CTO

This month in Chief Technology Officer:

MARKET MAP

The winds of change in aeration

The municipal wastewater sector is crying out for solutions to reduce its energy bill. Why haven't high efficiency blowers for aeration become the norm?

Amid the perennial conversation within the water industry about energy costs and how to reduce them, blowers for wastewater aeration are ready to play their part. Aeration is far and away the largest consumer of energy in municipal wastewater treatment plants (WWTPs), and blowers often provide the air supply that bacteria require to metabolise compounds in the wastewater.

The issue is plain. According to the US Department of Energy, American municipal wastewater plants consume 30 terawatt hours of electricity per year, equating to $2 billion in annual electricity costs. Electricity can make up as much as 40% of a WWTP's annual operating budget. As water quality discharge standards continue to tighten, the increased aeration required means energy needs are likely only to increase.

Blowers should have an integral role to play. Within this industry there has been a more intense focus on energy efficiency, and over the last ten to 15 years, new technologies have come to the US market. However, these technologies, with promises of higher efficiency, still command relatively little market share. As energy efficiency becomes more paramount and the new types of blowers have better proof of reliability, traditional technologies are now facing stiffer competition.

Other methods to optimise aeration have been covered before in CTO (*see GWI April 2018, p44*). This Market Map will look at aeration blowers, with a focus on the US market, due to its wide installed base of WWTPs, many of which are ageing and will require upgrading going forward.

Technology landscape

Due to the breadth of different technologies now present in the blower marketplace, the vernacular of the blower market can be difficult to navigate (a terminology is provided with this article). While the market generally divides into positive displacement (PD) blowers versus centrifugal kinds, there can be some confusion how to classify non-contact bearing-type blowers, which have shaken up the US market over the last decade or so. "They are all centrifugal-type turbo machines, but no one is really calling them centrifugal type machines," explained Black & Veatch's Julie Gass. "They're calling them turbo blowers, or high-speed turbo blowers. Integrally geared centrifugal machines are also turbos but are not called turbos." ▶

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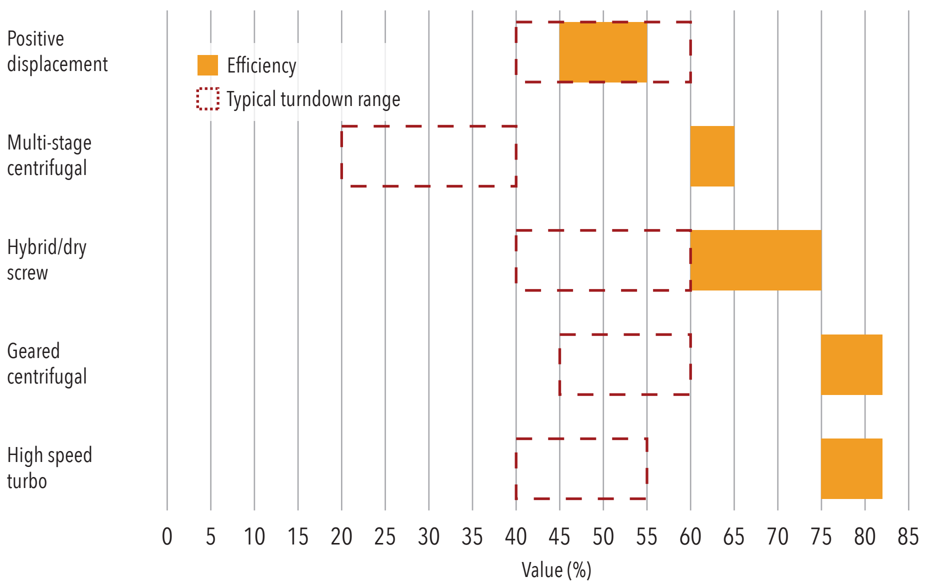
>
> Tom Jenkins, Jentech

HOW DIFFERENT BLOWERS PERFORM

The geared centrifugal and high speed turbo blowers offer the highest efficiency, with dry screw following close behind. It is thought that a value of 50% turndown is the minimum the market now wants to see.



Source: WEF; Simon

Centrifugal blowers divide into two main categories: conventional low speed such as single-stage and multi-stage and the newer high-speed turbo (HST) blowers, driven by purpose-built high-speed motors operating between 20,000 and 60,000 rpm. Conventional low speed PD and centrifugal blowers make up the lion's share of the municipal wastewater blowers market, with their low capital cost and ability to operate in dirty environments. Historically, smaller treatment plants which require large turndown, varying discharge head and frequent start-stop service have leaned towards the PD blowers while larger plants selected multistage or single-stage centrifugal blowers.

Since the turn of the decade, higher efficiency blowers such as HSTs – which use air or magnetic bearings – as well as integrally geared single-stage have emerged on the scene. Interest in HST blowers in the US market was high, especially for plants consuming millions of dollars of electricity per year.

They sounded appealing because much of the mechanical maintenance associated with PD and other centrifugal blowers was not required; for example, they did not need lubrication or couplings alignment. However, rather than being the perfect solution for every application, the HST blowers had different maintenance needs, namely electrical, which posed an issue. "That often requires maintenance capabilities that the plants do not have – they don't have anyone on staff that can handle that," Gass remarked. "In addition, the environment needs to be very clean."

While higher efficiency was promised, the market – including both the end-users and vendors – did not fully understand what HST blowers could do in the wastewater treatment space. "There were some growing pains, poor applications and mechanical issues, and it took a few years for the market to sort out the proper applications for those blowers," commented Tom Jenkins, principal at JenTech, a consultancy. HSTs have tended to be used in larger municipal plants – which often operate 24/7 at full capacity – because of their more limited turndown abilities (*see chart, previous page*) compared to other technologies, and the air bearings provide a limitation on the number of starts/stops.

Finding a middle ground

Inevitably, as the hype around the HSTs died down, a middle ground has been sought. HST blowers did not seem a good fit for smaller plants, so another type of blower began to find its feet in the market. The integrally geared centrifugal blower takes the efficiencies of the HSTs but using more standardised parts, therefore bringing the capital cost and electrical maintenance concerns down. Inovair, the industrial products division of Accessible ▶

THE FAMILIAR FIVE

The blowers market is comprised of five major technologies. They will all continue to have their place in the market, but it is expected that rotary lobe and multistage centrifugal will lose some market share to the integrally geared and high speed turbo products, as well as dry screw, which is the newest machine in the US market.

Blower type	Description	Pros	Cons	Typical plant size applied on
Positive displacement – rotary lobe	Usually two or three lobes to compress a given volume of air per revolution	-Low capital costs and easy to maintain -Can work in dirty environments	-Low efficiency -Significant low frequency noise and pulsations which are difficult to attenuate	Very small to medium
Positive displacement - screw	Newer technology that has a twisted lobe similar to screw compressors but no oil in the compression chamber. Has some internal compression unlike rotary lobe	-Higher efficiency compared to rotary lobe -Reduced pulsations and noise compared to rotary lobe	-Not very well proven for wastewater aeration -Packaging differs from one vendor to another so hard to structure a competitive bid	Small to medium
Multistage centrifugal	Air passes through up to ten stages, with individual impellers per stage, until discharge pressure is achieved by the last stage	-Mid-range capital costs -Standard maintenance can often be handled by plant staff	-Low efficiency at small sizes -Large footprint	Medium to large
Single-stage centrifugal – integrally geared	Single impeller for air compression and uses an integral gear box to increase speed of impeller beyond that of the motor. Uses guide vanes or VFDs to vary output volume and pressure	-Off-the shelf parts but offers high efficiency -Some maintenance tasks can often be handled by plant staff	-Typically higher capital cost than PD or multistage centrifugal	Small to large
Single-stage centrifugal – high speed turbo	Uses either air or magnetic bearings and impeller is directly attached to the motor drive shaft. Output is varied by VFDs. Also known as a gear-less turbo.	-High efficiency -Minimal mechanical maintenance	-Requires more specialised electrical maintenance -Higher capital costs due to specialised equipment - Air bearings less suitable for dirty environments	Medium to large

Source: GWI

Technologies, Inc., identified a gap in the market and was ready to launch its geared centrifugal blower for the municipal wastewater market in 2012. Integrally geared products typically carried too high a capital cost for smaller plants.

"We started developing a blower specifically for the smaller size wastewater treatment plants because that's where we really saw that the end-user wasn't able to utilise a turbo blower; they were too expensive and the utilities didn't have a staff that could maintain them," Inovair head of sales Patrick Gedgaudas told GWI.

Other companies have noticed growing client appreciation for the integrally geared centrifugal blower. Howden – which probably has the widest installed base of blowers for wastewater in the US - acquired expertise in the technology after the purchase of businesses from Siemens in 2017, which brought the Turblex brand in the United States and the HV-Turbo brand in Europe into its portfolio. Lone Star is another US-based player, while Italian firm Next Turbo is also trying to break into the US market.

Gedgaudas is also bullish about Inovair's prospects now that it has been in the market for over five years, telling GWI that its business has accelerated over the last two years. Going directly to operators of smaller plants proved valuable to educate the market about its product, and Inovair has secured success replacing older multi-stage centrifugal or PD blowers.

"Once clients saw the potential energy savings they said, 'we like the idea of the reliability and we need this in our facility'," said Gedgaudas. "They told us they like the energy efficiency that turbos are showing them, but they can't maintain them."

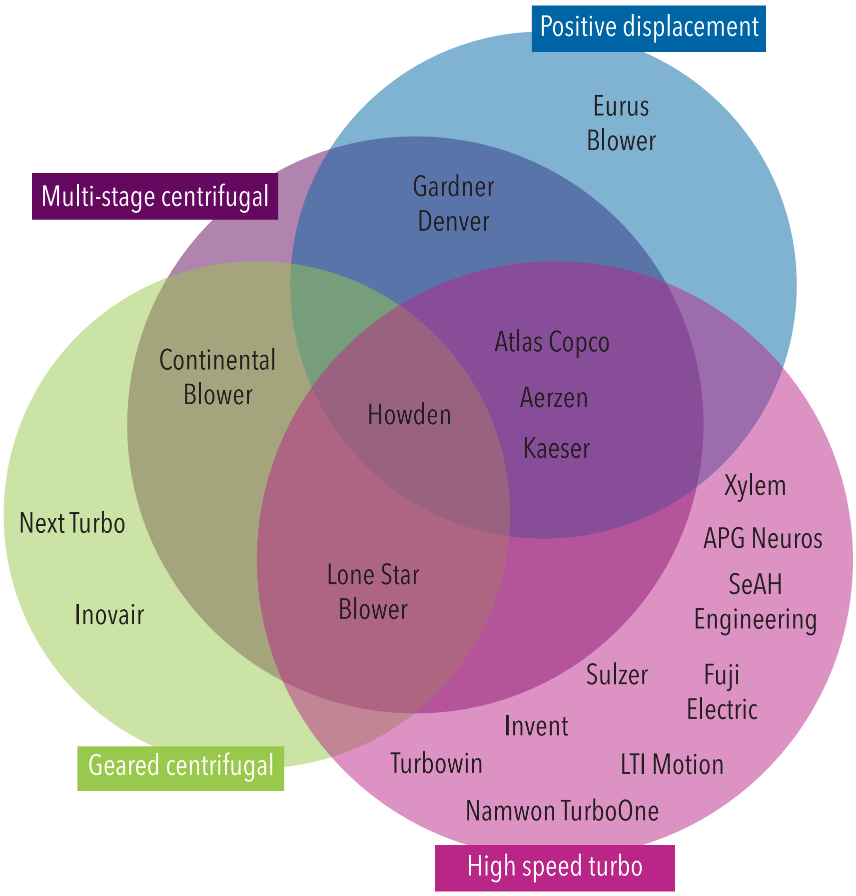
Who else is doing what?

As "turbo blowers" – both high-speed and integrally geared – start to gain momentum in the US, there has been some movement in the market dynamics. In July 2019 Kaeser Compressors bought PillAerator GmbH, adding turbo blowers (which use magnetic bearings) to its existing line of rotary lobe and rotary screw blowers.

APG Neuros meanwhile has recently received significant financial help (investments and loans) from the Canadian and Quebec governments to increase its share of the market. At the recent Weftec conference in Chicago, the firm advertised a gas turbine blower, which would offer energy independence to a treatment plant, significantly reducing its electricity costs. APG Neuros will also take advantage of its financial windfall to develop blowers with higher horsepower, in order to target larger plants.

A BUSY PICTURE

A number of companies such as Howden and Kaeser have looked to expand their portfolios into turbo blowers recently as market acceptance of those products grows. Several Korean companies with high speed turbo products have also tried to enter the US market.



Source: GWI

> A question I've been asked is 'which is more efficient, an integrally geared single stage [blower], or a gear-less turbo?' I don't think we've really had a good side-by-side comparison of that yet.
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> Julie Gass, Black & Veatch

Meanwhile, Howden plans to launch its high-speed turbo blower product into the US market next year, and is also looking at dry screw blowers, building on its existing expertise in dry screw compressors. These emerged in the US market soon after the HSTs, mainly pushed by manufacturers of PD blowers, including Atlas Copco, an early innovator in dry screw machines. Unlike positive displacement, dry screw blowers have some internal compression, giving an efficiency advantage.

Energy efficiency comes to the fore

Blowers' energy efficiency has always been a concern but as electricity prices rise and awareness of climate change impacts become more widespread, it is becoming more so. When a full lifecycle analysis is performed, high efficiency blowers often offer a 2-3 year payback on incremental capital price. Blowers are being subjected to more comprehensive tests beyond just looking at efficiency at a design point. The variations in wastewater flows are being taken more into account. ▸

"It's becoming more and more common to do a weighted energy evaluation that covers a spectrum of flows and operating conditions," Jenkins told GWI.

Another recent development welcomed by the industry is the new ASME PTC 13 testing code, which has been published this October. Previous testing codes PTC 10 for centrifugal machines and PTC 9 for positive displacement blowers were based on measuring power at the blower shaft, which does not capture the total power consumption of the newer technologies.

Gass explains: "Energy was measured as the power into the blower shaft. These new machines are close coupled, which means the impeller is connected to an extended motor shaft, so there's not really a way to measure shaft power. In addition, there are so many other ancillary losses."

HST blowers have customised motors and special VFDs, both of which usually suffer from energy loss, and these are not accounted for in the previous test codes. PTC 13 will have a wire power measurement, which includes all the ancillary devices on a blower, measuring total package energy consumption.

Another issue that the PTC 13 code rectifies is that different types of blowers could not be compared simply – the revised code enables both centrifugal and PD blowers to be assessed on a more "apples to apples" basis. It should bring some interesting findings. "A question I've been asked is 'which is more efficient, an integrally geared single stage, or a gearless turbo?' I don't think we've really had a good side-by-side comparison of that yet; in addition, it depends on the requirements of each plant," said Gass.

Moving on from just flow and pressure

An interesting dynamic is being thrown up as more is asked of blower manufacturers in terms of aeration process control. They have little to no control over aeration basin or diffuser system design, but Jenkins suggested to GWI that optimising the process performance is becoming just as big a factor as blower performance.

"I think the owners and the consulting engineers, rightly or wrongly, are looking to the blower suppliers to be that pivot point between the blower room end of the pipe and the business end of the pipe in the aeration basins," he said.

Controls for the blower have been packaged with the blower itself over the last twenty to thirty years but taking more responsibility when it comes to the actual treatment process is a step up. Nevertheless, more is expected from the suppliers. "As process control technology advanced the specifications were broadened to include process as well as blower controls," continued Jenkins. "Blower suppliers are accepting the need to provide these because that is how the specifications are written. They have been burnt by outside suppliers, and many are developing in-house control and process expertise."

It appears to make more sense that companies with expertise in aeration basin or diffuser system design would provide aeration controls, and this is developing slowly. Aeration specialists such as Environmental Dynamics International and SSI provide advanced aeration controls as well as blower packages.

As the Internet of Things (IoT) continues to permeate the water industry, the blower manufacturers have taken note. As it becomes harder to differentiate on technology alone, suppliers are stressing their controls and systems capabilities. Howden, for example, is heavily pushing its 'Uptime'

IoT product, working with Microsoft to produce more analytics for the customer and increasing its capabilities in prediction. Customers certainly want to put suppliers through their paces in terms of service.

How could the market develop?

Going forward, there will likely be space in the market for all blower types, although greater market acceptance and increased reliability of HSTs and integrally geared centrifugal blowers mean they are well poised to win greenfield projects as well as target a huge existing base of PD and multi-stage centrifugal installations.

Some have predicted how the HST blower market will play out between the air bearing technologies and their magnetic bearing counterparts. "The mag bearings on certain larger plant sizes are taking over," said Jenkins. "I think the air bearings will persist in the smaller plants, and I think that's the portion of the market that's vulnerable to incursion by the screw blowers."

As different configurations of biological treatment – such as sequencing batch reactors or integrated fixed-film activated sludge (IFAS) – emerge as retrofit options for conventional activated sludge, it will be important that blowers can handle on/off applications. For smaller plants and those with regular start-stop requirements, integrally geared centrifugal blowers may be preferred. What is certain is that blowers can become much more of an important part of the energy conversation as the demand for energy efficient products grows. ■

Terminology

Airflow rate: a key parameter when specifying blowers, the air flow rate – measured as mass rather than volume - is typically measured in standard cubic feet per minute.

Guide vanes: used on certain integrally-geared single-stage centrifugal blowers to control capacity (airflow rate) and pressure. Can be inlet, discharge, or both.

Non-contact bearing: refers to any bearing where the shaft and bearing surface do not make contact during operation. The three main types are air, magnetic or oil-flooded bearings, designed to support the high-speed rotation of turbo blowers. Non-contact bearings suspend a rotating blower shaft without the friction that may result from using conventional bearings.

Operating envelope: the capacity and pressure range of a blower that it can safely operate in.

Surge: the point where a centrifugal blower cannot generate sufficient discharge pressure to meet operating pressure, causing a reversal of air backwards through the blower. This results in an unstable operating condition, often high vibration, and can be damaging if the protection controls do not trip the blower off. Surge limits the turndown capability of a centrifugal blower.

Turndown: the amount that the blower's capacity or airflow rate can be reduced to meet demand, with regard to the maximum and minimum flow rates of the blower.

Variable frequency drive (VFD): typically applied to some centrifugal blowers and positive displacement blowers to control blower speed, resulting in air flow and pressure control as well.

FROM THE CHIEF TECHNOLOGY OFFICER

Blowers the best place to start for energy

Charlie Walker argues why delving into aeration blowers was timely, and why CTO will look to cover more equipment markets in future.

The perennial debate around energy demand in the water sector often leads to talk around how utilities can achieve energy neutrality (or even positivity). While this is achievable for some – and is already being demonstrated – it is typically a significant step-change for many others, requiring extra technology and expertise. Reducing energy demand related to aeration in a wastewater treatment plant is a good point of departure, given that it can account for over 50% of a plant's energy costs. Municipal wastewater treatment plants account for about 1% of the USA's electricity consumption.

Examining the market for blowers in this month's CTO has proved timely; as energy concerns grow, one would think that demand for the highest efficiency blowers available would be robust. This has not necessarily been the case over the last ten years. When new turbo blowers entered the US market over a decade ago, they seemed all the rage. However, as issues around maintenance and their use in unsuitable applications came to light, uptake of turbo blowers was stymied.

This is now changing. The turbo blowers have ironed out these issues and proven themselves over the last few years, while a newly introduced testing regime will enable better performance comparisons of different blower technologies (for example, comparing a positive displacement with a centrifugal blower). This in turn will enable easier decisions on choosing the best blower for the job.

Covering blowers has meant delving into an equipment market. Articles in CTO have not tackled many equipment markets in the past, focusing more on processes (e.g. brine concentration) or issues that technology can contribute to solving (e.g. treatment of PFAS). This has mainly been driven by the fact that the water treatment process has been the prime target of innovation while there is less focus on new technologies in fluid handling equipment.

However, the impact of digital solutions on equipment markets is substantial, and as we embark on our more granular technology forecasts for GWI WaterData, it is increasingly apparent that the dynamics of these markets are changing. Therefore, we plan to cover more equipment markets in future editions of CTO. One suspects that the internet of pumps (*see GWI January 2019, p44*) is only the beginning of what could be achieved. ■