Is It Hot Air or the Next Breakthrough? Evaluation of High Speed Direct Drive Blowers

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Overview

• Intro / Background
• Types of Blowers Evaluated
  – Single Stage Centrifugal
  – High Speed Direct Drive
• New Blower Evaluation
Aeration at WWTPs

- Biological Treatment
  - Typically the highest power requirement
  - Focus of this presentation
- Aerobic Digestion
- Effluent / Post Aeration
Types of Blowers

- Single Stage Centrifugal (integral gear)
- High Speed Direct Drive (turbo)
- Multistage Centrifugal
- Positive Displacement
Single Stage Centrifugal (IG)

- Single machined impeller
  - Spins at high rpm
- Standard induction motor (constant speed)
- Gearing system increases motor speed to impeller
- Inlet guide vanes and discharge diffuser vanes modulate to vary air flow
Single Stage Centrifugal (IG)

Variable Inlet Guide Vanes

Variable Diffusers

Courtesy of Siemens (Turblex)
Single Stage Centrifugal (IG)

- Used at small to large WWTPs
- Bearing lubrication system with air/water cooling
- Efficient over wide range of air flows
- Proven / reliable operation
- Somewhat noisy
- Little vibration
High Speed Direct Drive Blowers

- New to municipal market (1st unit installed in North America in 2004)
- Single machined impeller
  - Spins at high rpm (20,000 - 30,000)
- Typically permanent magnet motor used for higher efficiency at higher speeds
- Blower and motor directly coupled (motor also spins at high speed)
  - Entire unit built by manufacturer ("core")
High Speed Direct Drive Blowers

Courtesy of ABS

Courtesy of APG-Neuros

Courtesy of HSI
High Speed Direct Drive Blowers
High Speed Direct Drive Blowers
High Speed Direct Drive Blowers

- Manufacturers include:
  - APG-Neuros (most NA installations)
  - ABS
  - HSI
  - K-Turbo
  - Turblex
  - Gardner-Denver

Courtesy of HSI
High Speed Direct Drive Blowers

- Motor / blower speed varied with variable frequency drive (VFD)
  - Can turn down to about half design flow without much loss in efficiency
  - VFD and controls provided as part of blower package (inside enclosure or separate)

- Electrical components new to municipal wastewater market
  - High speed VFD (18 pulse) - may require harmonic filters
  - Permanent magnet motor
High Speed Direct Drive Blowers

- Bearings require no lubrication
- Air foil bearing (all manufacturers)
  - Uses blower air to create air foil around shaft
- Magnetic bearing (one manufacturer)
  - Electronic control system continuously monitors and adjusts magnets to position shaft
High Speed Direct Drive Blowers

Air Foil Bearing

Magnetic Bearing

Courtesy of APG-Neuros

Courtesy of ABS
High Speed Direct Drive Blowers

- Used at small to medium WWTPs
  - Limited max size (hp/air flow/pressure)
- New - limited operational history
  - Reliable operation so far
- Efficient over wide range of flows
- Replacement of blower, bearing, or motor typically results in replacement of “core”
- Very quiet and very little vibration
- Small footprint
New Blower Evaluation

- High power requirements warrant evaluating different types of blowers for new installations
- Many considerations for evaluation:
  - Monetary
  - Non-monetary
  - Site specific
Blower Evaluation Considerations

- System aeration requirements
  - Peak air flow and pressure
  - Other air flows
- Operating costs
  - Largest cost is typically power
- Maintenance costs
  - Lubrication
  - Air filter replacement
  - Equipment replacement
Blower Evaluation Considerations

- Type of power available and location of supply
- Building footprint and site access
- Operating history / reliability
Example

- Existing WWTP - 4 new aeration basins at 15 MGD annual avg capacity
  - Fine bubble diffusers
  - BOD removal
  - Nitrification
- Basin SWD = 24 ft (limited site area)
- Total air flow required
  - At avg flow = 10,500 scfm
  - At max month flow = 13,500 scfm
  - At peak flow = 22,200 scfm
Evaluation

- Integral gear - Turblex
  - 3 duty + 1 standby
  - 7400 scfm each

- Direct drive - ABS, APG-Neuros, HSI could meet design points
  - 5 duty + 1 standby
  - 4450 scfm each
# Capital Cost Comparison

<table>
<thead>
<tr>
<th>Cost</th>
<th>Integral Gear</th>
<th>Direct Drive (avg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blower Equip + Install</td>
<td>$1.5M</td>
<td>$1.6M</td>
</tr>
<tr>
<td>Structural / Architectural</td>
<td>$1.0M</td>
<td>$1.0M</td>
</tr>
<tr>
<td>Piping / Mechanical</td>
<td>$0.1M</td>
<td>$0.2M</td>
</tr>
<tr>
<td>Electrical / I&amp;C</td>
<td>$0.2M</td>
<td>$0.3M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2.8M</strong></td>
<td><strong>$3.1M</strong></td>
</tr>
</tbody>
</table>
O&M Cost Comparison

- 20 year period, 5% inflation
- Linear increase in flow
- $0.07 / kW-hr, 6.5% increase annually

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<thead>
<tr>
<th></th>
<th>Integral Gear</th>
<th>Direct Drive (avg)</th>
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<tbody>
<tr>
<td>Assumed overall</td>
<td>77%</td>
<td>74%</td>
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<tr>
<td>efficiency</td>
<td></td>
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<tr>
<td>Annual maintenance</td>
<td>$7500</td>
<td>$2500</td>
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<tr>
<td>costs</td>
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## Net Present Worth Cost Comparison

<table>
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<tr>
<th>Cost</th>
<th>Integral Gear</th>
<th>Direct Drive (avg)</th>
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</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>$2.8M</td>
<td>$3.1M</td>
</tr>
<tr>
<td>Power Cost</td>
<td>$3.0M</td>
<td>$3.1M</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>$0.4M</td>
<td>$0.2M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$6.2M</strong></td>
<td><strong>$6.4M</strong></td>
</tr>
</tbody>
</table>
## Integral Gear vs Direct Drive

<table>
<thead>
<tr>
<th>Integral Gear</th>
<th>Direct Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proven operational history</td>
<td>Limited operational history</td>
</tr>
<tr>
<td>Would require expanding bldg for additional blower in future</td>
<td>Could install additional blower inside current bldg</td>
</tr>
<tr>
<td>Complex but reliable lubrication system</td>
<td>No lubrication</td>
</tr>
<tr>
<td>Relatively noisy</td>
<td>Quiet</td>
</tr>
<tr>
<td>Fewer, larger blowers (3+1)</td>
<td>More, smaller blowers (5+1)</td>
</tr>
<tr>
<td></td>
<td>Smaller equipment footprint, less weight</td>
</tr>
</tbody>
</table>
Questions?

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