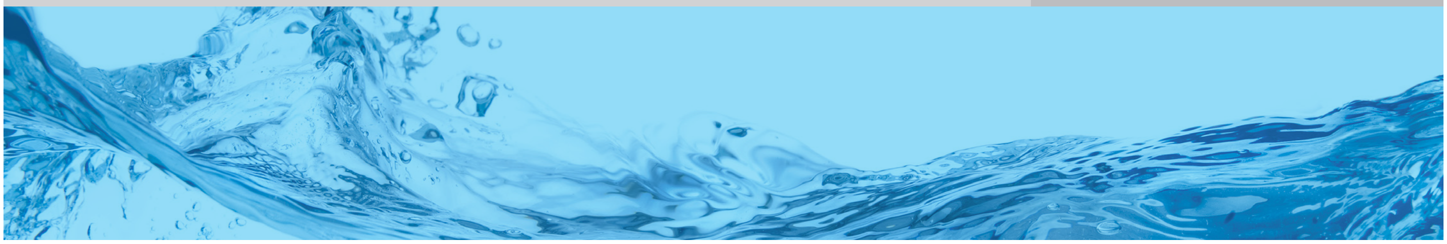

Lower Aeration Tank Water Levels to Reduce Static Pressure on Blowers

Principle

The activated sludge process is a common wastewater treatment step where influent wastewater is injected with air or oxygen by blowers via submerged diffusers, referred to as "aeration." Aeration promotes the growth of aerobic microorganisms that can then digest the organic matter in the wastewater. The microorganisms clump together and settle to the bottom of the settling tank (clarifier), prior to disinfection. The settled material, or sludge, is removed from the tank bottom before some material is recycled back into the activated sludge process and the remainder is sent for further processing.

The aeration process is commonly the most energy-intensive in activated sludge plants, often accounting for more than half of the plant's energy[1]. Therefore, improvements to the aeration process are key to reducing energy consumption. Most of this energy consumption is from the blowers that deliver air or pure oxygen to the wastewater. These blowers are essentially low pressure, high volume air compressors that both agitate the wastewater and produce air bubbles to "feed" the aerobic microorganisms via diffusers submerged in the aeration tanks. The electrical work required by the blower to move air through a pipe is shown below.

$$W_{elec} = \frac{\dot{V} \times \Delta P_{tot}}{\eta_{blower} \times \eta_{motor}}$$

Thus, the variables affecting the amount of energy consumed by the blower are the volume flow rate of the fluid being moved ($\dot{V}$), the pressure rise that needs to be overcome (ΔP_{tot}), and the efficiency of the blower and motor, respectively (η_{blower} and η_{motor}). Unlike typical pumping applications, blowers produce air flow, not pressure – the system's resistance to this air flow is what creates pressure[2].

Suggested Actions

- Determine current aeration tank water levels.
- Determine whether these can be lowered without any hindrance to the treatment process.
- If so, lower aeration tank levels to determined height and monitor process to ensure regular activity.

[1] Pabi, S, et al. 2013. "Electricity Use and Management in the Municipal Water Supply and Wastewater Industries." Electric Power Research Institute: 194.

[2] Jenkins, Tom. "Aeration Blower Requirements." Blower & Vacuum Best Practices Magazine. Accessed September 3, 2021. https://www.blowervacuumbestpractices.com/technology/aeration-blowers/aeration-blower-requirements.

The pressure rise needed to be overcome (shown in the equation below) is dictated by the difference in the inlet and outlet static head pressure, velocity head pressure, and elevation head as well as the frictional head pressure created by friction in the pipe.

$$\Delta P_{tot} = \Delta P_{static} + \Delta P_{velocity} + \Delta P_{elevation} + \Delta P_{friction}$$

In an aeration system, the most substantial pressure differential is from the depth of submergence of the diffusers in the aeration tank – typically accounting for 80 to 90 percent of the total pressure rise needed to be overcome[3]. Therefore, even small decreases in the water level above the diffusers could result in significant energy and cost savings from the blowers. It is important to not lower tank levels too low though because the depth of water determines the residence time of the diffused bubbles and therefore the oxygen transfer efficiency. A good rule of thumb is to have around 12-15 feet as a minimum tank level but every facility and every system is unique so be sure to monitor all processes whenever altering a variable such as aeration tank water levels[4].

Example

A hypothetical wastewater treatment plant will be used to demonstrate the energy saving benefits of reducing the submergence depth of the aeration diffusers by lowering the aeration tank levels to a safe and reasonable level. Currently, two blowers are supplying air to diffusers submerged 20 feet in the aeration tank. Each blower, on average, runs at a flow rate of 2,000 cubic feet per minute (cfm) to maintain proper aeration for the treatment process for a total of 4,000 cfm[3]. Assuming that the depth of submergence accounts for 80% of the total pressure needed to be overcome, the current pressure differential in the system would be equal to 25 ft-H_2O or 300 in-H_2O. With an estimated combined efficiency of 80% for the blowers and 90% for the motors, the baseline annual energy consumption (using the equation from page 1) for the blowers is calculated below.

$$\mathbf{W_{baseline}} = \frac{4{,}000\ [\text{cfm}] \times 300\ [\text{in-H}_2\text{O}]}{0.8 \times 0.9} \times \frac{0.746 \left[\frac{\text{kW}}{\text{hp}}\right]}{6{,}356 \left[\frac{\text{cfm-in}}{\text{hp}}\right]} \times 8{,}760\,\frac{\text{hrs}}{\text{yr}} = \mathbf{1{,}713{,}593}\ \frac{\mathbf{kWh}}{\mathbf{yr}}$$

Compare the baseline energy consumption of the blowers to the same facility but with slightly lower aeration tank levels. This facility finds that there would be no negative impacts to the aeration process or treatment process in general if they lowered the aeration tank levels a foot and a half to 18.5 feet. This would reduce the blower system pressure differential (still assuming that the depth of submergence

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[3] Aerzen. "Aeration Blowers in the Wastewater Industry in North America." Aerzen USA Corporation: 8. https://vertassets.blob.core.windows.net/download/116613d5/116613d5-d2a2-42c3-b3a5-a17700a0d648/whitepaperaerationblowerwastwaterindustry2.pdf.

[5] Rosso, D. 2018. "Aeration, Mixing, and Energy: Bubbles and Sparks." IWA Publishing.

accounts for 80% of the total) from the previous 300 in-H_2O to 278 in-H_2O. The new annual energy consumption for the blowers, assuming everything else is equal, is calculated below.

$$\mathbf{W_{lowered}} = \frac{4{,}000\ [\text{cfm}] \times 278\ [\text{in-H}_2\text{O}]}{0.8 \times 0.9} \times \frac{0.746 \left[\frac{\text{kW}}{\text{hp}}\right]}{6{,}356 \left[\frac{\text{cfm-in}}{\text{hp}}\right]} \times 8{,}760\ \frac{\text{hrs}}{\text{yr}} = \mathbf{1{,}587{,}930\ \frac{kWh}{yr}}$$

This results in energy savings of over 125,000 kWh per year which, at an estimated $0.10 per kWh, would equate to annual cost savings of about $12,500 with nearly zero implementation costs. Time and care should be taken in finding the right aeration tank levels, for each facility is slightly different, but small reductions in aeration tank levels can result in significant savings.

Resources

See the Sustainable Wastewater Infrastructure of the Future (SWIFt) website for more information on wastewater energy solutions at betterbuildingssolutioncenter.energy.gov/accelerators/wastewater-infrastructure

To view more Energy Tip Sheets visit energy.gov/eere/amo/tip-sheets-system

To access these and many other industrial efficiency resources and information on training, visit the Advanced Manufacturing Office Website at manufacturing.energy.gov