AERZEN USA

Efficiency Comparisons Between Aeration Blowers
Evaluation of Blower Technologies

Introduction

- Aeration System
  - Largest Consumer of Power in WWTP
    - 50% to 60% of plant operating cost
  - Life Cycle Costs far exceeds Initial Capital Costs

![Pie chart showing average operating costs of an air mover over 10 years]
Introduction

- Purpose of Presentation
  - Evolution of Blower Technologies
  - Matching the Technology to the Application
  - Right-Sizing of Blowers
  - Accurate Evaluation of Overall Costs
Traditional Blower Technologies

- Two Lobe Positive Displacement
  - Variable Speed

- Multi-Stage Centrifugal
  - Inlet Throttle Valve or Guide Vanes
  - Variable Speed
PD Blower Design Principles

- Positive Displacement Blower
  - Constant volume against varying pressure
  - Flow changes by varying speed with VFD
  - Large Turndown (Typically 4:1)
  - Easily adapts to changes in pressure & temperature
  - Widely used / Low initial cost
PD Blower Evolution

- Two-Lobe to Three-Lobe Technology
  - Pulsation Cancellation
    - Less wear and tear on components and piping
  - Single Forging of Shaft and Impeller
    - Stronger, More Stable at Higher Speeds
- More Effective Noise Reduction
  - Quieter packages
- Upgraded Seals (Piston Ring)
  - Longer maintenance intervals on internals
2-Lobe Conveying Cycle

Atmospheric pressure

System pressure

Abrupt pressure equalization causes noise and shocks (pulsations) 4 times per revolution.
Three-Lobe Conveying Cycle

Integrally cast return ports gradually pressurize casing.

Squeeze pulse is 180° out of phase with Pressure pulse.
Limitations of PD Blowers

- Efficiency
  - Slip between Rotors
  - Less efficient at Lower Flows
  - Less efficient at Higher Pressure
Compressor Design Principles

- Positive Displacement Compressor (VML)
  - Used since the 1940’s (Deep Cell Aeration)
  - Rotors mesh, compressing air inside housing
  - Flow changes by varying speed (VFD)
  - Best around 20 to 30 psig
  - Higher capital cost (2X PD blower)
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Evaluation of Blower Technologies

Limits of Screw Compressors

- Efficiency
  - Less efficient at Lower Pressures

![Graph showing adiabatic efficiency as a function of inlet flow for different pressures (8 PSIG, 10 PSIG, 12 PSIG) for VML60 model.](image-url)
Adaptation to WWTP Use

- **Low Pressure:**
  - 3 – 7 PSIG
  - Twisted Lobes

- **High Pressure:**
  - 7 – 15 PSIG
  - Screw Compressor
Centrifugal Design Principles

- Multi-Stage Blower
  - Widely used technology
  - High Flow, Small Footprint
  - High Efficiency at Design Point
Centrifugal Design Principles

- Centrifugal Blowers (Dynamic Compression)
  - Kinetic Energy to Potential Energy
Centrifugal Evolution

- Multi-Stage
  - Repeats the Compression Process in Series
  - Relatively low speed
    - 3600 RPM
Centrifugal Evolution

- **Turbo Blower – Gear Drive**
  - High efficiency, even at turndown
  - Bullgear raises Impeller Speed (Single Stage)
  - Inlet guide vanes and discharge diffuser vanes
  - Complex control system
  - High capital cost
  - More Cost Effective >400HP
Centrifugal Evolution

- High Speed Turbo Blower
  - Newest in WWTP market (<5 years)
  - Air-Foil Bearings, Permanent Magnet Motor
  - Integral VFD and Control System
  - More Affordable than Gear Drive
  - Wide Range of Sizes
  - Life Cycle Cost Payback
Centrifugal Design Principles

- Dynamic Compression
  - Sweet Zone of Efficiency
- Must Reside on Performance Map
  - Flow too Low or Pressure Too High: Surge
  - Flow too High or Pressure Too Low: Choke
- Performance Varies with Air Density
  - Summer (High Loads, Low Air Density)
  - Winter (Low Loads, High Air Density)
Centrifugal Design Principles
What is Surge?

- Compressor generating more air than needed by the system.
- Compressor's inability to continue working against the already-compressed air behind it.
- Oscillation of discharge pressure and flow rate.
Centrifugal Design Limitations

- Control Is Essential
  - Protect the Blower
  - Satisfy System Air Requirements
Centrifugal Blower Control

- Multi-Stage:
  - Throttling Valve / Inlet Guide Vanes
  - Speed Control (VFD)
- Gear Drive Turbo:
  - Inlet and Discharge Vanes, Speed Control
  - Control System (PLC)
- High Speed Turbo:
  - Motor Control (Speed, Current)
  - Control System (PLC or CPU)
What Technology to Choose?
Start With the System

- System Flow Requirements
  - Minimum, Maximum, Average
  - Factor in Diurnal Minimum
- Pressure (Constant or Varied, and How Much)
- Site Conditions (Elevation, Ambient Range)
- Control Requirements
  - On/Off, VFD, Combination
Evaluation of Blower Technologies

Performance Comparison

Hybrid Comparable to Turbo

Performance Advantage Vs. PD

Temperature Issues at Low Flow

Specific Power Comparison Delta Hybrid D62S, GM 60S, and TB100-1.0
(Inlet T1=68F, P1=14.5 PSIA, RH=0%) P2=11.6 PSIG

<table>
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<th>SCFM/kW</th>
<th>D 62S</th>
<th>GM 60S</th>
<th>TB100-1.0</th>
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Flow SCFM

400 800 1200 1600 2000
Temperature Concerns

Temperature Limits
Turndown at Higher Pressures for Standard PD
Performance Comparison

Specific Power Comparison: Delta Hybrid D62S, GM 90S, and TB100-0.8

- Efficiency Difference in Flow Range
- Comparable Design Point
Evaluation of Blower Technologies

Performance Comparison

Specific Power Comparison: Delta Hybrid D62S and TB100-1.0S
(Inlet T1=100F, P1=14.09 PSIA, RH=80%) P2=12 PSIG

Comparable Efficiency Throughout

Greater Turndown

Comparative Graphs
Performance Comparison

Break-Even Point

Inlet Conditions:
P1 = 14.7 PSIA
T1 = 68 F
RH = 36%
Discharge P = 8 PSIG
## Sensitivity Analysis

### Sample Power Comparison - Cheshire CT

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<tr>
<th>System</th>
<th>Weight</th>
<th>TM150-0.6T</th>
<th>D98S</th>
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<td>W-T-P kW</td>
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<tr>
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<tr>
<td>100%</td>
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Cost per kWH:
- $0.1426
- $0.1426

Annual Power Cost:
- $86,511.68
- $78,379.55
Site Conditions

31% Variation in O₂ Content

14% Variation in O₂ Content
Why Site Conditions Matter

- Density affects compression ratio
  - Higher Elevations Limit PD
- Percent O\textsubscript{2} impacts aeration requirements
  - ICFM vs. SCFM
- Maximum flow on Hottest Day
  - Perfect Storm Design
- Minimum flow on Coldest Night
  - More Likely
System Control Requirements

- On/Off Cycling
  - PD Blower / LP Screw / Multi-Stage - Good
  - NEMA Motor (4-6 starts/hour)
    - VFD Extends # of Starts
  - Turbo – Challenged if cannot run unloaded
    - High Frequency VFD may limit daily starts
  - Airfoil Bearings limited to 20,000 starts
    - Or <20,000 (Depending on Design)
Idling/Scrolling Function

- Bypass Valve Opens
- RPM Drops to ~10,000
  - Sufficient to maintain “loft” on Bearings
  - Minimal Power Draw (Avg 2%: 2 – 5 kW)
- Avoids Bearing Wear
- Avoids Start/Stop Cycles
- Useful in SBR/MBR Systems
Right-Sizing

Example: 10:1 turndown with 3 rotary lobe blowers, two of which are VFD-driven and 1 fixed speed

- Minimum demand on coldest day
- Maximum demand on hottest day
Right Sizing Options

- One 100% Unit/System with common spare.
  - Base Load, Upper Flow Range
- Two 50% Units with Common spare.
  - Greater Net Turndown
  - More Machinery
- Base Load Machine, Swing Machine
  - Mixed Technology
  - Optimize Efficiency Throughout Range
Life Cycle Costs

- Energy Usage
  - Anticipated Operating Points
  - Assign Time and Conditions
  - Require Manufacturer to Provide TOTAL kW
    - Include ALL Mechanical & Electrical Losses
  - ASME PTC-13
Life Cycle Costs

- Installation
  - Indoor or Outdoor
  - Integral VFD or Separate
  - Available Footprint
Life Cycle Costs

- Maintenance:
  - PD (Blower, Compressor):
    - Annual Oil Change
    - Belt Change (12-18 months)
    - Air Filters as needed
    - Bearings/Seals (15-20 Years)
  - Turbo:
    - Air Filters: Prefilter (1-2 Mos), Fine Filter (6 Mos)
    - Impeller Cleaning (3 Years)
    - Electronics (capacitors) (5 Years)
    - PM Motor (10 Years)
Your Final Decision

- Accurate Energy Cost Evaluation
- Life Cycle Costs
- Proven Technology
- Serviceability
- Accountability of the Manufacturer
Thank you for your Attention