techmag

DETERMINING AND REGULATING AIR FLOW

Solutions and their technical implementation in fans

FAST COMMISSIONING, ENERGY-EFFICIENT OPERATION

EC centrifugal fans for filter-fan-units in cleanrooms

SYSTEMATIC CLEAN COMBUSTION

Complete systems for combustion control

WHICH PLANETARY GEAR IS THE RIGHT ONE?

Economical, quiet, or robust - the application is crucial here

Power fans for cooling electronics

Up to 50% more air performance

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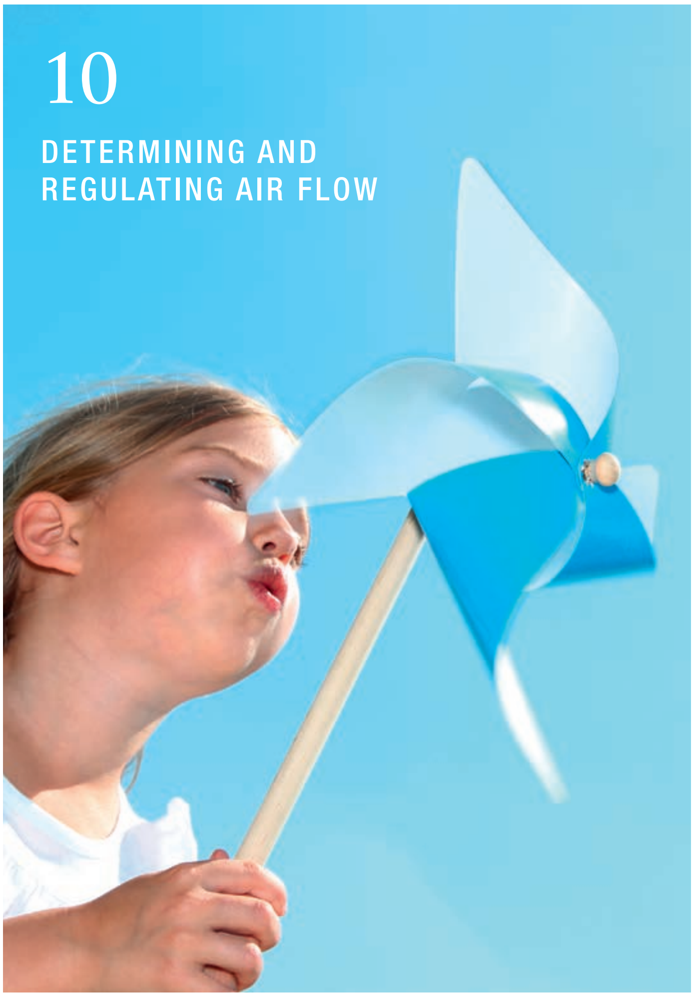


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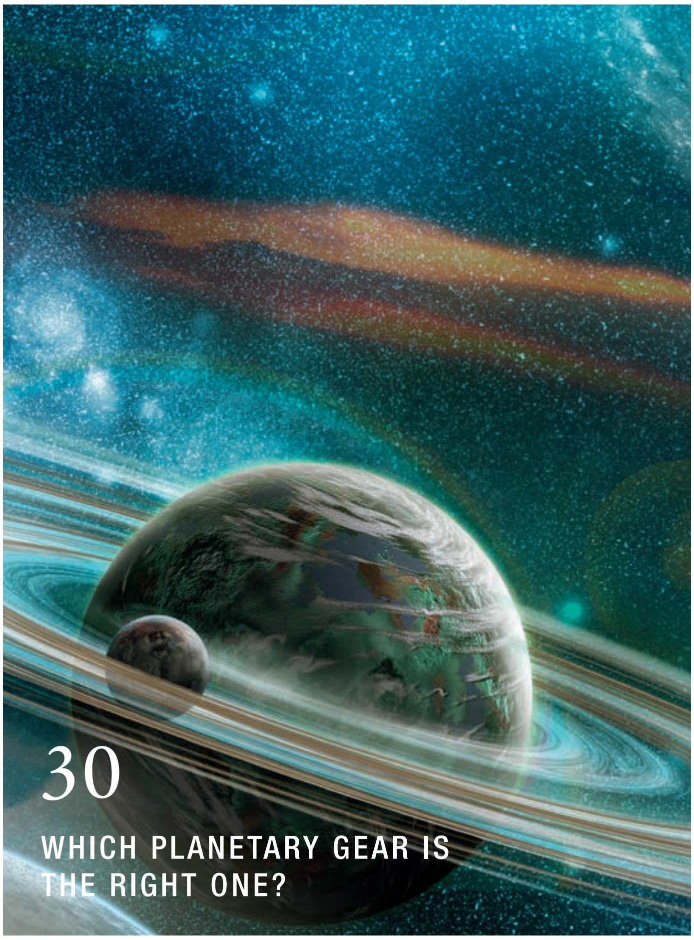

"We're setting new standards when it comes to power density!"

Rüdiger Hils

SALES DIRECTOR
COMPACT AIR TECHNOLOGY
EBM-PAPST ST. GEORGEN

Dear Customers, Partners and Friends of ebm-papst,

The opportunities afforded by the increasing use of digitalization are clear to see. However, the challenges associated with it are not always so obvious. After all, you also need a way of processing the increased amount of data produced every day – and the space for doing so is at a premium. Providing a reliable cooling system for the applications is essential for ensuring a smooth flow of data. Conventional ventilation solutions are increasingly unable to rise to this challenge. What we need are compact solutions that can dissipate large quantities of lost heat. We need compact champions when it comes to power density. Our St. Georgen, Mulfingen, and Shanghai sites have developed such a champion together with an important IT giant – the DiaForce.

The DiaForce is our future-proof, robust, and durable answer for making the most of the opportunities afforded by digitalization. With its concentrated power in a small footprint, it cools the heart of the IT infrastructure like never before, for example in data centers or in automation applications. The feature that makes all the difference is its unique geometry. It combines the best of a centrifugal and axial design in a single product – making it the most powerful fan in its power class, all while being up to 6 dB(A) quieter. Where previous axial compact fans used for electronics cooling – be they a single-stage or two-stage fan design – reach their limits, the DiaForce delivers 50 percent greater air performance than a conventional single-stage axial compact fan. As a result, we at ebm-papst are setting new standards when it comes to power density!

Have we piqued your interest? Then read the article about the DiaForce and the other exciting topics in this issue!

Up to 50% more air performance

Power fans for cooling electronics

The digital world is developing at a breathtaking pace; the electronics that process huge amounts of data are becoming increasingly powerful. However, due to the unstoppable increase in component density and ever increasing power throughput, cooling is becoming a challenge, both in telecommunications and automation. It's hardly possible to install more powerful fans or increase the number of them, as compact solutions are in demand and noise protection requirements must be complied with. A new compact fan from ebm-papst is a future-proof alternative, as it delivers up to 50% more air performance than conventional solutions. It generates less noise than fans of the same size with the same air performance. This enables more powerful electronics to be cooled at the same noise level.

FIGURE 1: **The digital world is developing at a breathtaking pace. However, due to the unstoppable increase in component density and ever-increasing power throughput, cooling is becoming a challenge.**

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Today, electronics cooling is mainly based on axial compact fans, especially because they are easy to integrate and deliver high air flow rates thanks to the principles involved. However, axial compact fans have their limits, for example if ever-more powerful electronics are housed in the same space or have to be made even more compact in telecommunications systems or data centers (Fig. 1, p. 5). To increase the cooling capacity, two axial compact fans are simply connected in series, which, in practice, is usually achieved using counter-rotating rotors. This kind of two-stage fan design results in a higher pressure in principle, but the system also has significantly higher noise levels. This means that it doesn't fulfill standards and guidelines for noise protection, such as those from NEBS (Network Equipment Building System), OSHA (Occupational Safety and Health Administration), ANSI (American National Standards Institute) or ETSI (European Telecommunications Standards Institute). Additional noise reduction is generally not an option, as it requires too much space and drives up the costs.

New development approach for a convincing solution

So the specialists at ebm-papst chose a new approach to develop a fan that delivers more power without being louder and yet is compact. The St. Georgen, Mulfingen and Shanghai sites pooled their expertise. In close consultation with a major electronics manufacturer, the DiaForce (Fig. 2) was developed, a new compact fan that can meet the future requirements of electronics cooling in all respects and

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FIGURE 2: **Compared to a conventional fan solution, the new DiaForce delivers up to 50% more air performance and also generates significantly less noise.**

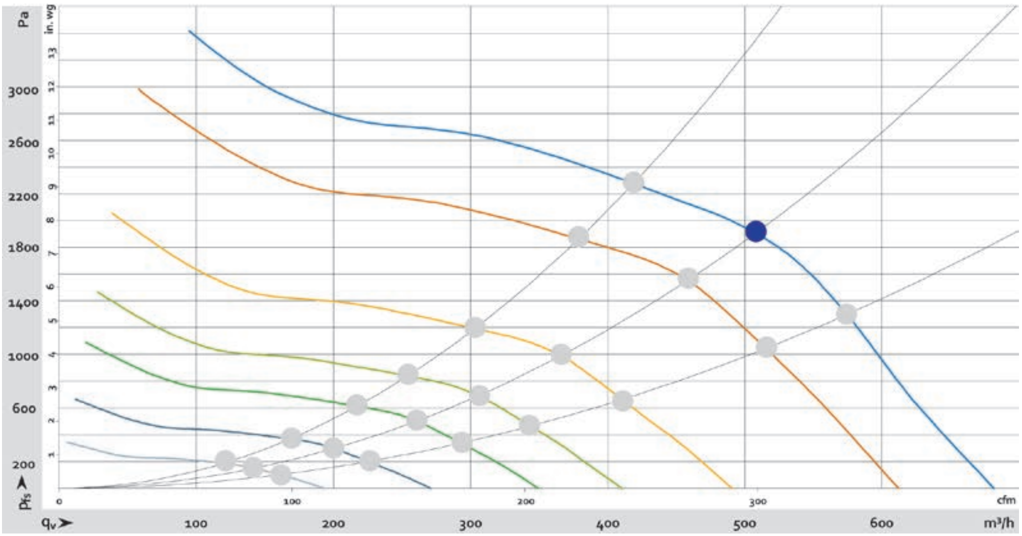

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FIGURE 3: **The typical pressure increase in the DiaForce: at the operating point marked blue in the example, the DiaForce reaches over 17,000 rpm with a power consumption of 516 W. This results in over 1,800 Pa in pressure and >500 m³/h in air performance.**

whose dimensions are the same as a conventional two-stage solution.

The concept behind the new development is convincing, but the DiaForce's secret lies in the unique geometry of its impeller and housing. This minimizes turbulence in the edge area, resulting in a significant reduction in noise. The fan impeller's outlet opening is also larger than the intake opening. This means that air flows through the fan in both an axial and radial direction, which ensures a high pressure increase (Fig. 3). Therefore, the DiaForce is characterized as being between an axial and a centrifugal fan. The basic axial design, which is cheaper to install, remains. A particular advantage in terms of aerodynamics is that the DiaForce offers an air performance curve with no dip. At the same time, aerodynamic optimizations make it the quietest fan with this power density (Fig. 4a, b and c, p. 8). The compact fan has up to 6 dB(A) lower noise emissions than a conventional axial compact fan and has up to 50% higher air performance. The higher air performance is often not required in normal operation, as fans that cool electronics often operate at partial load. However, a sufficient power reserve is crucial to ensuring that the electronics continue

The DiaForce's secret lies in the unique geometry of its impeller and housing.

to function sufficiently under conditions outside normal operation. For example, if the air conditioning in the room is faulty and the ambient temperature rises, there's enough of a reserve available to speed up the fan as required.

Powerful and intelligent DC motor

The developers have also taken an important step with the motorization. The driving force behind the compact fan is a three-strand, energy-efficient DC motor with a motor power of 500 W. The motor design is very compact and operates at high efficiency. The newly developed 500 W electronics have a lot to offer: a powerful microcontroller is at the heart of the intelligent motor regulation. It enables maximum possible torque in all load ranges and provides optimum efficiency and structure-borne noise. The integrated locked-rotor protection ensures safety. A configurable control input and various optional output signals are available as interfaces. Practical options include a signal go/no go alarm, an alarm with a speed limit, and an internal or external temperature sensor. The DiaForce is now available in size 120x120 x86 mm.

Intelligent maintenance concepts with FanCheck

The optional FanCheck function also enables intelligent maintenance concepts to be implemented: Fans are usually replaced unexpectedly when they fail. If the fans cool electronics that have high availability

FanCheck function continuously calculates the statistical service life based on the actual operating conditions.

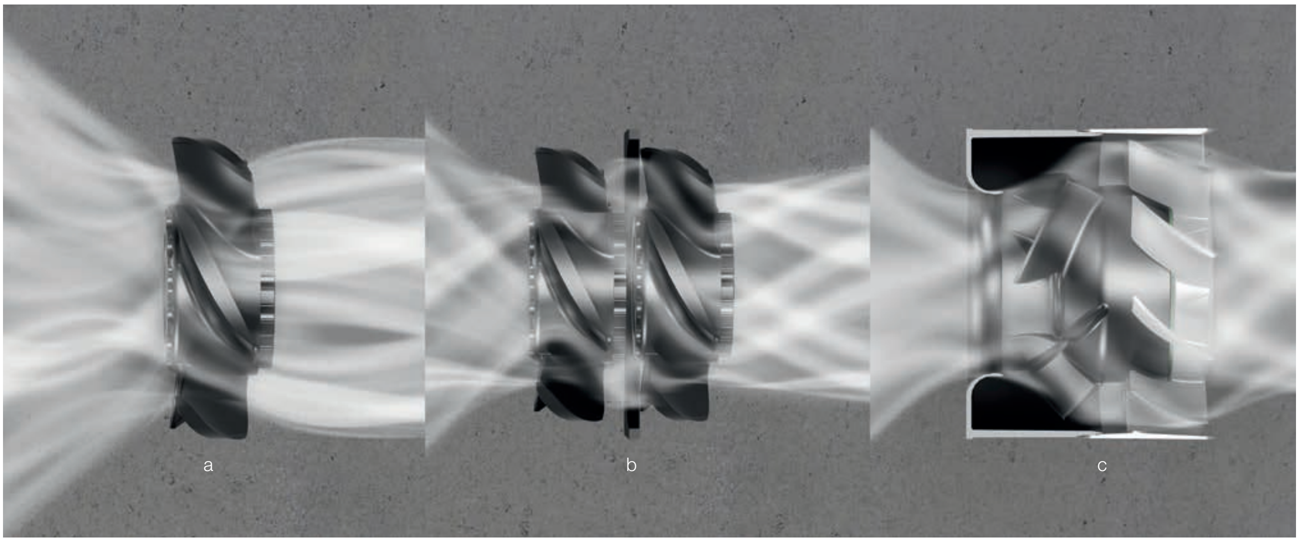

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FIGURE 4: **A direct comparison between a single-stage axial compact fan (a), a two-stage axial compact fan (b) and the new DiaForce diagonal compact fan (c).**

requirements, such as in data centers or mobile communication base stations, they have to be replaced very quickly. Some service concepts also stipulate that all the fans in the system have to be replaced if this happens. This often leads to significant outlay because of material costs and because service technicians have to travel to installation sites. The FanCheck function from ebm-papst solves this problem and continuously calculates the statistical service life of the fan during operation based on the actual operating conditions. This allows the replacement process to be planned cost-effectively and enables reduced replacement costs. In addition, it increases the availability of the devices. The customer can specify at which time and in which way the fan is to provide status information or warnings. It can monitor the remaining service life closely or trigger a simple alarm when the remaining service life goes below a previously set value. In this way, FanCheck can be easily integrated into existing control systems. This means that there's nothing standing in the way of "intelligent" and high-performance electronics cooling, as set out by GreenIntelligence, for information and communication technology in future.

GreenIntelligence

When it comes to choosing the right drive or fan, it's not just product characteristics, such as energy efficiency and performance values, that are crucial but also the intelligence and communication options that have been implemented. Examples of GreenIntelligence solutions for ventilation and drive technology include data acquisition using internal and external sensors, data processing, intelligent regulation of high-performance motor control systems and options for integrating the system into networks. Thanks to condition monitoring, users can keep an eye on the operating parameters of their system at any time and carry out a better error analysis and optimization because the operating history is documented. Demand-oriented and predictive operation enables longer operating times, minimizing energy consumption and noise generation, and self-regulating at different operating states. Predictive maintenance allows needs-based service work to be planned so that longer service intervals and high availability can be achieved with a low number of downtimes. ○

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Solutions and their technical implementation in fans

Determining and regulating air flow

Adjusting the air flow of a fan to the actual demand enables significant energy savings and noise reduction in practice. First of all, this applies to the fan itself; in many applications such as air-conditioning systems, this also has a positive effect on the energy requirements of other system components such as heaters, coolers or humidifiers. For energy-saving and quiet ventilation, it should therefore be possible to regulate the air flow of the fans used in ventilation, refrigeration, and air conditioning systems as precisely and efficiently as possible to a specified setpoint. Depending on the fan type and area of application, different methods can be used.

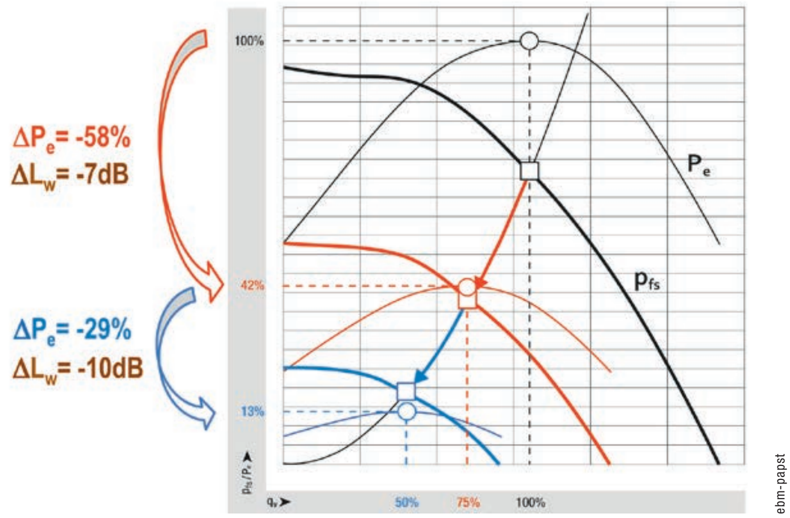

FIGURE 1: **Demand-based adjustment of the air flow enables significant energy savings and noise reduction.**

In many applications, regulation of the air flow to a specified setpoint offers the possibility of significantly reducing energy consumption and noise emissions (Fig. 1). In addition, application-specific and regional legal requirements must often be complied with, e.g. for ventilation of residential buildings.

Specifications for residential buildings

For example, DIN 18017-3 applies to exhaust fans in windowless bathrooms and toilets. According to this, the exhaust air flow may change by a maximum of 15% at a pressure difference of +/-40 Pa or +/-60 Pa. In individual ventilation systems with a common exhaust air line, a reduction in the exhaust air flow of the lowest unit of a maximum of 10% is permitted when operating all units. This is intended to ensure that the exhaust air flow changes as little as possible in the event of external wind forces acting on the building envelope.

There are similar legal requirements for decentralized ventilation of individual rooms or for central residential ventilation units with heat recovery. DIN EN 13141-8 applies to decentralized systems. Here, the units are divided into three quality classes depending on the resulting change in air flow at a pressure difference of +/-20 Pa (Fig. 2). In the case of central ventilation systems, the exhaust air flow must always be higher than the intake air flow according to the DIBT approval (German Institute for Construction Technology), but the excess exhaust air may not exceed 10%. Satisfactory values can only be achieved here if the air flow of the fans used in the application can be precisely determined and regulated as needed by adjusting the speed.

Methods compared

In principle, there is wide range of physical measuring methods for determining a volume or mass flow rate; however, not all of them are suitable for gases and therefore for fans. Magnetic-inductive measuring methods or those based on Coriolis force are ruled out, for example, as they only work with electrically conductive media or the forces generated with gases are much too small. Mass flow measuring meth-

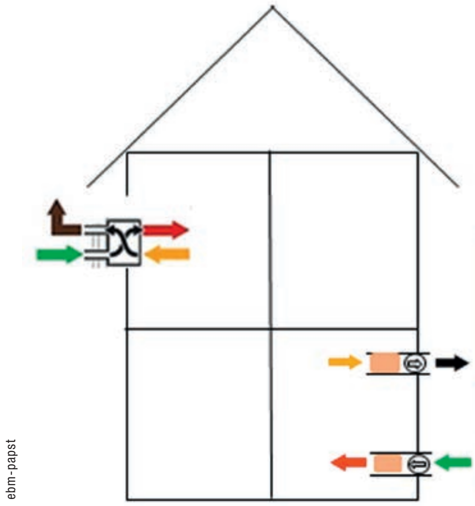

FIGURE 2: **Specifications in DIN EN 13141-8 for decentralized ventilation systems with heat recovery.**

Class	Maximum deviation of the air flow from the highest air flow value	
	at + 20 Pa	at - 20 Pa
S1	≤ 10	≤ 10
S2	≤ 20	≤ 20
S3	≤ 30	≤ 30

from DIN EN 13141-8:2011-09

ods with thermal sensors are, in principle, suitable for fans, but only under laboratory conditions, as the thin measuring wires are very sensitive.

Other measuring methods are highly accurate and robust, but relatively expensive to implement and therefore more suitable for test rigs. On an ultrasonic flow meter, two offset detectors record the transit-time difference of two ultrasonic waves proportional to the average flow speed (Figure 3, left, p. 14). Alternatively, flow speeds can be recorded using a vane anemometer or using a vortex generator according to the vortex principle (Fig. 3, right, p. 14). On a vortex generator, the shedding frequency of the vortices proportional to the flow speed is detected. In the case of the anemometer, the speed and air flow are proportional.

What is practical?

Things that are possible in principle do not necessarily turn out to be practical. Speed measurements can be used in the inflow or outflow of a fan in all fan types and the relatively small sensors do not cause any relevant pressure losses. In many applications, however, the additional costs for the sensors, their installation, and the effects of aging or contamination present substantial obstacles. In addition, flow

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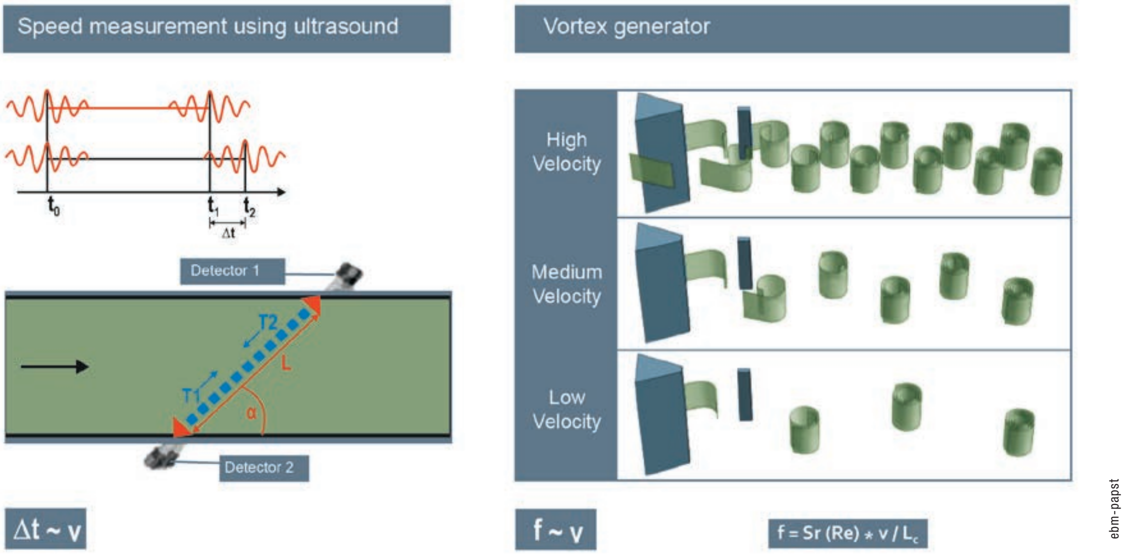

FIGURE 3: **Left: speed measurement using ultrasound; right: vortex generator.**

speeds measured "locally" – i.e. in one place – require precise knowledge of the operating point or installation-dependent speed distribution in the cross-sectional area through which the flow passes or corresponding unit-specific calibration to determine the air flow.

On the other hand, volume flow control systems based on measuring the pressure drop or pressure difference are now found relatively frequently in air conditioning systems or ventilation units (Fig. 4). A sensor is also required here for pressure measurement. However, in many cases the measuring points can be applied in such a way that the speed is not measured purely locally, but instead that enables at least an approximate "integral" measurement of the air flow to be taken via the pressure signal. In addition, there are normally no additional pressure losses and the processes are relatively independent of the inflow and outflow and the operating point. The greatest disadvantage of the pressure drop or pressure difference methods is that the measuring accuracy at low air flows is significantly reduced by the quadratic relationship between air flow and pressure. In addition, there are application-specific problems: for example, if the pressure difference across a heat exchanger or filter is used in a residential ventilation unit, the measuring signal is heavily dependent on contamination and bypass flows.

The measuring accuracy at low air flows is significantly reduced by the pressure drop or pressure difference methods.

Sensorless control

If there is a clear relationship between power consumption and air flow at a constant speed, an operating point can be determined by measuring the motor current and the speed. These characteristic curves are only found for forward-curved centrifugal impellers. The term "sensorless" control is often used in the context of electronically commutated blowers because only internal motor variables are used and no external pressure or speed sensors are required. Various ebm-papst blowers use sensorless control integrated into the electronics for constant volume control (Fig. 5, p. 16). To determine the operating point, this relies on a blower-specific and, in some cases, also unit-specific calibration polynomial. However, the relationship between power consumption and air performance which is cubic in the first approximation leads to significantly increasing control inaccuracies, even in this approach at low air performances. In addition, a change in the air density results in an error in air flow determination.

Efficient solution for backward-curved centrifugal fans

In the case of backward-curved centrifugal fans, sensorless air flow determination is not possible due to their characteristic curve. For this highly efficient fan design, the flow

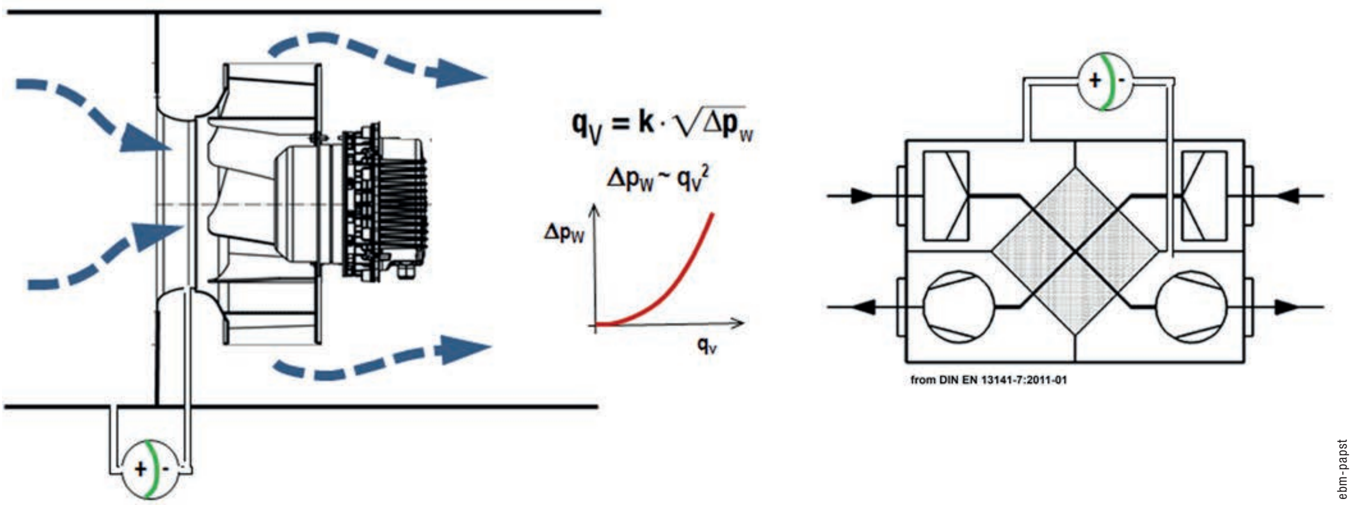

FIGURE 4: **Left: pressure difference measurement at the inlet nozzle of a centrifugal impeller in an air conditioning system; right: pressure drop measurement in a residential ventilation unit.**

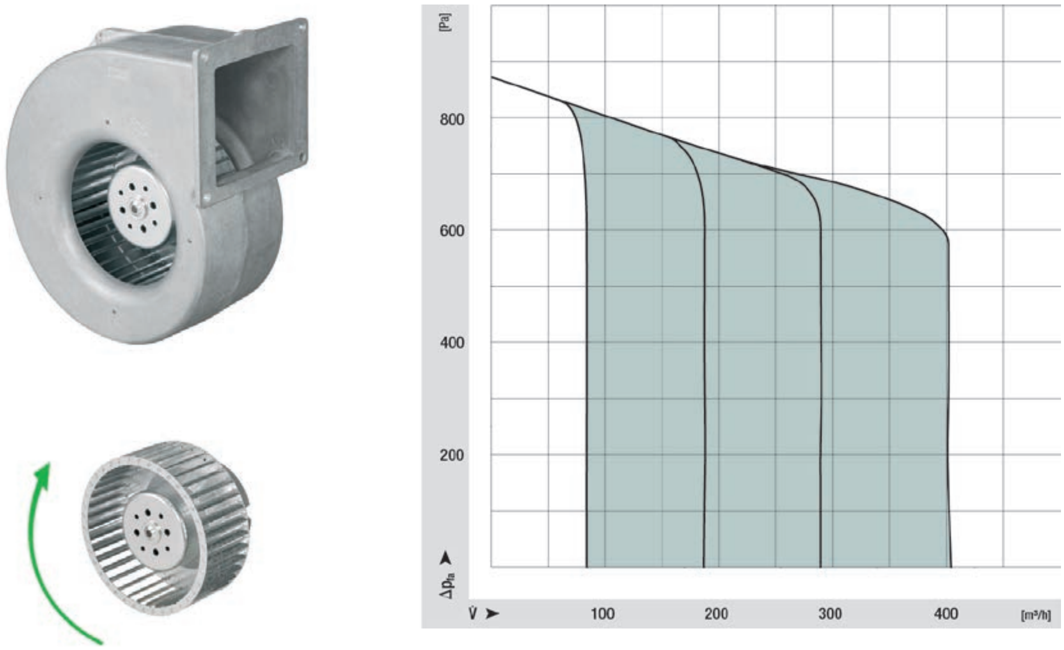

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FIGURE 5: **Sensorless constant volume control of a forward-curved ebm-papst centrifugal fan.**

specialists at ebm-papst have developed a ready-to-install plug & play solution: a vane anemometer positioned in the outlet nozzle of the scroll housing (Fig. 6). It continuously records the actual air flow without significant pressure losses or additional noise. The data is transferred to the integrated central control electronics of the fan. This adjusts the speed of the EC motor to the desired setpoint and regulates the air volume of the blower to the specified setpoint regardless of air density influences. As the speed of the vane anemometer is no longer quadratically, but only linearly dependent on the air flow and the speed of the EC motor is used as an additional internal correction variable, very high control accuracy can still be achieved even with low air flows. In addition, determination of the operating point is barely negatively affected by the effects of installation through recording the entire air flow.

With this very robust and fully integrated constant volume control, an extremely precise and efficient solution can be achieved over the entire control range. For residential ventilation units, this means, for example, balanced supply and exhaust air flows all year round. On the one hand, this prevents the unwanted supply of cold outside air; on the other hand, this prevents warm room air flowing outwards in winter through leaks through the building envelope, cooling down and thus creating condensation in the outer walls. The additional impeller does not result in any air performance losses or disruptive noise, meaning that the overall performance of the fan remains unchanged. Even contamination is not a problem, as has been demonstrated in tests under extreme conditions with dust and increased air humidity. ○


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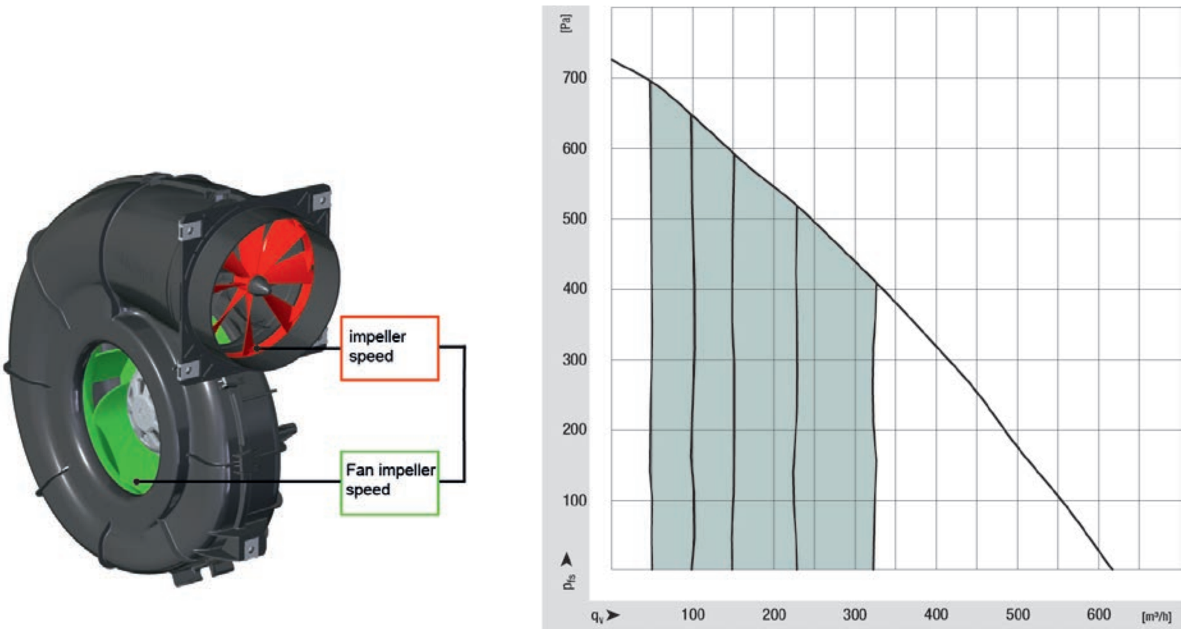

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FIGURE 6: **Constant volume control of a backward-curved ebm-papst centrifugal fan with vane anemometer.**

Complete systems for combustion control

Systematic clean combustion

ebm-papst

Modern and efficient heating technology plays a crucial role in the energy revolution succeeding. With CleanEco and CleanVario, ebm-papst has two complete systems for combustion control in its portfolio which make an important contribution to a clean future. This not only benefits the environment, but also manufacturers, installers – and of course end users.

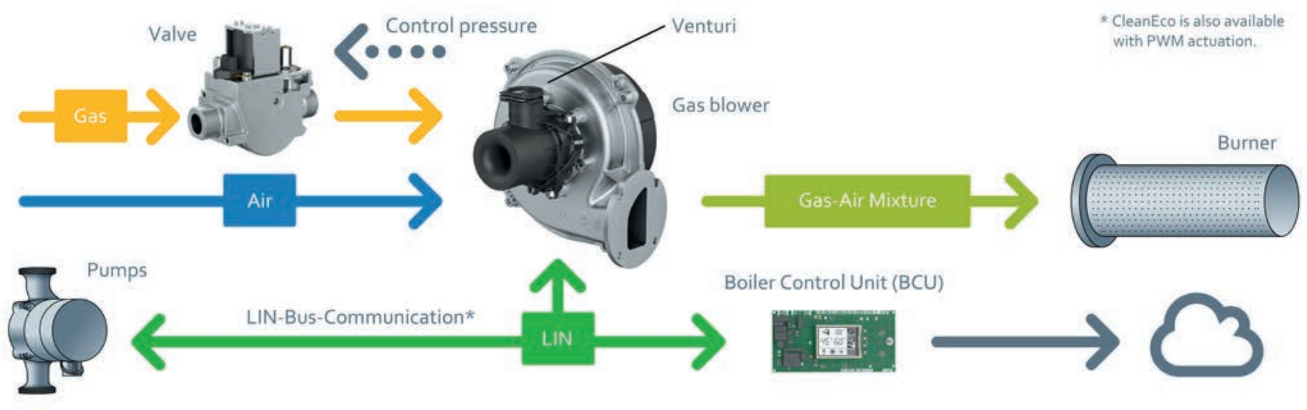

FIGURE 1: **Functional diagram of CleanEco pneumatic combustion control.**

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When it comes to a carbon-neutral future, most people talk about solar energy or wind energy. But there is another sector here that uses a lot of energy and has a negative impact on the global carbon footprint: heating. In Germany alone, this item accounts for more than 25 percent of total energy consumption; in private households, the share is even 90 percent. In addition, around 12 million heating systems are older than ten years in this country alone, and these therefore often have an unsatisfactory energy footprint. From a global perspective, the need to catch up is most likely even greater. In other words, if the energy revolution is to succeed, we need a heating revolution. The now well established energy-efficient gas-condensing technology, which has been continuously developed and refined over the past 20 years, makes an important contribution to this.

Combustion is crucial to the efficiency of these condensing units. The energy yield is only perfect with an optimum mixture ratio of air and gas. An excessive proportion of gas leads to harmful emissions such as soot and carbon monoxide, for example, and too much air reduces the efficiency of the combustion. It is therefore crucial that the components of the gas-air composite system are perfectly matched. In this regard, pneumatic combustion control has proven itself in practice for years. As a future-proof alternative, the electronic combustion control system is added to this. In the long term, it may even replace its pneumatic sister. Until then, however, both systems will run in parallel on the market. ebm-papst offers both variants as a complete solution for use in condensing units in residential buildings up to 150 kW: CleanEco (pneumatic) and CleanVario (electronic).

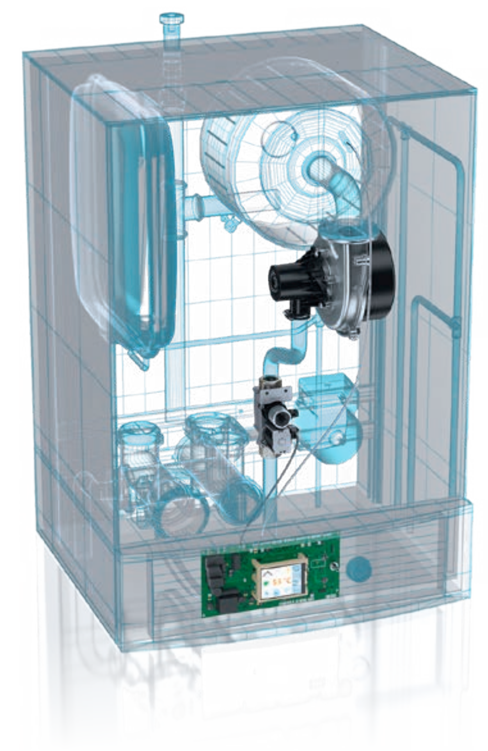

FIGURE 2: **CleanVario electronic combustion control.**

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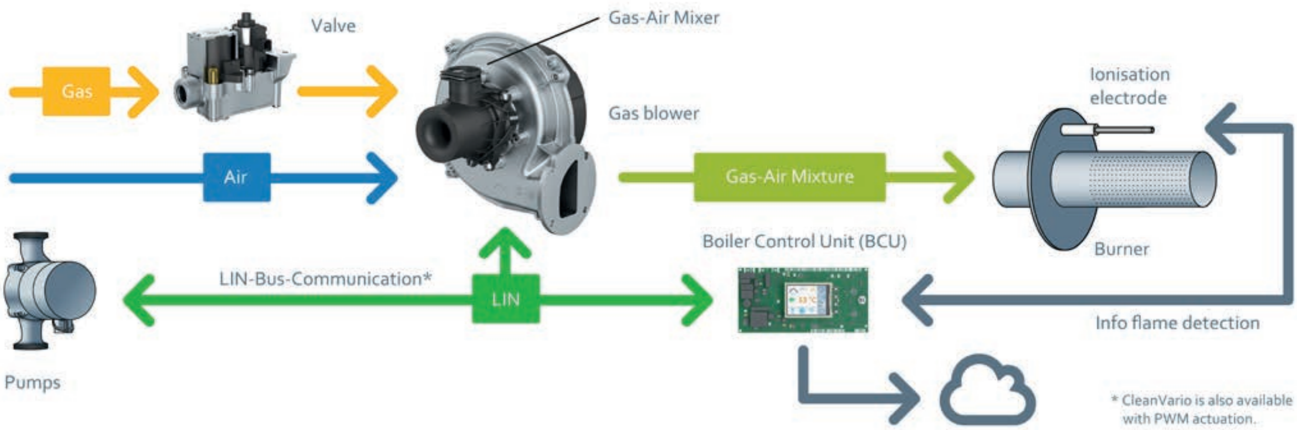

FIGURE 3: **Functional diagram of CleanVario electronic combustion.**

CleanEco: robust and tried-and-tested

The CleanEco pneumatic composite system consists of a blower, venturi, gas valve, and the control unit (boiler control unit – BCU (Fig.1). The principle: The blower draws in the air, a vacuum is created by the tapering of the venturi, which controls the gas supply via the valve. When correctly adjusted, this results in the optimum mixture of oxygen and fuel. The gas-air mixture remains stable regardless of counterpressure and changed exhaust gas resistance. Over the years, the engineers at ebm-papst have optimized the system so that modulation levels of 1:10 are now possible, meaning the output of the boiler adapts much more precisely to the demand actually required. But even though the pneumatic composite system is tried and tested and robust, it depends on a constant gas quality, as the valve is precisely set to the relevant type of gas fed in at the site of the installation.

CleanVario: a flexible system

And it is precisely here that a major change is happening. Looking at Europe makes this clear. Large gas fields, such as in the Netherlands, are almost depleted and new sources need to be found. This also includes alternative fuels. In addition to natural gas, in future hydrogen, liquid gas, or biomethane from power-to-gas plants will also flow through the pipes. This means that the condensing units of the future will have to react flexibly and have to deliver constant performance despite these fluctuations. A system is therefore required that is gas adaptive. The answer to this challenge already exists: the electronic gas-air composite system which goes by the name CleanVario at ebm-papst (Fig. 2).

When looking at the components, there is initially no major difference. There is still a blower, venturi, control unit, and gas valve here, but their interaction is different (Fig. 3). The mixing ratio is not controlled here by the vacuum but by electronic actuation of the gas valve. The gas valves in CleanVario therefore have a stepper motor which is used to regulate the feed precisely. But to ensure that the valve knows how much gas it is to provide for mixing with the air, it requires a parameter that signals when the mixture is perfect. In theory, the ideal mixture of fuel and air for complete combustion is a combustion ratio of $\lambda = 1$. If the value is below one, the oxygen content is too low; if it is greater, then it is too high. But how do you measure whether the combustion is running optimally? The best way is the flame itself.

The flame is crucial

For CleanVario, ebm-papst relies on so-called ionization technology. This utilizes the fact that the flame is electrically conductive. If a voltage is applied, an electrode can measure the so-called ionization current directly on the flame. This can be used to draw conclusions about the combustion quality. If the current is too weak, the valve receives the signal to supply more gas; if it is too high, it restricts it (Fig. 4). This enables the combustion to be controlled independently of the fuel. The system can thus automatically adjust to the gas type without any changes to the valve, and provide clean combustion. This

THE BEST OF BOTH WORLDS

Advantages with CleanEco

– Tried-and-tested and robust system for years
– Stable gas-air mixture regardless of back pressure and changed exhaust gas resistance
– High modulation up to 1:10
– Fast power modulation
– Adjustable excess air values over the entire modulation range
– Monitoring of hygienic combustion by flame signal monitoring

Advantages with CleanVario

– Clean combustion over the entire service life
– Reliable start and operation of the burner
– Flexible gas-air ratio in terms of time and over the entire modulation range
– Automatic gas family detection and adaptation to installation conditions
– Simple installation
– Suitable for all known combustion gases and admixtures of up to 30 percent hydrogen
– Continuous combustion monitoring enables improved diagnostics and predictive maintenance
– Greater flexibility in boiler design

COMPLETE SYSTEM FROM A SINGLE SOURCE

With both CleanEco and CleanVario, manufacturers get a perfectly coordinated complete system consisting of a boiler control unit (BCU), gas valves, venturis, and gas blowers. ebm-papst covers four performance classes with its product range: 2 – 35 kW, 4.5 – 50 kW, 9 – 80 kW and 15 – 150 kW.

now also works if up to 30 percent hydrogen is added. However, the major challenge here is to measure the ionization current precisely, as it is in the microampere range. The developers at ebm-papst have therefore put a lot of expertise into the flame amplifier, which, as its name suggests, strengthens the signals received by the sensor. It is important that interference signals, such as mains hum, are filtered out in the process.

Intelligence for the future

But without intelligent software, the data obtained would be worthless. For both pneumatic and electronic complete systems from ebm-papst, the intelligence is located in the boiler control unit (BCU), the central control unit. It regulates all electronic safety and control functions of condensing boilers. In the case of the CleanVario electronic system, it can collect and evaluate the data obtained from continuous combustion monitoring in order to ultimately optimize the unit‘s operation in the sense of a self-learning system, in the spirit of GreenIntelligence. During the next start, for example, the stored switch-off states can be used to quickly reach optimum start conditions. The electronic composite system also offers a major advantage in terms of predictive maintenance, as a lot more information about operation is available. For example, an increasingly small flame signal indicates that the electrode on the flame has to be replaced.

Everyone benefits

With CleanVario, manufacturers have the greatest possible flexibility. When it comes to boiler design, there is more leeway for developers because the valve can be installed in the unit regardless of position. Since the units are gas adaptive, this is not just an advantage with regard to fluctuating gas characteristics. Serving global markets is also much easier, as the gas valve no longer needs to be adapted to the specific conditions of the respective country. It is also much easier for installers because they simply have to install the unit without any time-consuming configuration. The end customer ultimately has a unit that provides clean and reliable combustion over its entire service life. That just leaves the environment. If modern gas condensing units are used extensively, the chances are good that we can meet the set climate objectives, too. CleanEco and Clean-Vario can help with this. ○

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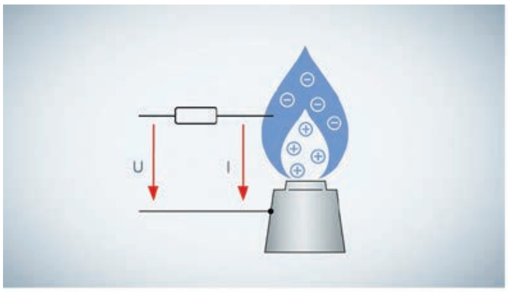
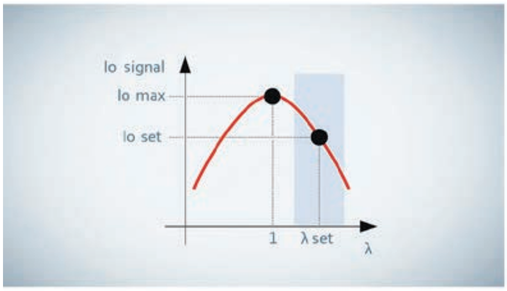
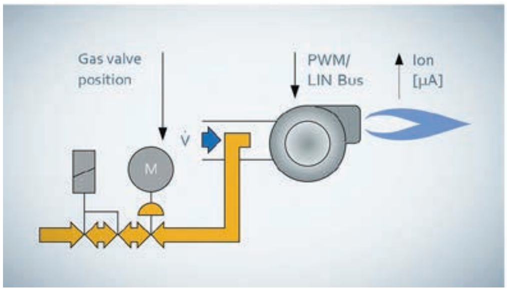
HOW IONIZATION TECHNOLOGY WORKS



During combustion, electrons are released. If you apply the electric voltage U, an electric current I flows through the flame – the “ionization current”. The level of current depends on the combustion.



The ionization signal is at its highest with complete combustion, i.e. at a combustion air ratio of $\lambda = 1$. Automatic calibration determines the ionization value for the desired air ratio range.



The data obtained goes to the boiler control unit, which controls the blower and the valve according to the required combustion power.
The combustion is regularly checked by the ionization current to regulate the gas flow.

FIGURE 4: **The ionization principle**

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EC centrifugal fans for filter-fan-units in cleanrooms

Fast commissioning, energy-efficient operation

Cleanroom conditions are now mandatory for many production processes, not just in semiconductor production. Typical examples include optical and laser technology, aerospace technology, biosciences, medical research and treatment, the production of food and pharmaceuticals, and nanotechnology. Cleanrooms have particular requirements when it comes to their ventilation systems. These requirements include sufficient air throughput and pressure, precise control of temperature and humidity, as well as a constant air purity achieved by filtering out even the smallest impurities. Filter-fan-units (FFUs) designed for ceiling installation combine fans with filter technology, making it possible to optimally fulfill these requirements. But there is another important criterion, especially in large cleanrooms: if several hundred or even several thousand FFUs are in use, commissioning should be carried out quickly and easily. New areas of application for individual FFUs are currently emerging. These are based on purging aerosols from the air with filter technology, thus reducing the virus load, e.g. in classrooms.

FIGURE 1: **The air supply in a cleanroom is not usually a standalone solution. Instead, it is integrated into the entire automation process and its PLC and SCADA systems. Just like all other sensor and actuator information, the fans in the FFUs also have to be integrated into the network group.**

Wachendorff / Exyte

Operating cleanrooms with FFUs is the most economical option to ensure a clean air supply. At the core of these FFUs are compact, modular, built-in fans that are as flat as possible, meaning that they require little installation space, and work with high energy efficiency. However, integrating the systems into a network is also becoming increasingly important. The air supply in a cleanroom (Fig. 1, p. 25) is not usually a standalone solution. Instead, it is integrated into the entire automation process and its PLC and SCADA systems. Just like all other sensor and actuator information, the fans of the FFUs have to be integrated into the system network, and their status information must be provided to the controls and visualization systems. The initial commissioning of a cleanroom system requires a significant output of time and money. Based on user reports, the time required to manually connect an FFU data point is around five to ten minutes. The more fans there are in use, the more potential there is to make savings. The fan and motor specialist ebm-papst has responded to this and offers EC centrifugal fans, which are specially designed for installation in FFUs and have a digital MODBUS RTU interface, with automatic addressing, which can significantly reduce commissioning costs (Fig. 2).

MODBUS RTU with automatic addressing

A master/slave-based bus always requires unique slave addresses. The fans are usually delivered with an address that is preset in the factory, which is always the same (e.g. slave ID = 1). Therefore, the addresses must be assigned a unique address during commissioning for operation in the network group, preferably in the order of the MODBUS cabling.

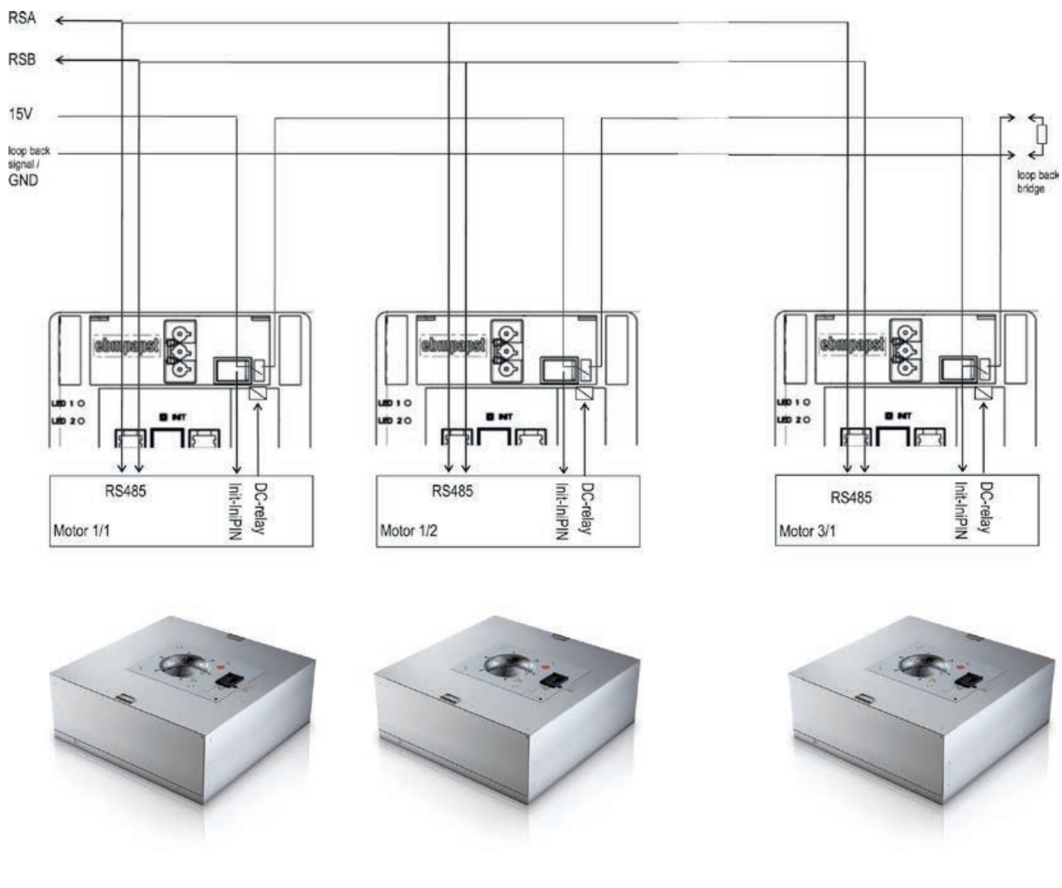

FIGURE 2: **Fans with a MODBUS daisy-chain interface (DCI) can be addressed automatically by the master via a hardware signal. This makes commissioning proceed much more quickly.**

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FIGURE 3: **The fans from the RadiCal product range are particularly well-suited for use in filter-fan-units.**

The master controller is able to manage the complete addressing procedure along with the localization of the FFU devices.

This time-intensive process is now automated using "DCI" (daisy-chain interface) addressing.

A fan equipped with a DCI is addressed by a hardware signal (15 V/24 VDC) via the Init pin on the RJ45 network plug, and thus temporarily becomes slave address 247. Only the unit activated in this manner "listens" to messages sent to this DCI address 247, and accepts a new MODBUS address sent by the master controller to this slave. Following successful re-addressing of this fan, its DCI relay is switched on and the hardware signal (15 V / 24 VDC) is switched on to the Init pin of the next fan module in the chain. This fan is now activated via the hardware signal (Init pin) and the addressing continues as described above. If the cable diagram is known, the position of the fan unit in the cleanroom ceiling can be determined using the order of the addresses or the cable route. The installation location can be identified using the order in which the addresses are allocated. Manual assignment is no longer necessary; the master controller is able to manage the complete addressing procedure along with the localization of the FFU devices which are installed in the cleanroom ceiling. There is a significant reduction in the time and costs for commissioning.

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FIGURE 4: **The EC fans can be easily integrated into the FFU. They are supplied as ready-to-connect systems, which have been tested at the factory.**

Energy-efficient and quiet

Once put into operation, the energy efficiency of the fans becomes an important matter. Nowadays, FFU manufacturers have to guarantee overall efficiency levels of at least 50% in cleanroom applications at the design point. Therefore, there is a great demand not only for fans that are as flat as possible, but also for fans that work energy-efficiently. EC technology therefore has a lot to offer cleanroom technology, as FFUs equipped with it can achieve efficiency levels of well over 50%. EC fans can also be used to meet strict noise emission requirements. RadiCal centrifugal fans lend themselves particularly well for this purpose (Fig. 3), as their impellers have been optimized according to aerodynamic criteria. They therefore contribute to a significant noise reduction of up to 7 dB(A) compared to the conventional industry standard, which human hearing perceives as half as loud. The quiet and energy-saving fans are available with diameters of 250, 310, 355, and 400 mm, and cover air performance levels in the ranges of 580, 1,170, 1,750, and 2,330 m^3/h, with a back pressure of up to 250 to 300 Pa. Thanks to their external rotor design, they are very compact and above all extremely flat, at a height of 190 to 275 mm, meaning that they can be easily integrated into the equally compact FFUs.

Impellers made of plastic composite materials have already been successfully introduced for use in many cleanroom environments, and have proven effective. Nevertheless, ebm-papst has had the relevant materials tested for cleanroom compatibility in an external laboratory. The fans in the RadiCal product range were examined thoroughly for substances that are prohibited in cleanroom operation, and evaluated according to the standards of the semiconductor

Thanks to a wide voltage input, the EC fans are suitable for international use.

industry. They passed the corresponding tests with flying colors, as the materials used are harmless, as is the outgassing process. This means that in cleanroom technology too, users can benefit from the energy-saving, innovative design of the plastic impellers. After all, plastic offers a much wider range of design options compared to sheet metal materials. As a result, the design of the whole fan leads to improved air flow through the impeller, which significantly increases aerodynamic efficiency.

Wide voltage input with active PFC

The EC fans can easily be integrated into the FFUs (Fig. 4). They are supplied as ready-to-connect systems that have been tested at the factory, either as EC centrifugal fans with a cable and connector panel, or as fully assembled fan installation modules complete with nozzle plate, motor support plate, profile struts, and guard grill. Thanks to a wide voltage input, they are suitable for international use with a wide variety of line voltages and line frequencies. The standard active PFC (Power Factor Correction) prevents the permissible harmonic limit values from being exceeded during the parallel operation of many EC fans, which would otherwise put a strain on the supply network. All energy distribution components such as network transformers, fuses, switches, and cable cross-sections can be designed to be much smaller and more cost-effective due to the active PFC. Additional external harmonic filters are not required. But it is not only in large cleanrooms where users are well-served by EC centrifugal fans. ebm-papst also offers suitable components and system technology for FFU operation and monitoring for smaller cleanroom cabins. O


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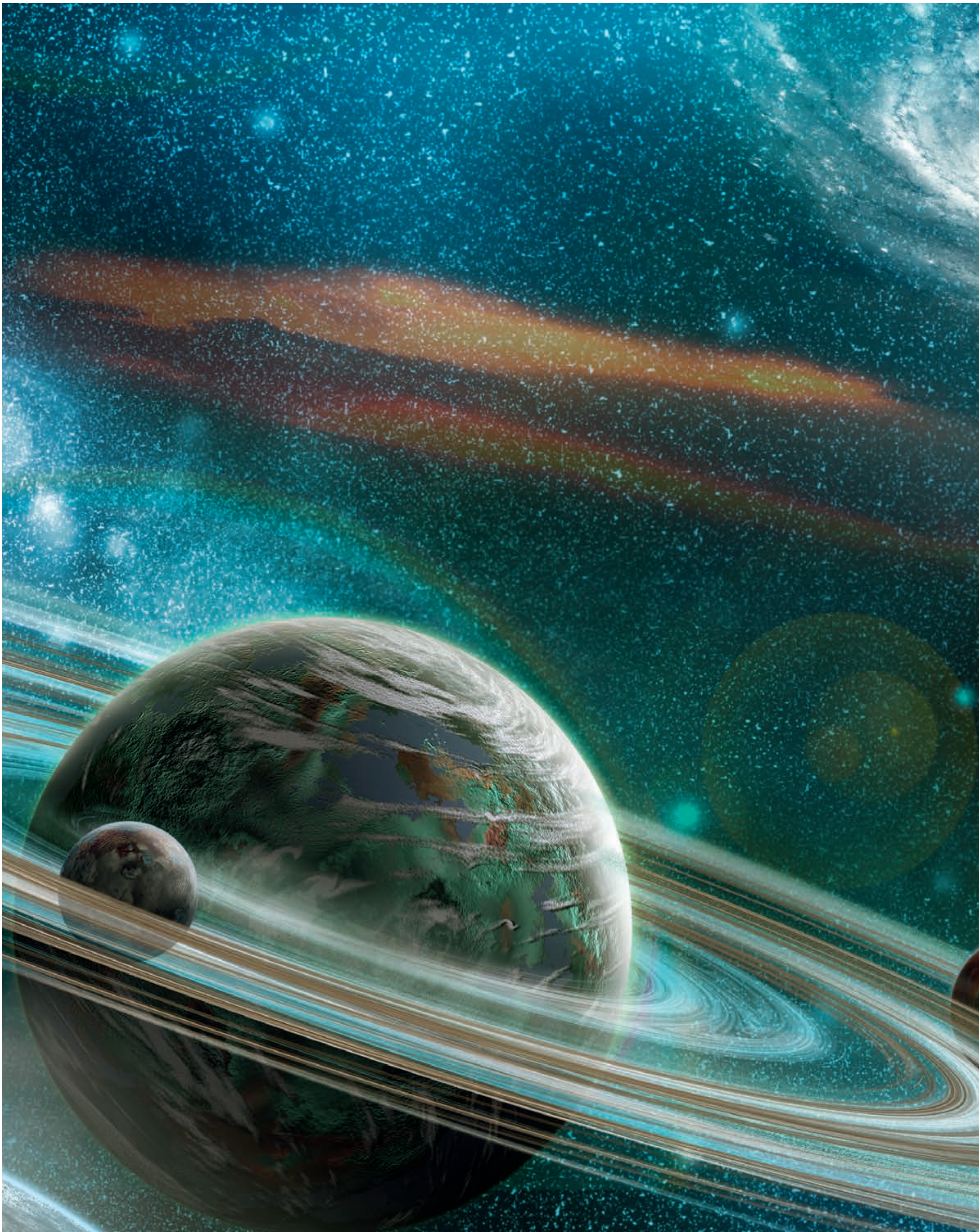
CLEANROOM TECHNOLOGY FOR AIR-PURIFIERS

We are currently seeing an emergence of entirely new fields of application for cleanroom technology devices and suppliers that specialize in the prevention and dilution of particle concentrations in rooms. After all, this is precisely what is required for preventing and diluting aerosol concentrations that cause, for example, virus loads in classrooms. This virus load can be reduced through air recirculation using the same filter technology as in cleanrooms. The indoor aerosol concentration is reduced by separating aerosols in the HEPA filter during recirculating air operation. Noise generation is also important to this field of application, as it determines the acceptance of the air purifiers. ebm-papst's quiet fans and the expertise of cleanroom device manufacturers make practical solutions possible here. After all, it is vital to clean the classrooms so that they are free of particles, thus minimizing the virus load.



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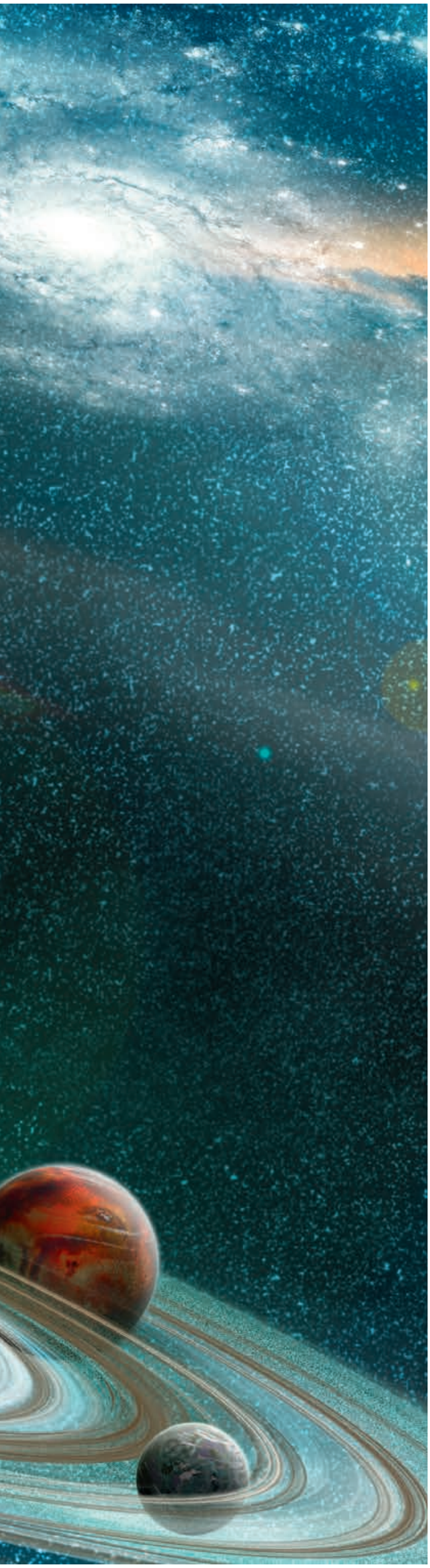

Economical, quiet, or robust - the application is crucial here

Which planetary gear is the right one?

When planets rotate around the sun, drive technology engineers and machine builders inevitably think about planetary gears – as here several planetary wheels roll between a ring gear and a centrally mounted sun gear. This design offers the advantage that, even with a compact design, high torques can be transmitted due to the load distribution across several planetary wheels. The drive and output shafts are in alignment, so there is no offset. With corresponding experience and sophisticated manufacturing technology, planetary gears can also be adapted to different application requirements: They can be designed to be optimized in terms of cost, be particularly quiet, or also very robust.

To meet the wide range of application requirements, different planetary gears are needed.

Planetary gears have a wide range of applications. They can be found in equipment, conveyor, and medical technology, as well as in barriers, door drives, e-bikes or in packaging technology. With this variety of applications, it is clear that different planetary gears are needed to meet the wide range of application requirements. After all, even planetary gears are not an all-in-one solution. Drive specialist ebm-papst therefore has several models in its product range, as users always need a solution that fits their application perfectly and does exactly what is needed.

In planetary gears produced on the production lines (Fig. 1) in Lauf near Nuremberg, the range therefore extends from planetary gears optimized for "simple" applications according to economic criteria, to high-torque or particularly smooth-running variants, right up to highly robust solutions that also offer high overload capacity. Here, the different gear designs have a basic principle in common: Their modular design provides an unusually high number of different reduction ratios in close increments. The reduction ratios are designed in harmonized stages and are deliberately finer particularly when it comes to the area of low output power.

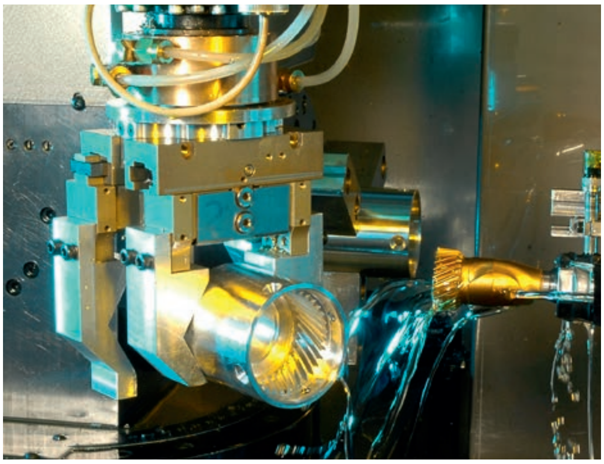

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FIGURE 1: **With corresponding experience and sophisticated manufacturing technology, planetary gears can also be adapted to different application requirements.**

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FIGURE 2: **Due to greater tooth widths in the input stage and the increased strength of the ring gear toothing made of hardened steel in the output stage, the PerformaxPlus planetary gear is particularly suitable for high torques.**

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FIGURE 3: **The compact Performax gears are all-rounders and impress with their high power density. Thanks to the reduction ratio of 17:1 in the first stage alone, it is also possible to use a single-stage gear unit where two stages would normally be required.**

For high torque

PerformaxPlus planetary gears (Fig. 2) are perfect, for example, for users who are looking for smooth, robust gear unit solutions for high torques. The gear design makes the best possible use of the available installation space: By using a radial screw connection for the individual housing components, a maximum effective diameter is available for the ring gear toothing. In contrast, solutions with an axial screw connection – as is otherwise common – limit the installation space available for the toothing so that only relatively small ring gear diameters are possible and therefore only limited loads can be transmitted. Due to large tooth widths in the input stage and the increased strength of the ring gear toothing made of hardened steel in the output stage, PerformaxPlus is particularly suitable for the high torques which are in demand, for example, in door technology and automation. At the same time, the steel housing ensures shock resistance. The optional HRL radial load stage can also be used to handle extra high radial loads, e.g. for belt pretensioning. Depending on the output speed, radial forces of up to 2,000 N can be transferred.

Compact all-rounder

The Performax planetary gear (Fig. 3) designed for "more simple" applications is also based on the radial screw design. It is therefore ideal for users who are looking for an efficient, economical gear solution, e.g. for use in medical rehabilitation equipment or conveyor technology. Helically toothed plastic impellers in the first stage ensure smooth operation, while the zinc die-cast ring gear in the second stage makes the production process economical. Thanks to the reduction ratio of 17:1 in the first stage alone, it is also possible to use a single-stage gear unit where two stages would normally be required. Instead of three, this gear unit works with reduction ratios up to 204:1 with just two stages. This saves space, increases efficiency, and also reduces costs.

Extremely smooth, quiet operation

In medical technology, there are many applications in which gear units need to be as quiet as possible, especially when the drives are operating close to the patient. Typical examples can be found in dialysis, on operating tables, or in diagnostics. Operation must be as smooth as possible here. The NoiselessPlus gears are a good choice in such cases. Their aluminum housing and the precise, noise-optimized helical toothing of the vibration-absorbing plastic impellers in both stages significantly reduce noise emissions. The noise level is load-independent even under extreme operating conditions and the double ball bearing of the output shaft means that even high radial loads do not reduce the service life. The single-stage or two-stage versions offer a wide range of reduction ratios from 4.33:1 to 231:1. Thanks to the machining of the housing during production, high flexibility is possible when it comes to customer connection.

Robust and powerful

Today, many industrial automation applications, as well as intralogistics applications, call for compact, powerful and simultaneously robust gear units (Fig. 4). Typical examples include shuttle vehicles or crossbelt conveyors. Here, the Optimax planetary gears, which are available in two sizes (Fig. 5), stand out. The larger variant, for example, offers peak torques of up to 150 Nm with an installation edge dimension of 63 mm and a length of just 102 mm in the 2-stage version. The finely coordinated reduction series ranges from 3:1 to 5:1 right up to 9:1 in the single-stage range. The two-stage version is available with reduction ratios 9:1, 15:1, 25:1 and 45:1.

Robustness is not only achieved by producing all gear tooth parts from hardened steel, but also by the design: Despite the small edge dimension, a very large ring gear diameter was realized, as the four axial fastening screws are placed in the corners of the square. Even high radial loads resulting from toothed belts or cams are not critical. The output stage has a very rigid design with two large ball bearings and thus offers a maintenance-free, calculated service life of up to 20,000 h in nominal operation with 500 N radial load. The gear units can be easily combined with 63 and 80-mm motors. For the smaller 42-mm motors, Optimax 42 is also a very robust, overload-resistant one or two-stage planetary gear, which is available with IP54 degree of protection as standard and rounds off the range.

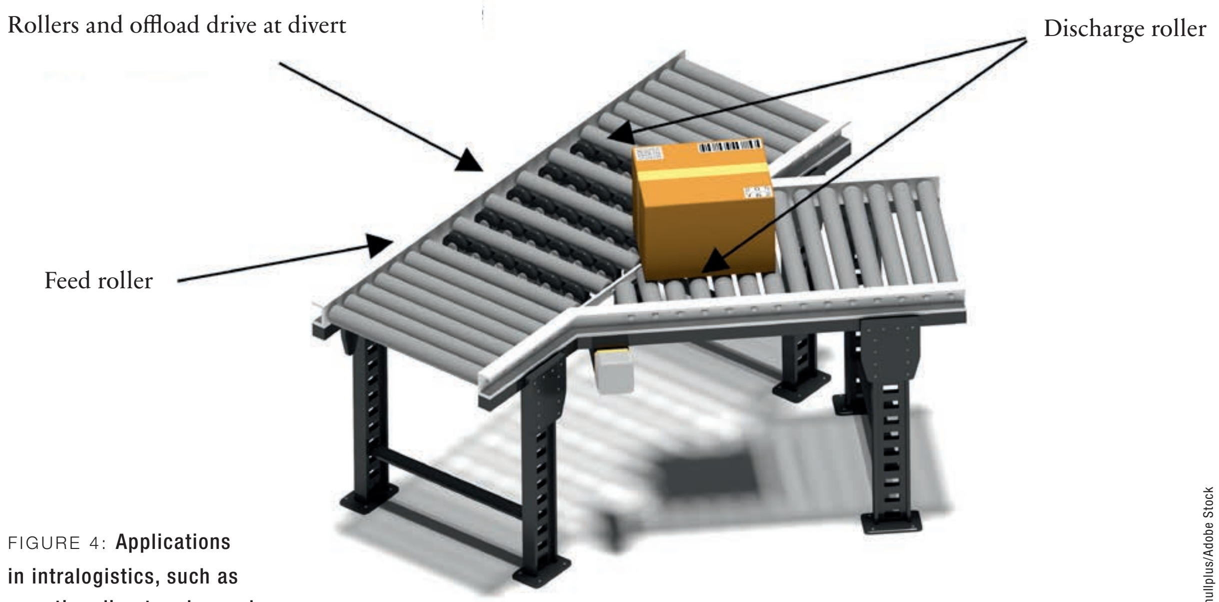

FIGURE 4: **Applications in intralogistics, such as a sorting diverter, demand compact, powerful and rugged gear units. Optimax planetary gears can stand out here.**

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Systematic drive solution

The planetary gears described are part of the sophisticated ebm-papst modular system and can be combined with all DC and EC motors. With the modern ECI motor families, for example, there is a wide range of dynamic motors, control electronics, gear units, and brake and sensor modules that can be combined to create a tailor-made drive. Individual complete drive solutions from a single source with perfectly matched components are therefore easy to realize and can be put together in the online portal, for example. Several thousand variants are possible in total. Defined preferred types are ready for shipment within just 48 hours, making them available unusually fast for sampling. O

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FIGURE 5: **Robust Optimax gear: All toothing parts are made of hardened steel and, despite the small edge dimension, a very large ring gear diameter was realized, as the four axial fastening screws are positioned in the corners of the square.**

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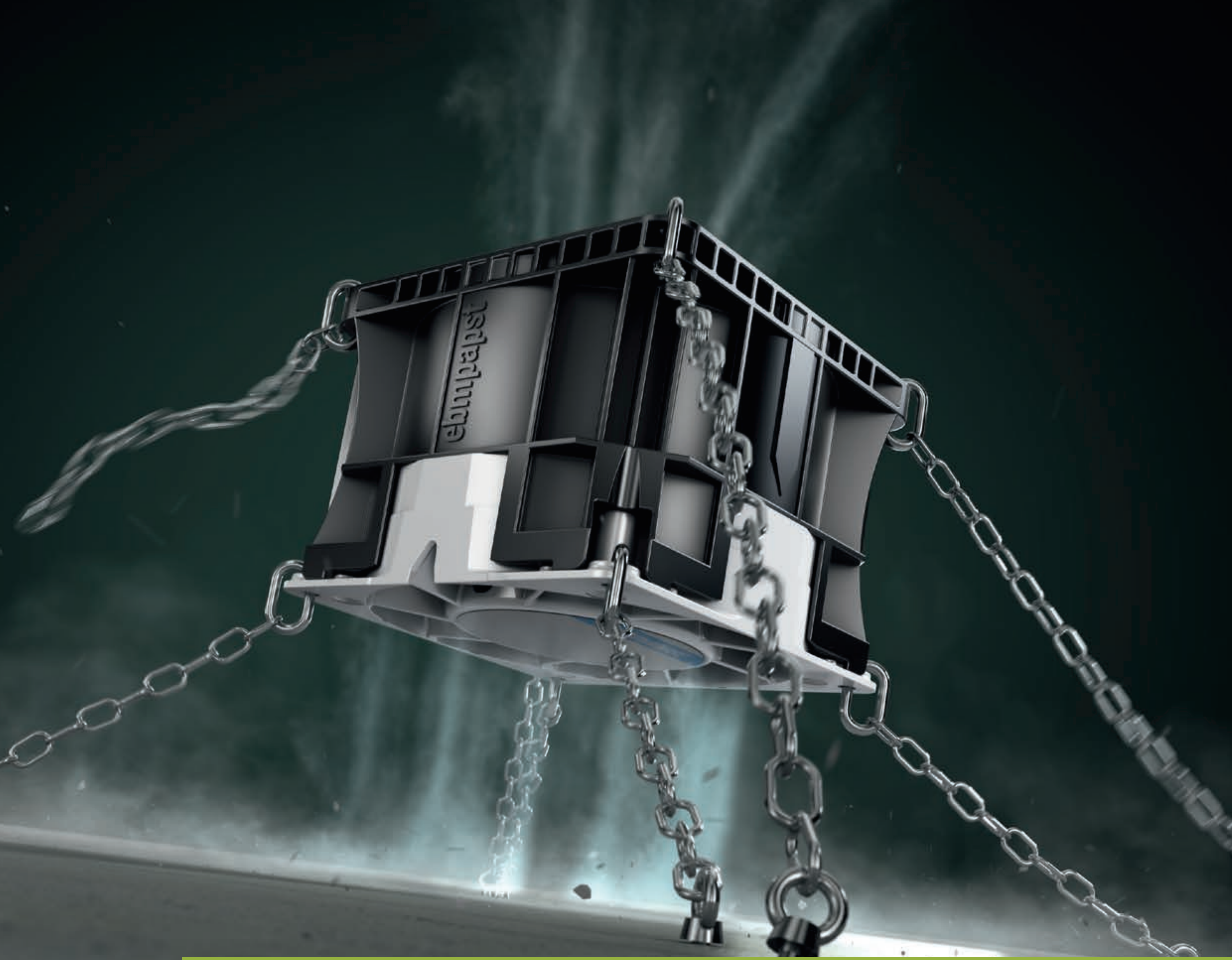
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