Applied Aeronautics Improves Aeration Technology in Wastewater Industry

by Thomas J. Whetam

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day now and then, a new technology appears on the scene and shows promise for application in the treatment of wastewater. Unfortunately, more often than not, these promising technologies do not live up to the hype and either underachieve on the performance side or become a maintenance liability. However, one such promising “new” technology is surpassing performance expectations and is proving to deliver as advertised on claims of reduced energy costs and simplified maintenance.

The introduction of revolutionary air-bearing technology for air blowers in 2005 was met with hesitation and skepticism on the wastewater market. But since the improved blower technology has been applied in the wastewater treatment industry, air-bearing turbo blowers are now installed in hundreds of locations in North America with many units on order for installation in the near future. The direct-drive, air-bearing turbo blower is demonstrated to have optimized and made aeration more energy efficient in wastewater treatment plants where traditional single-stage and multi-stage centrifugal impellers and positive displacement style blowers have been previously applied. This innovative technology is addressing the need today to do more with less in wastewater utility service to the rate paying public and is appropriately characterized as a “green” technology.

Blower History

The first positive displacement blower was invented and installed by Roots Brothers in Connersville, Indiana in 1859. Made out of wood, it was initially used as: “a more efficient water wheel, generating power for milling until someone noticed that such an arrangement would move a quantity of air and the use as an air blower was begun.” This was followed by the invention of multi-stage centrifugal blowers in 1945; single-stage centrifugal (gear driven) blowers in 1980; and, finally, single-stage centrifugal (magnetic driven) blowers in 1985. Since then, for almost 20 years, there was little technological advancement in the blower industry – until the single-stage turbo blower was introduced in 2003.

Turbo blower technology was founded in the aerospace and defense industry where aero engines were used in unmanned aerial vehicles (UAV) and in the F-16 military aviation program, making the technology tested and reliable. The core of the technology is the patented third generation bump foil air bearing which is oil free and non-contact, needing no lubrication or associated maintenance, and resulting in lower vibration from the rotor during operation. It proved to have durability and endurance which was demonstrated through 25,000 starts, an equivalent to more than 20 years or a lifetime of use in a typical operation.

Technical Components

Another key technology within the blower in addition to air bearings, is the high efficiency impeller (the rotor or rotating device used to force a fluid or air in a desired direction under pressure), which is designed by the best-in-class manufacturers using software based on aeronautical gas turbine engine technology. The best turbo blowers employ a solid forging impeller with five-axis machining for higher integrity and higher fatigue life, as well as a larger diameter and precise impeller shape that is combined with optimal speed, resulting in higher efficiency. The permanent magnet synchronous motor (PMSM) transfers electromagnetic frequency (EMF) to load, rather than windings and slip rings, with no physical contact between stator and shaft, offering high precision motor speed control. Driven by a sinusoidal pulse-width modulation (PWM) algorithm, the result is lower motor heat rejection and minimal cooling requirements and, ultimately, energy savings.

Other design features employed on the best-in-class machines include the cooling of the blower core, the variable frequency drive (VFD), and the control systems with the blower inlet air. With no heat rejection to the blower room, no auxiliary exhaust systems are required and no additional power consumption is required for cooling. Larger, or 200 and higher horsepower (HP), models include an integral glycol cooling system for higher performance and durability with no external water supply required. Finally, most turbo blower units are manufactured as a complete package including programmable logic controllers (PLC) located in the enclosure mounted local control panel, making it routine to run the blower in constant pressure, flow or DO (dissolved oxygen) control mode. Most PLCs also accept standard 4-20 mA (milliampere) or digital signals and can communicate status through an Ethernet system, wireless or hard wired connectivity. The turbo blower package normally comes complete with a sound proofing enclosure and various inlet and outlet air piping configurations to make “plug and play” a reality to meet varying flow rate and pressure conditions by placing the packaged units side by side and running them in parallel. Single core turbo blowers can now attain flow rates of up to 20,000 SCFM (standard cubic feet per minute) and a discharge pressure up to 15 psig (pounds-force per square inch gauge). Newer dual core models combine single-combine core units into two within the same enclosure unit to provide flow rates ranging between 3,000 and 20,000 SCFM and pressures up to 15 psig.

Green Design Benefits

The innovative design of the turbo blower results in many benefits. The primary benefit is arguably energy and operating cost savings of...
up to 35 percent when compared to conventional positive displacement blowers. Since energy consumption is one of the most significant components of a wastewater facility’s operating cost structure, up to a 35 percent savings represents significant overall plant operational savings. Additional savings can be achieved using the operational flexibility inherent in the turbo blower technology through turndown capabilities of up to 50 percent in single core and 76 percent in dual core machines, allowing the operator to adjust air flow to the precise amount needed. This process is typically automated using dissolved oxygen control or pressure/flow control and the integral programmable logical controller to pace blower output.

Unlike conventional blowers, the turbo blower package exhibits low noise and vibration due to noise attenuation enclosures that are present on the best-in-class turbo blower units. The noise attenuating enclosure can effectively control sound propagation and reduce noise levels to 80 decibel A-weighted measurement (dB(A)). The low vibrating characteristics of the no-contact air bearing eliminates the need for heavy foundations and complicated structural separation designs that are sometimes required for large, centrifugal and positive displacement blowers. Turbo blowers are competitively priced on a first cost (capital) basis when compared to traditional aeration blower technology. When life cycle costs are included and a present worth analysis performed, turbo blowers further distance themselves from traditional technology and typically offer cost advantages that can vary between 10 and 50 percent.

The turbo blower product promotes environmental sustainability, not only due to energy efficiency, but also through reduced footprint and installation costs. The turbo blower’s space footprint is approximately 30 percent smaller when compared to other blower technologies with similar flow rates. Finally, operating costs are further reduced thanks to the low maintenance characteristics of the blower, which is limited to the periodic need to clean or change the inlet air filter.

Today, the turbo blower technology is welcomed and accepted in the wastewater market. The Monroe County, NY Frank E. VanLare WWTP, the Williamsport, PA WWTP, and the Erie, PA WWTP, are some examples of wastewater treatment plants in New York and its neighboring state making the switch to turbo blowers for aeration needs because of significantly compelling financial and environmental reasons. The blowers allow WWTPs to be more environmentally sustainable, energy efficient, low maintenance and cost effective, giving these facilities an advantage in the challenge to continue reducing expenses in providing service.

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References
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