BLOWER TECHNOLOGIES USED IN WASTEWATER APPLICATIONS

Glen Roderique
Sales Engineer
OVERVIEW

- Introduction & Company History
- Types of Blowers used in the Wastewater Industry
- Types of High-Speed Turbo Blowers
- HST Performance Characteristics
- Blower Controls
- Summary of Blower Types
- Inovair Product Line
- Q&A
• Founded in 1994 in Lenexa, KS
• Focused on centrifugal supercharger systems for the automotive, marine, and motorcycle aftermarkets under the ProCharger brand.
• In 1999, began supplying centrifugal compressors used for forced-air deicing of commercial and military aircraft.
• In 2008, began supplying centrifugal compressors for various industrial processes
• Entered the MWWT market in 2012
BLOWER TYPES USED IN THE WASTEWATER INDUSTRY
WHY ARE WE CONCERNED ABOUT DIFFERENT TYPES OF BLOWERS?

- CAPITAL COST CONSIDERATIONS
- EFFICIENCY/ENERGY COST
- OPERATIONAL CONSIDERATIONS
- RELIABILITY & MAINTENANCE
Types of Blowers for Wastewater Treatment

- Positive Displacement (PD) Blowers
  - Roots, Gardner-Denver, Kaeser, Aerzen, etc.

- Multi-stage Centrifugal
  - Hoffman, HSI, Spencer

- High-speed Turbo Blowers
  - Integrally-geared – Inovair, Turblex, Roots
  - Air-bearing – HSI/Atlas-Copco, Neiros, K-Turbo/Aerzen
  - Magnetic bearing – Sulzer ABS
Positive Displacement Blowers

- Developed by the Roots Brothers in the mid 19th century
  - Utilize meshing lobes (2 or 3) to produce flow
  - Approx. 45-70% isentropic efficiency
  - No internal compression
  - Durable
  - Low cost
  - 50%+ turndown - VFD
  - High noise levels
  - Usually belt driven
  - Limited controls
  - Normal HP range: 5-250
PD Blower Curve

Positive Displacement Blower curve

Speed adjustment
Multi-stage Blowers

- Developed in the early 1900’s

• Uses multiple low pressure stages to produce pressure ratio

• Approx. 50-75% isentropic efficiency

• Offers limited turndown – inlet throttle or VFD

• Relatively low noise level

• Normally higher cost than PD’s

• Direct drive

• Normal HP range: 30-400
Multi-stage Blower Curve
High-Speed Turbo Blower Characteristics

- Utilize a single high-speed impeller to produce its pressure ratio
- Approx. 70-82% isentropic efficiency
- Advanced electronic controls
- Up to 55% turndown
- Higher cost
- Higher complexity
- Lower noise level
- Normal HP range: 30-5,000+
High-speed Turbo Blower Curve

<table>
<thead>
<tr>
<th>Flow (scfm)</th>
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</table>

HP basis on +/- 5% tolerance

Flow vs Pressure

- Blue: Design
- Red: 100%
- Green: 95%
- Purple: 91%
- Teal: 87%
- Orange: 84%
- Light Blue: 83%
TYPES OF HIGH-SPEED TURBO BLOWERS
Main Difference in Turbo Blowers

• All single-stage centrifugal impellers normally operate in the 10-50,000 rpm range.

• The method for achieving these speeds is the main difference in the various types of high-speed turbo blowers.
**Turbo Blower Types for MWWT**

The three main impeller drive configurations of centrifugal compressors:

- **Integrally-Geared** – Utilizes a high-speed gearbox to step up the speed of a standard 1,800 or 3,600 rpm motor, either belt or direct driven.

- **Air-Foil Bearing** – Utilizes a high-speed permanent-magnet motor directly coupled to the impeller. The motor’s rotor is supported by air-bearings.

- **Magnetic Bearing** - Utilizes a high-speed permanent-magnet motor directly coupled to the impeller. The motor’s rotor is supported by magnetic bearings.
History of Turbo Blower Technologies

- Integrally-geared centrifugal compressors were the predominant machines for the majority of the 20th century in the natural gas industry. Introduced in the wastewater industry in the later half of 1900’s. Mainly used in large installations because of high capital costs.

- Air-foil bearing technology was developed in the late 1950’s in the U.S. and got widespread use in aircraft environmental control systems. Introduced in the wastewater industry in approximately 2007 by Korean manufacturers.

- Magnetic bearing technology advanced from 1970’s-1990’s and was first used in natural gas compressors. Introduced in the wastewater industry in approximately 2007 by The ABS/Sulzer Group.
Integrally-Geared Turbo Blowers

Utilizes an internal gearbox as a speed increaser. May utilize rolling element and/or oil-film bearings

Advantages:
- High efficiency
- Small footprint
- Simple and intuitive design
- Industry standard components
- 75+ years of proven reliability, durability
- High bearing stiffness

Disadvantages:
- Gearbox efficiency losses
- Lubrication system maintenance (annual services)
- Gearbox whine/noise
Air-Bearing Turbo Blowers

Utilizes a permanent magnet motor integrated into the rotor and air foil bearing

Advantages:
• Quiet operation
• No lubrication system
• High efficiency
• Small footprint
• Cost effective for 100 HP+ applications

Disadvantages:
• Limited number of starts/stops
• Intolerable to contamination
• Requires factory servicing
• Proprietary electronics
• Losses through electrical components
Utilizes a permanent magnet motor integrated into the rotor and magnetic bearings

Advantages:
- Quiet operation
- High efficiency
- No lubrication system
- Small footprint
- High bearing stiffness

Disadvantages:
- Highest capital cost
- Complex electronics
- Requires factory servicing
- Losses through electrical components
High-speed Turbo Performance Characteristics
• High efficiency achievable at nearly any design point
• Flow capacity determined by speed and inducer diameter
• Pressure capability is primarily determined by exducer tip speed
• High pressure ratio capability
Evaluate blower selection on realistic conditions

### Table: Blower Performance

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HP basis on +/- 5% tolerance

### Graph: Flow vs Pressure

- **Design**
- 100%
- 83%
- 93%
- 73%
- 73%

Flow, SCFM vs p2, psig
Varying Tank Levels

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<tr>
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HP based on ±5% tolerance

Flow vs Pressure

- Design
- 100%
- 94%
- 89%
- 83%
- 76%
- 69%
Affinity Laws for Centrifugal Compressors

The affinity laws show the relationship between speed, flow, pressure and power.

- Flow increases linearly with speed
- Pressure increases with the square of the speed increase
- Power consumption increases by the cube of the speed increase
Blower Controls
Typical Plant Blower Control schemes:

- Continuous operation – No DO monitoring
- Manual DO measurement – Manual blower on/off control
- Manual DO measurement – Manual airflow control (VFD)
- Automatic DO control – Individual blower or master control panel
- Full SCADA/Plant control – automatic airflow and valve control
  - Constant-pressure header
  - Most-open valve (MOV)
High-Speed Turbo Control System

- Mass airflow sensor
- Inlet air temperature
- Inlet air pressure
- BYPASS valve - servo or actuator
- VFD
- PLC/LOCAL CONTROL PANEL
- SCADA or master control panel or DO input
- Oil pressure
- Oil temperature
- Discharge pressure
EFFECTS OF TEMPERATURE ON MASS AIRFLOW

% SCFM Airflow versus Temperature

- Constant Speed Machines
- Temperature Compensated HST

TEMPERATURE, °F

% OF SCFM DESIGN FLOW
BENEFITS OF TEMPERATURE COMPENSATION

CONSUMED POWER VERSUS TEMPERATURE

- Temp. Compensated HST
- Multi-stage Blower
- PD Blower
Can I add a VFD to my current PD or multi-stage blower to reduce my energy consumption?
VFD’s can provide good energy savings and process control, but there are things to consider:

- **How much turndown can I get from my blower?**
  - PD’s normally around 50% maximum.
  - Multi-stages around 30% maximum.

- **Are you operating at or near full blower capacity?**
  - VFD’s normally cost 2-3% to operate plus any associated filters. Would the savings offset the initial and on-going cost.

- **Do you ever operate into the service factor of the motor?**
  - VFD’s will drop the motor SF from 1.15 to 1.0.
Summary of Blower Types
Positive Displacement Blowers:

Capital Cost – ($), but enclosures and controls are an added expense.

Efficiency/Energy Cost – ($$$) Lower efficiency, higher energy costs.

Operational Considerations – Normally On/Off operation, but can utilize additional controls, 50+% turndown capability.

Maintenance & Reliability – ($) High reliability with low maintenance (oil/belts/air filters).
Multi-stage Blowers:

Capital Cost – ($$)

Efficiency/Energy Cost – ($$$$) Lower efficiency, higher energy costs.

Operational Considerations – Normally On/Off, minimal turndown capability (even with VFD’s).

Maintenance & Reliability – ($) High reliability with low maintenance (oil/air filters).
Integrally-geared HST Blowers:

Capital Cost – ($$$)

Efficiency/Energy Cost – ($) Higher efficiency, lower energy costs.

Operational Considerations – Full controls, up to 55% turndown, temperature and pressure compensation.

Maintenance & Reliability – ($) High reliability with low maintenance (oil & filter/air filters).
Air-foil Bearing HST Blowers:

Capital Cost – ($$$$

Efficiency/Operational Cost – ($) Higher efficiency, lower energy costs.

Operational Considerations – Full control, up to 45% turndown, temperature and pressure compensation, not good for start/stop processes.

Maintenance & Reliability – ($) High reliability, low maintenance (air filters).
Magnetic Bearing HST Blowers:

Capital Cost – ($$$$$+)

Efficiency/Operational Cost – ($) Higher efficiency, lower energy costs.

Operational Considerations – Full controls, up to 55% turndown, temperature and pressure compensation.

Maintenance & Reliability – ($) High reliability, low maintenance (air filters).
Things to consider when purchasing new blowers

- What are the current minimum and maximum airflow requirements and are they anticipated to change in the future?
- What are my energy costs ($/kwhr)?
- How often will the blowers start/stop?
- Does the tank level vary?
- Does the loading or effluent flow vary?
- How stable is the incoming power?
- Will the blowers be located outside or inside?
Inovair Products
Innovair’s 2200 Compressor

- Integrally-geared centrifugal compressor
  - 2-stage gearbox is integrated into the compressor unit in order to obtain the necessary impeller speed

- Typical operating speeds:
  - 35,000-45,000 rpm
  - Designed to operate up to 60,000 rpm

- 2200 Gearbox rated for up to 100 HP

- Designed for L10 bearing life of 10 years

- High precision gears manufactured to AGMA II standards

- Assemblies balanced to G2.5/G6.3

- Designed & manufactured in Lenexa, KS
BELT-DRIVE BLOWER PACKAGES

- High efficiency
- 30-125 HP
- 75-90 dbA
- Easily maintainable
- Compact footprint
- Cost competitive
DIRECT-COUPLED BLOWER PACKAGES

- High efficiency
- 60-25 HP
- 75-85 dba
- Easily maintainable
- Up to 4:1 turndown
- Modular design
- Indoor/Outdoor rated
• Questions

• Thank You

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