# Energy Optimization Strategies in a Sequencing Batch Membrane Bioreactor

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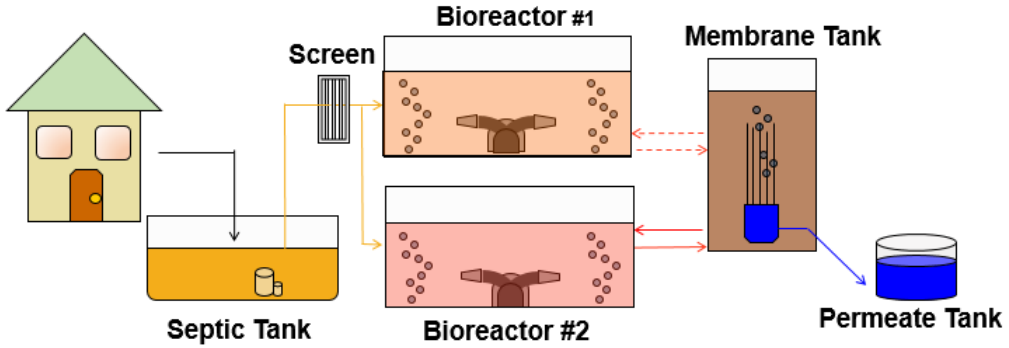
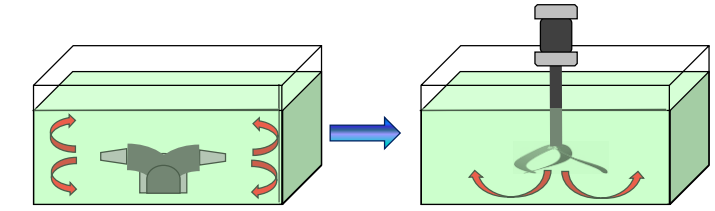
The SBMBR used in this study is a hybrid system that integrates a sequencing batch reactor (SBR) with a membrane bioreactor (MBR).




While treated effluent from the SBMBR is very high quality, high operating costs from aeration are a significant drawback.

My first set of experiments were **Oxygen Transfer Tests**
In a nutshell: How well is oxygen delivered to the bioreactor?
Are some mixing & aeration configurations better than others?



Power = **4.9 kW**

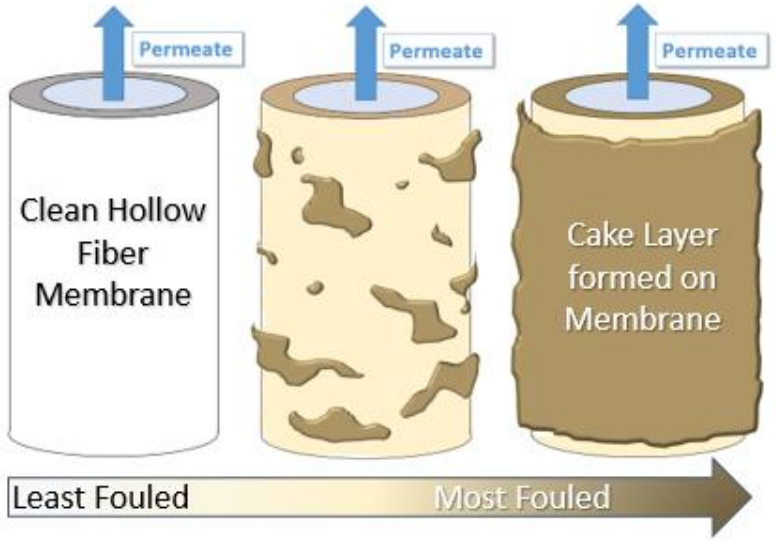
Power = **1.5 kW**

Coarse vs Fine Bubble Diffusers

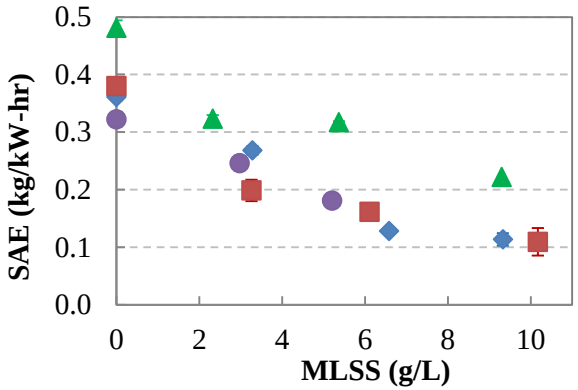
My second set of experiments were **Membrane Relaxation Tests**

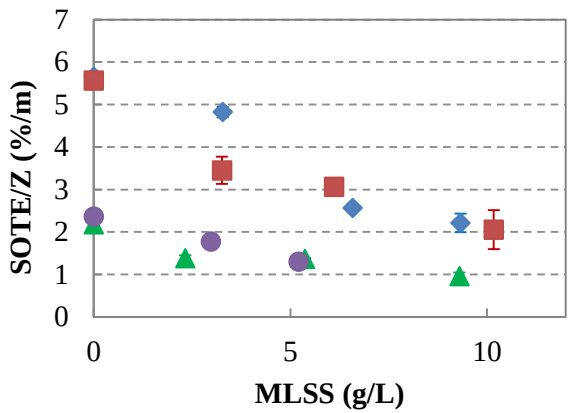
In a nutshell: Can pausing membrane permeation (membrane relaxation) reduce transmembrane pressure (TMP) buildup over time?

Literature suggests that membrane relaxation reduces TMP buildup over time by enabling the cake layer to more easily break apart. The cake layer is a buildup of particles along the membrane, also called fouling.



## Results – Oxygen Transfer




Legend: - Coarse Bubble, Low Flow
Coarse Bubble, High Flow
Fine Bubble, Mixing On
Fine Bubble, Mixing Off

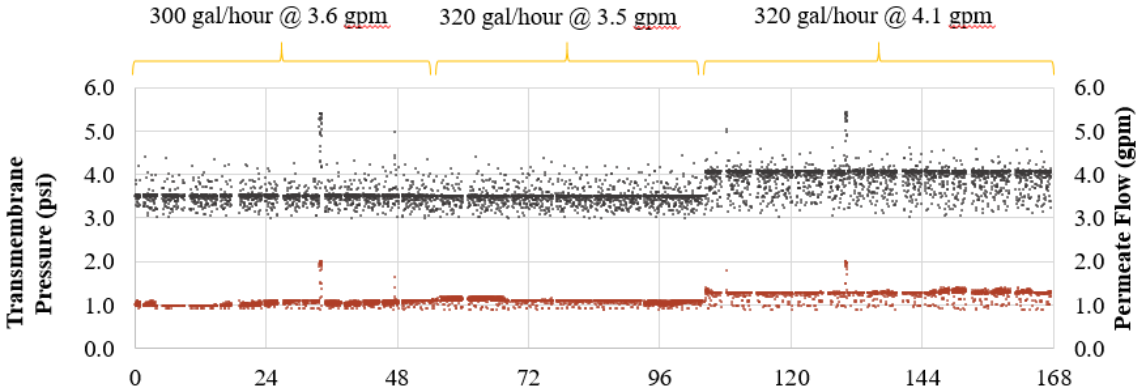
Upgrading the diffusers from coarse to fine bubble did not necessarily result in more efficient aeration. Shown in the figures, mixed liquor suspended solids (MLSS) is the concentration of suspended solids in the bioreactor. Higher concentrations of MLSS indicate more microbial activity, thus more oxygen uptake.

The standard aeration efficiency (SAE) (graph on the left), which normalizes oxygen transfer based on power consumption, was better for coarse bubble diffusers. Standard oxygen transfer efficiency (SOTE) (graph on the right) normalizes oxygen transfer to aeration flow rate. Fine bubble diffusers were more 2.5 times more efficient at transferring oxygen based on air flow than coarse, as shown in Figure 4A. **The discrepancy between SOTE and SAE suggests that our air blowers need to be upgraded and optimized for fine bubble diffusers.**

## Results – Membrane Relaxation

| | Historic Trends | Relaxation #1 | Relaxation #2 | Relaxation #3 |
|---|---|---|---|---|
| **Relaxation/hour** | **2.1 min/hour** | **12.1 min/hour** | **5.1 min/hour** | **11.5 min/hour** |
| **Average TMP, ± standard deviation** | 1.58 psi ± 0.71 | 1.01 psi ± 0.46 | 1.07 psi ± 0.41 | 1.28 psi ± 0.56 |
| **Averaged Permeate Flow** | 4.0 gal/min | 3.6 gal/min | 3.5 gal/min | 4.1 gal/min |
| **Permeation Time/hour** | 50.6 min/hour | 43.2 min/hour | 49.8 min/hour | 43.7 min/hour |
| **Gallons/hour** | 324 gal/hour | 300 gal/hour | 320 gal/hour | 320 gal/hour |
| **Flux** | 19.7 LMH | 21.3 LMH | 19.8 LMH | 22.5 LMH |

Legend: Transmembrane Pressure (TMP)
Permeate Flow




Average transmembrane pressure (TMP) was lower, from 1.58 psi with 2.1 min/hour of relaxation to 1.07 psi with 5.1 min/hour relaxation treating nearly the same amount of water. However, with Relaxation #3, increasing permeate flow to induce more relaxation did not result in lower average TMP than Relaxation #2, and both conditions treated the same amount of water. There is a point when excessive relaxation forces the permeate pump to work harder and operate at higher TMP to treat the target amount of water.