Turbo Blowers improve energy efficiency at an oxidation ditch wastewater treatment plant

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Introduction

- Mukilteo Water & Wastewater District’s Big Gulch Wastewater Treatment Facility

- Oxidation ditch activated sludge plant with brush rotor aeration

- Capacity expansion study: turbo blowers with diffused aeration gave significant energy efficiency improvement
Big Gulch Wastewater Treatment Facility

- Originally built in 1970; Upgrades in ‘84, ’89
- Oxidation-ditch secondary treatment
Hydraulic Profile of the Big Gulch WWTF
Don’t Always Focus On Your Rear-end
Don’t Always Focus On Your Rear-end

Influent Loading Trends at MWWD

- Average Annual BOD5
- Average Annual TSS
- Maximum Monthly BOD5
- Maximum Monthly TSS
- BOD5 Limitation
- TSS Limitation
Capacity Study and Engineering Report

- Intermittent soluble BOD loading spikes in 2006
- New sampler revealed TSS loadings much higher than previously measured
- Long-term trend of increasing loading rates
Capacity Study and Engineering Report

Report Recommendations:

- Loading source investigations in collection sys.
- Grit removal improvements
- **Activated sludge aeration capacity expansion**
- Aerobic digester aeration capacity expansion
Activated Sludge Aeration Alternatives

1. Additional brush rotor

2. Converting one oxidation ditch to diffused aeration with positive displacement blowers

3. Converting one oxidation ditch to diffused aeration with turbo blowers
Fundamentals of Turbo Blowers

- Introduced to U.S. market in past two years
- Single-stage centrifugal blower
- Integrated high-frequency VFD

K-Turbo blower at Mukilteo WWD
Impeller directly mounted on motor shaft
High-speed permanent magnet motor (up to 60,000 rpm)
Contact-less airfoil journal bearing

- 10 times larger diameter than oil bearing
- 10 times length than oil bearing
- Light load only
- Bump structure and Flexible top foil gives maximum supporting force
- Dry lubricant coating protect bearing surface during On/Off (20,000 time with Teflon)
Fundamentals of Turbo Blowers
Fundamentals of Turbo Blowers

• Reduced owner maintenance: no maintenance required for seals, lubrication, etc.

• Low power at motor start

• Can run unloaded at 1% of rated power
Comparison of Aeration Alternatives

Oxidation Ditch “A” peak energy consumption

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Aeration Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Oxygen Demand (lb/day)</td>
<td>Brush Rotors</td>
</tr>
<tr>
<td>Standard Oxygen Demand (lb/day)</td>
<td>4,527</td>
</tr>
<tr>
<td>Diffuser Air Flow Rate (scfm)</td>
<td>N/A</td>
</tr>
<tr>
<td>Max. Motor Power (hp)</td>
<td>115</td>
</tr>
<tr>
<td>Max. Motor Power (kW)</td>
<td>86</td>
</tr>
<tr>
<td>Power Savings at Max. Load vs. Brush Rotor (%)</td>
<td>48%</td>
</tr>
<tr>
<td>Power Savings at Max. Load vs. PD Blower (%)</td>
<td></td>
</tr>
</tbody>
</table>
### Comparison of Aeration Alternatives

#### Oxidation Ditch “A” annual avg. energy consumption

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Brush Rotors</th>
<th>Diffused Aeration with PD Blower</th>
<th>Diffused Aeration with Turbo Blower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Oxygen Demand (lb/day)</td>
<td>2,440</td>
<td>2,440</td>
<td>2,440</td>
</tr>
<tr>
<td>Diffuser Air Flow Rate (scfm)</td>
<td>N/A</td>
<td>665</td>
<td>665</td>
</tr>
<tr>
<td>Average motor power req'd (hp)</td>
<td>58</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>Avg. Annual Power Consumption (kWh)</td>
<td>380,000</td>
<td>183,000</td>
<td>137,000</td>
</tr>
<tr>
<td>Annual Power Savings (kWh)</td>
<td>197,000</td>
<td>243,000</td>
<td></td>
</tr>
<tr>
<td>Annual Power Cost Savings ($)</td>
<td>$13,800</td>
<td>$17,000</td>
<td></td>
</tr>
<tr>
<td>Annual Power Savings vs. brush rotor (%)</td>
<td>52%</td>
<td>64%</td>
<td>25%</td>
</tr>
<tr>
<td>Annual Power Savings vs. PD blower (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Comparison of Aeration Alternatives

**Oxidation Ditch “A” annual O&M costs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Brush Rotor Alternative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>380,000</td>
<td>kWh</td>
<td>$0.07</td>
</tr>
<tr>
<td>Repair and Maintenance</td>
<td>1</td>
<td>LS</td>
<td>$2,300</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. Diffused Air with PD Blower Alternative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>183,000</td>
<td>kWh</td>
<td>$0.07</td>
</tr>
<tr>
<td>Repair and Maintenance</td>
<td>1</td>
<td>LS</td>
<td>$2,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Diffused Air with Turbo Blower Alternative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>137,000</td>
<td>kWh</td>
<td>$0.07</td>
</tr>
<tr>
<td>Repair and Maintenance</td>
<td>1</td>
<td>LS</td>
<td>$1,800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of Aeration Alternatives

Oxidation Ditch “A” lifecycle cost comparison

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Construction Cost</th>
<th>Annual O&amp;M Cost Estimate</th>
<th>20-year Net Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush Rotor Alternative</td>
<td>$261,000</td>
<td>$28,900</td>
<td>$808,000</td>
</tr>
<tr>
<td>Diffused Air with PD Blower Alternative</td>
<td>$279,000</td>
<td>$14,900</td>
<td>$507,000</td>
</tr>
<tr>
<td>Diffused Air with Turbo Blower Alternative</td>
<td>$321,000</td>
<td>$11,400</td>
<td>$490,000</td>
</tr>
</tbody>
</table>
Comparison of Aeration Alternatives

- Selected alternative: **Diffused air with turbo blower**
- Despite higher capital cost, energy efficiency resulted in a payback period of 4 years
- Lowest 20 year lifecycle costs (3% lower than PD blower)
- 65% energy savings compared to brush rotors
- 25% energy savings compared to PD blower
Electric utility rebate

- Snohomish County PUD No. 1 monitored electricity consumption before and after Ditch “A” project construction
- Rebate for construction costs equal of $0.17/kWH of annual electricity savings
  - District to receive PUD Incentive Rebate of $39,171
Electric utility rebate

Pre-Metering Results: Ditch “A” Week 2 Rotor 1

![Graph showing electric utility consumption over time with key metrics: Mean 23.58 kW, Duration 7:00:00:00, Maximum 30.19 kW, Minimum 15.07 kW.]
Electric utility rebate

Pre-Metering Results: Ditch “A” Week 2 Rotor 2

Diagram showing real power kW over time, with peak of 29.40 kW and mean of 22.11 kW, duration 7206:00:00, minimum 13.67 kW.
Electric utility rebate

Post-Metering Results: Ditch “A” Blower
Installation of Blower & Diffusers

• Dewatering of Existing Tankage
• Removal /Disposal of Accumulated Grit and Debris
• Demolition/Removal of Old Equipment
• Locating Plumbing and Electrical
• Installation of New Equipment
• Testing of New Equipment
Installation of Blower & Diffusers

• Dewatering of Existing Tankage
Installation of Blower & Diffusers

• Removal /Disposal of Accumulated Grit and Debris
Installation of Blower & Diffusers

- Demolition/Removal of Old Equipment
Installation of Blower & Diffusers

• Locating Plumbing
Installation of Blower & Diffusers

• Locate Electrical

Where is that empty conduit?
Installation of Blower & Diffusers

- Installation

- And Protection of New Equipment
Installation of Blower & Diffusers

• Testing of New Equipment
Operational Considerations
Brush Aerators vs. Turbo Blower
With Fine Bubble Diffusers

- Ease of Repair
- Hydraulic Limitation
- DO Transfer Efficiency
- Need for Submersible Mixer
- Lubrication Required
- Aerosol Production
- Noise
## Operational Considerations: Brush Aerators

<table>
<thead>
<tr>
<th><strong>Pro</strong></th>
<th><strong>Con</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple “In-House” Repair</td>
<td>• Limits Hydraulic Level</td>
</tr>
<tr>
<td>• Submersible Mixer Not Needed</td>
<td>• Damages Floc Structure</td>
</tr>
<tr>
<td></td>
<td>• Lubrication Required</td>
</tr>
<tr>
<td></td>
<td>• Exposes Operators to Aerosols</td>
</tr>
<tr>
<td></td>
<td>• Energy inefficient</td>
</tr>
<tr>
<td></td>
<td>• Difficult to Control D.O.</td>
</tr>
</tbody>
</table>
## Operational Considerations

**Turbo Blower With Fine Bubble Diffusers**

<table>
<thead>
<tr>
<th><strong>Pro</strong></th>
<th><strong>Con</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unlimited Hydraulic Level</td>
<td>• Needs Submersible Mixer</td>
</tr>
<tr>
<td>• No Damage to Floc Structure</td>
<td>• Blower Repairs Proprietary</td>
</tr>
<tr>
<td>• No Lubrication Required</td>
<td>• Diffuser Inspection/Repair</td>
</tr>
<tr>
<td>• Minimal Maintenance</td>
<td>• Requires Dewatering of Basin</td>
</tr>
<tr>
<td>• Minimal Aerosols</td>
<td></td>
</tr>
<tr>
<td>• Energy Efficient</td>
<td></td>
</tr>
<tr>
<td>• Good D.O. Control</td>
<td></td>
</tr>
<tr>
<td>• Low Noise</td>
<td></td>
</tr>
</tbody>
</table>
Conversion of Ditch “B”

• District is converting Oxidation Ditch “B” to diffused air with turbo blowers

• Operational advantages; consistency

• 35% reduction in annual energy consumption for the oxidation ditch system
Conversion of Ditch “B”

- Removal of four 30-hp brush rotors (120 hp total)
- Installation of two additional 50-hp turbo blowers (one duty, one standby)
- Installation of two new 6-hp submersible mixers

- Equipment has been pre-purchased
- Construction is underway with startup in October
Conversion of Ditch “B”
Conclusion

Blowers and diffused air may be advantageous for oxidation ditch operation:

• Significant energy savings
• Operational flexibility

Turbo blowers offer further energy savings in comparison with positive displacement blowers (25% in the case of Mukilteo)