Innovations in Submersible Mixing

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Agenda

- Mixing principles
- Madison Nine Springs Cost Reductions
- South Shore Pilot Study
- Slinger, WI Phosphorus Reduction
Submerged Jet Mixing Basics
Creating Mixing and Bulk Flow

- Many flows, one source
- Inflow
- Primary flow
- Entrained flow
- Bulk Flow

Jet

Inflow  Entrained flow
Primary Flow
Inflow  Entrained flow
Mixer Positioning
Creating Mixing and Bulk Flow

Intensive mixing zone

Bulk Flow
Mixer Positioning
Mixer Jet

- Jet drives both primary flow and bulk flow
- Jet brings the surrounding liquid into motion
  - The surrounding low-velocity liquid is entrained
- Majority of the mixing is not in the prop-area
- Intensive mixing happens along the jet border
Flygt Mixer Positioning for a bulk flow loop

1. Determine an efficient bulk flow loop
2. Locate the mixer along the streamlines of the loop
3. Position for a long jet path
4. Smooth Jet deflection
5. Steer clear of obstacles
Submersible Mixer Positioning
1. Determine the most natural, efficient bulk flow loop
Submersible Mixer Positioning

2. Locate the mixer along the streamline of the loop
Submersible Mixer Positioning

3. Position for a long jet path

Long jet paths entrain more flow and develop a stronger bulk flow.
Submersible Mixer Positioning

4. Smooth jet deflection

Smooth jet deflection: Yields low hydraulic losses
Submersible Mixer Positioning
Long jet path & smooth deflection

[Diagram showing correct and incorrect positioning of a submersible mixer]
Submersible Mixer Positioning

5. Steer clear of obstacles

- Pipes, Pillars ...

- Bends, Aerators ...
Best Practice: Minimize Mixing Energy

Oversizing mixers should be avoided

- Wastes energy
- Too much turbulence can reduce equipment life.
- Especially if not properly positioned, the jet from an oversized mixer can damage nearby mixers.
Madison, WI Nine Springs WWTP

Anaerobic Selector Basin Dimensions

33’ Long
30’ wide
17’ deep
Less Mixing Yields Big Savings

2.5 HP / 4.0 HP  7.5 HP / 2.5 HP

Madison Metropolitan Sewerage District
Phosphorous removal the same Before & After

Before: 7.5 HP

After: 2.5 HP
Calculated costs

<table>
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<tr>
<th>Savings</th>
<th>Annual Cost</th>
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<tbody>
<tr>
<td>$165,821</td>
<td>$83,484</td>
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<tr>
<td>$82,337</td>
<td>$100,000</td>
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<tr>
<td>$150,000</td>
<td>$200,000</td>
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</table>

Before | After
Electrical usage

Before

- 94% Rest of WWTF
- 6% Mixers

After

- 94% Rest of WWTF
- 3% Mixers
- 3% Savings
When heavier solids are removed from wastewater by screening and grit removal, mixing energy can be safely reduced.
MMSD South Shore WWTP
Aeration basins
28 Aeration Basins

NORTH

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

SOUTH

Mixing Study Basins: 25, 26, 27

Process Flow
Study Comparing 3 Mixing Methods

1. Basin 25: Large Bubble Mixing System
2. Basin 26: Submersible Propeller Mixer
High efficiency mixer with built-in VFD

Easily change mixing to actual process conditions
Milwaukee MSD BioP Removal

**Basin 26**
Mixer Design:
- 8.2 ft Dia
- Adjustable speed
- 0 – 32 RPM
- High Efficiency
- Self-cleaning
- Debris-free

Mixing Power
- 0.17 kW
- 170 W

Power/Volume
- 0.28 W/cubic meter
- 7.87 W/1000 cubic feet

**Zone Size:**
- 48 feet long
- 30 feet wide
- 15 feet deep
- 21,600 cubic feet

**Basin 26: Shown above:** Air turned off to the diffusers in this zone
**Basin 25:** Large Bubble Mixing system installed
**Basin 27:** Air turned down to only mix, not aerate
Basin 25
Large Bubble Mixing

Basin 26
Submersible Horizontal Propeller Mixer

Basin 27
Fine Bubble Mixing
TSS Sampling Locations

Top-view of sampling locations:
How Low Can You Go?

Energy Consumption

- Large Bubble Mixer
- Flygt 4320 Mixer
- Fine Bubble Mixing

Chart showing energy consumption over time with different types of mixers.
TSS Sampling Locations

Side-view of TSS cross-section sampling locations 6 and 2:

- Southern basin wall
- Sludge Judge
- Water-level

Dimensions:
- 15'
- 28.5'
- 5'
Large Bubble Mixer Location #2 - TSS

Large Bubble Mixer Location #4 - TSS

Large Bubble Mixer Location #6 - TSS
Flygt 4320 Mixer
Location #2 - TSS

Flygt 4320 Mixer
Location #4 - TSS

Flygt 4320 Mixer
Location #6 - TSS
Fine Bubble Mixing
Location #2 - TSS

Fine Bubble Mixing
Location #4 - TSS

Fine Bubble Mixing
Location #6 - TSS
Flygt 4320 Mixer - Average TSS of Locations #2,4,6
Variable Speed / Power Settings

TSS (g/L)

- Avg Top
- Avg Middle
- Avg Bottom

15 RPM = 0.34-0.36 kW
10 RPM = 0.16-0.18 kW
5 RPM = 0.04 to 0.05 kW
7 RPM = 0.06 to 0.07 kW
Initial Operation
Mixer Running
15 RPM
0.34 kW
Good Mixing
Scum is periodically cleaned by turning up the mixer.
Minimizing Mixing Energy in Activated Sludge

How did we achieve such good mixing with such low mixing energy?

- **Mixer itself**

  - High thrust-to-power ratio
    - Flygt Banana Blade Mixers have *the highest published ISO 21630 thrust-to-power ratio* of any submersible mixer supplier
    - 5 times more effective than traditional compact submersibles
  
  - Adjustable thrust via integrated VFD
    - Enables operator to turn the mixing energy up or down to suit
  
  - Self-cleaning propeller does not collect debris
Minimizing Mixing Energy in Activated Sludge

How did we achieve such good mixing with such low mixing energy?

❖ Smart Mixer Position

- Engineered to take full advantage of the mixer jet within the basin geometry
- Minimizes hydro-mechanical losses
Milwaukee MSD BioP Removal
High efficiency mixing system

The mixer is positioned in the corner of the mixing zone.

For this zone geometry, that will create the most efficient bulk flow loop with the least hydro-mechanical losses as it flows in a race-track shaped loop.
Acknowledgements

Sid Arora, Kevin Jankowski, Katie French and Nina Fricano

*MMSD*

Greg Markle

*Veolia*
Slinger, WI

Submersible Mixing Versus Chemicals – Phosphorus Reduction
Questions?
Goals of BNR Mixing

1. Prevent settling
2. Prevent short-circuiting of inflows
3. Promote robust contact between microbes and wastewater.
4. Minimize energy consumption
5. Maximize process flexibility
High efficiency mixer with built-in VFD

Easily change mixing to actual process conditions
Growing load

- Population increase
- New suburbs
- New industries
Changing process targets

- Phosphorus
- Nitrogen
- Organic matters, BOD
Changing plant conditions

- Inlet screen
- Aeration system type and operation
- Sections redesign
- Bulkflow velocity
- Return activated sludge flow
Changing mixer conditions

- Oxidation ditches
  - Varying air flow

- Anoxic zones
  - Varying water flow

- SBR's
  - Varying water level

- Digesters
  - Varying media
Maintaining process results

Strong currents everywhere
- too much mixing

Clear layers (more than pictured)
- too little mixing

Much foam or crust
- too little mixing

Sludge deposits
- too little mixing
Processes not static, not always known

Choose power reserve for future, set speed for today’s need
Changing speed

- Propeller speed
- Power consumption
- Operating hours
- Soft start/stop setup
- Alarm handling
No external VFD

- Simpler
- Saving time and money
- Higher reliability
- Clear responsibility
- Better drive environment
New standard in mixer efficiency

- Building on the efficient mixing of legacy products Concept
- IE4 equivalent motor efficiency
Additional benefits

- Soft start, soft stop
- High power factor
- Auto overload reduction
Wide range

- Covers 4410, 4430, part of 4460, 4530
- Propellers 1.4 / 2.0 / 2.5 m
- Ratings 2 / 4 / 8 kW
- 50/60 Hz, 380-480 V
Installation