White Paper

ROBUSCHI

# Comparing Turndown & Long-Term Energy Consumption

Waste Water Aeration Blowers

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# Introduction

Engineers can make well-informed decisions about a project when they have sufficient data and personal experience to draw from, but no amount of useful information will ever enable anyone to accurately predict the future.

As a specific case in point, consider the unavoidable downside risks of trying to determine the 20-year life cycle of a new aeration blower in a waste water treatment plant (WWTP), based on expected growth and original plant capacity. To give that forecasting challenge another perspective, think about the technology that was available 20 years ago and how dramatically things have changed since then.

Unfortunately, that type of long-range crystal-ball prediction is exactly the problem which many consulting engineers are tasked with when they want to compare and evaluate blower technology for treatment facilities.

The parameters for those 20-year forecasts are typically based on anticipated oxygenation needs as calculated on Day One of plant operation, using viable and accurate data that's available at the time. Those numbers are then correlated to address the assumed eventual demands and a projected worst-case load for the treatment facility. The conclusions must be good enough to satisfy budget committees and permitting agencies, as well as energy providers and other stakeholders who are also working with the same information.

Since most designs optimistically include a supposition for increased loading due to population growth in the plant's service area, a great many blowers are significantly oversized from the outset. It also usually means that for much of its early life, the treatment facility may be operating at loads well below the design-specified average daily flow (ADF).

Although waste water aeration levels required in the healthiest state are three to five milligrams of oxygen per pound of air, it's not uncommon on Day One to get 10 to 20 milligrams if the blower can't be turned down.

The process demand for air is constantly fluctuating, so having an easy way to reduce the air flow rate to match lower demand is a logical and welcome response. When the blower can't be modulated down, it's inevitably going to be pushing excess air into the waste water. Delivering that unnecessary aeration not only increases the operator's energy costs, it creates additional ammonia and nitrogen in the waste water, thereby also incurring the subsequent threat of thousands of dollars of EPA fines.

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# The Importance of Turndown

Aeration generally accounts for 50 to 60% of the energy consumed in a WWTP. Some estimates say the number may be as high as 70%. Optimizing the efficiency of blower performance is therefore essential for controlling energy costs, but that step requires a blower system with sufficient turndown.

Turndown – also sometimes called rangeability – is simply a ratio of the high end of a blower's operating range compared to its low end, often expressed as a percentage. Operators need turndown to maintain process performance. The higher the turndown, the more flexibility the operator has. A 55% turndown is necessary for an effective control system.

A higher turndown capability means the system will be better equipped to meet the lowest air requirements without wasting energy. Greater turndown also provides more operational flexibility and enables the blower system to effectively satisfy the air requirements with fewer machines.

There are many factors to be considered when calculating how much turndown a plant should have. Blower turndown is generally more important than efficiency in optimizing energy use over the life of a WWTP. Careful selection of equipment is required to achieve the right balance of energy efficiency and sufficient flexibility to meet load variability and the ever-changing process air demands. Too much or too little air reduces solids from segregating.

# Choosing a Blower

Blower efficiency is a top priority during the design of a WWTP and the specifications of its aeration equipment. However, baseline energy efficiency may not be (and probably should not be) the most important consideration in assessing long-term operating costs of the blowers. In other words, the blower with the highest-rated efficiency will not automatically provide the lowest overall energy consumption for mixing, oxygenation, sludge recirculation, and final filtering processes.

If the choice of an aeration blower were simply based on its rated energy efficiency or the initial capital expenditure for the equipment -- without factoring many other key variables and operating conditions—selecting the most desirable aeration blower would be much easier to do.

Turndown capability is usually more important than energy efficiency when the facility's goal is to minimize power costs. As noted above, the inability to reduce air flow during times of lower demand is counterproductive. Even at high efficiency rates, blowing unnecessary air is still a waste of energy.

Technological advancements in aeration blowers are giving engineers many exciting new options for reducing energy consumption in waste water applications. On the other hand, a great deal of confusion exists in the marketplace as a result of conflicting manufacturers' claims, new regulatory pressures, and the inherent complexity of the many process variables themselves.

To complicate matters, consulting engineers around the world are discovering that some long-held beliefs aren't always reliable anymore. In today's environment, increasing ROI and lowering the overall cost of ownership of an aeration system can require a new approach.

For example, when high-speed turbo blowers originally arrived on the market several years ago, they were marketed as new innovation in the waste water treatment industry. Consulting engineers at that time were eagerly looking for energy-saving technologies. With the turbo's substantiated claims of big reductions in energy usage plus promises of less required maintenance, the new blowers had people wanting to know more.

Engineers who adopted the early turbo blowers were understandably impressed with their performance. As time has shown, though, the anticipated cost savings of the higher-efficiency turbos have not all been realized as hoped. Some of that discontent can be traced to the question of turndown and the turbo blowers' inability to adequately compensate for load fluctuations and other variables.

When operating near its "sweet spot" (i.e., the ideal pressure and flow specified by the engineer), the turbo definitely raised the bar. But the blower does not always operate at those points. Performance at a constant speed is only hypothetical. Turbo technology can be very energy-efficient and cost-effective in process applications that have narrow swings in turndown or minor variations in discharge pressure. Once there's a fluctuation in demand, the turbo blower is no longer in its sweet spot, and therefore not as efficient.

The performance of a turbo blower is also affected by the environment and site conditions at the facility. Factors such as seasonal temperature swings and changes in air density or barometric pressure will inhibit the unit's efficiency. When faced with those climatic fluctuations, the turbo has to adjust its speed, which causes the blower to operate far from its best performance level to be able to supply the correct amount of process air.

Those scenarios are among the reasons why a turbo blower operates in conjunction with a variable frequency drive (VFD) AC-to-DC convertor. The turbo's high-speed permanent magnet DC motor is factory-tuned by accurately machining turbine impellor and housing clearances to optimize design flow and pressure. But variable speeds are needed to allow for big temperature extremes and resulting differences in air density. For instance, at 100 degrees Fahrenheit in the summer, air density is going to be much lower than at 20 degrees in the winter when density is naturally higher. Turbo working point is affected by the pressure fluctuation. A WWTP operator has to be able to adjust the flow or run the risk of over-oxygenation.

# Advantages of a Screw Blower

Turbo blowers were introduced at the right time to address a number of industry needs, but over the years some drawbacks were exposed in many applications.

Now WWTP engineers are taking notice of a more recent -- and evidently more promising – innovation for aeration processes: low-pressure rotary screw blowers. The unique design and specialized capabilities of the new screw units create exciting economic opportunities, and various applications around the world are confirming very impressive results.

At first look, though, a screw blower may not seem as appealing as a turbo, because at its design point, a turbo is more efficient than a screw. But there's the catch – how often is a blower actually running at its design point? When efficient energy consumption and ROI are important criteria, a longer-term analysis of competing technologies must be considered. A significant part of that evaluation is turndown ability, and that's where screw blowers have an advantage.

Studies of various screw blower applications in treatment plants around the world have consistently reported annual energy savings of about 30%. One municipal facility in Sweden achieved a 46% reduction in energy costs.

A screw blower is a volumetric machine, while turbos and centrifugal blowers are dynamic. Because a screw blower is volumetric, that means it simply moves the air. It is not a kinetic-energy or dynamic machine, so it does not have to convert different type of energies. A plant's variable working pressure is easy to handle with volumetric screw technology.

The fact that a turbo blower functions kinetically is yet another facet of its higher levels of energy consumption, because energy is wasted when there's not enough speed in the blower and it creates a surge. The screw's efficiency is proportional to its speed.

In addition, the belt drive of a screw blower ensures the right capacity for the application. It allows the installation of the motor that's most suitable for the power absorbed by the compressor, and therefore enables operation at peak efficiency.

Other reasons to consider screw blowers are their less complex design, ease of maintenance, and quieter operation. Screw blowers are also better suited for intermittent use with frequent stops and restarts, which can further promote efficiency in certain process situations.

# A Better Way of Thinking

For many consulting engineers, rotary screw blowers represent an entirely new mindset – which is often the case with bold innovations. Nonetheless, careful evaluation of the respective pros and cons can support arguments in favor of screw machines over turbos, especially in the area of turndown capability.

In terms of changing traditional thinking, it's worth noting that one well-known engineering firm in the Northeast recently announced they were no longer specifying turbo blowers on sequential batch reactors (SBRs). SBRs are among the most popular processes in waste water treatment, but batch reactors require wide turndown because the height of the train changes so frequently. Lower liquid levels in the basin naturally have less pressure and demand less flow; failure to subsequently reduce oxygen input is highly inefficient.

Because of the superior energy efficiency of screw blowers, grant money and other funds are often made available through city, county, and state environmental programs, as well as from some federal government agencies and non-profit support groups. When such funding is provided, it makes the choice of a screw blower even easier to make.

When evaluating the purchase and applicability of a screw blower, an excellent starting point is to consult manufacturers' marketing cutsheets and other comparative literature. When properly prepared, that material will provide essential information about a unit's design, dimensions, specific turndown capabilities, energy consumption, performance data, and much more.

In summary, the low-pressure screw blower offers unsurpassed turndown capability to accommodate inevitable changes in flow at waste water treatment facilities, resulting in significantly lower energy consumption and related cost savings for the operators.

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