

Positive displacement blower vs. turbocompressor

Saving aeration costs

After comparing the aeration performance of existing positive displacement blowers with the aeration performance of an ABS turbocompressor HST, the Spanish wastewater treatment company FACSA achieved significant reductions in energy and maintenance costs with the turbocompressor.

ABS, a product brand within Sulzer Pumps, is synonymous with innovation and well-proven solutions for wastewater collection and treatment. The company's competence in wastewater handling has developed over more than 100 years. Today, the company offers one of the most complete wastewater technology portfolios in the world, and its products and solutions

help solve the challenges in municipal, industrial, commercial, and domestic sectors across the world every day.

An important ABS strategy is to provide the wastewater industry with solutions that reduce both energy consumption and carbon footprint and increase both equipment efficiency and reliability. To achieve these goals, a number of world firsts in technology

have been launched. It is known as the ABS EffeX revolution. The first step of this revolution started in 2009 with the launch of the ABS EffeX range of submersible sewage pumps XFP with built-in IE3 premium-efficiency motors. Six models in this range provide motors spanning from 1.3 to 350 kW.

In 2010, the medium-speed ABS submersible mixer XRW with an IE3 perma-

The picture shows Castellón de la Plana and the Desert de les Palmes Mountains from the air.



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nent magnetic motor followed. It gave users a total efficiency improvement of up to 35% compared with other existing medium-speed mixer designs. Later this year, ABS will be introducing two additional world firsts for saving energy and improving operational processes in wastewater treatment plants (WWTPs).

Outstanding HST turbocompressors

A further range of innovative ABS products with proven energy savings, reduced carbon emissions, and lower maintenance cost is the ABS turbocompressor HST series. These turbocompressors are used to powerfully aerate wastewater during the treatment processes. Lower life-cycle costs and easy operation are achieved through:

- Magnetic bearings—minimal energy loss and no mechanical wear
- Integrated design—compressor, motor, frequency converter, and control cabinet built in; an easy-to-install package
- Small footprint—smaller compressor room, lower building cost
- Low installation cost—no external starters or controls required. No crane or special foundation needed
- System modularity—permits parallel operation of numerous compressors allowing tailor-made installations
- Compatibility—can operate in parallel with all types of compressors, which facilitates flexible refurbishment

The ABS turbocompressor HST can be configured in groups to suit the aeration

requirements. The ABS Master Control Unit optimizes the compressor operation to match the desired output and controls the group of machines just as one would control a single unit. This optimizes the operation of the whole group in terms of output as well as energy consumption. The performance of four ABS turbocompressor HST models is presented in Figure 1.

Aeration devours energy

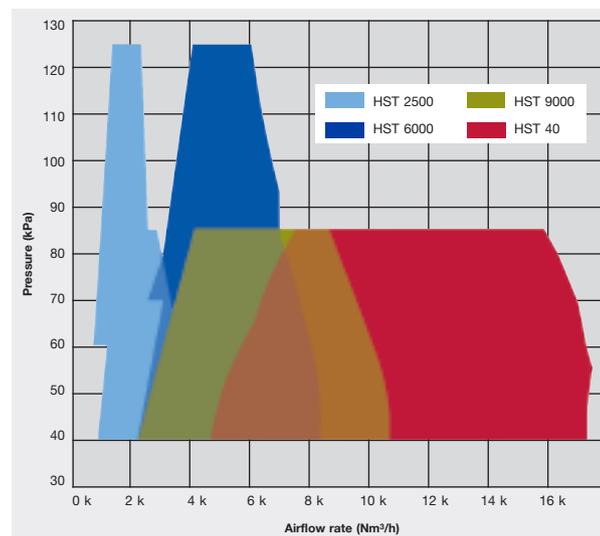
The biggest single cost of running a WWTP is the cost of energy used for running motors. This expense is estimated at between 15 and 30% of the total operational budget. If the energy costs are broken down, 43% derive from aeration equipment, 33% from pretreatment steps, and 24% from dewatering sludge treatment.

Because aeration is the biggest energy consumer, the Spanish WWTP company FACSA decided to compare the performance of its existing positive displacement blowers for aeration with a high-speed ABS turbocompressor HST 6000 to see if a significant saving in energy costs could be achieved with the latter.

Aeration at the WWTP

The study presented in this article, was performed at the WWTP of Castellón de la Plana, a city in the Levante region of Spain 2.

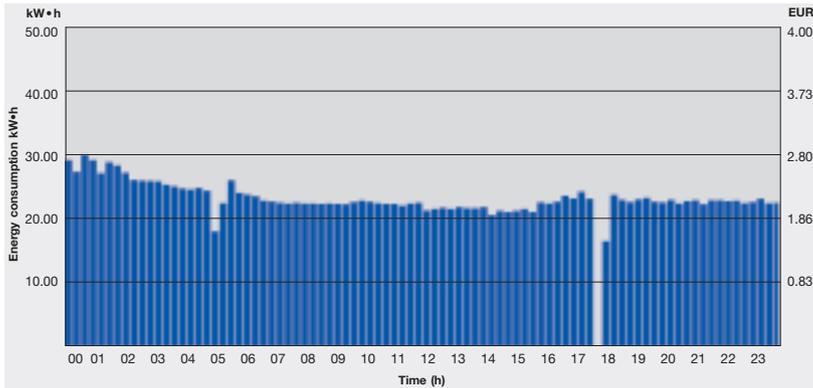
The treatment plant is designed for treating up to 45000 m³ wastewater/day and has a total power capacity of



1 Graph of pressure (kPa) versus airflow rate (Nm³/h) for four ABS turbocompressor HST models.

2 FACSA's wastewater treatment plant in Castellón de la Plana, Levante region, Spain.





3 Energy consumption of the ABS turbocompressor HST 6000.

1370 kW. The plant, built in 1980, has two lines of biological treatment with volumes of 4428 m³ and 5125 m³ respectively. Air is supplied through fine bubble diffusers by means of 4 positive displacement blowers: two blowers for each line. The power of all blowers is 160 kW, with a nominal flow of 11 238 m³/h for line 1, and 7326 m³/h for line 2 at standard conditions.

For this study comparing normal rotating positive-displacement (Roots-type) blowers to high-speed turbocompressors with magnetic-levitation technology, a turbocompressor with a similar capacity to the existing blowers had to

be used. The operating specifications and conditions of the selected ABS turbocompressor HST 6000 are the following:

- Design airflow: between 2475 m³/h and 7462 m³/h at standard conditions
- Altitude of treatment plant: 0 m (sea level)
- Ambient air temperature: between 0 °C and 35 °C
- Relative humidity conditions: 50 % to 80 %
- Pressure increase: 53 kPa (inlet pressure: 101 325 Pa; outlet pressure: 154 325 Pa)

The airflow is regulated by a built-in frequency drive that can vary speed and

torque to accurately and precisely control the air volume and pressure. It is this that provides significant energy saving at lower speeds.

Energy consumption analysis

To allow correct comparison of both aeration technologies, one treatment line was operated with alternating use of the positive displacement (Roots-type) blower and the magnetic-levitation turbocompressor, after which the ratio kWh/kg BOD₅ eliminated was compared.

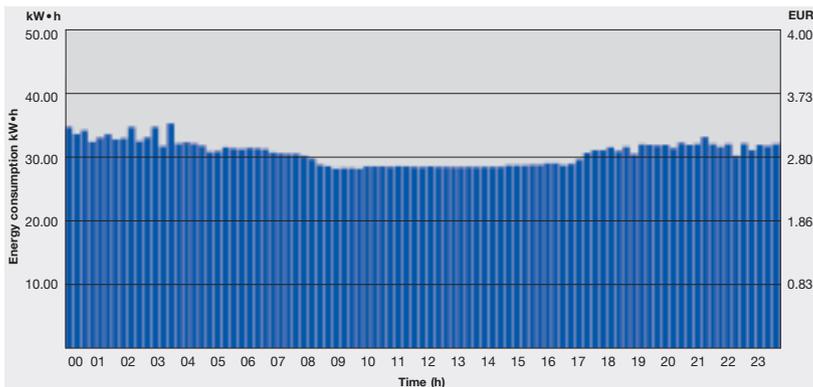
The biochemical oxygen demand or BOD is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. The same concentration of mixed-liquor suspended sludge (MLSS) was used in both cases to facilitate normalizing the results of one technology with those of the other. The energy consumption of both systems was compared using an analyzer that had been set up to measure the equipment operating data every 15 minutes.

Analysis of maintenance costs

The analysis of maintenance costs of both technologies was carried out theoretically by comparing the preventive maintenance tasks of both systems. The existing positive displacement blowers have a complete log of performed maintenance. However, such logs do not exist for the ABS turbocompressor HST as it had only recently been installed in the treatment plant (summer 2009).

Nevertheless, it should be stressed that since the start-up of the compressor in September 2009, no repair interventions have been made. Also, an important number of references exist of plants where the compressors have been

4 Energy consumption of the positive displacement blower.

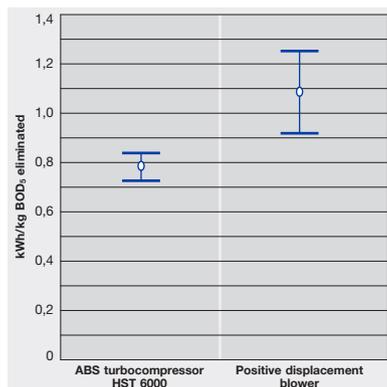


running numerous years without suffering damage or problems.

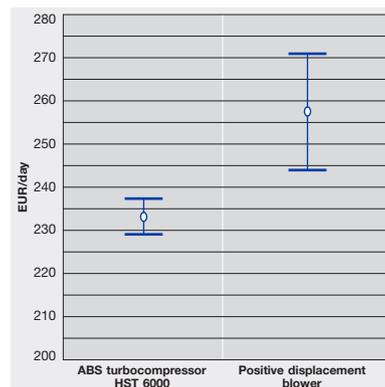
Energy consumption

Figures 3 and 4 show results obtained during two days where system conditions were practically identical. As can be seen, the energy consumption of the positive displacement blower is higher than that of the ABS turbocompressor HST. In figures 5 and 6, the energy consumption and characteristics of both technologies are presented. The EUR/day calculation was done applying an energy cost of 0.098 EUR/kWh.

Significant results were obtained when comparing the ratio kWh/kg BOD₅ eliminated and the ratio EUR/day. Figure 7, the analysis of variance (ANOVA) results, shows that the average value of kWh/kg BOD₅ eliminated using the ABS turbocompressor HST (0.86 kWh/kg BOD₅ eliminated) is much lower than the average value when using the positive displacement blower (1.23 kWh/kg BOD₅ eliminated). The energy consumption is lower by 0.37 kWh/kg BOD₅ eliminated for the ABS turbocompressor HST. Figure 8 of ANOVA results shows that the mean EUR/day for the positive displacement



7 ANOVA results for kWh/BOD₅ eliminated for the ABS turbocompressor HST 6000 and the positive displacement pump.



8 ANOVA results of EUR/day for the ABS turbocompressor HST 6000 turbocompressor and the positive displacement pump.

blower (EUR 258/day) is higher than the cost for the ABS turbocompressor (EUR 233/day).

Maintenance costs

Given the functioning principle of the ABS turbocompressor HST, the need for preventive and corrective maintenance of its mechanical parts is very low under the correct operating conditions. Considering the maintenance activities listed in system maintenance manuals, the theoretical maintenance costs for a period of five years for a worst-case scenario for a positive displacement blower are about EUR 19318 in 5 years.

Displacement blowers require exhaustive control of the bearings lubricating oil and moving parts in general. To

estimate the maintenance cost of the blower, an approximation was made including the material cost of the maintenance performed over the years and the maintenance personnel costs. A renovation, which costs about EUR 8150, has to be performed on the premises of the supplier when 20000 operating hours has been reached (approximately 2.5 operating years). Therefore, total maintenance costs for the positive displacement blower are about EUR 27468.

Additionally, it should be mentioned that cranes are required to move a positive displacement blower but only a normal forklift truck is needed to lift an ABS turbocompressor HST.

The ABS turbocompressor HST saves energy

On analyzing the data obtained in this study, it can be concluded that the operating costs of an ABS turbocompressor HST are lower than those of a conventional positive displacement blower. The higher energy efficiency results of the turbocompressor derive from the higher optimal operating range of the system, which means that small changes in pressure do not increase energy consumption as is the case for a normal displacement blower. Magnetic bearing technology avoids the use of conventional bearings and the operation of moving

5 Characteristics of the positive displacement blower.

Positive displacement blower				
Variable	Mean	Minimum	Maximum	Standard deviation
kWh/kg BOD ₅	1.1	0.63	1.57	0.306
EUR/day	258.08	210.14	298.08	24.183

6 Characteristics of the ABS turbocompressor HST 6000.

ABS turbocompressor HST 6000				
Variable	Mean	Minimum	Maximum	Standard deviation
kWh/kg BOD ₅	0.78	0.43	1.47	0.193
EUR/day	233.60	187.01	290.59	24.067

parts—such as the belt transmission system in a conventional positive displacement blower—to save significant energy.

After several months of running both existing blowers and ABS's magnetic-levitation turbocompressor, FACSA concluded that with the magnetic-levitation technology, between 20 and 30% energy savings had been obtained. The ratio of power intake divided by the kilograms of biological oxygen demand BOD₅, went down from 1.23 kW/kg BOD₅ eliminated to 0.86 kW/kg BOD₅ eliminated. This means energy savings of EUR 25146 per year, taking into account a cost of 0.098 EUR/kWh. Additionally, comparing the maintenance cost of 27468 EUR/5 years for the positive displacement blower with the preventive and corrective maintenance cost of 15771 EUR/5 years for the ABS turbocompressor HST, EUR 11697 is saved using the latter.

Satisfied participants

All participants in the comparative study described above are very satisfied with the results. David Castell, Manager of the WWTP operated by FACSA in Castellón, gives his views.

"I'm very satisfied with the operation of the ABS turbocompressor HST 6000 , which achieves scientifically proven energy savings of 20–30%. As a result of our energy reduction, I estimate that our carbon dioxide reduction is now 350–400 tonnes of CO₂ per year with the turbocompressor. From a maintenance point of view, the system has been running for 2 years in Castellón and has required no interventions at all since its installation.

Two other major benefits are much appreciated. The small size and lighter



 ABS turbocompressor HST 6000.

weight of the ABS turbocompressor HST means that this system is much easier to handle manually than a blower. It can be moved using just an ordinary trolley—no need for a forklift truck. With a new plant, one can build a smaller room for housing the machine. No cranes or other heavy lifting equipment are required. In addition, the quietness of the ABS turbocompressor HST means that regulations governing noise are more easily complied with. Staff must use protective equipment when working with positive displacement blowers but not with turbocompressors. This means more comfortable working conditions for workers and no complaints from people who live near a WWTP running a turbocompressor.

FACSA now has two ABS turbocompressors HST installed, including the one in Castellón, and I'd certainly be glad to be informed of any new technology from Sulzer in the future that improves the performance of wastewater processes."

The ABS sales engineer for the Levante region, Juan Luis Alonso, is also very pleased.

"We have always been confident that the ABS turbocompressors HST series could satisfy the demands of our customers as regards significant energy saving, reduced maintenance costs, and quiet system operation. The success of the ABS turbocompressors HST run by FACSA and the publication of their comparative study has generated a lot of interest, which has led to six further ABS turbocompressor aeration systems being installed in the Levante region. Now that their high performance has been proved without a doubt through our close cooperation with FACSA, we look forward to even greater success in the future."

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