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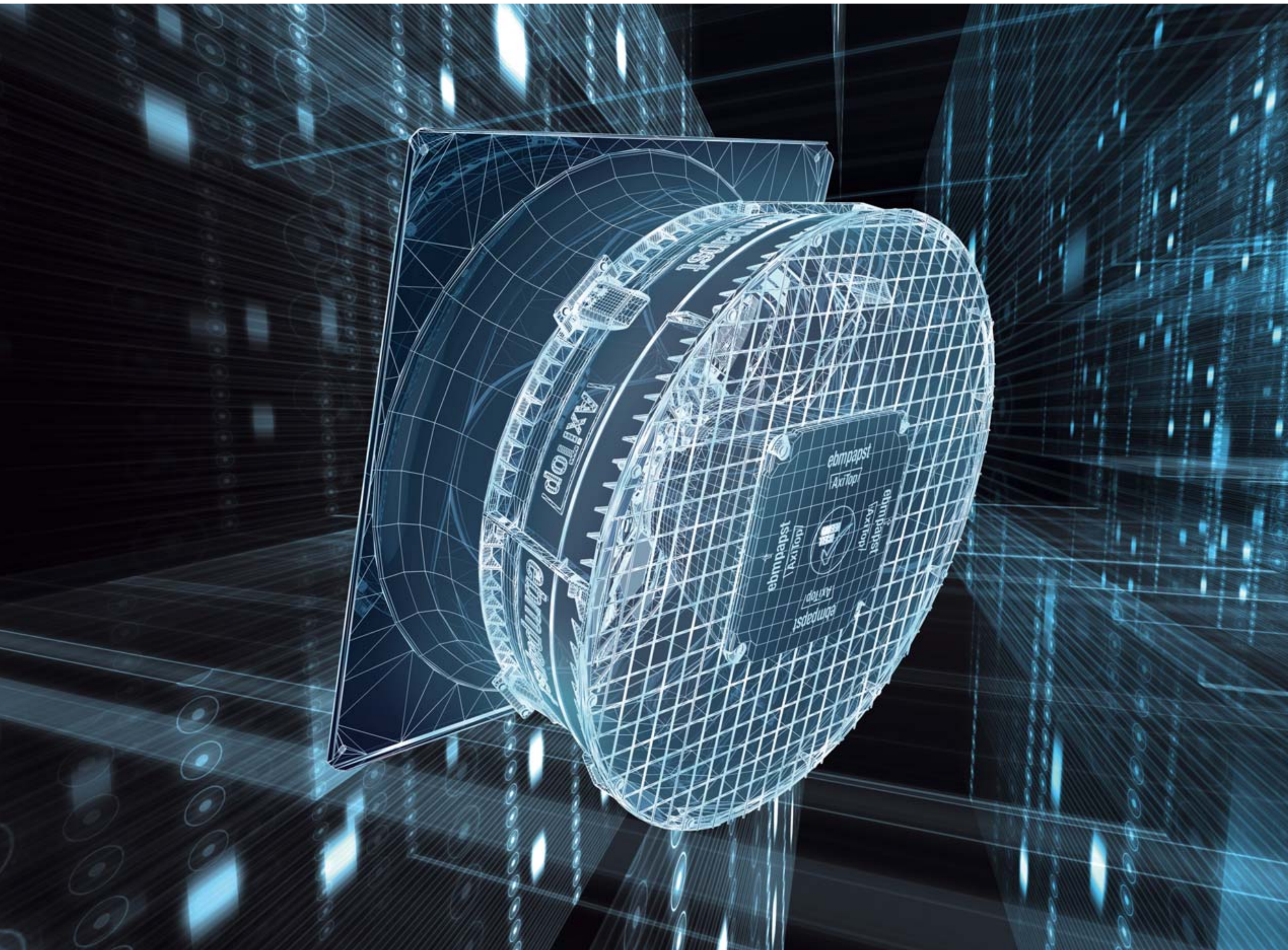
Technology by ebm-papst



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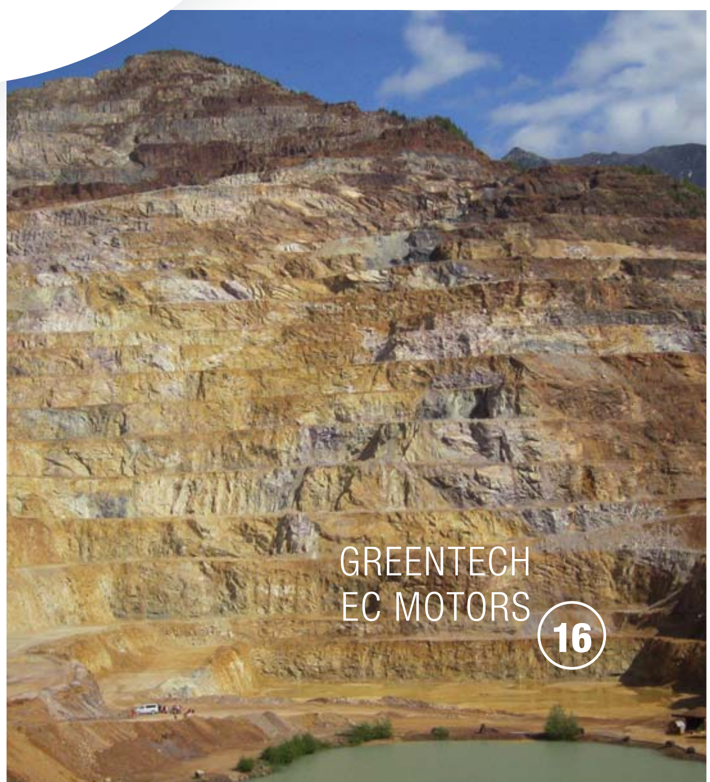


"Customer benefit – that is the basis of our product development"

Customer benefit – to present a benefit for our customers – that is the basis of our product development. An impressive example is the new AxiTop, which we present in this edition. The starting point for this development was the fact that only about half of the shaft power that is needed to drive a low-pressure axial fan that is common on the market is transformed into usable air performance. This portion of the shaft power thus provides the contribution to customer benefit. The other half is largely converted in an air movement, but has no advantage for the customer. Quite the opposite, this creates added noise, and energy is wasted unnecessarily. The solution is the diffuser. We call the product AxiTop. It converts the previously "useless" moving air at the fan outlet into another pressure increase. With that, the customer benefit is drastically increased: with the same usable air performance, the radiated noise and the performance consumed is greatly reduced. In other words: with the same axial fan and the AxiTop, a significantly higher air performance can be attained, and this with greatly reduced noise!

An entirely different customer benefit through our products is described in another contribution in this edition. High-efficiency electric motors depend on permanent magnets. A portion of the motors offered on the market fall back on so-called "rare earth materials" as material for the permanent magnet. This material today comes almost exclusively from China; through artificial scarcity created by throttling the supply, the price for this material increased drastically a little over two years ago. In the coming years, dramatic price fluctuations and an uncertain supply is to be expected. In this way, an important customer benefit of our EC motors in fans, such as those for the ventilation, refrigeration and air-conditioning industry, is demonstrated. Due to the external-rotor motor principle, we make do with "weaker"-magnets here, without decreasing the efficiency. Hard ferrites are used as a permanent magnet material. With that, our motors contain magnet materials that, to the benefit of our customers worldwide, will also be available without limitations at stable prices in the future as well.

Alongside these two, there are many additional examples of customer benefit from our products; you will find some in this edition. Have fun reading!

Dr. Jürgen Schöne,
R&D Director Aerodynamics and Motortechnology
at ebm-papst Mulfingen

Fans with a wear-free run-down brake

More safety and air flow, less turbulence and operating noise

Figure 1: The new fan with integrated ActionBrake is just as compact as the conventional models.

Fans are part of the standard equipment in almost all industrial facilities today. They cool, suction, regulate humidity and do much more. The benefit is plain to see, but compact dimensions and high blower output with low power consumption also bring some limitations to safety. A standard fan today runs at a relatively high speed. The fact that the bearings move easily means that the fan has a long run-down time when shut off. Since rotating parts always entail danger of injury, safety is guaranteed via guard grilles. These, however, cause aerodynamic disadvantages. A new approach that avoids these disadvantages with a greater level of safety is an active brake in the fan. If the fan gets switched off, the wear-free electronic brake reduces the run-down time to less than two seconds. The kinetic energy is quickly dissipated, thereby drastically reducing the risk of injury.

Rotating masses store energy. This property, which is desired in flywheels, becomes a source of danger in other rotors. This also applies to fans whose rotors transfer the energy of the motor to the air through blades. Large volumes of air can be moved at high speeds, even with compact dimensions. Simultaneously, however, the energy stored in the impeller also increases, and with it the potential hazard. For protection, the fan specialist ebm-papst from St. Georgen now provides - in addition to guard grilles - a new, aerodynamically better alternative: ActionBrake, the active brake integrated in the fan motor. In less than two seconds it reduces the speed to harmless values without requiring additional installation space or generating additional drag, as with a guard grille (Figure 1). By way of comparison, a standard fan without a brake requires 20 seconds to reduce the speed to harmless values.

State of the art of technology If a service technician switches a device off and opens it, the rotating rotors of the fans pose a substantial potential hazard. This applies particularly to modern compact fans, which operate at high speeds in order to overcome high counterpressure or to generate a large air flow. At the same

ActionBrake, the active brake integrated in the fan motor reduces the speed to harmless values in less than two seconds

Figure 2 (left): Clearly visible, guard grilles not only stand out visually, they also impede the air flow.

	with guard grille inlet side	single fan @ 8900rpm	with guard grille inlet side + outlet side
Overall Level	88.2 dB(A)/1pW	84.8 dB(A)/1pW	88.0 dB(A)/1pW

Table 3a: Comparison of Sound Power Level; Fans with and without a guard grille

Because of the integrated rapid braking the fan can operate at optimum efficiency

time, low-friction bearings operate in the fans to increase the energy efficiency and service life. Consequently, the energy stored in the rotor makes for long run-down times. If the rotation is suddenly stopped by an object or even a finger, the kinetic energy abruptly discharges. This leads to damage or, in the worst case, injury. To prevent this, regulations stipulate the use of protection against accidental contact with quickly accessible fans, in other words, guard grilles (Figure 2). Precisely with high-peformance fans, however, this negates a portion of the sophisticated aerodynamic properties. The grille generates turbulence and thereby noise and counterpressure, resulting in lower blower output. Thus the grille acts as an energy dissipator, like a gently and continuously applied brake. The higher speed here generates even more additional noise (Table 3a, Figure 3b).

Safety without external components The new approach proceeds from integrated rapid braking via the fan drive. This means that no more disruptive obstructions are implemented in continuous operation; the fan can operate at optimum efficiency. This also reduces installation effort and eases the installation. The principle behind the wear-free brake is simple as well as tried-and-tested: The motor becomes a generator and the generated current is then converted into heat. The technology offers various options for the design. Higher outputs require external brake resistors; small outputs use the motor windings as a brake resistor by means of a short-circuit switch. Therefore the fan experts were set the task of optimally designing the ActionBrake to meet the needs of the fans, while doing without external components wherever possible. Through a series of tests, the optimum variant was found to be the short-circuit switch for the motor windings. Initially in this case, however, very large currents can arise at high speeds by means of the induction. This means that the windings have to endure a high but short-term heat load, and the control transistors have to be designed for these pulse currents. Additionally, high currents in coils always means there will be a strong (counter) magnetic field. Thus there is a danger of the magnets in the rotor demagnetising. These problems are solved by a suitable selection of components and configuration of the magnets. Therefore the brake lifting magnet operates as reliably and as long as usual.

If the operating voltage is switched off, the electronics enter the braking mode. In doing so, they draw their power supply from the loaded filter capacitor. If the voltage decreases, the capacitor is recharged by short charging pulses from the "brake generator". This is done to maintain the function, and thus the activation of the short-circuit transistors of the electronics, until the rotor

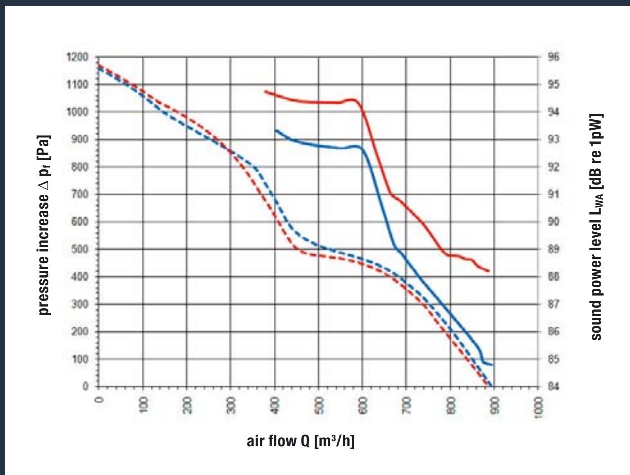


Figure 3b: Comparison of characteristic curve; Fans with and without a guard grille

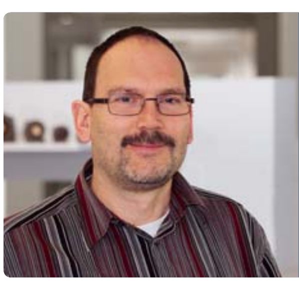
LEGEND

- *air performance / single fan*
- *performance with fingerguard*
- *acustics single fan*
- *acustics with fingerguard*

comes to a standstill. To do so, the brake short circuit is temporarily disconnected. With a typical fan, this enables braking times of under three seconds. The inner heat capacity of the components and the maximum braking energy then produce a temperature level that reliably lies below the maximum operating temperature of the components used. This ensures long-time operation that is free of malfunctions and maintenance.

The new active braking upon switching off the power supply at the fan opens new options to the user. In short, the brake lifting magnet brings a whole series of benefits all at once: elimination of guard grilles and their installation, which translates into less noise, better output and lower costs by means of lower power consumption. Also in terms of logistics, the lower number of parts is a noticeable plus. Thus the new brake lifting magnets save time and money while maintaining the level of safety. ○

The new brake lifting magnets save time and money while maintaining the level of safety



Author is Dipl.-Ing (Graduate Engineer) (FH) Frank Heller, Development Engineer for Hardware, Basic and Technology Development at ebm-papst St. Georgen

You would like more information on this topic? Please address your question to: Frank.Heller@de.ebmpapst.com

AxiTop – Less noise and more efficiency

New diffuser reduces exit losses in fans

For refrigeration and cooling equipment, the heat generated in the circulation process has to be transferred to the ambient air via a heat exchanger. To accomplish this, fans move cool air through a heat exchanger and allow the heat to dissipate. There is a whole range of options for designing and configuring especially efficient, quiet and durable fans. A new, passive component, the so-called diffuser, provides for a substantial improvement in efficiency and noise. Its pressure-boosting effect minimises exit losses and makes it easier to adapt the fan to commercially available heat exchangers.

Ventilation and air-conditioning units usually run in continuous operation, or at least with long operating cycles. That make maximum economy with the input drive energy important, for every additional watt costs money and impacts the environment. For that reason, energy efficiency is an important criterion when choosing a fan. Today, statutory stipulations also play a role. The efficient use of energy and resources is and will remain a global objective for the decades ahead. In Europe, the first tier of the ErP Directive became effective as of January 1, 2013. Against this background, it is no wonder that ultra-efficient EC technology is increasingly replacing conventional AC technology as the fan drive of choice due to its greater efficiency.

Exit losses – the underestimated "energy guzzlers" Energy-efficient and quiet operation of the complete fan is a function of both the motor and the impeller, which the fan uses to move the air volume needed to create the cooling air flow through the heat exchanger. Aerodynamic expertise is needed when designing the impeller, for example to avoid separations and backflows which would cause both energy loss and unwanted noise. Even today, the impellers employed in the GreenTech EC fans satisfy the most demanding standards. But there is another point which has to be taken into account when considering the efficiency of a fan:

The inherent exit loss for fans with unimpeded airflow is often an underestimated energy guzzler. Figure 1 (page 10) shows the power flow of the input drive power P_o for an axial fan with unimpeded airflow. The drive power P_o is split into static blower output (P_{us} = product of the air flow and static pressure increase of the fan), which is of use to the user, and various losses caused by

The new diffuser AxiTop reduces energy consumption and is easily retrofitted

the conversion into this useful power. The largest loss factor in the process is the dynamic output component (P_{ud}) of air performance, which is also known as exit loss. This is made up of the product of air flow and dynamic pressure. The motor and fan manufacturer ebm-papst has now picked up this issue and has developed a new kind of diffuser, the AxiTop. Replacing the conventional guard grille of the fan by the AxiTop diffuser (Fig. 2, page 10) significantly reduces losses at the air outlet. Efficiency increases while operating noise is reduced at the same time. In principle, the diffuser works like a reverse nozzle, as follows:

Dynamic energy converted into static pressure Every medium is only able to absorb a certain amount of heat energy for each degree Kelvin. The possible temperature difference and the amount of heat to be expelled define the cooling air flow required. This air volume has to be delivered by a fan through the heat exchanger under consideration. To do this, a pressure differential is necessary which is sufficient to overcome the flow resistance of the exchanger. Normally, the delivered air flows at high speed from the exit side of the fan and dynamic pressure (p_{fd}) dissipates into the environment. Dissipation means that the kinetic energy of the flow is converted into turbulence and then due to friction into heat that

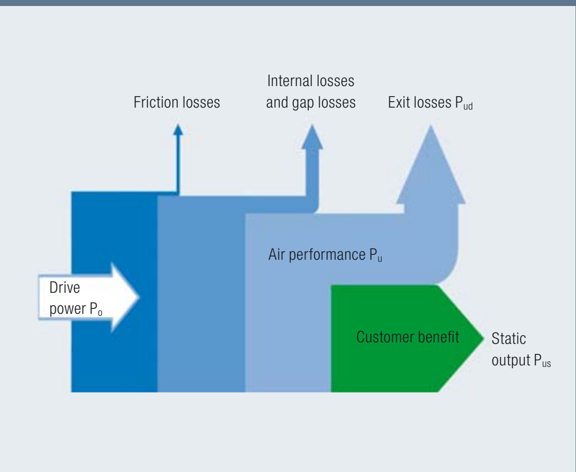


Figure 1 (left): Power flow of an axial fan with unimpeded airflow

Figure 3 (right): The AxiTop diffuser allows part of the dynamic pressure to be converted into useful static pressure by retarding the flow.

LEGEND

- p_f
- p_{fs}
- p_{fd_cges}
- p_{fd_cax}
- p_{fd_cu}
- Start of diffuser
- End of diffuser

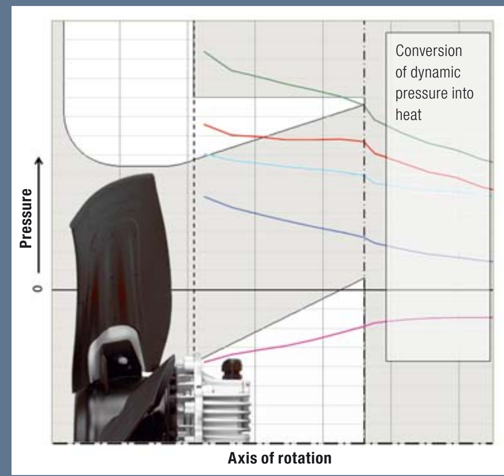


Figure 2: The AxiTop diffuser from ebm-papst provides for a significant improvement of efficiency and noise. Its pressure-boosting effect minimises exit losses and makes it easier to adapt the fan to commercially available heat exchangers.

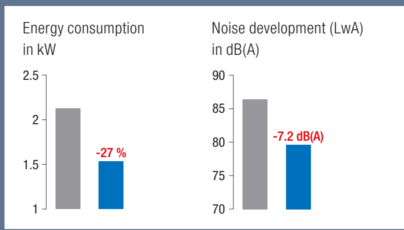
is often no longer technically utilised. With the AxiTop diffuser, much of the dynamic kinetic energy is converted into static pressure (p_{fs}) by way of retardation. Physically, this is easy to explain: The total pressure generated (p_f) by a fan is the sum of the static pressure pfs and the dynamic pressure p_{fd_cges}. In turn, taking the density r into account, the dynamic pressure can be split into three speed components (cylinder coordinates), the axial component $p_{fd\_cax} = \rho/2^*c_{ax}^2$, the circumferential component $p_{fd\_cu} = \rho/2^*c_u^2$ and the radial component $p_{fd\_cr} = \rho/2^*c_r^2$.

In the diffuser, the axial and circumferential components of dynamic pressure ($\rho/2^*c_{ges}^2$) are reduced due to the air slowing in the expanding cross section and, due to the conservation of energy (Bernoulli´s principle), the usable static pressure component increases (see Fig. 3). Efficiency can be significantly increased in this way if all components are co-ordinated to be aerodynamically optimised.

In practice, the use of the AxiTop diffuser does not just mean lower energy consumption; it also means greater degrees of freedom for the user and for the development engineer. The diffuser configuration can be optimised for different characteristics, depending on the application concerned. Either a greater blower output is possible with unchanged energy input, or unchanged air performance is possible with lower energy consumption. A diffuser can also greatly improve the noise behaviour. This acoustic improvement is especially interesting when fans are working is a noise-sensitive environment, for example in overnight operation in ventilation and climate control systems in residential buildings or in rooms where people meet and where there are also noise protection regulations to be fulfilled.

Significant potential to be exploited The potential of the possible energy savings, increased efficiency and noise reduction provided by an optimal diffuser is substantial for common heat exchangers on the market. This has been confirmed in extensive test series. Figures 4a and 4b illustrate a specific example. Replacing a normal fan with a guard grille with the same fan with a support bracket, guard grille and diffuser allows savings of 27 % for energy consumption while enabling an operating noise level 7.2 dB(A) lower with the same air flow (see Fig. 4a).

Alternatively, if the greater efficiency of the fan with differ is exploited, it will deliver about 9 % more air flow with the same input power, and at the same time noise emissions will be reduced by 4.9 dB(A) (see fig. 4b). This value has been determined on an exemplary customer application. Depending on the individual configuration, the optimised efficiency can be used either to reduce power input or to increase air performance. So



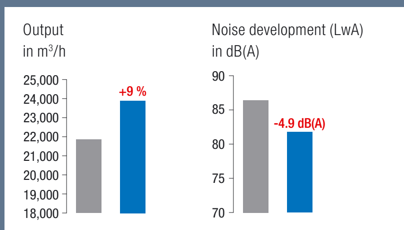
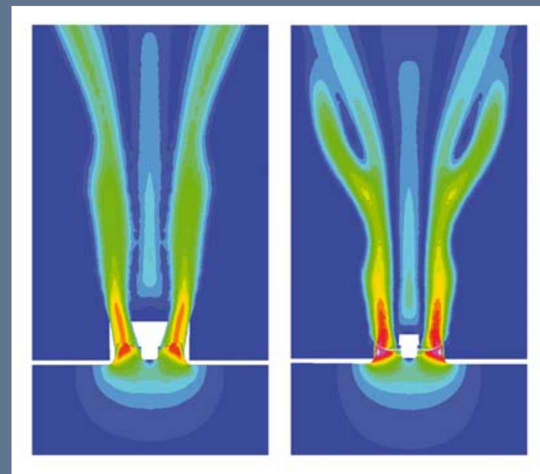


Figure 4a (left, up): Energy consumption and noise development are significantly lower with unchanged air performance.

Figure 4b (left, down): Blower output is increased and noise reduced with unchanged power input. Details from an example application.

Figure 5 (right): The thrust range is not affected by the AxiTop diffuser. The illustration shows the axial flow rate with diffuser on the left and without diffuser on the right.

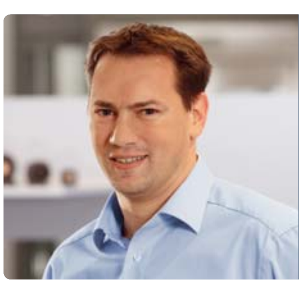


not only does the user save energy during operation; the design engineer for a climate control system can get by with smaller heat exchanger surface areas. The space needed for the cooling unit can be reduced with unchanged or even improved noise behavior and constant refrigeration capacity. The reduction in the space needed is an argument which cannot be neglected, above all for larger heat exchangers. A diffuser is even worthwhile if it subsequently turns out that the system does not have a sufficient refrigeration capacity, e.g. in the case of a design error. It enhances the air performance without increasing noise. In such cases, the installation of an additional heat exchanger (and the associated costs) can often be avoided.

Can be retrofitted and used in existing wall rings Equipping existing heat exchangers with a diffuser is easy and only requires a few changes to ventilation and air-conditioning units. The diffuser is fitted in place of the guard grille. Existing wall rings can still be used. The AxiTop diffuser from ebm-papst is just 250 mm high so it needs very little space.

With these dimensions, the development engineers have succeeded in achieving a very good compromise. Physically, a diffuser cannot be large enough in order to increase static pressure. But dimensions which are as compact as possible are required in practice. CFD simulations combined with parametric optimisations have produced an excellent aerodynamic result. The change in the outflow profile causes the flow to split slightly, enabling the thrust range of the fan to be maintained. Figure 5 shows the different characteristics of the exit speed cax, which is of relevance for the thrust range, with and without a diffuser.

The new AxiTop diffuser is designed for fans of the sizes 800 and 910. Versions for 500 which are frequently employed with heat exchangers will follow in the near future. It doesn´t matter whether the fan works with GreenTech EC or with an AC drive. However, in the interest of energy efficiency, the combination with GreenTech EC fans in certainly preferable. ○



Authors are Dipl.-Ing. (FH) Oliver Haaf, head of Product Development, Aerodynamics group (left) and Dipl.-Ing (FH) Markus Engert, Predevelopment, Aerodynamics (right) at ebm-papst Mulfingen

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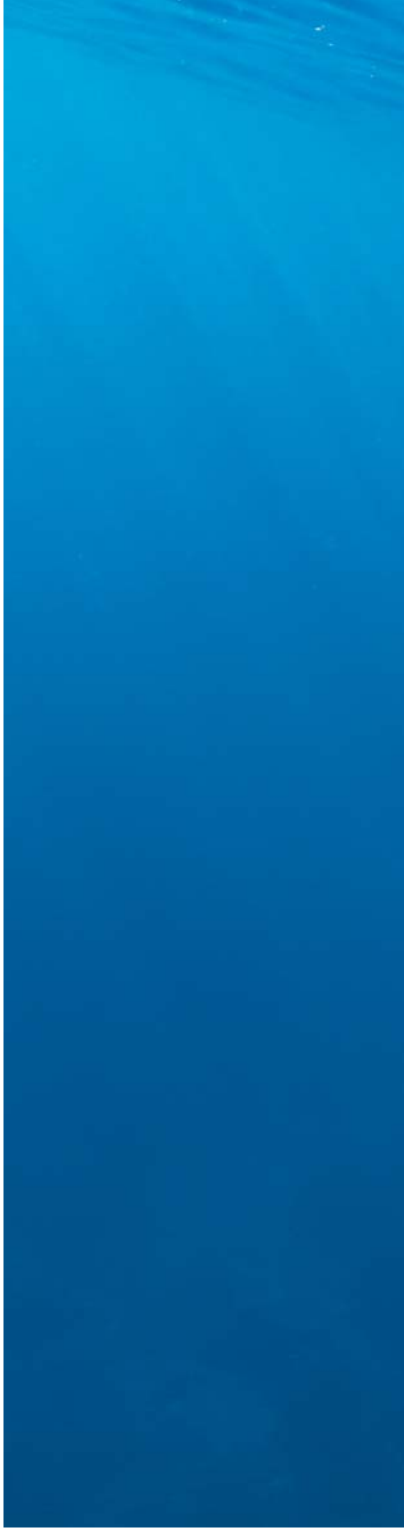


Integrated diagnostic system for fans

Individual early failure detection takes into account ambient conditions

The life span calculation generally applied to fans today is based on the assumption of statistical averages. For this, there are various calculation formulas and evaluation criteria for loads such as temperature, speed or dust and humidity. If operating conditions greatly deviate from the norm, this approach cannot provide any meaningful values for the actual service life of an individual on-site fan. In order to achieve a more reliable statement about the actual service life potential here as well, in addition to general laboratory findings, the actual on-site loads have to be measured during operation, added up and included in the calculation. A new diagnostic tool for fans collects the relevant data for this and calculates the individual remaining service life under the actual operating conditions. Thus operation and maintenance of difficult-to-reach fans are decisively improved and the reliability of the overall system increases.

Statistical statements are only as good as permitted by the assumed input data. Even the best calculation program is not able to provide any realistic statement about the service life of a product if the assumptions are incorrect. However, precisely with fans for exposed applications in a safety area or for systems that are difficult to access, such as cellular telephone stations on mountains, the most exact possible determination of (remaining) service life is important to the operators. Therefore it is ideal if the calculation includes the actual load of the individual fan where it is used. If this takes place right in the fan, and if the fan can issue an alarm signal when a configurable safety threshold is exceeded, that improves the reliability of the overall system.

Therefore there is no need for any cost-intensive preventive replacements; that saves time, money and personnel.

Existing evaluation method Existing, conservative catalogue information regarding service life refers to an accepted, average operating point; for example, service life L10 of 70,000 hours at 40°C ambient temperature and 3,600 revolutions per minute. Therefore they are more of a standard value for the practical evaluation, since operating temperature and speed continuously change throughout the day and over the seasons, thereby affecting the service life. To this are added unforeseeable factors, such as dust or humidity, which are taken into account only in special cases in the laboratory. Usually, current evaluations of lifetime are based on laboratory testing with defined standard conditions for temperature and speed (Figure 1, page 14).

For theoretical considerations of statistics and testing, the average service life of the entire production is used. To achieve shorter testing periods, often the thermal load is also set unrealistically high in order to achieve faster ageing of the components. Changing operating conditions, which always occur in real-world applications, are

Figure 1: In the endurance test room – the data for the conventional life span calculation is acquired using the climate chamber.

The new diagnostic tool can determine the individual service life of the fan

not taken into consideration in this procedure.

In order to make statistical statements concerning fans, it is enough to take into consideration the service life of the rotor bearing. Failures of the electronics or the motor winding are significantly smaller and can normally be neglected. On this basis, ebm-papst developed a diagnostic tool implemented in the fan that determines the individual service life of the fan while taking into consideration the respective ambient and operating conditions. This way the existing limitations of the operating statistics are completely redefined by exact fundamental data and the latest methods of calculation.

New approach The new service life prediction takes into account the individual history of the fan in its respective operation and thus statements about an expected remaining service life can be made in individual cases using the application conditions. Changing temperatures (day/night cycles or seasonal fluctuations) are taken into account, as are the accepted dust pollution on-site and the actual speed. This data is used by the electronics integrated in the fan to calculate the service life (Figure 2).

The new early failure detection is conceived particularly for users who can replace the fan only at high cost or at certain times (for example, re-

Figure 2: Compact fans with high output and internal self-diagnostics for service life

Service life or reliability

Service life and reliability are two terms that are often used and equally easy to mix up. Service life, often abbreviated to L10, specifies a period in hours during which up to 10 percent of the devices will have failed. An L10 value of 100,000 hours means that 90 % of tested devices have reached this run-time. In contrast, reliability is specified with the value Mean Time Between Failure (MTBF). Since fans normally cannot be repaired, a more apt designation would actually be MTTF (Mean Time To Failure). Despite this, MTBF has become the expression that is most commonly used. Statements regarding MTBF values only apply during the planned period of validity (e.g. usable service life). The failure rate can increase significantly after that due to signs of wear. A MTBF value of 1,000,000 h (more than 110 years) means that if 1,000 devices were running at the same time, one of them would fail every thousand hours, i.e. every 42 days (1,000 h * 1,000 = 1,000,000 h).

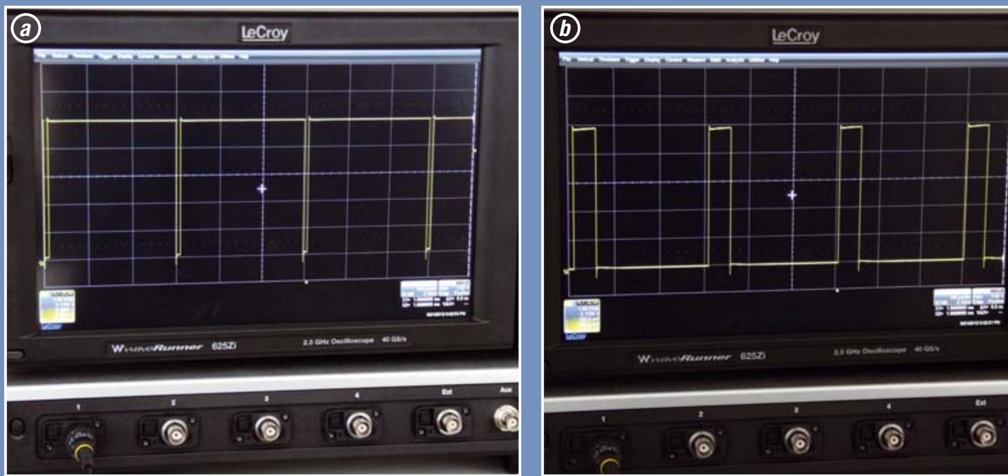


Figure 3a and 3b: The remaining service life can also be output digitally via a PWM signal a) high, b) low or as an analogue value via an additional RC element.

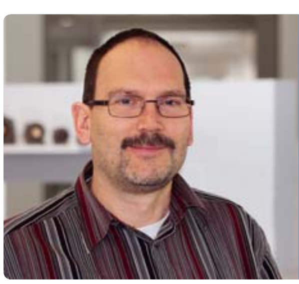
mote measuring stations, radio buoys). With the new options, the replacement intervals can be planned in a timely manner or adapted to the individual requirements. Fans no longer have to be "preventively" replaced, which reduces investment and maintenance costs and increases operating reliability.

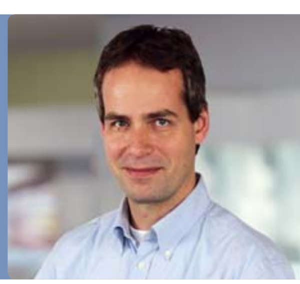
Real-world applications Instead of operating on preset values, the new system uses data that is updated on an ongoing basis, such as operating speed, ambient temperature and downtimes. Basic data, such as the bearing design (ball or sleeve bearing), the type of bearing lubrication and the grease used, and other ambient conditions is preset. That way service life reserves can be used, since the current forecast always takes into account the overall history of the fan.

The diagnostics system is based on empirical correlations from real-world applications and decades of endurance tests under various conditions. Customer-specific output formats, such as L5 instead of L10, can be taken into account.

The output can be wired out via either the alarm wire or an additional wire and can be called up digitally. The remaining service life can also be output as an analogue value via a PWM signal to an RC element. Thus the product can be used nearly up to the actual end of its life without losing reliability. That conserves resources, increases value creation and reduces costs of procuring replacements and maintenance costs (Figure 3a, b). ○

The new diagnostics system not only conserves resources but also reduces replacements and maintenance costs





Authors are Dipl.-Ing (Graduate Engineer) (FH) Frank Heller, Development Engineer for Hardware, Basic and Technology Development (left) and Dr. Lutz Ramonat, Research and Development Centre, Bearing Technology and Reliability (right) at ebm-papst St. Georgen

You would like more information on this topic? Please address your question to: Lutz.Ramonat@de.ebmpapst.com or Frank.Heller@de.ebmpapst.com

External rotor motors need no rare earth magnets

Energy-efficient GreenTech EC motors for fan technology

Permanently excited electric motors rely on permanent magnets due to their function. Especially strong magnets can be produced in the sintering process from compounds with rare earth materials, such as samarium cobalt or neodymium iron boron. After the artificial scarcity of these materials and the resulting drastic rise in costs, the prices have been falling recently. However, since now as before China controls a large part of the quantity supplied, the user must continue to reckon with extreme price fluctuations. Likewise, availability is not guaranteed.

Also in future, the costs for rare earth magnets will be very difficult for the manufacturers of electric motors to calculate. Therefore permanent-magnet excited electric motors, which are particularly energy-efficient, are often regarded as expensive in user circles. It is not necessary, however, that each electric drive operating with high efficiency also really depends on strong rare earth magnets. EC motors with an external rotor design, for example, which are used in energy-saving fans, run with “simple” and cost-effective and anywhere available ferrite magnets, and they work at efficiencies of over 90 % in some cases.

What is an EC motor? Since the terms in drive technology are not necessarily always used with clear and unambiguous definitions, it makes

sense first to clarify which motors are actually meant in conjunction with the rare earth discussion. Whether a brushless DC motor (BLDC), a brushless permanent-magnet (BLPM) motor or an electronically commulated (EC) motor, always means a permanently excited synchronous motor, which is operated with power electronics – mains-powered or with a DC power supply. The so-called BLDC/BLPM motors are usually operated with square-wave currents (block commutation). The EC motors can be operated with square-wave currents as well as with sinusoidal currents (sinusoidal commutation). Doing the latter the drive achieves a significant noise reduction over square-wave currents. The design with sinusoidal currents corresponds to the classic synchronous motor. The basic function of the EC motor is easy to understand (Figure 1, page 18):

The rotor, which has permanent magnets, rotates synchronously with the rotary field of the stator. Unlike the mains-powered asynchronous motor, the rotor speed is not automatically coupled to the frequency of the supply voltage, but it is determined by the commutation electronics. Therefore operation of the EC motor always requires additional electronics. This determines the angular speed of the stator rotating field, at which the rotor synchronously rotates. The correlations between voltage and speed and between current and torque are largely linear. Consequently, with

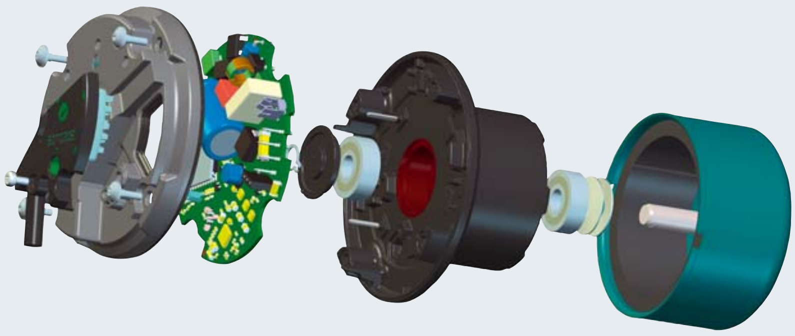


Figure 1: Exploded drawing of the permanently excited synchronous motor, also called brushless direct current motor or EC motor.

The GreenTech EC fans are completely independent of the market trend of rare earth magnets

respect to its torque-speed characteristic, the motor acts like a DC shunt motor. To detect the rotor position, either rotor position sensors are integrated in the motor, or the commutation electronics measure the rotor position without sensors via the parameters field EMF and motor currents. The no-load speed depends on the applied voltage and the number of windings of the stator winding. Therefore in the limits which are defined by the physical parameters (such as output power, torque, temperature rise etc.), nearly arbitrary operating speeds can be implemented slip-free (synchronous with the stator rotating field), which can even lie above the power frequency, unlike the mains-powered asynchronous motor. For example, if a fan is operated with an EC motor, the speed can always be adapted to the requirements of the ventilation system or the process. In partial-load operation, therefore, the energy consumption can be significantly reduced, because the required input power of a fan changes according to the speed to the power of 3. Aside from this, EC motors feature a significantly higher efficiency (Figure 2) than mains-powered AC motors both in partial-load operation and at full load, and they usually do this with a smaller size. One reason is that EC motors do not require a magnetising current, so that current heat losses of the rotor disappear. Another reason is the possibility to implement a special winding arrangement with a low end winding (single-tooth winding / concentrated winding, which reduce the winding losses). Even if the rare earth magnet discussion does not favour these motors, they are simply the best choice in terms of energy efficiency.

Dynamic requirements determine the choice of magnets With EC motors you are not always forced to rely on the strong rare earth magnets, because their excellent magnetic quality is really needed only for highly dynamic servo drives, such as those used in robotics. On the one hand, compact dimensions are required; on the other hand, however, the lowest possible rotor mass is required to minimise the moment of inertia. These requirements are attainable only with highly remanent and highly-coercive rare earth magnets. Therefore, manufacturers of such servo drives primarily concentrate on reducing the required magnet mass and height by means of complex optimisations; and they have already achieved very remarkable savings here.

Motor and fan specialist ebm-papst Mulfingen is not even faced by this problem with its fans, which are equipped with energy-efficient GreenTech EC motors. Despite the high efficiency, these drives run without rare earth magnets. The external-rotor motor principle provides the key for this:

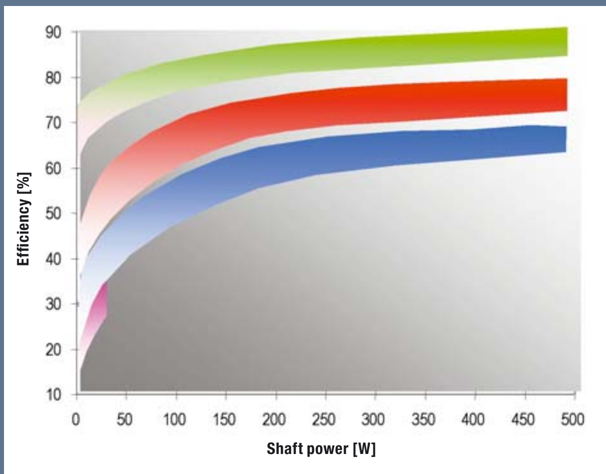


Figure 2 (left): EC motors have a significantly higher efficiency than comparable asynchronous motors.

LEGEND

- *EC motor*
- *Three-phase asynchronous motor*
- *AC capacitor motor*
- *Shaded-pole motor*

Figure 3 (right): Cutaway drawing of centrifugal fan with external rotor motor – the rotor rotates not in, but about the stator.

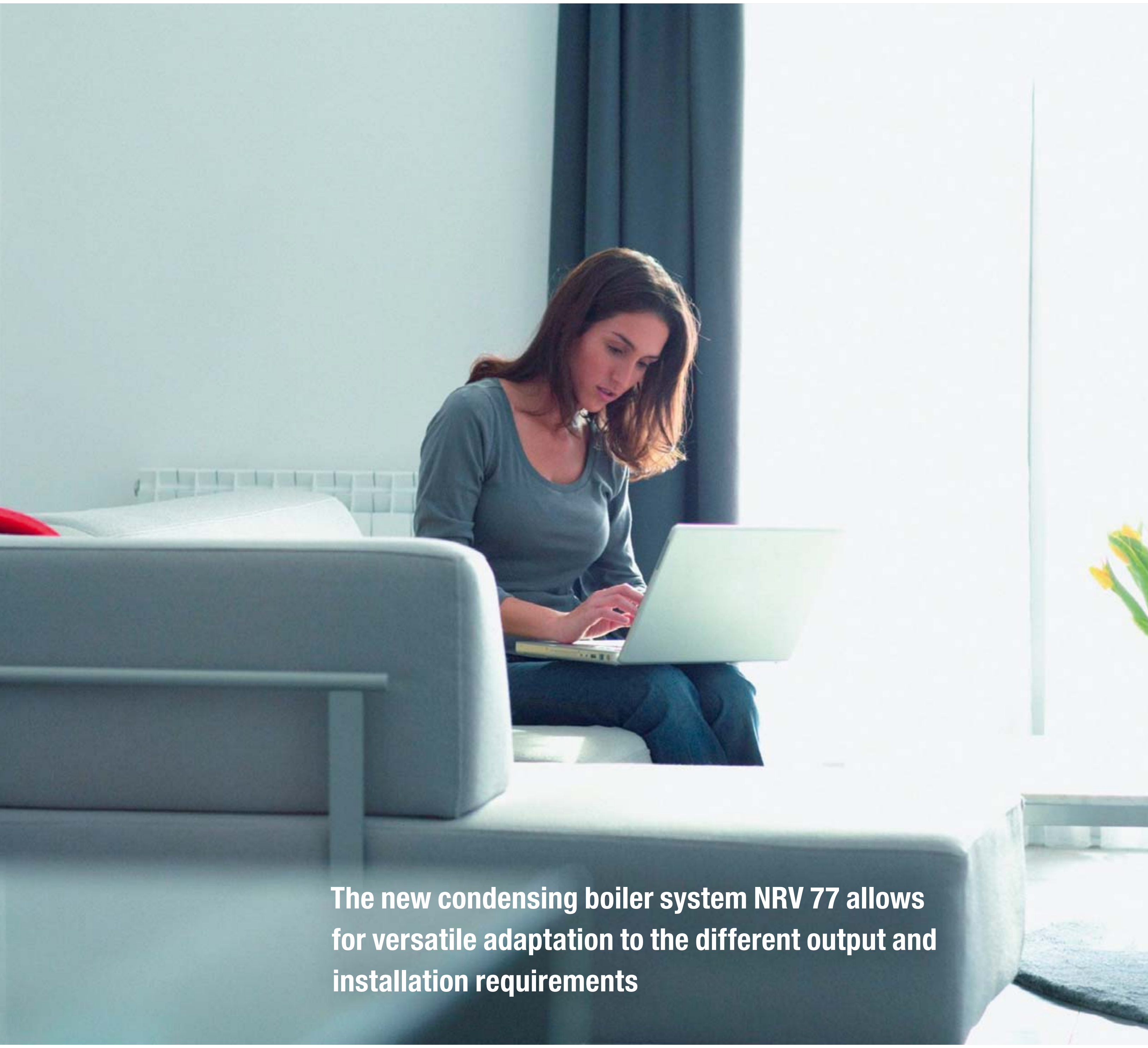
The rotor is on the outside At this kind of motor, the still-standing part, the stator, is located on the inside and is surrounded by the rotating part, the rotor (Figure 3). The externally positioned rotor rotates about the internal stator. Conditioned by this arrangement, the external rotor motor can achieve a higher torque (magnet volume, air gap surface, radius) than the internal rotor motor of the same package length, the same magnet system and the same magnet thickness (reduced magnet volume, reduced air gap surface, smaller radius). By cleverly using the design parameters in the fan and blower area, an external rotor motor using hard ferrite magnets can attain torques and efficiencies which the internal rotor motor can achieve only with rare earth magnets (because of the limited volume and mass). Unlike servo drives, fans do not require high dynamics. Quite the opposite is required: a certain moment of inertia is desirable for the fans to have smooth starting and acceleration behaviour. Without restrictions rare earth magnets can be given up and ferrite magnets can be used, which are not only significantly more cost-effective, but also have stable market prices due to their availability.

The motor design with an external rotor is advantageous for fans in another regard as well. This way, the axial or centrifugal impellers can be mounted on the rotating rotor, thus directly on the "housing" of the motor (Figure 4). Compact dimensions, especially in an axial direction, are the consequence and cooling is made simpler as the moved air of the fan is also cooling the motor housing. The design with sinusoidal commutation also provides for particularly low-noise operation. The energy-efficient GreenTech EC fans are therefore completely independent of the market trend of rare earth magnets. ○

Figure 4: Energy-efficient fans whose motors make do without rare earth magnets.

Authors are Dr. Jürgen Schöne, R&D Director of Aerodynamics and Motortechnology (left) and Werner Müller, Department Manager of Motor Development (right) at ebm-papst Mulfingen

You would like more information on this topic? Please address your question to: Juergen.Schoene@de.ebmpapst.com or Werner.Mueller@de.ebmpapst.com


The new condensing boiler system NRV 77 allows for versatile adaptation to the different output and installation requirements

Versatile system consisting of a fan, gas valve and venturi mixer

Optimised components for a wide modulation range for gas condensing boilers

As an environmentally friendly heat source, gas has multiple advantages. In conjunction with modern gas condensing boilers, the fuel is optimally converted into useful heat. Gas condensing boilers can be made very small, are long-lasting and very quiet. For practically every application, therefore, you can find optimally adapted heating units on the market. In order to build these devices as compactly as possible and still do justice to the extensive variance, there is now a new, highly compact unit consisting of a fan, venturi and gas valve. It covers the large power range from 2 to 35 kW and can be easily adapted to different installation conditions in the gas condensing boiler. That saves time and money in design engineering and stock-keeping.

State-of-the-art gas condensing boilers are available in a large number of variants. The heart of such a device, however, is always the fuel management system, in other words, the optimum dosing and treatment of the constant fuel-air mixture. With the NRV 77, ebm-papst Landshut, the specialist for state-of-the-art condensing boiler system technology is now offering a new system for this, which allows for versatile adaptation to the different output and installation requirements. The objective of the innovation was to cover a large power range with the smallest, most compact dimensions possible, and simultaneously be able to vary the arrangement of the components when integrating them into the gas condensing boiler. Furthermore, the NRV 77 takes into account the development of heat outputs which are becoming ever smaller.

The whole is more than the sum of its individual parts The fuel management system is composed of multiple single components. Along with the fan for the combustion air and the gas valve, the newly developed venturi is the component that is the key to success. All three components have to be optimally matched to each other

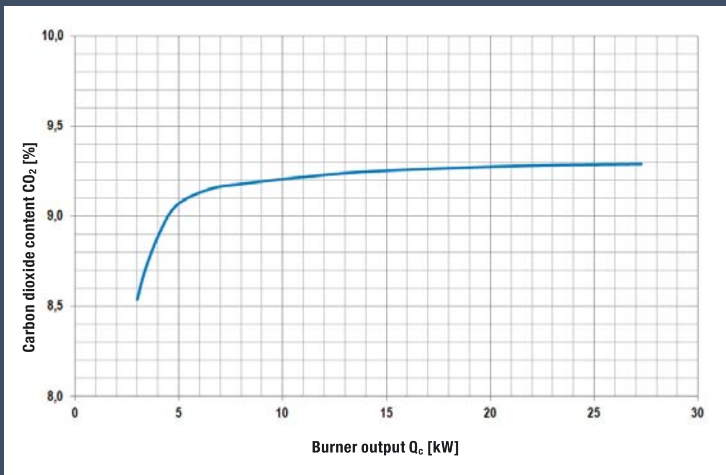


Figure 1 (left): Typical CO_2 curve

Figure 2 (right): NRV 77 with gas outlet

The new NRV 77 gas-air mixture permits use in a wide variety of different gas condensing boilers

for the respectively required heat output. This is the only way to guarantee efficient, low-emission combustion.

The fan: always the correct air flow For conveying fresh air, this means that the fan used can always reliably move the air flow required for heat outputs from 2 to 35 kW. The reason for this is that a fan with a relatively small impeller diameter is used. This enables low air flows to be achieved with minimum speeds that can still be controlled well. To be able to cover the upper power range as well, speeds of up to 11,500 rpm are required.

However, the high speed and the long service life desired for use in heating require a special bearing design. Therefore the bearing geometry and above all the lubrication have to be adapted to these conditions. Carefully selected greases with ideal viscosity, temperature behaviour and ageing stability are the decisive factor here. Intricate (long-term) test bench trials in conjunction with long-time experience helped in the search for the optimum lubricant for a speed-proof bearing with lifetime lubrication.

The gas valve: large modulation range For the smallest heat outputs the required fuel gas quantities are downright minuscule. NRV systems have a modulation range from 1 to 7, over which the air-fuel ratio of the combustion has to be controlled. What is called the main injection throttle of the gas valve is an important element here. It consists of a rotating plastic part, which is fastened in place on a sheet. The parts have to be as flush as possible with one another to ensure that the entire gas quantity is fed through the main injection throttle and no leaks past the throttle can develop. A leak would have a negative impact on the minimum heat output. Moreover, the choke (plastic part) has to move easily, so that the air-fuel ratio of the combustion is configured at the rated load.

The objective here was to find the best possible compromise, which was achieved by tempering the installed plastic part in the sheet metal and by optimising the sheet metal part. Thus it was possible to achieve the goal of creating a largely leakproof main injection throttle that can be moved ideally.

The venturi mixer Venturi nozzles are frequently used to generate the required vacuum, through which the correct gas quantity is dispensed through the gas valve. A single venturi is not able to cover the entire power range of the fan and gas valve. But each new venturi nozzle means a new mold.

In order to find a flexible and cost-effective solution for our customers, we created a venturi with an integrated displacement body. Its diame-

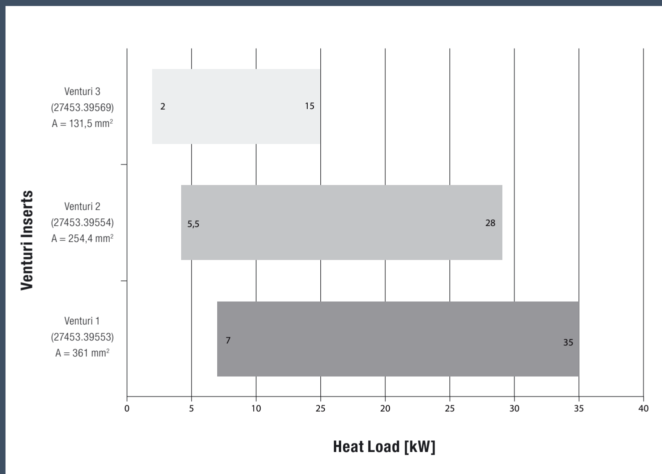


Figure 3: Power range of the NRV 77 multi-venturi

ter can easily be adapted in the overall tool by using an insert, but this does not have any negative impact on the venturi´s performance. Additionally, the entire venturi can be flexibly attached to the fan with various mounting options. We call this patented solution "multi-venturi".

Technology in numbers Thanks to the multi-venturi solution, system solutions (gas-air mixture) can also be cost-effectively provided in new tools in customer-specific, small annual production volume without investment costs. The product launch of the NRV 77 includes three performance classes, which cover the power range from 2 to 35 kW. Additionally, depending on the installation conditions, the gas valve can be turned in up to 15 different positions. A liquid seal is inserted between the multi-venturi and fan housing. This sealing point is 100 % tested in the plant.

Due to its wide output-control range, the new NRV 77 gas-air mixture permits use in a wide variety of different gas condensing boilers. Stockkeeping is reduced as a result of the large output variability; the design can rely on uniform standard components as a result of the flexibility. This not only saves money and time in development and production, but also improves the market opportunities by providing better quality at a favourable price. ○

Author Frank Schlopakowski is Manager New Design Department / Systems at ebm-papst Landshut

You would like more information on this topic? Please address your question to: Frank.Schlopakowski@de.ebmpapst.com

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*ebm-papst
Mulfingen GmbH & Co. KG
Bachmühle 2
D-74673 Mulfingen
Phone +49 (0) 7938 81-0
Telefax +49 (0) 7938 81-110
info1@de.ebmpapst.com*

*ebm-papst
St. Georgen GmbH & Co. KG
Hermann-Papst-Straße 1
D-78112 St. Georgen
Phone +49 (0) 7724 81-0
Telefax +49 (0) 7724 81-1309
info2@de.ebmpapst.com*

*ebm-papst
Landshut GmbH
Hofmark-Aich-Straße 25
D-84030 Landshut
Phone +49 (0) 871 707-0
Telefax +49 (0) 871 707-465
info3@de.ebmpapst.com*

www.ebmpapst.com

*Responsible for content:
Kai Halter*

*Editor:
Katrin Lindner*

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