Aeration System Optimization Can Offer the Greatest Long-term Savings

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Outline

• Aeration Blower Types
• Efficiency Comparison
• Turbo Blowers
• Blower Sizing Consideration
Wastewater Treatment Plant Power Usage by Unit Process

Actual Percentages Depends on:
- Overall Process
- Process Design Parameters
- Effluent Criteria

Estimated Power Usage
20-mgd Nitrifying Activated Sludge Facility

- Aeration: 49%
- RAS Pumping: 2%
- Secondary Clarifiers: 1%
- Chemical Addition: 3%
- Filter Feed Pumping: 5%
- Filtration: 2%
- Gravity Belt Thickener: 2%
- Anaerobic Digestion: 9%
- Centrifuge: 11%
- UV Disinfection: 4%
- Lighting and Misc.: 3%
- Screening: 0%
- Aerated Grit Removal: 1%
- Primary Clarifiers: 1%
Aeration System Components For Activated Sludge Plants

Blowers provide the motive power to deliver air to the diffusers
Aeration Blower Types

- **Positive Displacement**
  - Rotary Lobe
    - Constant, or variable speed drive

- **Centrifugal**
  - Multi-Stage
    - Inlet throttling
    - Variable speed drive
  - Single-Stage Centrifugal
    - Direct Drive
    - Single-point guide vane control
    - Two-point guide vane control
Existing Blower Technologies
Positive Displacement Blowers

- Lower flow, higher pressure
  - <3000 cfm, 10 psi
- Low turn-down, can’t throttle inlet
- Low efficiency
- Noisy
Existing Blower Technologies
Multi-stage Centrifugal

- Each Stage Increases Discharge Pressure
- Higher flow >3000 cfm
- Low efficiency, low turn-down
  - ~ 30% turn-down
- Industry standard for many years
- Usually inlet butterfly and/or VFD Control
Existing Blower Technologies
Single-stage Centrifugal

- Guide Vane Control
- Higher turn-down than multi-stage
  - ~ 50%
- More efficient than multi-stage
  - >70%
- Sound attenuation required
Existing Blower Technologies
Single-stage “Turbo” Blower

- Higher turn-down – 45%
- More efficient than multi-stage
  • >80%
- Sound attenuation required

• Two Types
  1. Constant Speed, Variable Vane? Vs
  2. Variable Speed?
Existing Blower Technologies
Single-Stage Turbo Blowers

Variable Vane/Constant Speed Control
- Integrally Geared Single-Stage Blowers
- Guide Vane Control
  - Inlet/Outlet Vanes Independent
  - Inlet Vary Head
  - Outlet Vary Volume
- Higher Speed
- More Expensive
- More Common In Large WWTPs
Existing Blower Technologies
Single-Stage Turbo Blowers

Variable Speed Control
  – Variable Frequency Driven
  – Many Manufacturers
    • Neuros (Korea)
    • K-Turbo (Korea)
    • HST (Finland)
    • Atlas-Copco
    • HSI
    • HV Turbo
Turbo Blower Background / History

• On Market for Approximately 15 Years
  – Only Recently Embraced by North America Engineering Community

• Utilize Very High Speed Motor > 30,000 RPM
  – Impeller Design Based on Jet Engine Turbine

• Few Installations in the U.S.
  – However, Thousands In Europe and Asia

• Motor and VFD Are Custom Engineered
Turbo Blower Energy Related Benefits

- High Efficiency > 70% wire to air
  - Some states offer energy saving rebates
- High turndown > 50%
  - Much easier to meet low flows efficiently
  - Avoid surge conditions
- Lower horsepower under most operating conditions
Turbo – Blower, More Benefits

- Small Footprint
- Historically Very Low Maintenance
- Cost Competitive
Turbo - Blower Impeller Comparison

HV-Turbo

Neuros

ABS-HST

KTurbo

Atlas Copco
Turbo – Blower System Components

- Drive Unit
- Bearings
- Inlet Filters
- Blow-off Valve
- Vibration
- Auxiliary Cooling
Bearings

- **Air Bearing**
  - Two Parts – Corrugated Bump Foil and Inner High Temperature Allow Core
  - At 2,000 RPM – Thin Air Film Created
  - Upon Power Failure – Touchdown Pad

- **Electromagnetic Bearings**
  - Power (i.e. 500-600 Watts) Used to Hold Turbine in Suspension
  - Upon Power Failure – Turbine Rests on Touchdown Bearings
Inlet Filters

- 10 Micron Industrial Air Filter on Inlet Cabinet
  - Change Every 6 Months
- Bag Filter In Separate Housing On Inlet
  - Change Yearly
Blowoff Valve

- Blowers Must Startup Under Zero Discharge Pressure
  - Typically Takes 20 sec
- Requires Silencer

Neuros Blowoff  ABS Blowoff
Auxiliary Cooling

Water Cooling Unit
Specification Development

- Equipment Varies Greatly From Each Manufacturer
- Requires Performance Based Spec
  - Wire to Air Power Evaluation
  - Must Include All Auxiliary Items
  - Power Guarantee
- Pre-purchase?
High Speed Turbo Blowers and Dissolved Oxygen Control

- Typical D.O./Blower Control
  - Cascade loop
    - D.O. controlled by modulating valves to maintain D.O. set point
    - Blower controlled by modulating inlet valve to maintain discharge pressure set point.
- Turndown capability of Turbo Blowers allows D.O. control of Blower
High Speed Turbo Blowers and Dissolved Oxygen Control

- Advantage of D.O. control of blower – Power Savings
Conclusions

• Turbo technology has become more accepted in the U.S.
• Energy savings and many other benefits
• Cost competitive
Blower Sizing Considerations

- **Calculate O₂ required by process**
- **Review Existing Data**
- **O₂ Transfer Efficiency**
  - Calculate O₂ that must be delivered to meet process requirements
- **O₂ in air constant at standard conditions**
- **Convert O₂ Requirements to Air Flow (scfm, m³/hr, kg/s)**
- **Adjust “Standard” to “Actual” Conditions**
Determining SCFM Depends on a Number of Factors

- Denitrification
- TKN
- COD
- Nitrification
- SOTE
- Elevation
- Diffuser System
- Tank Depth
- Air Flow
- $O_2$
- $\alpha$
- $\beta$
Blower Sizing Results From A Multi-Step Design Process

1. Existing data evaluation
2. Influent wastewater characterization – fill data gaps
3. Model calibration and verification
4. Preliminarily size new facilities
5. Incorporate airflow into model output
Steps Required in Blower Selection

• Finalize blower size based on:
  – air requirements (scfm, m3/hr, kg/s)
  – inlet air temperature range
  – inlet air relative humidity range
  – inlet pressure range
  – discharge pressure range

• Determine horsepower (kW) to produce the required airflow at the required inlet air conditions

• Compare different blower performance predictions on a Net Present Value basis
Important Facts Related to Blower Design and Operation

• Blowers usually designed for 3 to 5 performance points:
  – Capacity
  – Discharge pressure
  – Inlet air temperature
  – Inlet relative humidity

• Blowers almost never operate at these “selected” points due to changing conditions
  – air inlet conditions
  – air flow requirements
  – discharge pressure varies, but to a lesser extent (depends on required air flow and head loss, and tank depth fluctuations)

The most efficient blower systems respond quickly to changes and must be efficient across the normal “range” of flows.
Conclusions

- Minimum airflow quantity and duration are important.
- Maximum day is not as important as once thought, and can skew airflow rates resulting in unnecessarily large blowers.
- Discrete airflow requirements are generated as a normal part of process modeling during design.
- Multiple point evaluation (more than 3-5) enables a more realistic comparison of the true value of different manufacturers’ offerings.
- Blowers are expensive to purchase and operate - sufficient time must be invested to perform a thorough evaluation.
- Each plant is unique and the blower requirements must be evaluated based on the site specific requirements.
- Witness testing is a must!
Questions?