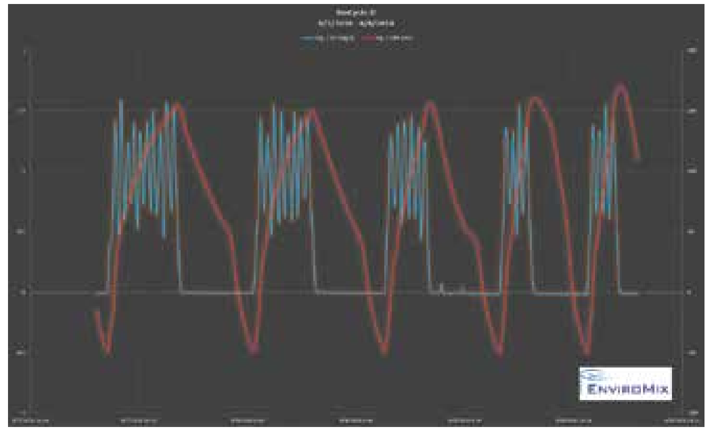

THE MIXING TECHNOLOGY MATTERS

BioMix compressed gas mixing operates by releasing intermittent bursts of compressed air from the tank floor that expand as they rise in an upward mixing motion, evenly distributed across the entire area of the tank. When tank floors are sloped, headers are located along contour lines of the tank floor at different elevations to provide bottom up mixing. The picture shown demonstrates how mixing can be improved with sloped floors.

With variable depths or variable sludge concentrations, the mixing system has the versatility to adjust mixing intensity to meet the demand by adjusting frequency or duration of each burst. Because aerobic digesters are often repurposed tanks and operate at variable depths with variable solids concentrations, a mixing system with the flexibility to overcome these challenges is critical.

All aerobic digesters need aeration, which means there are considerations to be made in selecting a mixing technology that will work optimally in a tank with aeration equipment: impact on the aeration piping system, effect of air from the aeration system on the mixers, and capability to deliver variable mixing intensity for variable mixing demand must all be considered. Propeller mixers, while suitable for many applications, have contending purposes in the presence of aeration. Mixer blades should be kept off and away from air bubbles to prevent cavitation and damage to the blades and motors, air piping should be kept away from mixer blades and typically must be substantially reinforced to withstand the thrust created by the propeller mixer, and operating depth is limited to prevent air vortices from damaging the equipment. BioMix compressed gas mixing is fully compatible with fine or coarse bubble diffused aeration. Because the energy is distributed across the entire tank floor, there is minimal impact on the design of the aeration piping system. Mixing can be operated intermittently or concurrently with the diffused aeration system providing operational flexibility.

INSTRUMENTATION FINE TUNES

For the 2018 startup, and likely for years to come, the Benton, IL plant will receive much less than its 1.65 MGD design flow. A traditional aerobic digester cannot turn off blowers to match the WAS loading; they must mix at the constant air rate. With decoupled aeration and mixing, ORP and DO instruments are used to manage setpoints, and turn blowers off for longer than the dedicated eight hours per day. If the Benton WWTP is only producing 50% of the sludge it would at its design condition, it will require 50% of the blower runtime. The process has the operational flexibility to capitalize on greater energy savings while the facility is operating at under-loaded conditions. The graph demonstrates a brief glimpse into the operation of the Benton digesters, a rising ORP – red line, indicates the blowers are turned on, an oscillating DO – blue line indicates the blowers are adjusting speed to meet a DO setpoint, and a decreasing ORP represents anoxic conditions are being achieved. A traditional aerobic digester would have a DO climb and remain high, indicating that air is no longer needed for the process. Additional process control and flexibility can be realized through tracking and responding to pH in the aerobic digesters.

A BRIGHT FUTURE FOR BENTON, CASTLE ROCK, EMPORIA, CLAIRTON, AND MORE TO COME

Municipalities today are selecting technology on the basis of the full cost of ownership over the life of that technology whether that cost is environmental footprint, maintenance costs, or energy costs. The proper augmentation to your process and existing treatment equipment can offer energy savings along with modernized controls and process optimization.

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