How to Participate Today

- Audio Modes
  - Listen using Mic & Speakers
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- Submit your questions using the Questions pane.
- A recording will be available for replay shortly after this webcast.

Today’s Moderator

Katie Zheng
Planning Manager
SouthWest Water Company
Texas Water Utility
Today’s Presentations

- Fundamentals of Operation and Maintenance
  - Thomas E. Jenkins, P.E.
- Total Control – Optimizing Your Process Correctly
  - Paul Petersen
- Aeration System Optimization – Lessons Learned from the Field
  - Hank Andres, P.Eng
- Selecting the Right Blower Type for the Application, Maximum Efficiency, and Ease of Maintenance
  - Julia V. Gass

Tom Jenkins, PE

- Independent consultant
- President JenTech Inc.
- Forty plus years experience with blowers and controls
- Adjunct Professor, University of Wisconsin, Madison
- Member of ASME PTC 13 Code Committee
Aeration Blower Fundamentals

Fundamentals of Operation and Maintenance

Topics

• Common Types
  • Positive displacement: screw and lobe (Roots type)
  • Centrifugal: turbo, multistage, geared single stage
• Control methods for different types of blowers
• Failure modes for each type
• Monitoring and diagnostics for each type
• Typical maintenance for each type
Disclaimer

- For all types of blowers the manufacturer’s recommendations should be followed:
  - For operation
  - For maintenance
  - For repair

Positive Displacement (PD) Blowers

- Constant volumetric flow at constant speed
- Pressure rises and falls to match system requirements
Positive Displacement (PD) Blowers

- Two types:
  - Lobe (Roots) type
  - Screw type
- Simple operation, low maintenance
- Variable speed is only practical control method
  - Variable Frequency Drive (VFD) typical

Positive Displacement (PD) Blowers

- PD must be controlled by variable speed

- Lobe Type
  - Compression external
  - Efficiency best at highest speed

- Screw Type
  - Compression combination of internal and external
  - Efficiency best at intermediate speed
Positive Displacement (PD) Blowers

- Maintenance is similar for both types
- Lubrication is critical
  - Monitor oil levels and cleanliness
  - Change oil at recommended intervals (≈ 500-1000 hours)
  - Use right type: synthetic or petroleum, viscosity
- Belt tension and wear
- Inlet filters and pressure relief valve
- Temperature
- Noise

Positive Displacement (PD) Blowers

- Monitoring and control is similar for both types:
  - Temperature sensors: Discharge and differential
  - Pressure sensors: Discharge, inlet (filter)
  - Motor amperage sensors: High and low and overload
  - Oil level and temperature sensor
Centrifugal (Dynamic) Blowers

- Variable volumetric flow rate
- Pressure capability varies across a narrow range
Centrifugal (Dynamic) Blowers

• Three types:
  - Multistage
  - Geared single stage
  - Gearless single stage (turbo)

• Can be controlled by inlet throttling, discharge throttling, variable speed, and guide vanes

• High efficiency, low or very low maintenance

Centrifugal (Dynamic) Blowers
• Packages with all controls and accessories are available

Multistage
- Pressure achieved using several impellers in series

Geared single stage
- Pressure achieved using high-speed impeller & gears

Gearless single stage (turbo)
- Pressure achieved using high-speed impeller & motor
Centrifugal (Dynamic) Blowers

- Most maintenance is different for each type:
- Multistage generally only require bearing lubrication
- Geared single stage requires attention to lubrication system
  - Oil quantity and quality
  - Lube system filtration
- No lubrication required with gearless single stage
- All types require attention to inlet filters

Centrifugal (Dynamic) Blowers

- Monitoring and control for all types includes:
- Surge control/protection (surge is pulsating flow)
  - Shutdown
  - Blow-off valves
  - Modulating control
- Discharge temperature sensors
- Inlet (filter) and discharge pressure sensors
- Motor amperage sensors: High and low and overload
Centrifugal (Dynamic) Blowers

- Capacity control varies
- All types can use variable speed (VFD)
  - This is the most efficient control method for all
  - Mandatory with gearless single stage
  - Common with multistage
  - Becoming common with geared single stage
- Multistage are often inlet throttled
- Geared single stage use inlet guide vanes or variable discharge diffuser vanes or both

Summary

- Both PD and centrifugal blowers require some maintenance
- Both PD and centrifugal blowers can use capacity control to match system demand
- If there is a lube system, it requires the most attention
- Proper maintenance extends equipment life and reduces energy
Paul Petersen

Municipal Sales Manager
Atlas Copco Compressors

- 9 years of experience with aeration blowers
  - Applications Engineering
  - Project Management
  - Product Management
  - Industrial & Municipal Blower Sales
- Published by TPO, Plant Services, and Blower & Vacuum Best Practices Magazines

Total Control

Optimizing Your Process Correctly
Don’t Reinvent The Wheel

• If equipment comes with built in control – use this to your advantage.

• If equipment comes with built in protection – use this to your advantage.

• Don’t “design it yourself.”
  ▪ If you’ve never manufactured one, you are not the expert – the manufacturer who makes hundreds per year is.
Don’t Reinvent The Wheel

**Don’t**

- Specify controller brands - if you are naming a reputable manufacturer, they’ll support their own product better than someone else’s
- Specify individual sensor/gauge manufacturers – use the manufacturer standard
- Specify non-standard accessories be supplied by vendor – use the manufacturer standard
- Try to buy and maintain one-of-a-kind solutions – the manufacturer can’t support what you designed yourself!
  - This always leads to buyer’s remorse!

**Do**

- Specify the desired functionality
- Specify the plant communication protocol:
  - Modbus/Profibus
  - Ethernet IP
  - Analog + Digital I/O
- Specify the power supply voltage
- Require that integrated controls be supported by a local service organization

---

Ex: Integrated PD Blower Controls

- Plug & Play blower solution is easy to install
  - Single 460V electrical & discharge pipe flange
- VSD integrated in blower cabinet
- Local dial-a-speed doesn’t require external speed signal
  - Switch for remote control allows external 4-20mA input
- Basic alpha-numeric controller monitors discharge air pressure and temperature, provides alarm and shutdown, service notifications
- Upgrades available for graphic controller and remote monitoring capabilities
Don’t Reinvent The Wheel

• Ex: Integrated Screw Blower Controls
  • Plug & Play blower solution is easy to install
  • TEWC permanent magnet motor
  • Neos VSD integrated in blower cabinet
  • User-friendly Elektronikon® Touch protects the blower, gives warning indications, allows maintenance scheduling, and local pressure control
  • SCADA integration via hardwired I/O
    – Network communication optional
    – Local dial-a-speed optional
  • SMARTLINK allows online monitoring of these features plus sensor trending and energy efficiency reporting per ISO 50001

Don’t Reinvent The Wheel

• Ex: Integrated Turbo Blower Controls
  • Plug & Play blower solution is easy to install
  • Modulating BOV allows safe operation below the surge line for better process control
  • Factory-programmed control loops for header pressure control (local signal) or air flow control (external signal)
  • Continuously monitors:
    – Shaft position
    – Inlet air temperature
    – Cooling air temperature
    – Discharge air pressure & temperature
    – Motor winding temperature
    – Electrical cabinet temperature
    – Inlet filter differential pressure
    – Blower differential pressure
    – Shroud differential pressure
Don’t Reinvent The Wheel

- Ex: Central Blower Controllers
  - Offer different control modes based on user preference
    - Equalize running hours of all connected machines
    - Lead/lag sequencing
    - Optimize energy use for a given setpoint
  - Separate from process controllers for valves
  - Can be combined with DO controllers and valve controllers for lower cost than custom PLCs
  - Provide higher aeration system efficiency
  - Off-the-shelf solution can be retrofitted to existing systems and programmed to suit individual plant needs
    - Can be serviced by local technicians

Don’t Reinvent The Wheel

- DO control of blowers on custom PLC maintained air flow within 11% of setpoint
- DO control of blowers with Optimizer blower controller installed between existing PLC and blowers maintained air flow within 1% of setpoint
Don’t Partially Automate

- Ex: In California
  - 4 basins
  - 2 DO probes per basin
  - 5 HSTB
  - 1 MCP
  - ZERO automated valves

- Don’t use manual control valves with automated blowers
  - Operators can’t adjust flow into each zone for accurate DO control, even if total system air flow is correct
  - Result is DO hunting = wide DO swings, lack of process control in each zone

---

Don’t Partially Automate

- Ex: In New Jersey
  - 5 aeration trains
  - 3 DO probes per train
  - 4 fixed speed MSCB
  - Air valves controlled by SCADA

- Existing automated valve system works with manual equipment
- Poor efficiency
Don’t Partially Automate

• Ex: In New Jersey
  • 5 aeration trains
  • 3 DO probes per train
  • 2 fixed speed MSCB
  • 2 new variable speed HSTB
  • 1 new MCP controls new blowers only
  • Old valve control system kept in place

• Half of the equipment is controlled in auto, half controlled in hand
• Old automated valve system does not work with new automated equipment
  • Creates artificial demand

Don’t Partially Automate

• When the DO probes sense too much air, the air control valves start to close
• Closing the valve increases the system pressure
• When the blower senses higher pressure, its minimum speed is increased to avoid surge
• This delivers more air to the basin
• The valve continues to close until the system pressure is greater than the blower limit, causing a fault and shutdown
Keep Separate Things Separate

- Different processes operating at different flows or pressures should have dedicated equipment, not a centralized system
  - Centralized supply creates artificial demand

- Ex: In Iowa
  - 4 turbo blowers
  - 3 digesters – all at different SWD, out of phase
  - Deepest tank needs the most air, so valves on other tanks close to create even more resistance
    - Can’t accurately control air to each digester (only “most,” “some,” and “least”)
    - Significantly higher power costs

Solution in process
- Eliminates artificial demand

- Ex: In Iowa
  - 4 screw blowers

- 3 digesters – all at different SWD, out of phase
- Dedicated blower for each digester, with common spare
Keep Separate Things Separate

- Each process train has greatly different demand, with a common supply
  - Creates artificial demand

- Ex: In New Jersey
  - 5 aeration trains
    - Each train has different BOD
  - 3 DO probes per train
    - Only effluent probe used for blower control
  - 2 HSTB replaced 2 of 4 fixed speed MSCB
  - 1 new MCP controls new blowers only
  - Old valve control system kept in place

Potential solution
- Not yet implemented

- Ex: In New Jersey
  - 5 aeration trains
    - Each train has different BOD
  - 3 DO probes per train
    - Only effluent probe used for blower control
  - 2 variable speed HSTB
  - 2 fixed speed MSCB
  - 1 new PLC controls ALL blowers & all valves
Keep Separate Things Separate

• Different processes operating at different flows or pressures should have dedicated equipment
  • Otherwise creates artificial demand
• Ex: In Massachusetts
  • DO control monitored by SCADA
  • 3 fixed speed MSCB manually controlled

Keep Separate Things Separate

• Ex: In Massachusetts
  • 1 rotary screw VSD blower replaced 1 of 3 fixed speed MSCB
  • DO control tied into new blower only
• Instead of trying to automate all 3 blowers, only the VSD blower uses DO control
• It turns on/off automatically and increases/decreases flow automatically
Conclusion

• To correctly optimize:
  
  ▪ Utilize standard, integrated controls in new blowers & connect to plant DCS/SCADA via your preferred method.

  ▪ Automate an entire aeration system. Partially automating will exacerbate existing problems or create new ones.

  ▪ Use dedicated pieces of equipment for processes with different static head, flow requirements, and batch times – centralizing similar equipment on different processes makes accurate control impossible.

Hank Andres, P.Eng.

• Sr. Process Engineer, Ontario Clean Water Agency

• 19 years experience in the field
  ▪ 12 years consulting engineering
  ▪ 7 years in capital projects group at OCWA

• OCWA – 300+ WTFs, 200+ WWTPs

• Experience in both the municipal and industrial sectors

• Completed numerous capital projects to optimize process and achieve energy efficiency/savings
Outline

- Overview of OCWA Energy Conservation Initiatives
- Turbo Blower Retrofit Overview
  - 4 Installations: Belmont, St. Marys, Wasaga Beach and Kingsville (Ontario, Canada)
- Aeration System Operation – Items to Consider
- Concluding Thoughts
OCWA Energy Conservation Initiatives

• Since March 2013, OCWA has had a contract with the Independent Electricity System Operator in Ontario, Canada

• Core Mandate:
  ▪ To identify energy conservation measures at water and wastewater treatment facilities
  ▪ To implement energy-efficient technology and process control strategies that will achieve energy savings

Turbo Blower Retrofit Overview

4 Installations: Belmont, St. Marys, Wasaga Beach and Kingsville, Ontario, Canada
# Overview of Existing Facilities

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Belmont WWTP</th>
<th>St. Marys WWTP</th>
<th>Wasaga Beach WWTP</th>
<th>Lakeshore West WWTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Type</td>
<td>Aerated/Facultative Lagoon</td>
<td>Biological Nutrient Removal</td>
<td>Extended Air</td>
<td>Conventional Activated Sludge</td>
</tr>
<tr>
<td>Design Flow (m³/d)</td>
<td>1,720</td>
<td>5,860</td>
<td>15,433</td>
<td>5,400</td>
</tr>
<tr>
<td>Average Daily Flow (m³/d)</td>
<td>670</td>
<td>4,270</td>
<td>6,780</td>
<td>4,880</td>
</tr>
<tr>
<td>Existing Blower Type</td>
<td>Positive Displacement</td>
<td>Centrifugal</td>
<td>Centrifugal</td>
<td>Centrifugal</td>
</tr>
<tr>
<td>Number of Blowers</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Existing Blower Horsepower (hp)</td>
<td>2 x 75 hp 2 x 50 hp</td>
<td>4 x 100 hp 2 x 75 hp</td>
<td>3 x 125 hp 2 x 75 hp</td>
<td>3 x 75 hp 3 x 75 hp</td>
</tr>
<tr>
<td>Existing Blower Capacity (each – m³/hr)</td>
<td>2,330</td>
<td>2,810</td>
<td>4,032 (125 hp), 2,016 (75 hp)</td>
<td>1,850</td>
</tr>
<tr>
<td>Discharge/Operating Pressure (kPa)</td>
<td>50 to 56</td>
<td>51 to 59</td>
<td>48 to 53</td>
<td>55 to 62</td>
</tr>
</tbody>
</table>

## Turbo Blower Energy Consumption and Associated Energy Savings

<table>
<thead>
<tr>
<th></th>
<th>Belmont WWTP</th>
<th>St. Marys WWTP</th>
<th>Wasaga Beach WWTP</th>
<th>Lakeshore West WWTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Week Monitoring Period (kWh)</td>
<td>13,778</td>
<td>16,890</td>
<td>32,830</td>
<td>13,180</td>
</tr>
<tr>
<td>Monitoring Period Duration (days)</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Monitoring Period Average Demand (kW)</td>
<td>40.9</td>
<td>80.3</td>
<td>80.9</td>
<td>39.2</td>
</tr>
<tr>
<td>Estimated Baseline Annual Consumption (kWh)</td>
<td>832,900</td>
<td>743,700</td>
<td>1,314,000</td>
<td>763,240</td>
</tr>
<tr>
<td>Estimated Turbo Blower Annual Consumption (kWh)</td>
<td>358,200</td>
<td>440,250</td>
<td>709,100</td>
<td>343,540</td>
</tr>
<tr>
<td>Energy Savings (kWh)</td>
<td>473,700</td>
<td>303,450</td>
<td>604,900</td>
<td>419,700</td>
</tr>
<tr>
<td>Energy Savings (%)</td>
<td>57%</td>
<td>41%</td>
<td>46%</td>
<td>55%</td>
</tr>
<tr>
<td>Energy Savings ($0.12/kWh)</td>
<td>$56,800</td>
<td>$36,400</td>
<td>$72,600</td>
<td>$50,400</td>
</tr>
<tr>
<td>Simple Payback Period w/ IESO Incentives (years)</td>
<td>2.6</td>
<td>5.2</td>
<td>4.1</td>
<td>3.7</td>
</tr>
</tbody>
</table>
Aeration System Operation - Items to Consider

1. Blower Sizing and Turndown
2. Probe Location(s)
3. Dissolved Oxygen Control Strategy
4. Valves
5. Air Piping

Process Analysis and Troubleshooting

A process model was useful for evaluating the impact of influent load variability on oxygen demand and plant performance:
Process Analysis Examples
A process model was useful for evaluating the impact of influent load variability on oxygen demand and plant performance:

- St. Marys WWTP periodically experiences wastewater contributions from local food processing industries
- Wasaga Beach WWTP experiences elevated influent loading during the summer season due to an increased seasonal population
- Lakeshore West WWTP periodically wastewater contributions from local greenhouse operations and wineries

Process Analysis – Blower Sizing and Turndown
- What are the facility oxygen demands under a various loading conditions? ⇒ what is the required blower size and turndown?
- What are the expected blower operating points? ⇒ now and in the future?
Process Control Troubleshooting

Selecting the probe location along a plug flow tank is an important consideration to achieve an adequate level of process control → \textbf{where is the ideal location?}

3-pass plug flow tank

Process Control Troubleshooting

Selecting the probe location along a plug flow tank is an important consideration to achieve an adequate level of process control → \textbf{model can also be used to evaluate probe locations and fine tune process control strategies}

**DO Control of Total Air Demand**

**DO Sensor Location**
- DO sensor should be placed about \( \frac{1}{3} \) to \( \frac{1}{2} \) of the way along the length of a plugflow tank.
- Placing the sensor at the beginning of the tank leads to over-aeration.
- Placing the sensor at the end of the tank means you will miss load changes and are prone to under-aeration and final effluent TAN exceedances.

2. Moderate Complexity Aeration Control System

**Pressure Control**
- Optional: Linearizes relationship
- Blowout capacity

**MOV Control**
- Air distribution valves adjusted manually
- Most-open valve approach due to Alex et al. (2016)
3. High Complexity Aeration Control System (USEPA, 1989)

One for each zone

Pressure transmitter

Pressure controller

MOV controller

Maximum valve position found

Valve position

Amperage controller

Optional: Linearizes relationship

Blower capacity

Amperage setpoint

Blowers

Pressure setpoint

MOV setpoint

Airflow controller

Pass 4

DO sensor

Pass 3

Pass 2

Pass 1

<Figure courtesy of: inCTRL SOLUTIONS>

- Most-open valve approach due to Alex et al. (2016)

Wasaga Beach WWTF Blower Upgrade

600 MWh in annual energy savings

Better control over air flows to aeration tanks, improved floc formation and settleability in secondary clarifiers

4.1 year payback period for project based on total project cost

Existing DO monitoring system could be utilized to control turbo blower via PID controller
Wasaga Beach WWTF Blower Upgrade

Wasaga Beach is popular summer destination, subject to high peak loads on long weekends (Canada Day etc.)

Existing DO probes installed at the end of plug flow tank, PID controller response to peak loads was sluggish

Combination of old/broken diffusers and new fine bubble diffusers made it difficult to balance air to both tanks

Solution: DO probes moved to 1/3 length of PFT for better response, PID controller tuning was updated
Solution: Old diffusers were replaced, valves may be upgraded in future

Advanced Aeration Control - Valves

- Jet/Elliptic Diaphragm Control Valves
  - Reduction of system pressure losses
  - Allows for precise control of air flow (Doody, 2017)
    - Less air is wasted, quicker response time to process
  - Has a larger stable flow/control range
  - Particularly useful for controlling the air flow split between aeration and sludge tanks when using a common blower
Existing System Air Piping and Valve Considerations

- Non-symmetrical air piping could limit turndown range and energy savings
- Existing control valves may not provide adequate control at lower airflows
- Lower valve % Open could increase system pressure and energy consumption

Concluding Thoughts

- Aeration Blower retrofit projects can provide enhanced process control and result in significant energy savings
  - Blower sizing and turndown is important but not the only consideration
  - Probes need to be in the proper location to achieve the desired level of process control
  - DO control system complexity should be considered relative to the payback
    - Sometimes stable and simpler control is better
  - Jet/elliptic diaphragm valves can provide more precise air control and a larger control range
Acknowledgements

1) A Comprehensive Aeration System Model for WRRF Design and Control
   Oliver Schraa1*, Leiv Rieger1, and Jens Alex2
   1 inCTRL Solutions Inc., Oakville, Ontario, Canada.
   2 ifak e.V., Magdeburg, Germany.
   * Email: schraa@inctrl.ca

2) Design and Operation of Advanced Aeration Control Systems
   Alexandra T. Doody1*, Maureen D. Neville2
   1 CDM Smith, Austin, Texas
   2 CDM Smith, Boston, Massachusetts
   * Email: DoodyAT@cdmsmith.com

Thank You
More Information?

Hank Andres, P.Eng.
handres@ocwa.com
Tel: 416-575-0092
Selecting the Right Blower Type for the Application, Maximum Efficiency, and Ease of Maintenance
Discussion Topics

- Advantages of centrifugal vs positive displacement
- Comparative efficiencies
- Advantages/disadvantages of each blower type
- Life cycle cost evaluation
- Maintenance
- Controls
- Creative ways to justify a capital project
- Best practices

Common Applications for Centrifugal and PD Blowers

Centrifugal

- Continuous air demand with near constant water level or water level which varies by a few feet
- Applications where capacity needs to vary without using a Variable Frequency Drive (VFD)
- Medium to large flow rate applications such as many wastewater aeration applications

PD

- Applications with significantly varying water levels such as sludge holding tanks
- Small flow rate applications
- Intermittent duty applications
- Pneumatic conveying
- Dry screw PDs are now being used for some continuous duty applications
## Comparative Efficiencies

<table>
<thead>
<tr>
<th>Blower Type</th>
<th>Nominal Blower Efficiency, %</th>
<th>Nominal Turndown, % of rated flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Displacement w/VFD</td>
<td>60 to 45</td>
<td>50</td>
</tr>
<tr>
<td>Dry Screw PD w/VFD</td>
<td>70 to 50</td>
<td>40</td>
</tr>
<tr>
<td>Multi-stage Centrifugal</td>
<td>76 to 50</td>
<td>60</td>
</tr>
<tr>
<td>Single-stage Integrally Geared Centrifugal</td>
<td>80 to 72</td>
<td>45</td>
</tr>
<tr>
<td>High Speed Turbo Gearless Centrifugal</td>
<td>80 to 72</td>
<td>50</td>
</tr>
</tbody>
</table>

### Positive Displacement (PD) Blower Types

![Blower](image)
# Advantages & Disadvantages - PD Blowers

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low capital costs for small units</td>
<td>Low efficiency</td>
</tr>
<tr>
<td>Ideal for significant water level variations</td>
<td>Pulsations and noise</td>
</tr>
<tr>
<td>Ideal for engine drive applications and pneumatic conveying</td>
<td>VFD is required for capacity variation</td>
</tr>
<tr>
<td></td>
<td>Timing gear contact may result in more maintenance vs centrifugal machines</td>
</tr>
</tbody>
</table>

## PD Blower Types

### PD Lobe Blower

### Dry Screw Blower

Graphics courtesy of Atlas Copco
PD Blower Types

Advantages & Disadvantages – Dry Screw Blowers

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea for water level variations but efficiency not as good as standard PDs at very low water levels</td>
<td>Capital costs higher than standard PD blowers</td>
</tr>
<tr>
<td>Efficiency improvement vs standard PD blowers</td>
<td>Packaging from one vendor to another is not apples-to-apples; writing a competitive spec is difficult</td>
</tr>
<tr>
<td>Ideal for engine drive applications and pneumatic conveying</td>
<td>VFD is required for capacity variation</td>
</tr>
<tr>
<td></td>
<td>Timing gear contact may result in more maintenance vs centrifugal machines</td>
</tr>
</tbody>
</table>
Centrifugal Blower Types

**Multistage Blowers**

Lawrence, KS WWTP

---

**Advantages & Disadvantages - Multistage Blowers**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower capital costs compared with other centrifugal technologies</td>
<td>Not as efficient as other technologies used for wastewater aeration, especially when turned down</td>
</tr>
<tr>
<td>Capacity can be varied by inlet throttling without a VFD</td>
<td>Longer and heavier than other centrifugal technologies</td>
</tr>
<tr>
<td>No metal-to-metal contact within the machine</td>
<td>Not suitable for significant water level variation</td>
</tr>
<tr>
<td>Less objectionable noise than integrally geared</td>
<td>Less precision due to parts being cast</td>
</tr>
</tbody>
</table>

---
Centrifugal Blower Types

Integrally Geared Single Stage Blowers

Advantages

- High efficiency
- Proven technology
- Capacity control without a VFD; efficiency relatively constant throughout operating range
- Precision manufacturing
- Dual point control

Disadvantages

- High capital costs
- Pressurized oil lube system and oil cooling system require maintenance as well as vane linkages
- Noisier than multistage machines
- Larger footprint than gearless turbo units
- Some maintenance tasks required a factory technician such as vane linkage cleaning
Centrifugal Blower Types

**Gearless Turbo Blowers**

- High efficiency
- Very little mechanical maintenance
- Non-contact bearings
- Precision manufacturing
- Quiet operation, sound enclosure standard
- Light weight
- Shorter lead times

Advantages & Disadvantages – Gearless Turbo Blowers

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>High efficiency</td>
<td>Higher capital costs vs multistage and PD units</td>
</tr>
<tr>
<td>Very little mechanical maintenance</td>
<td>Still a relatively new technology</td>
</tr>
<tr>
<td>Non-contact bearings</td>
<td>Electronics, non-contact bearings and permanent magnet motors</td>
</tr>
<tr>
<td>Precision manufacturing</td>
<td>required factory service</td>
</tr>
<tr>
<td>Quiet operation, sound enclosure standard</td>
<td>Operating in surge for any amount of time can sometimes result in</td>
</tr>
<tr>
<td>Light weight</td>
<td>damage</td>
</tr>
<tr>
<td>Shorter lead times</td>
<td></td>
</tr>
</tbody>
</table>
Why Perform a Life Cycle Cost Evaluation

- Aeration blowers are the single largest power consumer at a WWTP typically comprising 40 to 70% of plant power consumption
- More efficient technologies are typically higher in capital costs
- Revolution in blower technologies over the last 10 years

How to Perform a Life Cycle Cost Evaluation

<table>
<thead>
<tr>
<th>Operating Points</th>
<th>Conditions</th>
<th>Air Flows</th>
<th>Weighting Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maximum month air flow, summer ambient conditions</td>
<td>14,600 scfm</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>Annual average air flow, average ambient conditions</td>
<td>13,500 scfm</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>Minimum air flow, winter ambient conditions</td>
<td>1,500 scfm</td>
<td>10%</td>
</tr>
</tbody>
</table>
# How to Perform a Life Cycle Cost Evaluation

## Table 2 – Capital Costs

<table>
<thead>
<tr>
<th>Blower alternative</th>
<th>Capital cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 1: Integrally geared (3 large duty, 1 large standby, 1 small duty)</td>
<td>$2,172,625</td>
</tr>
<tr>
<td>Alt 2: Gearless turbo (3 large duty, 1 large standby, 1 small duty)</td>
<td>$1,750,000</td>
</tr>
</tbody>
</table>

## Table 3 – Operating Costs (Power)

<table>
<thead>
<tr>
<th></th>
<th>KW</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 1: Integrally Geared</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating point 1</td>
<td>804.8</td>
<td></td>
</tr>
<tr>
<td>Operating point 2</td>
<td>691.5</td>
<td></td>
</tr>
<tr>
<td>Operating point 3</td>
<td>88.7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5628.7</td>
<td>562,9000</td>
</tr>
<tr>
<td>Alt 2: Gearless Turbo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating point 1</td>
<td>203.0</td>
<td></td>
</tr>
<tr>
<td>Operating point 2</td>
<td>609.0</td>
<td></td>
</tr>
<tr>
<td>Operating point 3</td>
<td>83.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5008.1</td>
<td>500,809</td>
</tr>
</tbody>
</table>
## How to Perform a Life Cycle Cost Evaluation

### Table 4 – Summary of Present Worth Evaluation (20 Year Period)

<table>
<thead>
<tr>
<th></th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrandy Geared Blowers</td>
<td>Gearless Turbo Blowers</td>
</tr>
<tr>
<td>Present worth capital costs, $</td>
<td>$2,173,000 24% Higher</td>
<td>$1,750,000 Lowest</td>
</tr>
<tr>
<td>Annual operating power costs, $</td>
<td>$563,000 12% Higher</td>
<td>$501,000 Lowest</td>
</tr>
<tr>
<td>Present worth power costs, $</td>
<td>$7,650,000 12% Higher</td>
<td>$6,806,000 Lowest</td>
</tr>
<tr>
<td>Total present worth, $</td>
<td>$9,823,000 15% Higher</td>
<td>$8,556,000 Lowest</td>
</tr>
</tbody>
</table>

## Maintenance Tasks

<table>
<thead>
<tr>
<th>Single Stage Integrally Geared Centrifugal</th>
<th>Single Stage Gearless Turbo Centrifugal</th>
<th>Multistage Centrifugal</th>
<th>Rotary, Positive Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet filter element</td>
<td>Inlet filter element</td>
<td>Inlet filter element</td>
<td>Inlet filter element</td>
</tr>
<tr>
<td>Lubricant addition and changeout</td>
<td>Non-contact bearing replacement</td>
<td>Lubricant addition and changeout</td>
<td>Lubricant addition and changeout</td>
</tr>
<tr>
<td>Lubricant filter</td>
<td>Permanent magnet motor replacement</td>
<td>Antifriction bearing replacement</td>
<td>Antifriction bearing replacement</td>
</tr>
<tr>
<td>Vane linkage</td>
<td>Electrical/harmonics issues</td>
<td>Seal replacement</td>
<td>Lobe clearance adjustments</td>
</tr>
<tr>
<td>Oil cooler cleaning</td>
<td></td>
<td></td>
<td>Seal replacement</td>
</tr>
</tbody>
</table>
How Maintenance Considerations Impact Blower Type Selected

• Gearless turbo blowers have almost no mechanical maintenance. Electronics maintenance needs to be performed by factory technicians.
• Some plants prefer to do their own oil changes, alignment, etc.
• If the plant prefers a factory technician or maintenance contract, gearless turbo blowers may be the answer. If the plant prefers to do their own mechanical maintenance, a more traditional technology may be a better fit.
• Combination of traditional maintenance by plant staff and a maintenance contract may be the best choice.

A Word about Controls

• A dissolved oxygen control system with most-open valve control also saves power consumption.
• An integrator experienced with WW aeration controls is key to making this work.
• Single source responsibility for blowers and basin control helps this go most smoothly. The blower mfr or their integrator is often the best entity to perform this work.
Creative Ways to Justify or Finance a Capital Blower Project

- Consider replacing only some units
- Consider electric utility rebates
- Consider ESCO projects

Best Practices

- Lowest life cycle cost blower technology
- Efficient control system which functions without “hunting”
- Bid for efficiency – specify guaranteed power numbers or require an evaluated bid
- Verify performance by shop testing
Summary

- Advantages of centrifugal vs positive displacement
- Comparative efficiencies
- Advantages/disadvantages of each blower type
- Life cycle cost evaluation
- Maintenance
- Controls
- Creative ways to justify a capital project
- Best practices

Questions & Answers

Thank you for joining us today!