Direct Drive, Energy Efficient, High-Speed Turbo Blowers

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Introduction of Blower Technologies

- PD Blowers
  - 1854
- Multi-Stage Centrifugal Blowers
  - Single wheel 1918
  - Multi-stages 1945
- Single Stage Centrifugal Integral Gear
  - 1980
- Single Stage Centrifugal Magnetic Driven
  - 1985
- Single Stage Centrifugal Direct Drive
  - 2003
High Speed Blower Technology

- **Air Bearings**
  - Journal and Thrust Bearing
  - Single or Twin Impellers
  - Originally developed in 1960s for airplane ventilation systems
  - Operate 20,000 to over 40,000 rpm
    - Efficiency increases with increasing speed
- **Magnetic Bearings**
  - Journal Bearings and Touch Down Bearing

Air Bearing Blowers
Air-foil vs Magnetic Bearings

- Two different machines
- Air-foil much smaller, lighter machine
- Remainder of presentation deals with Air-foil bearing blowers
Manufacturers and Available Models

Air-foil Bearings

<table>
<thead>
<tr>
<th>Company</th>
<th>Bearings</th>
<th>Impeller</th>
<th>scfm (6.5 psi)</th>
<th>Max HP</th>
<th>Installations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nueors</td>
<td>Air</td>
<td>Single</td>
<td>7700</td>
<td>300</td>
<td>86</td>
</tr>
<tr>
<td>HSI</td>
<td>Air</td>
<td>Twin</td>
<td>8000</td>
<td>300</td>
<td>3</td>
</tr>
<tr>
<td>Turplex</td>
<td>Air</td>
<td>Single</td>
<td>7700</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>Kturbo</td>
<td>Air</td>
<td>Twin</td>
<td>8100</td>
<td>300</td>
<td>5</td>
</tr>
</tbody>
</table>

Advantages of Direct Drive, Air-Foil Blowers

- Energy savings
- Higher surge margin
- No lubrication requirements
- Minimum scheduled maintenance
- Easy to install
  - 25% reduction in building footprint
- Compact
- Light weight
- Quiet
High Speed Blower “Green” Advantages

Increased Efficiency = Reduces Emissions

Small Footprint = Reduces Cast Iron Consumption

Cooling Air Usage = Reduces Heat Rejection

Air Lubrication = Oil Free Air

Integral VFD = Precise Flow Control

Minor Vibration = Reduces Noise

Minimum Maintenance

<table>
<thead>
<tr>
<th>MAINTENANCE SCHEDULE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily or Before Each Operation</td>
</tr>
<tr>
<td>Check the filter pressure drop while the blower is running. Clean or replace the inlet filter before the filter pressure drop reaches 3 kPa.</td>
</tr>
<tr>
<td>Check for unusual noise and vibration.</td>
</tr>
<tr>
<td>Ensure area around the blower is free from debris, flammable or explosive materials.</td>
</tr>
<tr>
<td>Monthly *</td>
</tr>
<tr>
<td>Inspect inlet filter element. Clean or replace if necessary</td>
</tr>
</tbody>
</table>

* Inlet filter replacement schedule may vary depending on the running environment.
State of the Industry

- Different forms of procurement
- Highly competitive pricing
- Evaluated bids based on power consumption
- No standard ASME test
- Existing lines expanding and changing

Demonstration at Franklin, NH

Direct Drive Single-Stage Centrifugal
WRPB WWTF – Franklin, New Hampshire

- Winnipesaukee River Basin Program
  - State-owned and operated
  - 10 community regional facility
  - Located in lakes region of New Hampshire

- Secondary Treatment Facility
  - Placed into operation 1979
  - 11.5 mgd design flow; 6.6 mgd current flow

WRPD Aeration History

- Original plant
  - 5-Cord PD each rated @ 3200 cfm
  - Coarse bubble diffusers
  - Blowers replaced with 5-Roots PD 824 RCS in early 1990s
    - 124 HP, 2650 cfm, 8.0 psi, 2250 rpm
  - Fine bubble diffusers installed in mid 1990s
  - Two of the Roots blowers removed
  - Automatic DO control installed in 2000
    - Original motors and DC drives replaced
      - New motors and VFDs
    - Vibration issues prohibited auto DO control
    - Significant constraints on blower operation
      - Plant running inefficiently with high DOs @ low demand, insufficient DO @ high demands
Multi-phased Capital Improvement Program

- **Focus**
  - Sustainable design with long-term sustainability
  - Appropriate incorporation of green technologies
  - Governor mandated reduction of energy consumption by 10% in state facilities
    - Energy consumption at all new construction 20% less than state energy code

- CDM retained in June 2008

- Initial focus: Aeration system
  - Accounts for 36% of total electrical consumption @ plant

60 Day Neuros Pilot at Franklin NH

- Unit supplied by APG-Neuros Inc., Quebec Canada Neuros Co., Inc
- Started operation in Franklin Sept 25, 2008
- Operating evaluation through November 2008

- **Goals**
  - Validate claims made by direct drive manufacturers
  - Increase blower reliability
  - Simplify operation
  - Significant reduction in energy consumption
Packaging of Neuros NX Turbo Blower

- Air Outlet
- Blow/off Valve
- Discharge Duct
- VFD
- PLC based Local Control Panel with Touch Screen
- VFD Cooling Air Inlet
- Blower Core
- Sinus Filter

* VFD: Variable Frequency Drive

Demonstration Blower Characteristics

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>APG-Neuros Inc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>NX150-C070</td>
</tr>
<tr>
<td>Speed (max)</td>
<td>21,870 rpm</td>
</tr>
<tr>
<td>Motor</td>
<td>150 HP Permanent Magnet</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>8.5 psi (impeller) 10.7 psi (machine)</td>
</tr>
<tr>
<td>Impeller</td>
<td>Single, Forged Aluminum (Axial + Centrifugal)</td>
</tr>
<tr>
<td>Air Flow Range</td>
<td>1,175 – 2,600 scfm</td>
</tr>
<tr>
<td>Bearing Type</td>
<td>Bump Air Foil, Oil less</td>
</tr>
<tr>
<td>Dimensions</td>
<td>30 in wide x 68 in length x 53 in high</td>
</tr>
<tr>
<td>Weight</td>
<td>1,675 lbs</td>
</tr>
</tbody>
</table>
Installed Blower

Operating Points on Blower Curve
Demonstration Blower Power Draw

Demonstration/Scadakwvs Demonstration kw
Demonstration & Existing Blower

**kw** (from Plant Scada)

**Demonstration Blower Air Flow**
Demonstration/Scadascfms vs Demonstration scfm

Demonstration Blower scfm/kw
(from Demo Instrumentation)
Comparison of Demonstration & Existing Blowers

🔹 All comparisons of power draw and air flow rates based on data from plant Scada system
🔹 Values of power draw using scfm/kw ratio truncated at airflow rates of 1,500 scfm
  - Values with airflow rates < 1,500 discarded
  - Inclusion of correct values less than this would likely further increase the power consumption difference in favor of the demonstration unit.
    - Scfm/kw values for the existing Roots units was constantly decreasing with decreasing airflow rates

Demonstration & Existing Blower scfm/kw
(from Scada)
Efficiency Comparison
Demonstration to Existing Blowers

- Air flow rates approaching max capacity of existing units:
  - Demonstration unit 20% more efficient
- Air flow rates at lower limits of existing capacity
  - Demonstration unit 30% more efficient
- Average air demand @ WRBP WWTF = 2,600 scfm
  - Efficiency of the demonstration unit at 2,600 scfm 32% less than average power consumption of existing blowers

Blower Noise

- Measurements at approx 3 ft from blower enclosure.
- Operating at 1360-1390 cfm, 18400 rpm, 6.6 psi discharge
- 69-75 dBA
- Startup (20 seconds)
  - 95-100 dBA
- Shutdown (4 seconds)
  - 90-95 dBA
- Shutdown and startup through relief discharge directly to room
Conclusions from Demonstration

- Direct drive unit consumed 32% less power than existing PDs (direct wire to water)
- Automatic DO control & optimized unit sizing will reduce power consumption to 49-54% less than existing PDs
- Unit efficiency constant over full operating range
- Very quiet operation (69 to 75 dBA with no silencers)
- Small space requirement
- Equipment pad and anchor bolts optional
- Vibration free from speeds approaching surge to full speed of 21,870 rpm
- Installation is “plug & play”