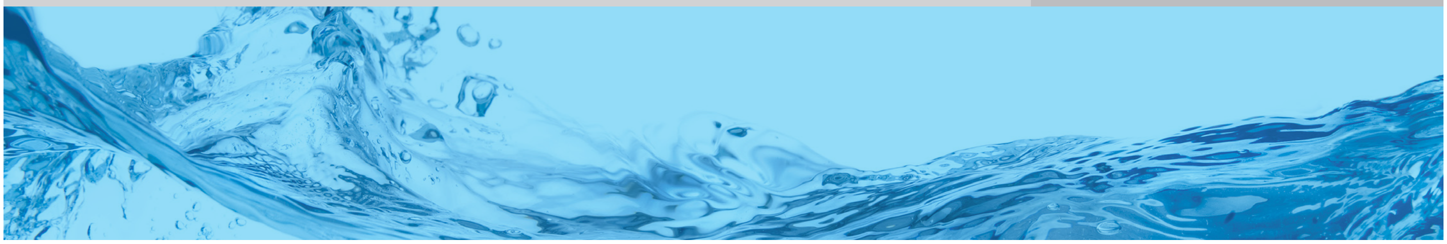

Utilize Fine-Bubble Diffusers in Aeration Tanks

Principle

During secondary treatment at a wastewater treatment plant, aerobic microorganisms consume and digest any organic impurities that remain in the sludge. Since these microorganisms require air, oxygen has to be blown into the aeration tanks such that the amount of oxygen is not the limiting step in the secondary treatment process. This tends to lead to over-aeration, which may hamper treatment and cause problems later on in the process such as reduced settling of the microorganisms, in addition to increasing the energy usage from the blowers[1]. This aeration typically accounts for about one-half of a facility's energy usage – by far the most energy intensive step in the treatment process. Therefore, any improvements that can be made to the aeration process are key to reducing energy consumption.

Diffusers are submerged in aeration tanks and break the air (provided by blowers) into bubbles for the aeration process. Typical coarse-bubble diffusers provide an oxygen transfer rate of about 2.0 lb-O_2/hp-hr. Mechanical aerators have similar estimated values of between 2.0-3.0 lb-O_2/hp-hr. Fine-bubble diffusers produce smaller bubbles which increase the oxygen transfer rate in two aspects – greater surface area per volume and longer time spent in the liquid. Therefore, fine-bubble diffusers perform much more efficiently with oxygen transfer rates of about 6.5 lb-O_2/hp-hr[2]. This increased oxygen transfer rate allows for the blowers to be run at much lower loads, thereby reducing energy consumption for the same amount of aeration.

Suggested Actions

- Determine current diffuser type.
- If mechanical or coarse-bubble, consider replacing with fine-bubble diffuser.

[1] Higgins, Walter, and Jim Kern. "Too Much Air? Understanding the Critical Role of Aeration Systems." Treatment Plant Operator Magazine, March 1, 2016. Accessed September 3, 2021. https://www.tpomag.com/editorial/2016/03/too_much_air_understanding_the_critical_role_of_aeration_systems.

[2] US EPA. 1985. "Summary Report: Fine Pore (Fine Bubble) Aeration Systems." United States Environmental Protection Agency: 1-56.

Since fine-bubble diffusers have about double the oxygen transfer rate of typical coarse-bubble diffusers, they only require about half of the air required from the blowers to accomplish the same amount of aeration as coarse-bubble systems. Therefore, converting to fine-bubble diffusers is best suited for aeration systems equipped with variable frequency drives which allow the blower to decrease the amount of air discharged.

Table 1. Typical Clean Water Oxygen Transfer Rates (EPA 1984)

Diffuser Type and Placement	**Oxygen Transfer Rate lb–O_2 / hp–hr**
Course Bubble Diffusers	2.0
Fine Bubble Diffusers	6.5
Surface Mechanical Aerators	3.0
Submerged Turbine Aerators	2.0
Jet Aerators	2.8

Assuming the aeration system utilizes centrifugal blowers and are automatically switched on or off based on dissolved oxygen levels, energy savings from utilizing a fine-bubble diffuser instead of an alternate method of aeration is calculated by multiplying the current average power draw of the blower by the ratio of the current and proposed oxygen transfer rates (OTR), as shown below:

$$W_{savings} = W_{blower_{current}} \times \left(\frac{OTR_{current}}{OTR_{proposed}} \right)$$

Costs for switching from coarse-bubble diffusers to fine-bubble diffusers vary based on many factors such as plant operating capacity, age of existing equipment, number of diffusers currently operating, and typical cleaning schedule. Thus, it is difficult to accurately predict the expected costs of retrofitting an existing system with fine-bubble diffusers but many studies conducted have shown simple paybacks of between two to six years[3]. The economic benefits are much greater if the fine-bubble diffusers are installed at the beginning of a project or as the current coarse-bubble diffusers reach the end of their life, resulting in simple paybacks of less than two years[4]. Therefore, retrofitting the current system with fine-bubble diffusers at the end of the current coarse-bubble diffuser life would result in much better economic payback.

Potential Drawbacks

While fine-bubble diffusers are great for reducing energy consumption in aeration systems, there are some drawbacks resulting from the smaller diffuser pores and smaller bubble volume. Coarse-bubble diffuser aeration systems typically require limited routine maintenance for the blowers since the larger diffuser pores foul at a much lower rate. In addition to the routine blower maintenance, fine-bubble diffuser systems require diffuser cleaning every two to five years and membrane diffuser change-out every eight to twelve years[5]. Without this regular maintenance, the fine-bubble diffuser pores can become clogged and,

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[3] Herbert, Joe. "Process Aeration: Micro-Bubble Generators." Michigan Water Environment Association. https://mi-wea.org/docs/Session%204%20-%20Microbubble%20aeration%20session.pdf.

[4] US EPA. 1989. "Design Manual: Fine Pore Aeration Systems." United States Environmental Protection Agency: 1-328.

[5] Mulinix, Scott. "Aeration 101 – Back to Basics." Arkansas Water Environment Association. https://awea-ar.org/images/downloads/2012_Specialty_Conference_Presentations/aeration101_scott_mulinix_presentation_rev1.pdf.

therefore, reduce the oxygen transfer rate and the associated potential energy savings. In addition, the smaller volume of the bubbles produced by the fine-bubble diffusers results in weaker mixing of the suspension solids which can result in further sludge build-up and less effective digestion[6]. Therefore, for especially deep tanks or heavy biosolids where effective mixing is critical, coarse-bubble diffusers could result in less maintenance and cleaning costs compared to a fine-bubble diffuser aeration system.

Example

As an example, let's assume that a wastewater treatment plant is utilizing a single 100-hp (75 kW) blower fan at maximum capacity with coarse-bubble diffusers (~2.0 lb-O_2/hp-hr) for their aeration treatment. If this plant were to switch to fine-bubble diffusers (~6.5 lb-O_2/hp-hr) for aeration, the power savings would be calculated as below:

$$\mathbf{W_{savings}} = 75\text{ kW} \times \left(\frac{2.0\,\frac{\text{lb} - \text{O}_2}{\text{hp} - \text{hr}}}{6.5\,\frac{\text{lb} - \text{O}_2}{\text{hp} - \text{hr}}} \right) = \mathbf{23.1\text{ kW}}$$

If this hypothetical blower runs 20 hours per day, 365 days per year, there would be annual energy savings of about 170,000 kWh which would save nearly $17,000 each year (at an estimated $0.10 per kWh). If the blowers can be ramped up and down with variable frequency drives based on dissolved oxygen levels, additional energy savings could potentially be had due to fan affinity laws barring a statically-dominated system[7].

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

[6] Frankel, Tom. "Fine Bubble vs. Coarse Bubble Diffusers." SSI Aeration, July 19th, 2019. Accessed September 3, 2021. https://www.ssiaeration.com/fine-vs-coarse-bubble-diffusers/#fine%20cons.

[7] See Chapter 8 of the DOE Guide "Continuous Energy Improvement in Motor Driven Systems" for more information: https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_guidebook_web.pdf.