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SKY-HIGH SAVINGS

Retrofitting a ventilation system with FanGrid

COMPACT FANS FOR THE TECHNOLOGIES OF THE FUTURE

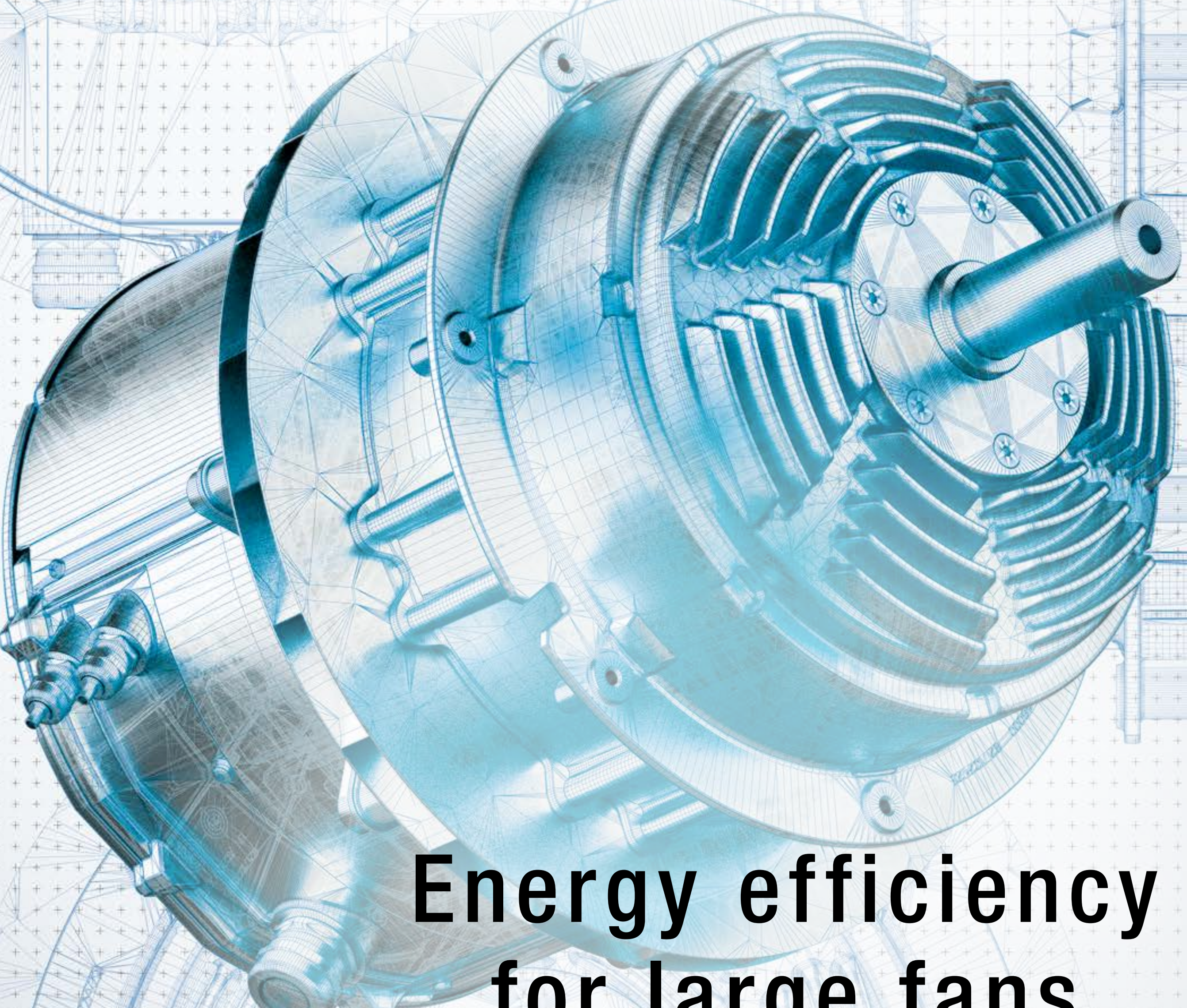
High air performance with an edge length of just 10 cm, thanks to a contra-rotation concept

WITH CFD SIMULATION FOR OPTIMUM FAN USE

Reduce pressure losses, increase efficiency

GREEN HEAT WITH HYDROGEN

New solutions for the heating industry



Energy efficiency for large fans

High-performance 24 kW EC external rotor motor

PAGE 4

“Advance in new drive dimensions”

Rainer Müller

HEAD OF DEPARTMENT
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EBM-PAPST MULFINGEN

Dear customers, partners and friends of ebm-papst,

AC motors are still dominant in areas where large-sized fans with a diameter of up to two meters are used in ventilation technology. These are not particularly energy-saving and therefore will no longer fulfil future efficiency requirements. To be able to offer an efficient solution here, we have entered a new dimension with the FanDrive DV280: In comparison to our existing portfolio, we have doubled the power with this large drive and increased the torque by a factor of 2.5.

We combine this enormous power with a particularly compact design. To achieve this, we have relied on the tried-and-tested external rotor principle and developed it further in two central aspects. Firstly, the cooling system is optimized for a high power density. And secondly, thanks to its very robust design, we also meet the needs of the harsh environmental conditions found in this industrial sector. At the same time, we are paying attention to sustainability by deliberately doing without rare-earth magnets – without compromising on efficiency, sound or service life.

Providing customer benefits are a top priority for us. That is why we offer the new motor as an easy-to-handle complete unit with electronics, impeller and inlet ring. With this solution, all components are perfectly synchronized at the factory, which spares effort at the construction site and the risk of having to synchronize the individual components.

Would you like to find out more about this powerful drive? Then read the article about the FanDrive DV280 – and, of course, the other exciting topics in this issue!

Rainer Müller

High-performance 24 kW EC external rotor motor

Energy efficiency for large fans

Large fans are often used in ventilation technology, in systems for generating process cooling, and in cooling towers. Fan impellers with diameters of one or two meters and larger are not uncommon here. Their driving force is usually motors with proven AC technology combined with variable frequency drives, transmissions or belt transmissions. However, by the time the next stage of the Ecodesign Regulation for fans comes into force, many of these solutions will no longer meet the increased requirements. The suitable alternative will then be new high-performance EC external rotor motors that operate at high efficiency levels. The fans cover power ratings of up to 24 kW and are suitable for air flows of up to 100,000 m^3/h in an axial fan application. The motor's space-saving external rotor design also results in significantly more compact centrifugal fans, making transport and assembly in the field much easier, for example.

If modern EC motors are used as the driving force in fans instead of conventional AC technology, energy consumption and hence operating costs can be significantly reduced. It pays to convert to EC technology for other reasons as well. EC fans have infinitely variable speed control and operate at high efficiencies even in partial-load operation. They also offer networking options and, if appropriately designed, can withstand even harsh ambient conditions. These advantages can now also be used with larger fans that deliver huge air flows. With its new FanDrive DV280 (Fig. 1) ebm-papst has developed a new high-performance EC motor whose output of up to 24 kW and impressive torque of 180 Nm make it suitable for universal use on large fans worldwide. The robust motor is designed for heavy wheel loads, operates with the high efficiency of up to 95 percent that is typical of EC motors (better than IE5 in accordance with IEC/TS 60034-30-2) and is therefore an energy-efficient alternative to the powerful AC motors that are commonly used in this area of application (Fig. 2). The new motor does not require any rare earths for its integrated permanent magnets and is also very compact due to the external rotor design typical of ebm-papst, while at the same time being well protected against environmental influences thanks to its robust construction.

With its new FanDrive DV280 ebm-papst has developed a new high-performance EC motor which is suitable for universal use on large fans worldwide.

FIGURE 1: **Powerful EC motor with external rotor design. With outputs of up to 24 kW and a torque of up to 180 Nm, it is suitable for universal use on large fans.**

Fewer wearing parts, compact design and many functions

As a direct drive, the EC motor offers many advantages in practical use. For example, no wear-prone and high-maintenance belt transmissions are necessary. The fan impeller, which can be either centrifugal or axial, can be mounted directly on the robust stub shaft or motor rotor flange. As the complete control electronics (Fig. 3) are integrated in the motor, there is no need for external devices such as variable frequency drives that have to be assembled, wired and parameterized. The electronics of the EC motors can be replaced for possible maintenance work without having to disassemble the motor or fan. The electrical interfaces are programmable, which reduces the number of connection terminals required and hence the wiring work.

But the new motor also has plenty to offer in other respects. For example, a vibration sensor is integrated, which enables automatic resonance detection and ultimately increases operational reliability. This is because premature fan failures are usually caused by vibrations due to the installation situation. To detect these, a test start-up is carried out during commissioning in which the vibration level is recorded and analyzed over the entire speed curve. If excessive vibration velocities are now detected in certain ranges, the control software in the electronics automatically adjusts itself so that these speed ranges are "hidden" during further operation. This means that they are passed through, but there is no continuous operation in these ranges (Fig. 4, p. 8). If an imbalance occurs during operation, for example due to contamination, this is also detected and displayed at a suitable point so that appropriate remedial measures can be initiated. Operators can manually edit the software settings at any time and always have full control. The motor's heat dissipation has also been optimized. Reliable cooling is provided both by the special housing geometry (Fig. 5) and an additional fan, which actively cools the electronics during operation.

Complete plug & play solution

Thanks to its external rotor design, the motor also has impressively compact dimensions. This means that the entire fan

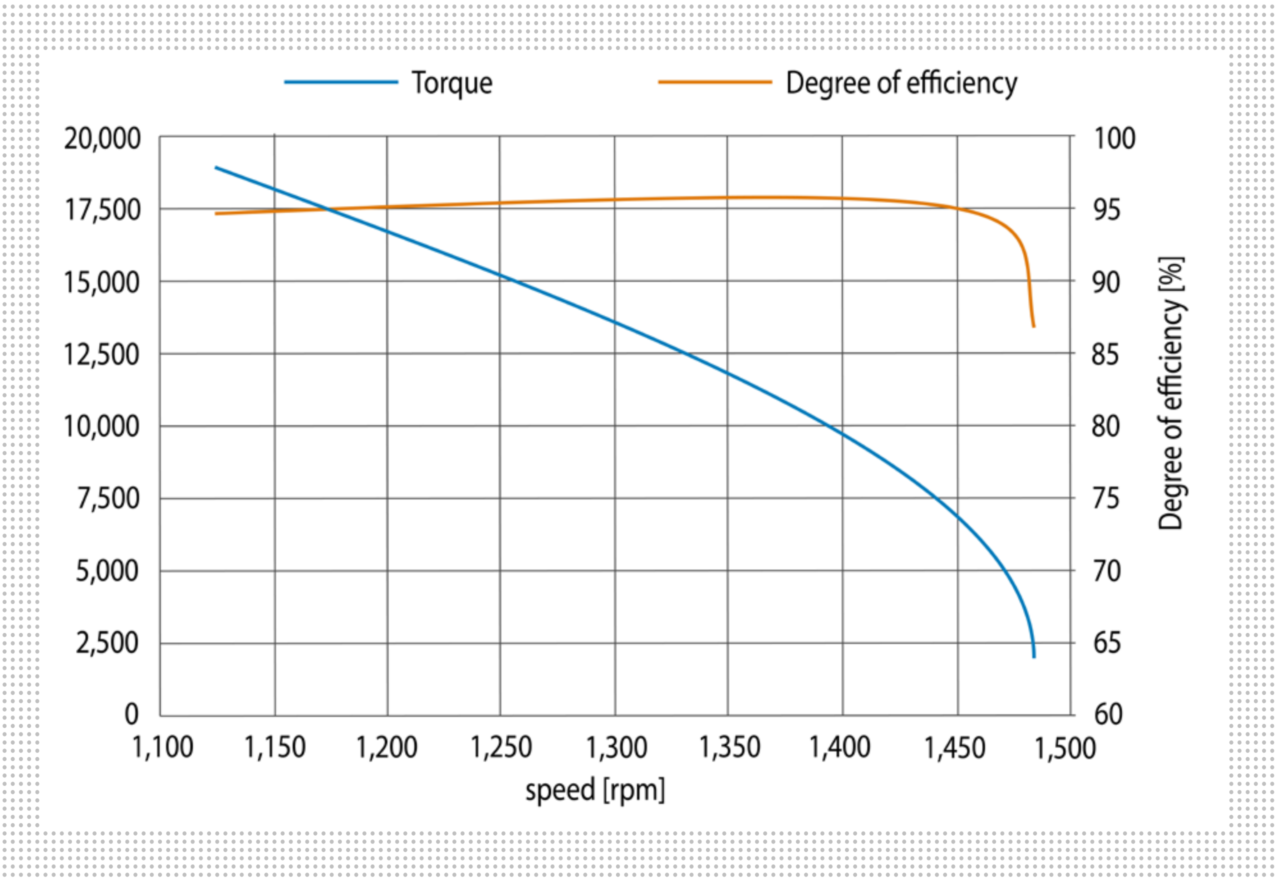

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FIGURE 2: **Even in partial-load operation, the FanDrive DV280 EC motor from ebm-papst has an efficiency of over 95 percent and delivers a torque of up to 180 Nm.**

FIGURE 3: **The electronics of the EC drives can be replaced for possible maintenance work without having to disassemble the motor or fan.**

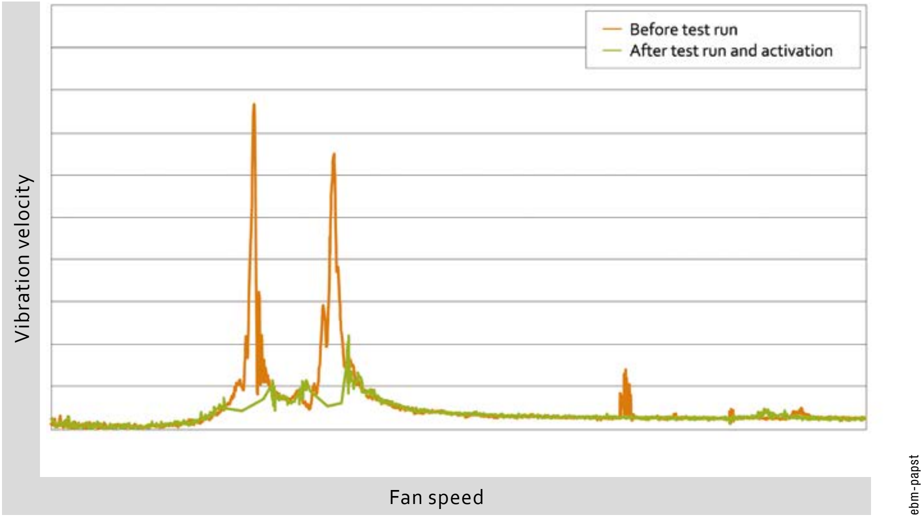

FIGURE 4: **If standard resonance detection is activated, ranges with excessive vibration velocities are detected and passed over.**

Automatic resonance detection for more operational reliability

Centrifugal fans are used in a wide range of applications. Depending on the installation situation, resonance can occur in unpredictable speed ranges. If the fan is often operated in such critical ranges, the drive motors' bearing system may be damaged, leading to fan failure. For system operators, these vibrations can be measured but are not easy to suppress. In its RadiPac centrifugal fans, ebm-papst solves the problem with an automatic resonance detection function that minimizes the effect of vibrations. A test start-up is carried out during commissioning in which the vibration levels over the entire speed curve are recorded and analyzed. If excessive vibration velocities are detected in specific ranges, the control software automatically sets itself to "fast-forward" through these speed ranges in the future (Fig. 4). In this way EC centrifugal fans can be operated without risk of damage. Operators can manually edit the software settings at any time and always have full control.

unit requires less space, making transport and assembly of the complete plug & play solution much easier. This is particularly beneficial when ebm-papst combines the new motors with backward-curved centrifugal impellers (Fig. 6). These are attached directly to the outer rotor, with the motor immersed in the impeller. As a result, the fan requires little space in the axial direction. Even large, size 800 RadiPac centrifugal fans that convey air at up to 40,000 m^3/h wide open and reach maximum pressures of 2,300 Pa, fit through normal doors in retrofit projects, for example, and do not have to be delivered by crane. The plug & play fan systems arrive at the construction site with perfectly coordinated motor, electronics and fan technology as fully assembled, compact units – which

FIGURE 5: **The special housing geometry ensures reliable cooling of the power electronics.**

FIGURE 6: **The complete fan unit (here in the form of a RadiPac centrifugal fan) requires less space, which can make transport and assembly much easier. These plug & play, ready-to-connect complete solutions also offer users the added benefit that the motor and impeller are perfectly coordinated.**

makes handling and commissioning child's play. The special blade geometry of the RadiPac product range drastically reduces flow losses. The inlet ring made of galvanized sheet steel is designed for perfect interaction with the new impeller. The sophisticated impeller geometry not only reduces flow losses, but also noise generation. In addition, its robust mechanical design means that the impeller has an impressively long service life. ○

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FIGURE 1: **The Swiss Tower is an impressive high-rise in Dubai.**

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Retrofitting a ventilation system with FanGrid

Sky-high savings

Completely replacing old ventilation systems is time-consuming and costly. The fan retrofit project at a high-rise building in Dubai shows that there is huge potential for savings with EC fans arranged in the FanGrid and a demand-based control system.

The Swiss Tower is a 40-story high-rise building in Dubai that houses offices and luxury apartments (Fig. 1). The building is constantly supplied with fresh, cooled air from a total of four air handling units (AHUs). Each AHU is responsible for supplying fresh air to several floors and was previously equipped with belt-driven AC fans. The old systems were always running at full load, and there was no way to regulate them according to demand, which would have made sense due to the changing occupancy of the office spaces. The bottom line was that operation was costly and resulted in a high level of energy waste.

For these problems, retrofitting the AHUs was both the most economical solution and the one that could best be implemented in the required time. The main requirement of the project was to reduce the power consumption of the fans and to exploit further energy saving potential by establishing a control system. The upgrade was also intended to extend the service life of the AHUs. The contract for the retrofit was awarded to Jon Davies and his company Qey Energy Solutions, which worked closely with ebm-papst Middle East and Taka Solutions to develop an efficient solution.

An efficient complete solution

In order to keep the downtime of the AHUs as short as possible during the retrofit work, they were upgraded one after the other. However, this meant that during the downtime, parts of the building could no longer be supplied with fresh air. This time pressure meant that the new fans had to be installed quickly and without complications. Qey's "Matrix-Air+ EC" solution made this possible. This fan package, consisting of EC fans, fan terminal boxes, fan bulkheads and control panels, was delivered directly to the AHUs as a pre-prepared complete solution and installed. When it came to the first component, the choice fell on EC centrifugal fans from ebm-papst's RadiPac series. Its compact design and low weight compared to a single large AC fan made the replacement easy and stress-free, as no heavy equipment was needed for installation – which saved time and money too. Since the RadiPac is supplied as a plug &

play solution, commissioning the EC fan is also a quick process. A total of 26 RadiPacs were installed as FanGrids in the intake and exhaust sections of each of the four AHUs (Fig. 2).

FanGrid ensures operational reliability

A FanGrid consists of several small fans arranged next to or above one another and operated in parallel. This redundant design increases the dependability of the system and ensures greater operational reliability (Fig. 3). If one fan fails, the other EC fans compensate for the missing air volume. This provides the necessary reliability, especially for large systems, and even more so in particularly hot regions such as Dubai. Another reason for a FanGrid was to extend the system's service life. This can be achieved by operating several small fans at partial load as required instead of one large fan constantly at full load. Another advantage of this type of setup is that air can flow more evenly through upstream and downstream components such as filters and heat exchangers. This results in more efficient filtering of the air, as well as better heat transfer performance – which in turn reduces the operating costs of the system. Several small fans also usually require less installation space and are lighter than a single large fan, making replacement easier.

Energy savings with EC technology

The main aim of the retrofit was to save energy, which is why a fan with an EC motor was chosen. Its high motor efficiency level of over 90% alone makes large savings possible compared to the AC motor. In addition, with the old AC fans, only two operating levels were possible: either they were off, or they were operated at maximum speed; there was nothing in between due to the lack of control electronics. This means that regardless of the actual occupancy of the building, all systems always ran at full power, even if at certain times it would have been sufficient to supply individual parts of the building with a lower air volume. By contrast, EC fans can be continuously controlled between 0 and 100%, meaning that the speed can always be adjusted to meet demand. This results in significant potential for savings, as the power consumption increases or falls in line with the speed to the power of three ($P \sim n^3$). So if the speed is reduced by half compared to the nominal speed, the power consumption is reduced by a factor of 8 and is therefore only 12.5 % of the rated output. If, on the other hand, half of the AC fans are switched off and the other half are still operated at full load, only 50% of the power consumption can be saved.

Demand-based fresh air supply

The second part of the retrofit involved upgrading the control system. The Swiss Tower already had a building management system; the aim with regard to the ventilation systems was now to develop a time-dependent strategy for controlling them. One advantage was that, thanks to the security scans at the entrance and exit, data was already available on the building's occupancy, which varied according to the time of day. Working with Taka Solutions, Qey used this data to determine the airflow requirements on a time-dependent basis and programmed an internal schedule using software developed specifically for retrofit projects (Fig. 4). Office occupancy is lower in the mornings and evenings, which is why the power is reduced at these times, whereas during the afternoon the building is at its highest capacity, temperatures tend to be at their hottest, the AHUs have to

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FIGURE 2: **Instead of a single fan, FanGrids were installed in the four AHUs. The pre-prepared fan pack-age makes installation quick and easy.**

FIGURE 3: **In a FanGrid, the RadiPacs are installed next to or above one another and operated in parallel. This ensures particularly high operational reliability.**

FIGURE 4: **The demand-based control system regulates the air volume flow depending on the time.**

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FIGURE 5: **The control electronics with RS485/MODBUS RTU interface are already integrated in the RadiPac.**

deliver a greater volume of air, and there is the most demand for cooling (Fig. 5). The ideal prerequisite for this is the RadiPac's RS485/MODBUS RTU interface, which enables the fans to be intelligently controlled while also allowing the operating data of each individual fan to be monitored. The RadiPac also enables differential pressure measurement, as it has a pressure tap for connecting a differential pressure transmitter. This also allows conclusions to be drawn about the air flow rate that is currently being handled. Thanks to the MODBUS interface, Qey's software can monitor and control the speed as specified by the schedule, and also monitor the air flow, energy consumption and, if necessary, alarms and quickly initiate countermeasures.

Target achieved – energy consumption reduced by more than 60%

Documenting and monitoring the operating data are important for checking the energy savings achieved by the retrofit and can facilitate additional improvements to the control system in a further step. This is because after a certain time, during which the internal schedule is tested, further adjustments and refinement of the control system may be necessary. Constant monitoring of each individual fan also ensures reliability: problems can be identified quickly and negative consequences prevented at an early stage.

Finally, by monitoring and documenting the operating data, it is also possible to determine how much the retrofit has saved: The peak demand for the old motor was 31 kW. After the retrofit, the peak demand for the maximum air flow required is 16.5 kW. The demand-based control system has also meant that the new maximum power consumption is only used occasionally and when required, and no longer non-stop (Fig. 6). The combination of ebm-papst's efficient RadiPac fans, Taka Solution's extensive knowledge of building analysis, and Qey's MatrixAir retrofit solution resulted in a successful project implementation. Energy consumption was reduced by more than 60%. ○

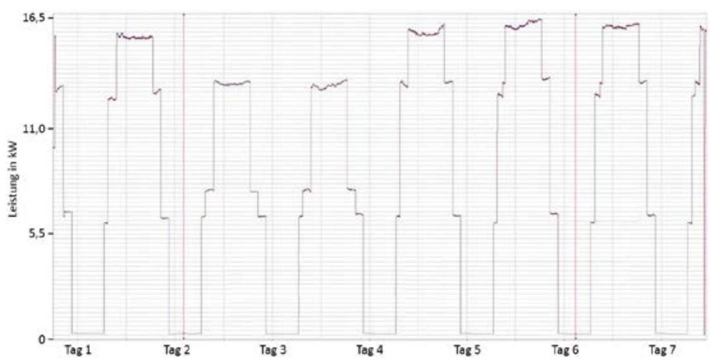

FIGURE 6: **Here, the time-dependent fan speed control can be recognized. After the retrofit, the new peak demand is only 16.5 kW (previously 31 kW).**

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Reduce pressure losses, increase efficiency

With CFD simulation for optimum fan use

Everyone is looking for the perfect fan for their refrigeration and air conditioning applications. But fans are complex flow machines that react to every aerodynamic influence in their surroundings. Therefore, a fan installed in practice is often not as quiet as hoped or is less efficient than promised on the data sheet. To enable comparability, these are

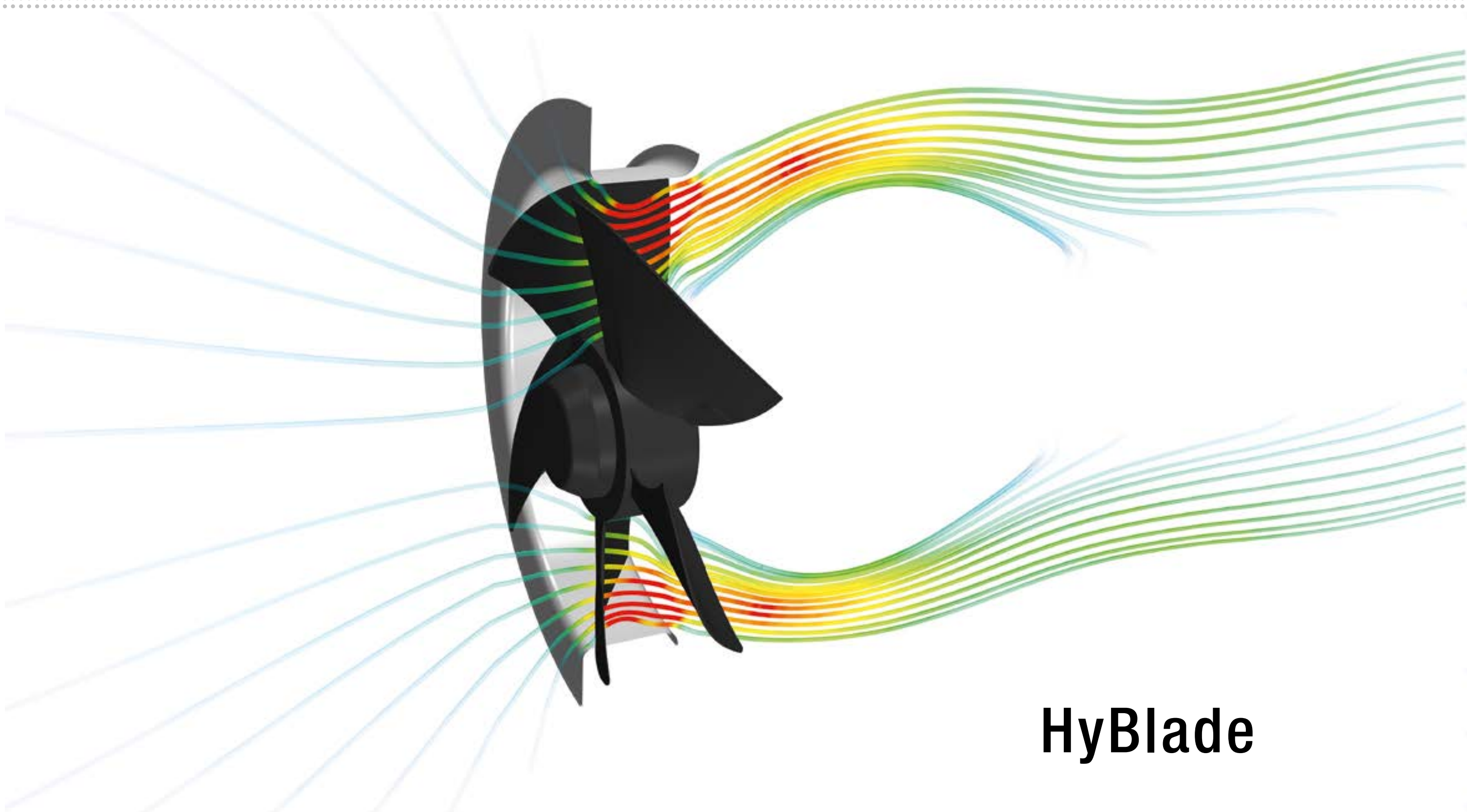
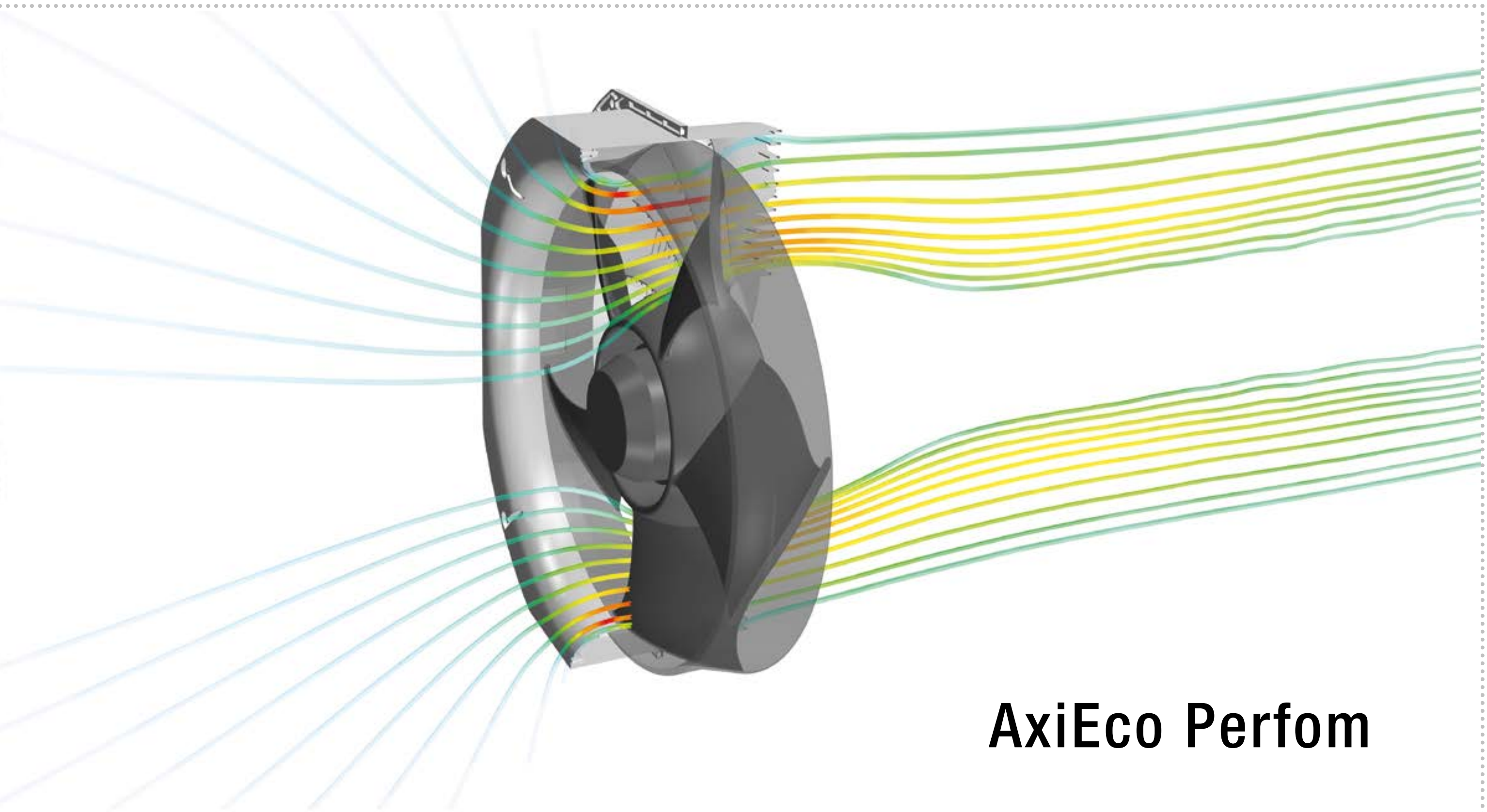


FIGURE 1: **CFD simulation is used to continually improve the impeller geometry of the fans – for greater efficiency and better air flow.**

determined on the test stand under standardized aerodynamic laboratory conditions. By contrast, the reality, which sees interactions between the fan and the customer device impact the flow variables, can only be reliably measured via individual investigations on samples. Simulation provides further help with this: the behavior of a fan in the specific application can be precisely calculated and visualized with CFD (Computational Fluid Dynamics, i.e. numerical fluid mechanics). This is worthwhile, as even small optimizations in the installation situation reduce pressure losses, increase efficiency or minimize running noise.



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Numerical aerodynamics and simulation are part of day-to-day development work for motor and fan manufacturer ebm-papst. For many years, its engineers have been working on developing their fans using powerful CFD tools, not only for optimizing complex impeller geometries (Fig. 1), but also for motor or electronics cooling concepts or in the context of acoustic testing for noise characteristics. Customers benefit from this extensive expertise and from the aerodynamic design of their own end devices that are going to contain ebm-papst fans.

Potential simulation in the product development process

The simulation of fluid mechanics makes flow and flow variables such as pressure or velocity visible in the entire calculated area. In terms of measurement, it is often not possible to measure at certain points or, under certain circumstances, the measuring instruments influence the flow, or a variety of measuring sensors and methods are required to obtain comparable information. The measuring set-up that results is then complex and expensive. In addition, a sample device that can be measured must have been set up beforehand. If an unfavorable flow situation is then found in the device during such tests, this can often only be implemented with a successor product as part of a redesign for time and cost reasons.

That is why it is better to simulate the installation situation for aerodynamics in the early development phases of a customer device. This facilitates a flexible response to aerodynamic weaknesses in the design because the customer's digital prototype can be optimized before a first sample is actually set up. The calculation result of the actual state forms the basis for assessing the quality of adapted design variants.

This ensures at an early stage that the installed fan really works with the desired properties without high costs accumulating. It is therefore worth taking advantage of the possibilities of CFD at an early stage of development. (Fig. 2).

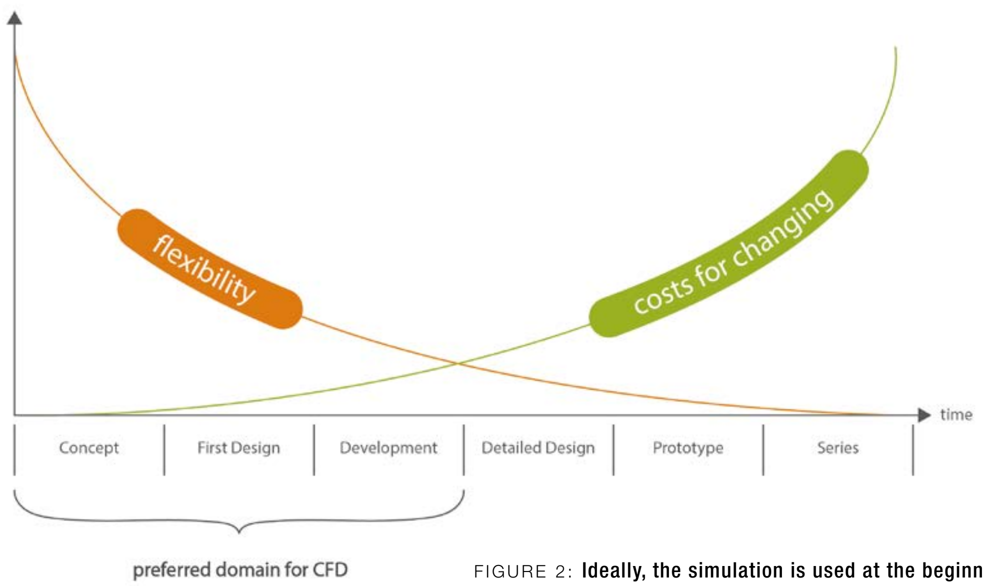

FIGURE 2: **Ideally, the simulation is used at the beginning of a project as far as possible so that solutions can be assessed at an early stage.**

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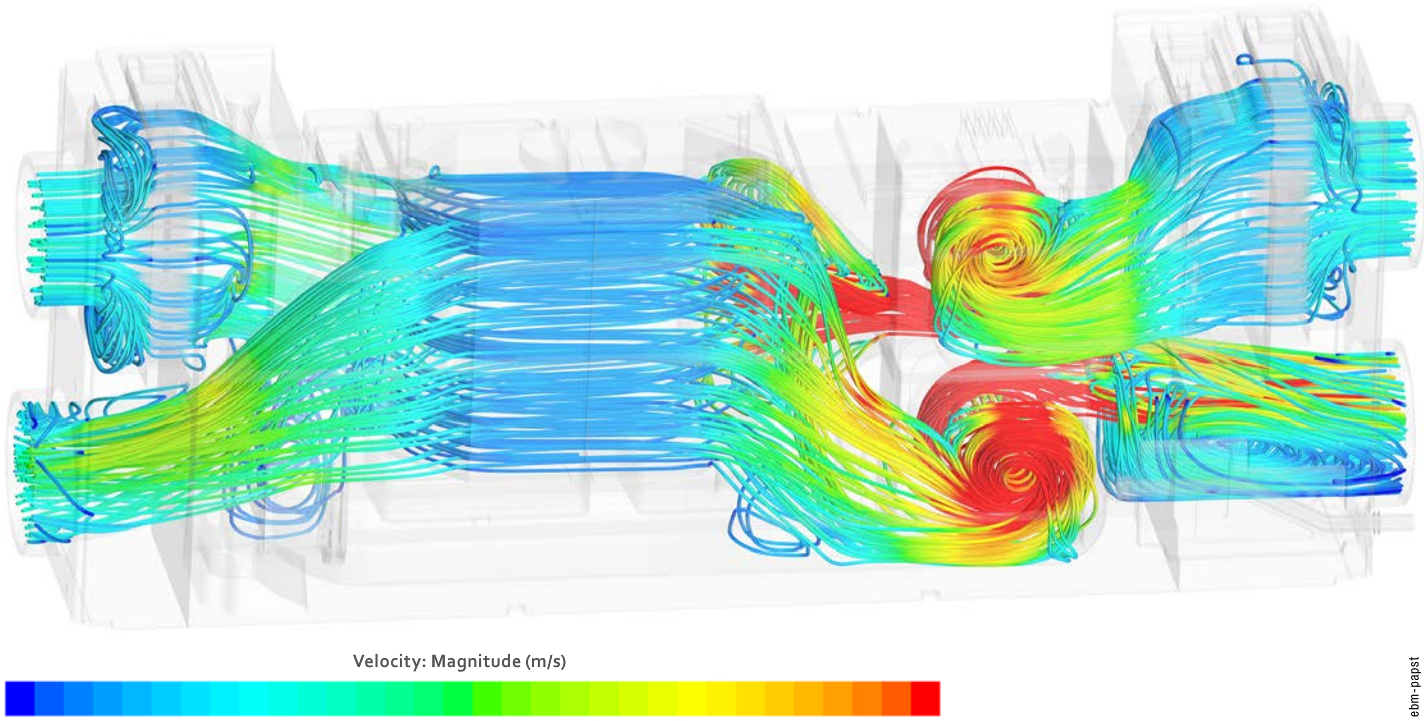

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FIGURE 3: **Visualization of air flow through a ventilation unit**

Simulation as a service

CFD can be used to calculate, visualize and improve the flow conditions in the customer device, or to compare different concepts with one another. The fan's energy consumption and sound depends on how the housing encourages air flow, whether it is drawn in axially from the front, centrifugally from all sides or on one side. In poor cases, this can double the power consumption or halve the efficiency, and can significantly increase the noise level. CFD helps in understanding the aerodynamic conditions in the device (Fig. 3).

Before the simulation begins, the objective should first be defined and a few questions answered. Does air have to flow through a heat exchanger as evenly as possible? Is the simulation supposed to detect pressure losses? Does the customer want to perform a general check on the choice of fan? Is the device in which the fan operates supposed to be as quiet as possible? Once these types of questions have been clarified, the 3D CAD data and the expected operating point (pressure, air flow, speed) of the fan provide the basis for simulation. In addition, there are also characteristic curves from the filters, heat exchangers or guard grills installed in the device, for example. The data are cleared up and unnecessary details are removed (cleaning). Then the simulation is prepared in a preprocessing phase, meaning that certain boundary conditions are specified and the geometries are networked. The grid structure divides the space that the air passes through into many individual cells, which form the basis of the mathematical calculation. The simulations then run on high-performance computers that are in a server room at the ebm-papst site in Hollenbach.

Practical examples: Exploiting potential for optimization

Using the simulation results, the engineers then estimate the potential for optimization and develop concrete suggestions for improvement. For example, a customer developed an air purification device in which the fan was to be used for pushing air out. However, the simulation showed significant turbulence (Fig. 4, p. 18), which increased the power consumption at the operating point. Using the fan to draw air in, i.e. changing its

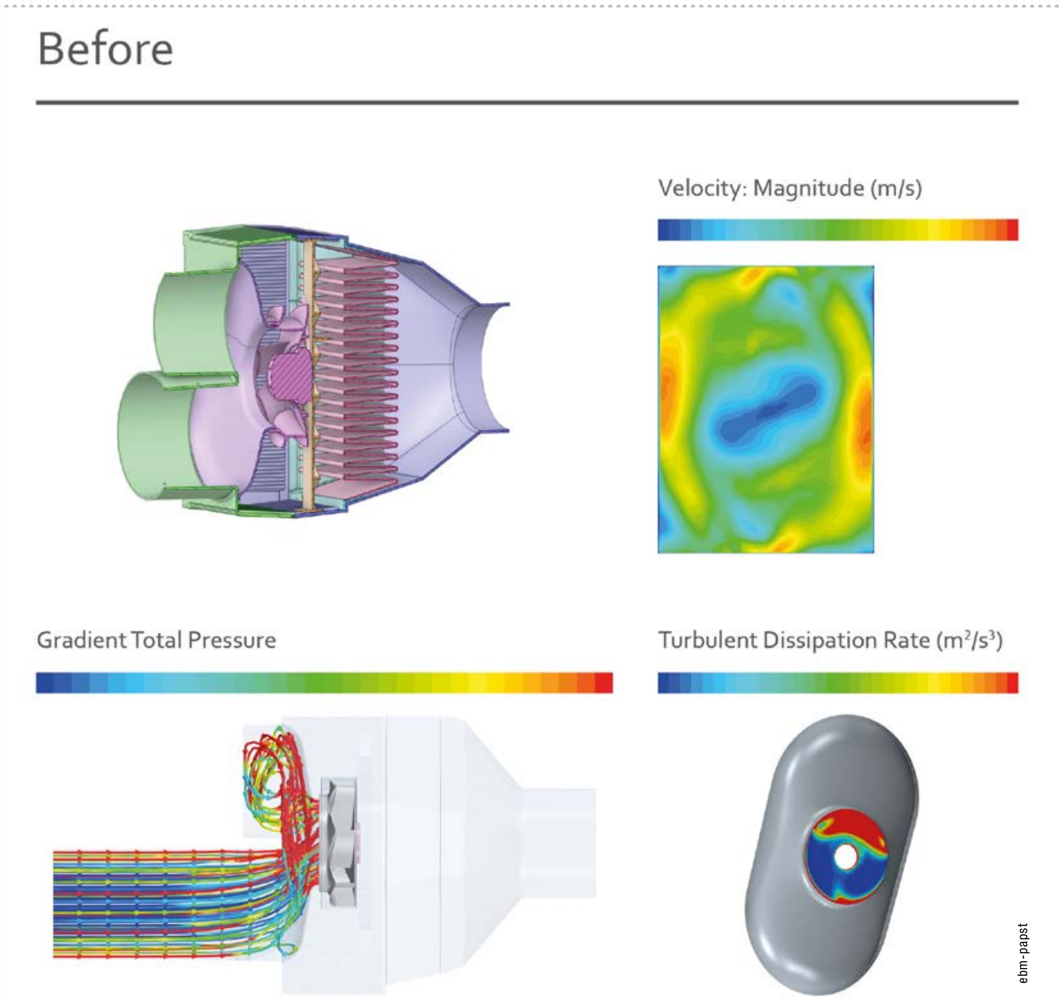
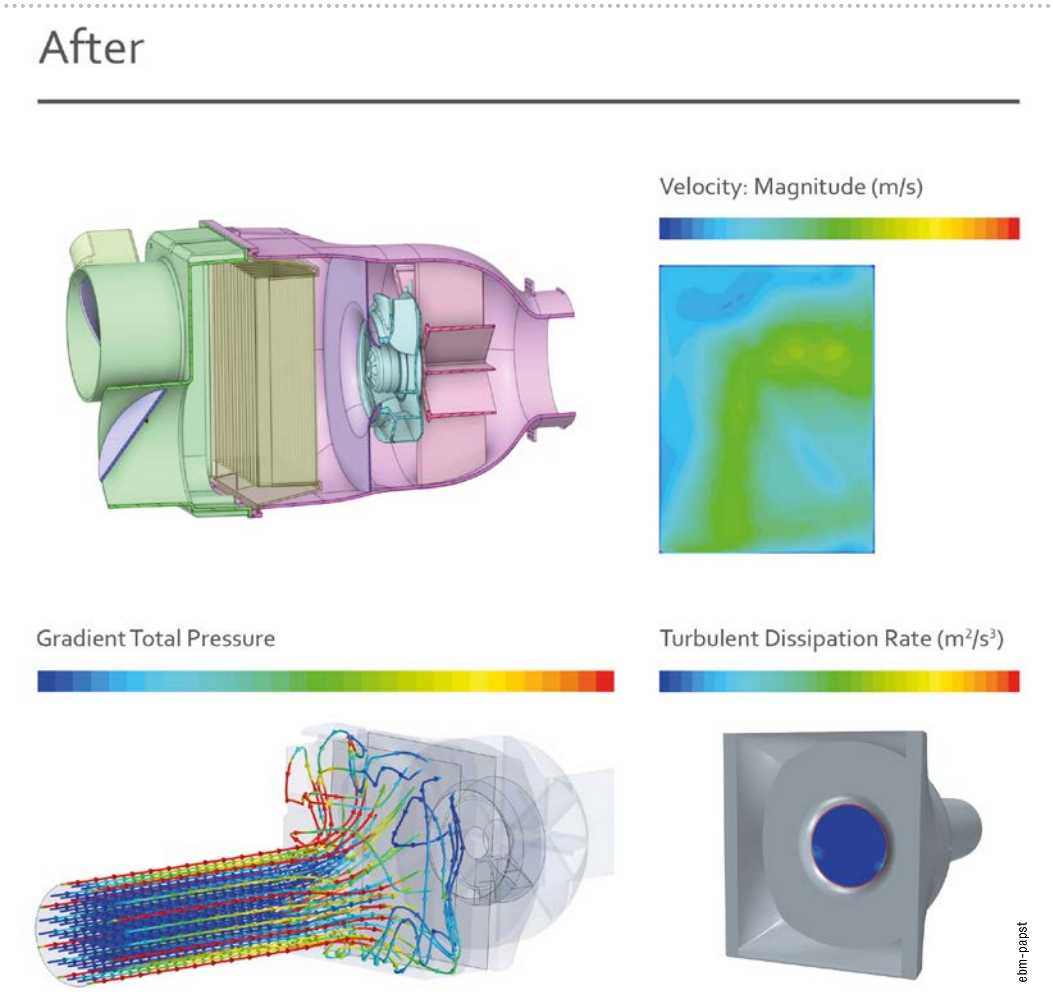


FIGURE 4: **In an air purification unit, the air flow could be significantly improved by changing the fan installation position.**

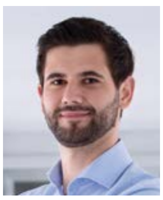
installation position, proved to be helpful here. The air flow is now very uniform, the power consumption is decreased and there is also a positive effect on operating noise.

Another example: Using simulation results, the efficiency of a heat pump could be significantly improved. Thanks to geometric changes, the pressure losses in the device fell by a total of 17 %. The individual sub-areas in the device were assessed separately and the product design was adapted accordingly. Here too, the user benefited from the opportunities provided by CFD calculation.

These examples show that it is worthwhile for end device manufacturers to rely on numerical flow simulation and to apply these at an early stage of development to avoid subsequent development costs. ebm-papst supports this with its long-standing CFD experience and offers such evaluations and calculations to ensure that the fans operate as efficiently as possible in the application. Even small optimizations to the installation situation can reduce pressure losses, increase efficiency, or minimize running noise. ○



The power consumption dropped and the device operates more quietly.



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High air performance with an edge length of just 10 cm, thanks to a contra-rotation concept

Compact fans for the technologies of the future

The digital world is developing at a fast pace. Volumes of data and data throughput are constantly increasing. Communications technology, mobility, industry, and data centers, as well as technologies such as indoor farming and increasingly "smart" building automation, all need ever more powerful electronics to process enormous data flows. At the same time, packing density is rising inexorably. More and more computing power is expected to take up as little space as possible. This makes cooling a challenge. Now a new compact fan is opening up interesting possibilities; with an edge dimension of only 10 cm, it delivers up to well over 500 m^3 of air per hour.

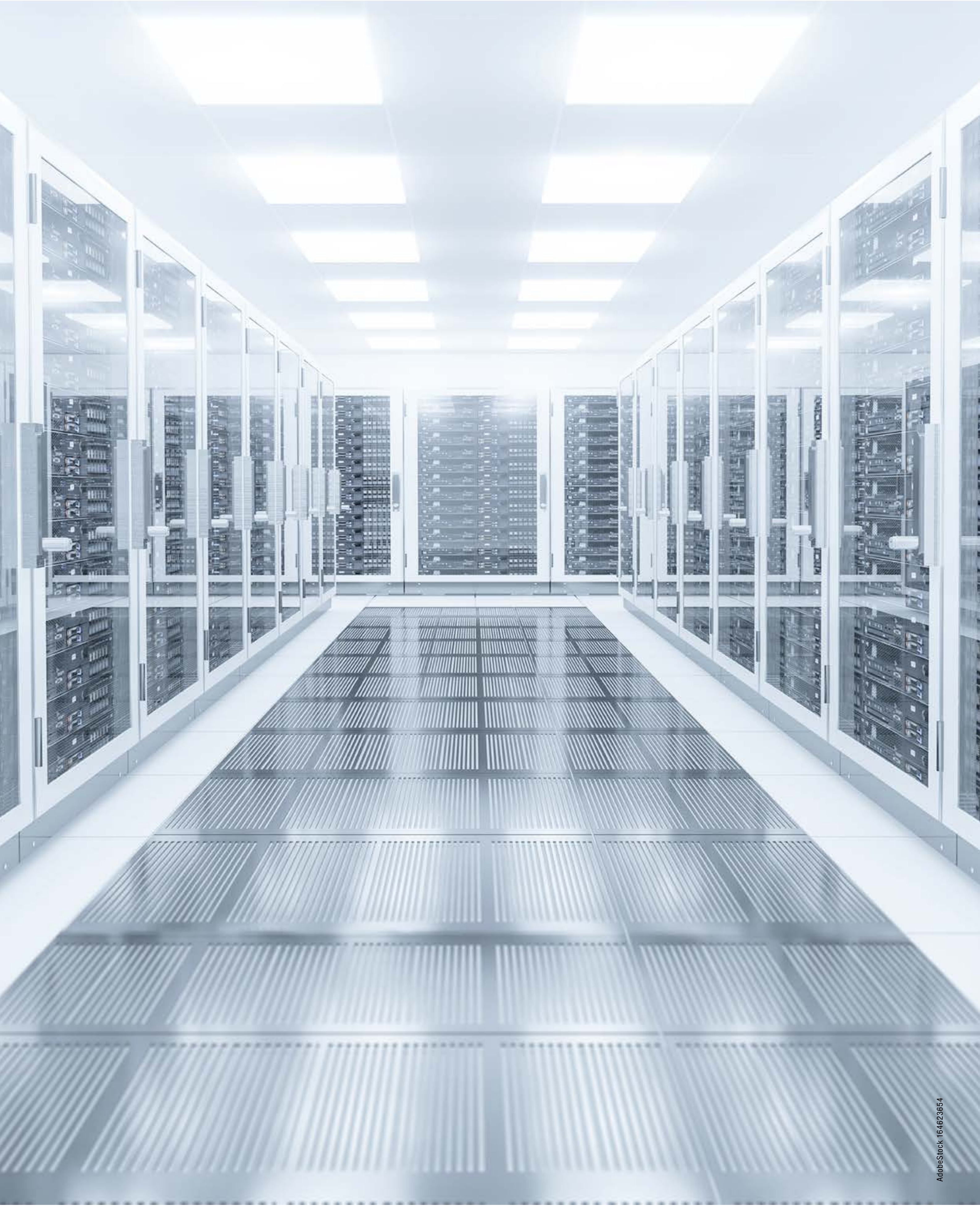

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FIGURE 1: **Power fans for high-performance electronics.**

Today, electronics cooling is largely based on axial compact fans, particularly because they are easy to integrate and offer high air flow rates due to their design. However, "normal" axial compact fans reach their limits when increasingly powerful electronics need to be accommodated in the same space or have an even more compact construction, because the aerodynamic resistances increase with increasing device compactness. To increase the cooling capacity, you could therefore simply connect two axial compact fans in series – running in the same or in opposite directions. In principle, this results in the required air performance. However, this solution requires more installation space and has disadvantages in terms of mechanical vibrations. In addition, the fans can have an adverse effect on each other in terms of aerodynamics, which can result, for example, in increased noise.

Optimized fan pair cools high-performance electronics

For a power fan that delivers more power and is still as compact as possible, ebm-papst has therefore adopted a new approach: with the AxiTwin 100 (Fig. 1), the motor and fan specialists, in close cooperation with a company from the telecommunications sector, have developed a compact fan that has been designed as a contra-rotating system. With an edge dimension of 10 cm and a depth of 9 cm, four of these fans fit into a 19" rack, as is typically used for coo-

In close cooperation with a company from the telecommunications sector, ebm-papst has developed with the AxiTwin 100 a compact fan that has been designed as a contra-rotating system.

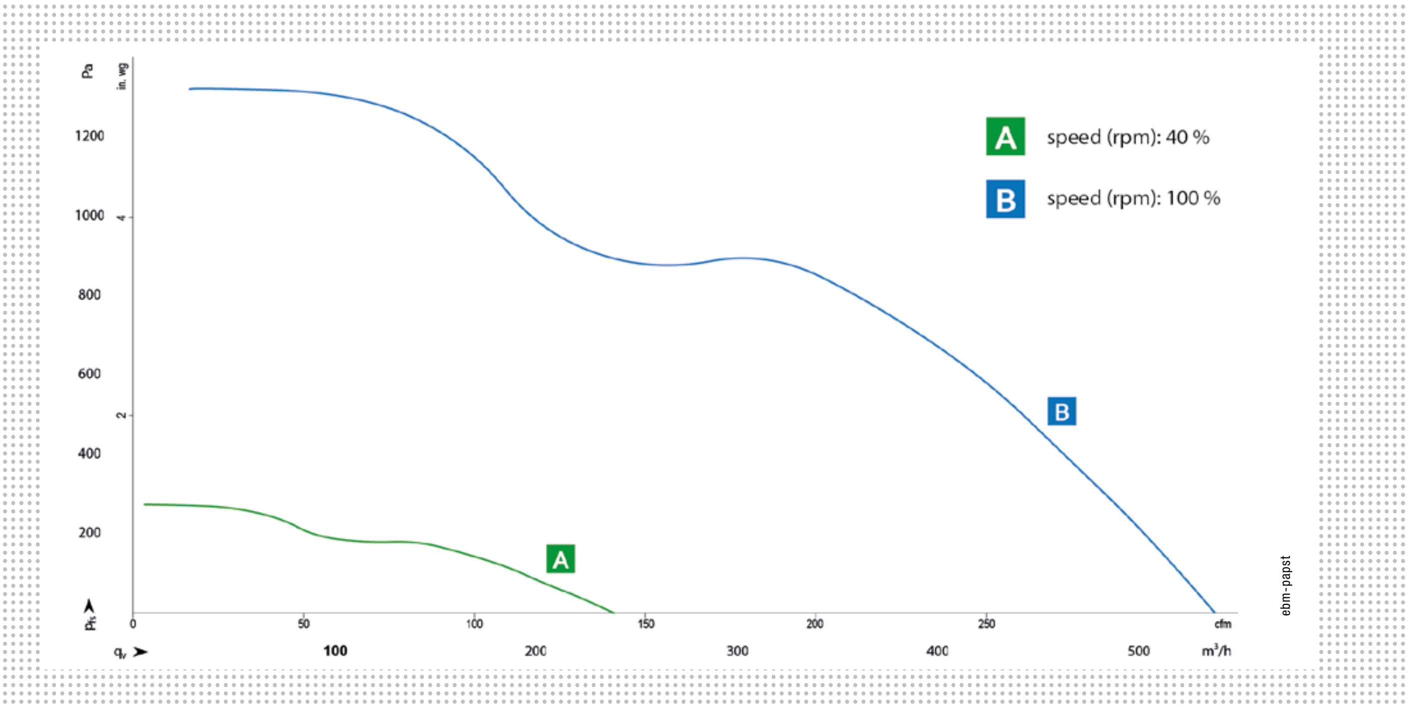

FIGURE 2: **Up to 536 m³/h air performance at up to 1,300 Pa pressure.**

FIGURE 3: **Second-stage fan impeller: turbulence and swirl are reduced. The blade's extreme sickle shape also contributes to noise reduction; the comparatively small surface of the blades increases efficiency.**

ling in blade servers. This guarantees reliable heat dissipation even when used with tightly packed electronics, as each fan delivers up to 536 m³ of air per hour and a maximum static pressure increase of up to 1,300 Pa (Fig. 2).

In doing so, the new fan for electronics cooling does not just combine two individual fans, but uses a newly developed flow geometry for the two consecutive blade rows which takes into account the aerodynamic operating point, thus numerically optimizing both at the same time. The fan then consists of two rotors that are connected via an innovative flange. The first rotor, with its five blades, is largely responsible for the air flow, while the second three-blade rotor is primarily responsible for the pressure increase (Fig. 3). Around two thirds of the pressure is generated in the second stage. The second stage also reduces turbulence as a result of its sophisticated aero-

FIGURE 4: **The flange is more than a spacer. Thanks to its optimized geometry, it reduces the generation of vortices and noise at the second stage.**

dynamics with its extremely sickle-shaped blades. It also contributes to noise reduction because the comparatively small surfaces of the blades increase its efficiency.

A major advantage of the contra-rotating fan principle is the reduction of the speed component of the air flow in the circumferential direction. In this design, the flange (Fig. 4) between the two stages is not just a support structure or spacer, but a patented feat of engineering. It links both stages vibrationally in such a way that each stage attenuates the vibrations of the other (Fig. 5). The double-sided bearing tube, which connects the two stages together, and the integrated guide blades mean that the design is extremely compact. The geometry of the flange guide blades was also determined using the simulated flow field between the two rotors at the intended device operating point. This minimizes vortex generation at the guide blades and interaction of this vortex with the second row of blades, thus contributing to noise reduction. The flange is made of aluminum, which ensures high rigidity and at the same time enables good heat dissipation.

Powerful EC drives with new electronics

The driving forces behind the fan impellers are energy-efficient GreenTech EC drives with a motor power of up to 180 W. The three-phase motors are also very compact, work with a high level of efficiency both in normal partial-load operation and at full load, and are designed for continuous operation thanks to electronic commutation. The newly developed 300-W electronics also have a lot to offer. They have not been integrated into the motor, but have been installed in the corners of the housing for even better heat dissipation and therefore an even longer service life. This means that the surface of the flange can contribute to cooling them too. The individual stages only require a small connection board on the motor for the winding. Standardized signal inputs such as PWM input, analog

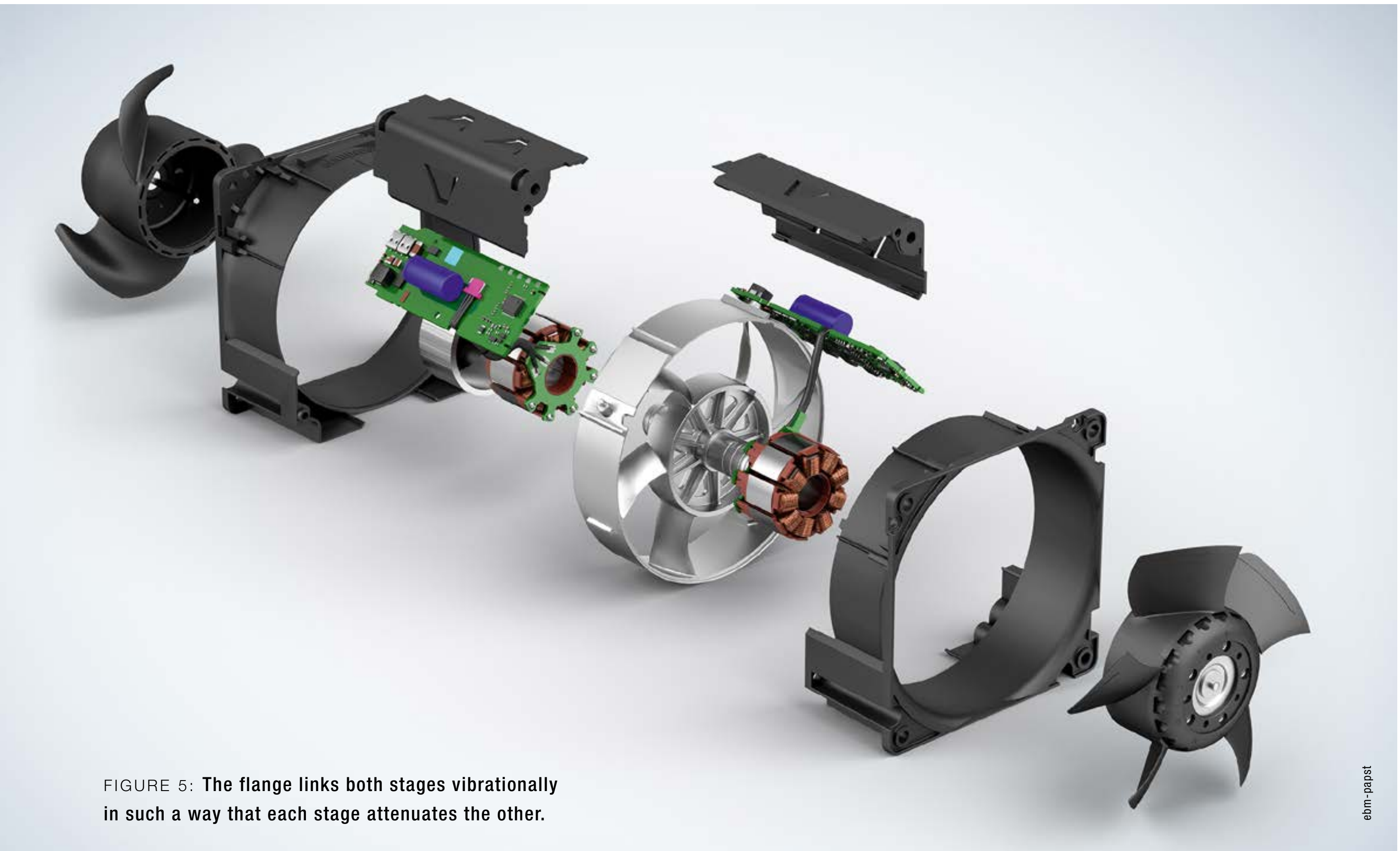

FIGURE 5: **The flange links both stages vibrationally in such a way that each stage attenuates the other.**

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control input, as well as tach/alarm output signals, can be integrated individually as required. In the standard version, the fan has a PWM input and an open collector tach output. Optional humidity protection is also available for demanding environments.

The two-stage design of the contra-rotating system also ensures the necessary redundancy for applications with critical 24/7 availability requirements, such as computers at major banks. If a single rotor fails, there will not be any backflow as the other rotor will continue to rotate. Each stage can be controlled separately, but always in coordination with one another. The speed ratio is defined, but it can be altered separately in individual cases, for example in order to optimize efficiency or reduce noise levels in certain ranges of the power level.

The AxiTwin 100 is an extremely powerful compact fan with small installation dimensions for applications where a lot of computing power needs to be cooled in a small space. Its range of applications extends across all cutting-edge technologies, from rack cooling for blade servers and extremely diverse information technology solutions to super computers in the field of blockchain technology. Application-specific modifications are also possible, as the design can be adapted to other sizes.

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New solutions for the heating industry

Green heat with hydrogen

Hydrogen is seen as a key element in the energy transition and could replace natural gas as a heat supplier in the not too distant future. To prepare its equipment for this, the heating industry needs solutions quickly – and the condensing technology experts at ebm-papst are supplying them.

A climate-neutral future is only possible if the world gradually abandons fossil fuels and replaces them with clean energy sources. Heating is still a major contributor to global CO_2 emissions. Although gas condensing boilers are already very efficient, a green fuel like hydrogen would make for a better carbon footprint. It will be a while before all gas-based heating systems are fully converted to hydrogen, but it's only a matter of time.

Two trends: Admixture or 100 percent H2

Given the long service life of gas condensing boilers of over 15 years, it makes sense to develop future-proof solutions today. The United Kingdom is clearly the pioneer here: from 2025, all newly installed gas boilers in the UK must be designed to be convertible for 100 percent hydrogen operation at no significant expense. So a certain amount of time pressure exists. However, the industry is not unprepared. Heating technology manufacturers have been working on solutions for several years now, and there are various field tests throughout Europe that are trialing hydrogen use in local grids (see Box 1: H2 boiler for tiny house). On an industrial scale, however, development is still in its infancy.

The market is currently working in two directions: On the one hand, manufacturers are making their equipment fit for blending hydrogen with conventional natural gas. Ten percent is now possible without any problems, and 20 percent is currently establishing itself as the new standard. All in all, significant CO_2 savings are possible. Although somewhat higher admixtures of around 30 percent are still manageable, further increases beyond this limit are not technically feasible. Therefore, the second line of development is to build devices that can be operated with both natural gas and one hundred percent hydrogen.

Box 1

H2 boiler for tiny house

Dutch heating technology manufacturer Intergas has already tested what the future of heating could look like on a small scale. The company has developed a boiler that heats a tiny house with one hundred percent hydrogen. The specialists from ebm-papst have contributed their know-how to the project from the very beginning and have also provided components. The gas valve and blower ensure that the boiler operates safely. ebm-papst was also able to assist with certification by the Dutch testing agency Kiwa. Intergas is already implementing the next project: At the end of 2022, 33 houses near Groningen are to be connected to a hydrogen network.

Intergas developed a boiler for a tiny house that uses 100% hydrogen (image source ebm-papst, photographer Miquel Gonzales)

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FIGURE 1: **The RadiMix system solutions have been tested by DVGW for 20 percent hydrogen.**

Box 2

The hydrogen experts

The combustion specialists at ebm-papst started their first tests as early as 2 years ago and have accumulated valuable know-how in this area to date. Recently, there has even been a dedicated hydrogen laboratory in Landshut, where new processes for mixture control can be developed and tested. The following components and solutions are ready for hydrogen use today and are certified for 20 percent hydrogen:

- **RadiMix VG 100: The blower ensures the optimum mixing ratio of air and gas in every operating state.**
- **G1G 170: The blower is particularly suitable for maximum energy efficiency.**
- **D01 | E01 | F01: The entire gas valve range from ebm-papst is ready for hydrogen use**
- **CleanEco and CleanVario: The two composite systems make full use of their advantages even with 20 percent hydrogen.**

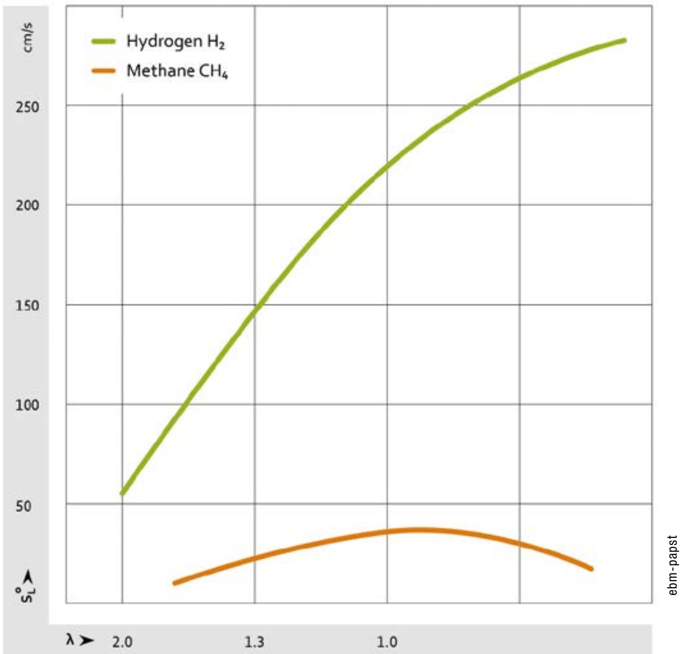
What makes hydrogen special

In principle, manufacturers can retain the operating principle of their condensing units in both cases. However, due to the properties of hydrogen, three aspects in particular must be taken into account. Hydrogen is the lightest of all chemical elements with the lowest density. This means that it has a higher permeability than natural gas, and special attention must be paid to the tightness of the components in the boiler. The second aspect concerns the choice of suitable materials. More crucial, however, is the combustion behavior. For one thing, the flame velocity when hydrogen burns is eight times higher than with methane, and for another, it ignites very quickly.

With an admixture of up to 20 percent hydrogen, combustion behavior remains of secondary importance. However, it is still important to pay special attention to combustion. Hydrogen has a lower calorific value than natural gas and the Wobbe index, which is important for fuel gas exchange, is also lower. This means that it is necessary to make adjustments to ensure that the system is as efficient as it is when operated with natural gas. For the efficiency of the condensing units, it is therefore all the more crucial that the components of the gas-air composite system are perfectly matched. Only with an optimum mixing ratio of natural gas, hydrogen and air is the energy yield perfect. The CleanEco (pneumatic composite) and CleanVario (electronic composite) system solutions from ebm-papst, consisting of blower, venturi, gas valve and control unit, are already prepared and certified for the use of 20 percent hydrogen. Most of the gas blowers in the various performance classes, for example, have been tested by DVGW (Deutscher Verein des Gas- und Wasserfaches e. V.) and approved for H_2 admixture (Fig. 1). The same applies to the gas valves from ebm-papst. The blowers ensure the optimum mixing ratio of air and gas in every operating state (for more products, see Box 2).

For the admixture, the CleanVario electronic composite system in particular can make the most of its advantages because it is gas adaptive and can adapt to different fuels. The ideal mixture of fuel and air for low-emission and also efficient operation is achieved when the combustion air ratio is between 1.2 and 1.3 λ. To check whether combustion is proceeding at an optimum rate, an electrode directly on the flame measures the ionization current in the CleanVario. Depending on how high or low this is, the gas valve is electronically controlled to increase or restrict the gas flow. This

FIGURE 2: **The graph shows the flame velocity as a function of the air concentration. Hydrogen (green line) ignites much faster than methane (orange line), especially at high concentrations.**



makes it possible to control combustion independently of the fuel. Here, we have succeeded in further developing the reliability of the system beyond the state of the art by intelligently linking all actuators and sensors. The ionization technology works reliably up to an admixture of 30 percent hydrogen. At 100 percent, however, it does not. The ionization current is then barely measurable.

Safe ignition, safe operation

When 100 percent hydrogen is used, combustion behavior takes on a crucial importance. Due to the element's high flame velocity and reactivity, the heating technology industry is primarily concerned with the issue of safety. However, if you have a precise knowledge of its combustion behavior, you can safely control the combustion of hydrogen.

The ignition process is particularly critical. The danger is that a flashback will occur. In this case, the flame travels from the burner back toward the gas-air composite system, against the direction of flow. This happens when the flame spreads very quickly after ignition and the pressure is so high that new fuel mixture cannot flow into the burner fast enough. The flame therefore finds itself a way to continue feeding and migrates towards the fuel mixture (Fig. 2). One way to make ignition safe is to increase the air content during the starting process. The advantage is that hydrogen ignites at very low concentrations compared to natural gas. Once the critical ignition phase is over, the unit returns to efficient normal operation after a fraction of a second.

However, a flashback can also occur during operation, namely when lower outputs are called up. The reason for this is the high flame velocity of the hydrogen. The flame comes to a standstill where the flame velocity is as high as the efflux velocity. At rated output, this happens at a sufficient distance from the burner surface. If the output is reduced, the efflux velocity decreases and the flame migrates towards the burner surface (Fig. 3). Above a certain critical level, there is a risk that the flame will enter the burner and migrate upstream. Steps must therefore be taken to ensure that the efflux velocity does not fall below a certain level, even at low heating outputs.

Gas-air composite system for 100 percent hydrogen

ebm-papst is working on a new operating concept to prevent flashback. Since economical and equally durable alternatives to ionization technology have yet to be found for the electronic composite system, a pneumatic solution makes the most sense as of now. The pneumatic composite system is usually set for a specific fuel-air ratio when it is installed. However, the system does not provide any information on the mixture flow rate entering the burner. In order to reli-

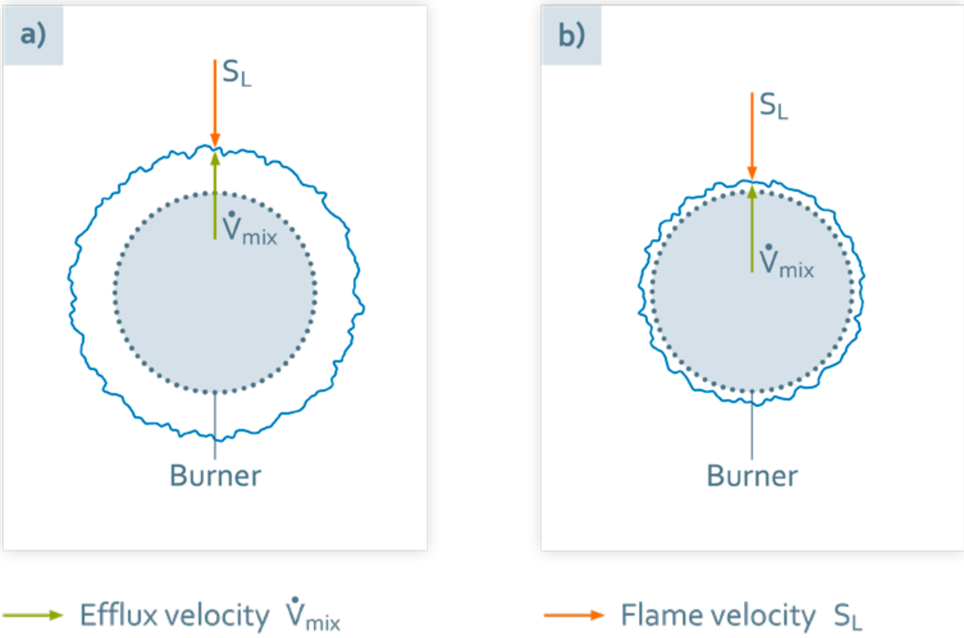


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FIGURE 3: **At full power (a), the efflux velocity and flame velocity are equal. The flame stabilizes at a sufficient distance from the burner surface. If the efflux velocity at low power (b) is too low, the flame may migrate into the burner and a flame flashback may occur.**

ably prevent flashback during operation, it is important to precisely control the efflux velocity. ebm-papst is currently working on an electronic-pneumatic composite system that can do just that and is also prepared for the requirements, for example, by means of adapted startup behavior.

Ready for the future

It is difficult to predict exactly what the future of heating will look like. What is certain, however, is that hydrogen will play a significant role in enabling the global community to achieve its climate targets. For a transitional period, the admixture of about 20 percent to normal natural gas is likely. The components from ebm-papst are prepared for this application. And they will be, too, when 100 percent hydrogen flows into the boilers. ○

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