History And Overview Of Direct Drive Turbo Compressors

By: Dave Parsons Product Manager High Speed Turbocompressors
Aeration Blowers

- Aeration consumes 40-70% of energy used in activated sludge plants (WEF MOP OM-9)

- For supplying diffused aeration grids, 2 types:
  - Positive Displacement (1854)
    - Approx. 60% efficient
    - Typically smaller (<100 hp)
    - Output varies with speed, not pressure
    - Factory or OEM packages available
    - Widely applied, low capital costs
Aeration Blowers

- Multistage Centrifugal (1945):
  - Approx. 65-75% efficient
  - Wide range of sizes, typ. >50 hp
  - Output varies with pressure
  - Widely applied for over 100 yrs.
  - Can be more expensive initially than positive displacement

- PD and Multistage blowers are the workhorses of the industry but the need to reduce energy costs demanded new technology.
Times Have Changed, New Technology Arrived

- With renewed emphasis on energy efficiency, new styles of blowers have now become the leaders.

- High speed turbocompressors offer several potential advantages over traditional blowers:
  - Higher efficiencies
  - Lower maintenance costs
  - Variable output
  - Quiet operation
Centrifugal blower 1st Turbo Compressor

HV Turbo First High Speed Turbo in Europe (1985?) and in US TURBLEX (Now Siemens Turbo Machinery)

Standard Motor

High efficiency, even at turndown

Speed Increasing gear box with journal bearings raises Impeller Speed (Single Stage)

Inlet guide vanes and discharge diffuser vanes

Complex control system

Forced Oil Cooling System

High capital cost

Maintenance at Medium level: Air filters, oil exchange, cleaning of the guide vanes (IGV, ODV), slide bearings life is approximately 8 - 12 years, ball bearing 3-5 years
History Of Direct Drive Turbo Compressors

- Development project of 100 kW power plant with 30 kW turbogenerator at Lappeenranta University of Technology 1981 - > 1985

- ORC (Organic Rankine Cycle) power plant for a saw mill 1987 - > 1989

- High Speed Tech Oy established by professors involved 1988 (non-operating company)

- Rauma Repola made power plant to MIR submarine for deep sea conditions (20 000 feet) 1989-1992

- Submarine used later in Titanic movie to film real Titanic in the bottom of the Atlantic ocean
Heading to first installations

- Rauma-Repola acquisition 1992 -> High Speed Tech Oy Ltd activated
- Technology development and prototypes for microturbine, microgenerator, high pressure pump, compressor, vacuum pump
- Target was set to aeration compressor and vacuum pump 1994
- Basic product development until 1996
- First delivery to Botnia Pulp mill in Joutseno, Finland in 1996
  - 9 pieces 6000-2-H compressor started in **October 1996**
  - Later 1996-1997 two compressors more
  - Installation still in use
  - 9...10 compressors running all the time
- Introduced to US market at **Chicago WEFTEC 2002**
- First US installation of 6 units at DePere WI (now New Water formerly Green Bay Metro) **October 2004 Start UP**
Magnetic Bearing

- Includes 5-axis vibration monitoring
- Includes proven complete diagnostics tools & remote monitoring
- Shaft unbalance possible without metal to metal contact:
  - No vibration transmitted to the motor stator
  - Automatic unbalance compensation
- 100% non-contact (even at start-up and shut-down)
- Proven bearing technology with HST:
  - 1996 – 1999: analogue MBC
  - 2005 – present: digital MBC12

Maintenance

- 25 years or longer before bearing maintenance is needed
High speed technology:

- Single stage radial turbocompressor
- Manufactured using standard components
- Integrated frequency converter with control software
- Variable speed control to match process demand
- Induction motor specifically designed for HST
- Real time monitoring and fault detection
- Magnetic bearings with shaft position control
  - Non contacting
  - No friction losses
  - No wearing parts
  - Oil free air delivered
High Speed Unit Details:

- Impeller
- Labyrinth seal
- Upper and lower axial and radial magnetic bearing
- Cooling fan
- Upper touchdown brg.
- Upper and lower position sensor
- Motor rotor
- Lower touchdown brg.
ASSEMBLY OF THE HIGH SPEED UNIT

Rotor
Induction or Magnetic

MOTOR FRAME

Stator Induction or Permanent Magnetic

SPIRAL BASE
IMPELLER
BACK PLATE
D-END BEARING
N-END BEARING
TUNNEL FLANGE
FAN
END PLATE
GUIDE FLANGE
Impeller, Safety bearings and Cooling Fan
ABS Turbocompressor family

- High speed turbocompressors with active magnetic bearings
- Oil free air to aeration process with high efficiency
- Compressors with induction motor (flow range 450-6400 SDFM)
  - HST 2500 (92-134 input hp)
  - HST 6000 (201-322 input hp)
  - HST 9000 (255-322 input hp)
- Compressors with permanent magnet motor (flow range 1300-10,400 SCFM)
  - HST 9500 (268-375 input hp)
  - HST 40 (402-536 input hp)
  - HST 20 (150-250 input hp)
Direct Drive High Speed Turbocompressors

- Different styles from different manufacturers


- Air Foil Bearings – HSI HT (now Atlas Copco); Aerzen (Old K-Turbo); APG-Neuros; Turblex/Siemens (no longer on market?), TurboMax, Roots (GE Energy)

- There may be others that I have not mentioned
Other Magnetic Bearing Unit

- Atlas Copco ZB Units Input kW range of 100kW to 160kW (maybe more offerings) and air flow ranges from 590 CFM to 3500 CFM.

- Piller’s Pillerator Input kW range of 150kW to 300kW and air flow range 500CFM to 8,200CFM
Other Magnetic Bearing Unit

- Spencer Ayrjet flow range to 8200 ICFM and horsepower range to 400HP

- Hoffman Revolution flow range from 500 SCFM to 9700 CFM and HP range?
Gas Bearing

- Three basic types:
  - Bump foil (Neuros, Aerzen)
  - Leaf foil (HSI)
  - Tilting pad (history)

- Requires:
  - Good balancing
  - Accurate bearing manufacture
  - Accurate coating manufacture

- No automatic monitoring
  - Vibration measurements
  - Log files, remote monitoring etc

- Maintenance
  - Requires repair of bearing and bearing surfaces every 6-8 years
3rd Generation Bump Foil Air Bearing

Thrust Bearing

Journal Air Bearing

HIGH SPEED ROTATION

PRESSURIZED AIR BY HYDRODYNAMICS

~ 5 to 20 μm
Leaf Type (Air Foil) Bearing
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
Air Bearing Units

- Neuros NX Series flow rates from 400 - 21,000 cfm and Single core for 50 – 350hp units dual core for 400 – 700hp

- Aerzen TB Series flow rates from 500-9500 CFM and from 50-400 HP
Installation – Lingen, Germany:

Installation:
- WWTP, municipal
- 2 x S2500-1-H-4
- 2 x S6000-1-H-4

Total flow:
- 10,590 scfm

Flow / unit:
- 735-1765 scfm (S2500)
- 1765-3530 scfm (S6000)

Pressure:
- 12.2 psi
Design & Installation Flexibility Louvered or Flanged Inlet

NX200 - Single Core

NX500 - Dual Core
Design and Installation Flexibility Multiple Units

NX100 & NX150 - Single Core
HST 2500-1-L-5

Start Up November 2009

In a 25 day billing cycle, the City’s electric bill was reduced by $2600.00. No additional work was done except replacing existing multi stage blowers with ABS HST blowers.

References:
James Dixon – City of Geneva (334-684-9554
DePere WWTP, Wisconsin:

- **Installation:**
  - WWTP, municipal
  - 14.5 MGD
  - Start Up 2004
  - 6 x S9000-1-H-5

- **Total flow:**
  - 25,000 scfm

- **Flow / unit:**
  - 1950-5000 scfm

- **Pressure:**
  - 9.9 psi
Replacing existing blowers
One HST 9000-1-H-5
Water height 20 feet
Remote control with I/O
Start Up May 2008

References:
Nick Menninga P.E.-
nickmenninga@dg sd.org

Engineer: Baxter & Woodman
Paval Hajada, PHD P.E.
phajda@baxterwoodman.com
815-459-7860
Naperville, IL USA

- (6) HST 9000-1-L-5
- Start Up October 2009

**Contacts:**
Engineer:
Nathan Cassity, PE, BCEE
Process Engineer, National Water Design Center, Midwest
D 920.451.2475  M 920.918.0397
nathan.cassity@aecom.com

End User:
Mr James Dean
630-305-5373
DeanJ@naperville.il.us
Thank you for your attention!

Questions?

EFFICIENCY HAS A NEW FACE.
ABS TURBOCOMPRESSOR HST 40.