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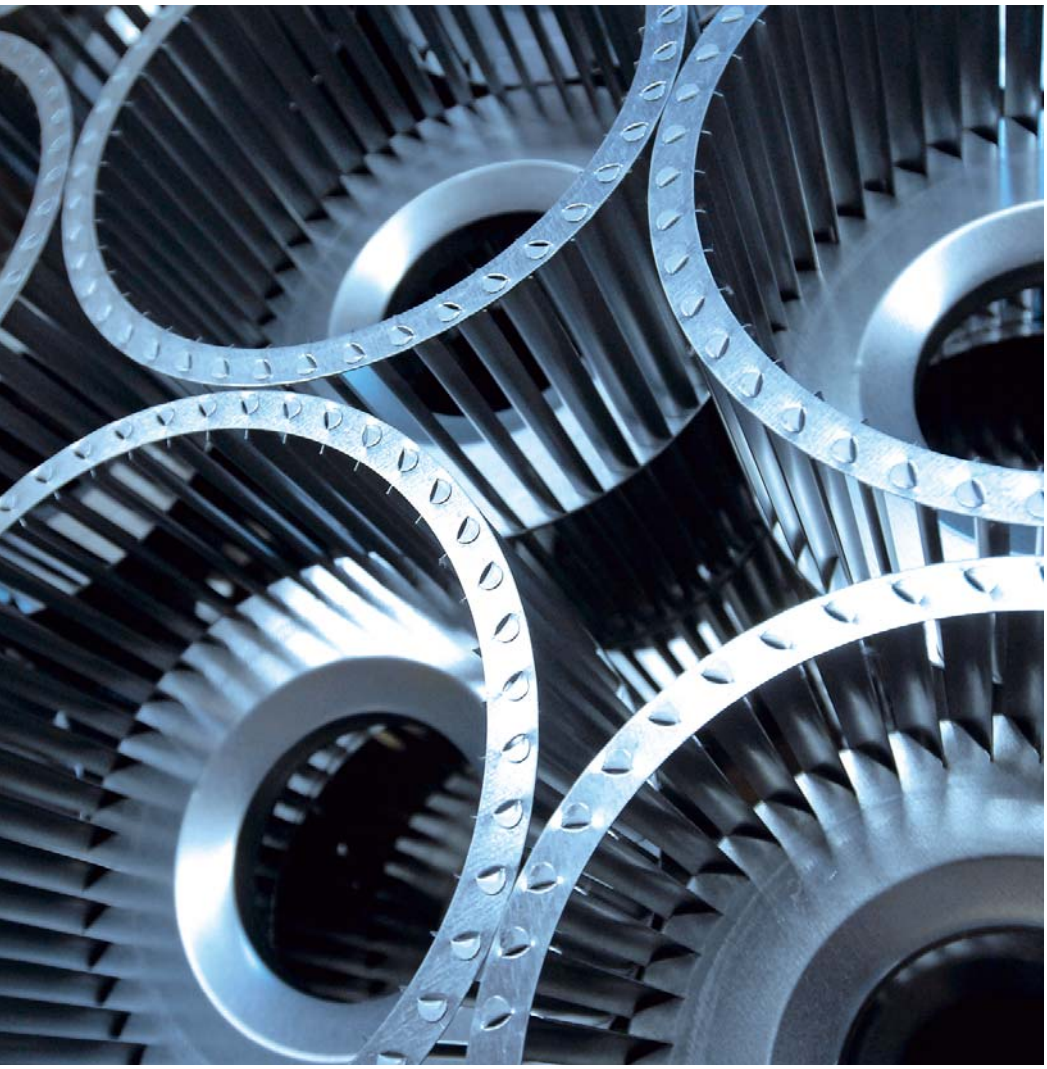
NEW IDEAS AT A GLANCE



The engineer's choice

ebmpapst

Editorial

Dear customers, partners and friends of ebm-papst,

When buying a car, we look at low fuel consumption, and when we buy a new refrigerator, we want it to have an efficiency rating of at least A++. The consciousness that leads us to choose energy-efficient products also drives us at ebm-papst, and our customers, forward. After the recession of the last two years, we are feeling the effects of this tailwind clearly.

"ebm-papst accepts the callenge of innovative ventilation technology"

Legal requirements are also providing favourable basic conditions for the spread of energy-efficient products. For example, the ErP directive for fans is starting to bring results. Though it does not take effect until 1 January 2013, it is a great challenge even today, as manufacturers must begin their preparations in advance. As you know, a design-in requires a certain amount of lead time: getting from the idea to a product that is ready for series production can easily take a year.

The directive is having an increasing effect in other product segments. In coming years, it will also apply to home ventilation units, defining new, low limit values for these as well.

Increasing energy costs also support the process of new thinking. Where previously, the focus was on one-time investment costs, product lifecycle costs are now taken into account more frequently in the purchase decision. It is fans, in their wide variety of applications, that incur the largest proportion of their total costs over their operating time. Even if a fan is only a small energy consumer in an industrial environment, the new generation allows savings of up to 50 % compared to conventional devices. As a result, a higher investment pays for itself very quickly in lower operating costs.

This application calls for new, more efficient motors and innovative ventilation technology. ebm-papst has accepted this challenge at an early stage and has pursued it consistently ever since. One example is the latest generation of fans. The HyBlade® axial fans and "RadiCal" centrifugal fans in GreenTech EC technology provide the right answer to these requirements. We are devoting intense efforts to implement these requirements in our entire range of products.

I hope that you will enjoy reading the new issue of tech.mag, and that it will provide you with many new and interesting ideas.

Uwe Sigloch
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Content

Page:

Controlled home ventilation for new buildings and renovation

© Dimplex

"Fans for home ventilation systems: reliable, quiet and energy-efficient"

In the latest version of the German Energy Savings Ordinance (EnEv) of 2009, the German federal government reduced the maximum permissible energy requirement for new buildings by 30 % compared to the EnEv of 2007. In the next step, energy stipulations are set to become stricter by a further 30 % in 2012. These targets will also apply to renovations. This will make heating systems employing renewable energies and home ventilation systems that extract heat from the exhaust air to heat up the fresh air indispensable. At the same time, the energy efficiency standards expected of such solutions are very high, which in turn has an effect on the components employed. This also affects fans, which already have to satisfy very high standards with respect to efficiency.

Naturally, implementing the required energy efficiency means higher costs for the home builder, regardless of whether it is a new building or a renovation. However, "environmentally compatible" does not necessarily have to mean "expensive" in the long run. Firstly, the financial "energy-saving premium" will in time pay for itself – regardless of future energy prices. Secondly, state subsidy schemes relieve the financial burden. Builders of new buildings can take advantage of loans from the KfW (the German state banking group for reconstruction), whose interest rates and possible repayment subsidies depend on the level of efficiency achieved. If you wish to renovate an existing building, you have the choice of a wide range of subsidisation standards. Even if the current subsidy schemes fall victim to future cutbacks, the energy saving measures are still worthwhile for both new buildings and renovations, and not just for environmental reasons. Good insulation and ventilation enhances the general comfort of the house, and the increase in the value of the property should also not be neglected.

The decisive component: the fan

Home ventilation systems with heat recovery are especially suitable for low-energy and passive houses, but they are also employed in the renovation of older buildings. For apartments and single-family homes, central systems are usually employed (see text box, page 8). Here, the fresh air and the exhaust air are conveyed through ducts by two fans. Heat recovery and air filtration are managed by the central unit (Fig. 1), which can be placed practically anywhere, e. g. in the cellar.

Fig. 1: Home ventilation system with heat recovery, closed on the left and open on the right, with heat exchanger removed. The fans for fresh air and exhaust air form the "heart" of the system. These have to work reliably, quietly and energy-efficiently (image source: company Dimplex).

“EC drives made by ebm-papst: the right choice for home ventilation systems”

The fans for the fresh air and exhaust air form the “heart” of the system. They are required to work reliably and energy-efficiently as such ventilation systems are usually in continuous operation. Moreover, it is essential for low-noise and low-vibration motors and fans to be used. Because the ventilation ducts are routed throughout the building, droning motors would cause significant noise disturbance. At the end of the day, nobody wants to hear a thing from the ventilation.

The right drive: unbeatable EC technology

The drive employed is a key criterion when selecting the right fan. Today, “asynchronous motors” are still employed to drive fans in ventilation and climate control systems. These AC motors are of a straightforward design and are powered directly from the A/C or three-phase current supply. Neither mechanical collectors nor electronics are needed to power the armature. They are robust and reliable, but they have one decisive drawback: depending on the design, the are only able to achieve an efficiency rating of about 50 %. The efficiency describes the relationship between the achieved mechanical output and the electrical input. In other words, it is a measure of the energy efficiency of a drive. Modern EC drives, specially developed by motor and fan specialist ebm-papst for use in home ventilation systems, perform substantially better in this respect, which is due to the way they work.

On the EC motor, a magnetic rotor synchronously follows an electronically generated rotating field. EC motors are direct current motors that are straightforward to control. They work with an efficiency of up to 90 %. Operating costs are reduced, the climate control solution pays for itself relatively quickly and significantly less CO_2 is created from the very first minute of operation, reducing the impact on the environment. At the same time, the drives are also remarkably quiet (Fig. 2). The key to this is the especially low-noise commutation.

The right blade geometry

Apart from the motor, the geometry of the blades is an important factor when choosing the right fan. For home ventilation systems, centrifugal fans are employed, where a distinction has to be made between forward and backward curved blades. In home ventilation systems, forward curved centrifugal fans are predominantly employed. Here, the relationship between the power input, speed and air flow is approximately linear. That means that the air

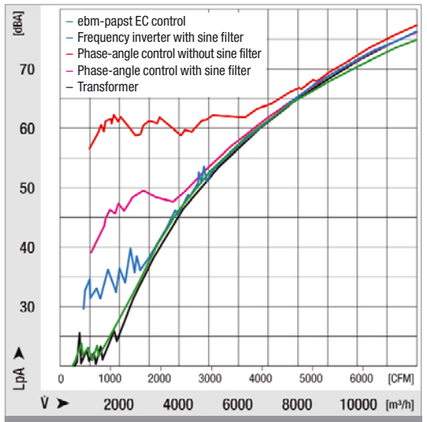

Fig. 2: Noise behavior of different types of motor in comparison (green: ebm-papst EC motor / rest: AC motors with different types of control system / image source: ebm-papst).

No alternative to energy-efficient fans:
Controlled home ventilation for new buildings and renovation

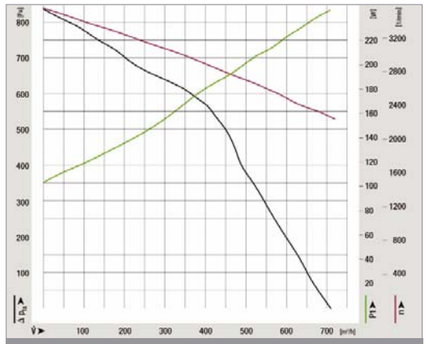

Fig. 3: Sensorless air flow measurement with forward-curved impellers (image source: ebm-papst).

flow can be calculated using the speed and current draw, and the air flow can be controlled without an air volume sensor (Fig. 3). The electronics integrated in the EC motor takes care of these additional control functions. The sensorless air flow control also creates further advantages. This means that there is no reduction in air flow caused by contaminated filters. Moreover, the regulation of the air flow is more straightforward when the system is set up, which is an additional cost factor that should not be underestimated.

Fig. 4: Energy-efficient and low-noise centrifugal fans for air flows up to 400 m³/h (image source: ebm-papst).

“Tailor-made” solutions for different applications

Because the necessary air flow depends on the size of the space to be ventilated, there are different centrifugal fans available with GreenTech EC technology for air flows of up to 180 m³/h, 300 m³/h and 400 m³/h (Fig. 4). These fans are housed in a compact scroll housing and are directly connected to the 230 V AC voltage supply with a frequency of either 50 Hz or 60 Hz. The required air flow can be set using either a pulse width modulation signal or a variable voltage between 0 V and 10 V.

The speed monitoring function integrated into the motor electronics emits one pulse per revolution. Various devices can be connected to this output, for example a counter, controller, alarm transmitter or a speed indicator. There is no need for a anti-vibration mount as the three-core design of the EC drive and the optimised commutation technique prevent motor noises from being generated. These advantages can of course also benefit decentralized ventilation systems. Here, there is also a wide range of powerful fans that combine energy-efficient EC technology with quiet running and a range of practical control and regulation options.

Another interesting application for efficient fans is in heat pumps (air/water and air/air). These are often combined with central ventilation systems, especially in low-energy houses (Fig. 5, page 8). In such combined solutions, the two fans in the ventilation system are supplemented by another one for the heat pump. The “RadiCal” centrifugal fan range employs GreenTech EC technology and is very well suited to this application. Not only are these fans extremely energy-efficient, they are also very quiet (Fig. 6, page 8). The fans are currently available in sizes 133 mm to 500 mm with input capacity of 35 W to 3 kW. This fan range also helps to ensure not only that the energy savings that are stipulated by law are achieved, but also that they are economical for the user.

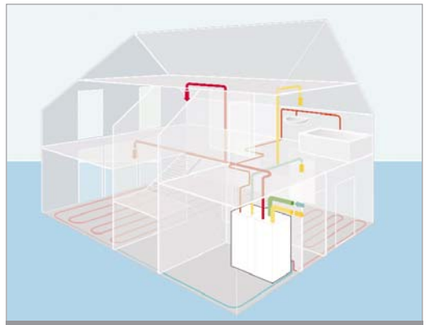

Fig. 5: Schematic illustration of a combined solution: heat pump with centralized ventilation system. In such combined solutions, the two fans in the ventilation system are supplemented by another for the heat pump (image source: company Stiebel).

Fig. 6: Excerpt from range: "RadiCal" in size 500 for use, for example, in heat pumps (image source: ebm-papst).

Centralized or decentralized?

When it comes to climate control in buildings, planners and operators have the choice between centralized and decentralized solutions. The market used to be dominated by centralized air-conditioning systems. Today, decentralized solutions for individual rooms or for smaller units are becoming increasingly popular as they allow individual adaptations to suit the needs of the user and detailed individual invoicing. These units are integrated directly on the facade of the building and they do not need a ducting system for the fresh air and exhaust air. This makes them perfect when renovating existing buildings. However, heat recovery and air filtration are more straightforward and more efficient with centralised systems, and maintenance work is easier to schedule and perform. This usually makes then the better option for single-family homes or multi-storey apartments.

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EU focuses on "green" fans

© gettyimages/Steve Chenn

“Fans in GreenTech EC technology exceed the legal specifications”

By adopting the Kyoto Protocol, the European Union has undertaken to reduce CO_2 emissions by at least 20 % by 2020. One measure for achieving this is the EuP directive (Energy-using Products directive) adopted by the EU in 2005, which was renamed the ErP directive (Energy-Related Products directive) in 2009 and is also referred to (in Germany) as the eco-design directive. Within its framework, the savings potential of energy-relevant products are examined and minimum requirements are defined. For example, in the field of lighting, this has already had concrete impact: 100 W and 75 W bulbs have already officially disappeared from the market. Now, mandatory limits applicable for fans were defined in June 2010.

When the ErP directive becomes effective for fans, fan manufacturers will be required to design their products for the European market to comply with defined efficiency standards to make an important contribution to reducing energy consumption. This will affect all fans in the power range from 125 W to 500 kW, regardless of whether or not they are operated as single units or as integrated components within a system. This concerns all conceivable applications, from refrigeration and air-conditioning technology through to mechanical engineering and IT applications.

Two-stage plan with strict standards

The EU has specified a two-stage plan with strict standards to keep “energy-burners” off of the European market in the future. The first stage will become effective on 1 January 2013. Some 30 % of all fans currently on the market will then no longer satisfy European regulations. In the second stage, from 2015, another 20 % will be replaced by more efficient products. These will satisfy the specified minimum efficiency levels.

The user can recognise fans that satisfy the requirements of the directive by the CE sign, which will then give energy efficiency the same significance as compliance with the low-voltage and EMC directives. Labelling in the way practiced with washing machines, refrigerators etc. is not planned for fans as the fan manufacturers usually have no influence over the installation conditions.

Challenging limits

To decide whether a fan is compliant with the ErP directive, the efficiency of the complete, ready-to-use fan is assessed, i. e. the unit comprising control electronics (if fitted), motor and fan impeller (see Fig. 1). The corresponding limits have been set very high. Figure 2 illustrates the limits that are set to become valid in 2013 and 2015, shown in the form of black lines. At the same time, the efficiency of conventional centrifugal fans from ebm-papst’s broad product range are entered in the diagram. The “efficiency cloud” shows that not all fans satisfy the future requirements. But it can also be seen that for every fan that will no longer be permitted in the future, there is already an energy-efficient replacement that not only fulfils the specifications of the directive, but actually exceeds them.

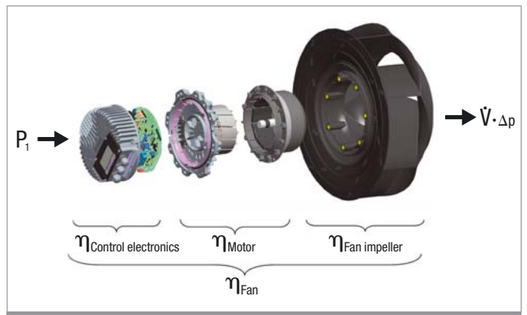

Fig. 1: To decide whether a fan satisfies the ErP Directive, the efficiency of the complete fan is assessed, i. e. the unit of control electronics (if fitted), motor and fan impeller.

For axial fans, forward and backward curved centrifugal fans, tangential blowers and diagonal fans, the EU has specified the corresponding formulas with which the respective minimum efficiency can be calculated. In the assessment, different power ranges and mounting conditions are taken into account for the measurements (see Fig. 3). The target efficiency, that is the concrete specification for an axial fan in the power range from 0.125 kW to 10 kW, can be calculated using the following formula: Minimum efficiency ηmin = 2.74 x ln (power input P1 in kW) – 6.33 + N. Where N is a constant defined in the directive. For axial fans, this will have the value 36 from 1 January 2013 and 40 from 1 January 2015. This factor can be looked upon as a kind of political “setting screw” for a further tightening of requirements in

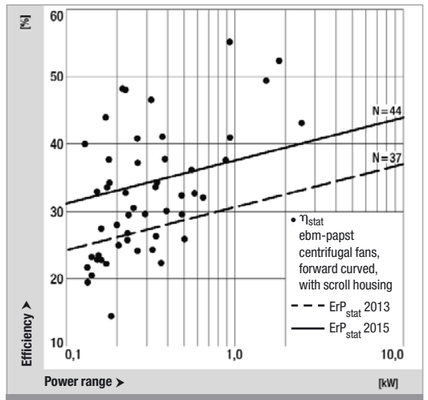

Fig. 2: The efficiency cloud shows that many fans exceed the values demanded.

Fan type	Installation situation (A-D)	Efficiency (static or overall)	Power range P_1 in kW	Minimum efficiency	Efficiency N 01.01.2013	Efficiency N 01.01.2015
Axial fan	A,C	Static	$0.125 \le P_1 \le 10$	$\eta_{min} = 2.74 \cdot \ln(P_1) - 6.33 + N$	36	40
			$10 < P_1 \le 500$	$\eta_{min} = 0.78 \cdot \ln(P_1) - 1.88 + N$		
	B,D	Overall	$0.125 \le P_1 \le 10$	$\eta_{min} = 2.74 \cdot \ln(P_1) - 6.33 + N$	50	58
			$10 < P_1 \le 500$	$\eta_{min} = 0.78 \cdot \ln(P_1) - 1.88 + N$		
Centrifugal fan, forward curved and Centrifugal fan with radial blade ends	A, C	Static	$0.125 \le P_1 \le 10$	$\eta_{min} = 2.74 \cdot \ln(P_1) - 6.33 + N$	37	44
			$10 < P_1 \le 500$	$\eta_{min} = 0.78 \cdot \ln(P_1) - 1.88 + N$		
	B,D	Overall	$0.125 \le P_1 \le 10$	$\eta_{min} = 2.74 \cdot \ln(P_1) - 6.33 + N$	42	49
			$10 < P_1 \le 500$	$\eta_{min} = 0.78 \cdot \ln(P_1) - 1.88 + N$		
Centrifugal fan, backward curved without housing	A,C	Static	$0.125 \le P_1 \le 10$	$\eta_{min} = 4.56 \cdot \ln(P_1) - 10.5 + N$	58	62
			$10 < P_1 \le 500$	$\eta_{min} = 1.1 \cdot \ln(P_1) - 2.6 + N$		
Centrifugal fan, backward curved with housing	A,C	Static	$0.125 \le P_1 \le 10$	$\eta_{min} = 4.56 \cdot \ln(P_1) - 10.5 + N$	58	61
			$10 < P_1 \le 500$	$\eta_{min} = 1.1 \cdot \ln(P_1) - 2.6 + N$		
	B,D	Overall	$0.125 \le P_1 \le 10$	$\eta_{min} = 4.56 \cdot \ln(P_1) - 10.5 + N$	61	64
			$10 < P_1 \le 500$	$\eta_{min} = 1.1 \cdot \ln(P_1) - 2.6 + N$		
Diagonal fan	A,C	Static	$0.125 \le P_1 \le 10$	$\eta_{min} = 4.56 \cdot \ln(P_1) - 10.5 + N$	47	50
			$10 < P_1 \le 500$	$\eta_{min} = 1.1 \cdot \ln(P_1) - 2.6 + N$		
	B,D	Overall	$0.125 \le P_1 \le 10$	$\eta_{min} = 4.56 \cdot \ln(P_1) - 10.5 + N$	58	62
			$10 < P_1 \le 500$	$\eta_{min} = 1.1 \cdot \ln(P_1) - 2.6 + N$		
Tangential blower	B,D	Overall	$0.125 \le P_1 \le 10$	$\eta_{min} = 1.14 \cdot \ln(P_1) - 2.6 + N$	13	21
			$10 < P_1 \le 500$	$\eta_{min} = N$		

Fig. 3: To determine the efficiency, the EU specifies the relevant formulas that are used to calculate the minimum efficiency for each type of fan.

ErP directive demands high efficiency:
EU focuses on “green” fans

ErP directive demands high efficiency:
EU focuses on “green” fans

the future. For the HyBlade® axial fan illustrated in Figure 4 with a drive output of 0.69 kW at optimal operating point, the formula states that an efficiency of at least 28.65 % must be achieved from 2013 and at least 32.65 % from 2015, based on the static pressure increase. The curve indicates 40 % efficiency, which is already substantially higher than the minimum requirement for 2015. This fan thus already satisfies the future specifications.

“ebm-papst fans convince with energy efficiency, reliability and durability”

The future belongs to EC technology

The efficiency cloud shows examples of just how demanding the limits specified by the ERP directive are. Against this background, the EC technology developed some years ago by ebm-papst is the first choice for electrically powered fans. Compared to conventional fans with asynchronous motors (AC technology), EC motors achieve an efficiency of more than 90 %. That means energy consumption up to 50 % lower compared to AC solutions. Moreover, the speed of EC fans can be controlled so that the air volume can be adapted to suit the specific requirements, which also results in further substantial energy savings.

Thanks to the successful interaction of motor, electronics and aerodynamics, ebm-papst’s EC fans do not just convince with respect to their energy efficiency. They also work extremely quietly thanks to their optimised commutation techniques and the aerodynamic configuration of the impellers.

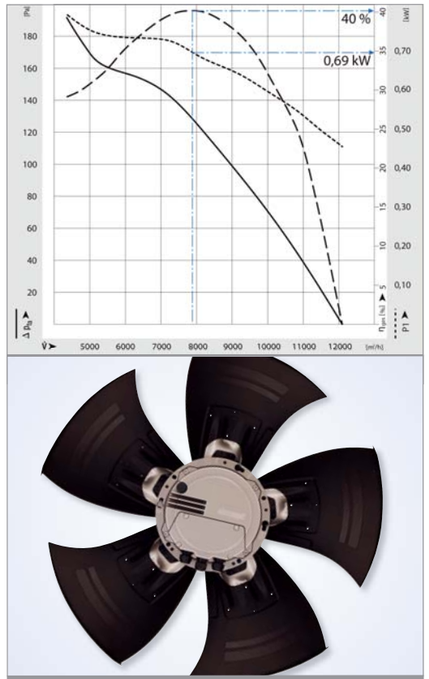

Fig. 4: HyBlade® axial fan in EC technology, which not only fulfils the strict energy efficiency requirements, but actually substantially exceeds them.

And on top of everything, they also convince with their reliability and durability.

Directive for motors

What applies to fans also applies in principle to electric motors. In this context there is often a lack of clarity leading to misunderstandings. The fact is that electric motors are required to achieve at least efficiency class IE2 from June 2011 in accordance with European Union directive no. 2009/640/EC (ErP directive). Only then will these motors be permitted to remain on the market in Europe. However, not all of the standard motors today will be affected by this directive.

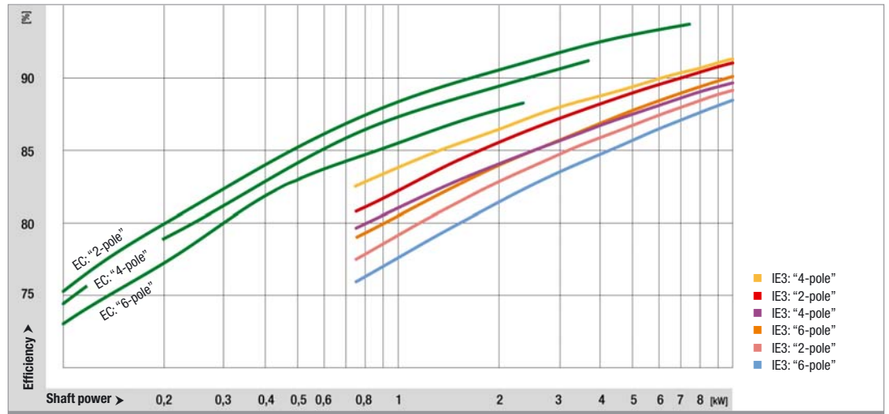

Fig. 5: EC motors (green) substantially exceed the efficiency level required by the directive for AC motors (other colours).

The directive defines a “motor” as an “electric single speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motor that has 2, 4 or 6-poles, a rated voltage of up to 1000 V and a rated output between 0.75 kW and 375 kW”. EC external rotor motors like the ones used to drive energy-efficient fans are therefore not subject to this directive. Nevertheless, their efficiency can still be compared to the values stipulated in the directive. Here, it becomes clear that EC motors already substantially exceed the efficiency levels demanded (see Fig. 5). This shows that EC motor technology is the better alternative when planning energy-efficient devices and installations.

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Gas fittings, blower and control from a single source

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“ebm-papst offers a complete range of components from a single source”

For single-family and multi-family homes, eco-friendly gas will remain a popular heat generation medium in the future. The cost-benefit ratio for a modern, low-pollutant gas heating system remains unbeatable. To make the problem of matching the individual components easier for the developers of gas heating systems, complete packages comprising blower, gas metering system (gas fittings or multifunction controls) and control unit are the best choice. Here, the individual controls within the overall gas metering system are optimally matched. They reliably comply with all emissions limits across the entire power range of the gas heating system and guarantee economical operation.

As a supplier for modern heating systems, ebm-papst has long offered the latest blower technology for gas burners. In order to satisfy the stricter requirements regarding the quality of combustion, engineers now prefer a complete range of all necessary components from a single source. With the acquisition of the multifunction gas control division of Dungs, the extensive product range now also includes gas fittings for controlling the combustion air and the gas feed in the power range up to 80 kW.

The mixture is the key

Optimum combustion is only possible if the volume of gas exactly matches the volume of oxygen in the combustion air. In practice, this so-called mixture has to be maintained as precisely as possible over a broad control range of the burner. Too much gas means unburned particles such as carbon monoxide (CO), energy loss and toxic exhaust fumes. Too little gas means that too much air is being heated unnecessarily. This also causes valuable energy to disappear up the chimney. Gas metering does not depend on the type of heating system. Regardless of whether the blower burner uses forced air ventilation or if it is an atmospheric burner: both the gas feed volume and the mixture with fresh air always have to be right.

The solution to the problem can be approached in many different ways. Electronic control systems with air volume and air mass sensors (Fig. 1) are just as possible as the tried and tested venturi nozzles, which use a vacuum to mechanically control the gas feed (Fig. 2, page 16). While the fully electronic control systems from the ebm-papst product range offer the optimum solution for special cases, the tried and tested, pneumatically regulated multiple gas controls are first choice for a reliable, inexpensive, modern heating system. Again here, the right match means that there is no need to fear compromise in terms of comfort, cost-

Fig. 1: Gas control with air mass sensors in the Lambda Constant system.

“A broad product range from a single source will help users to achieve the best possible match”

effectiveness or environmental protection. The principle of “everything from a single source” is a guarantee for the user that he will get matching components that are exactly tailored to his specifications. You know who the responsible person is if there are any difficulties and “the ball” is not passed back and forth between several different suppliers. That is an advantage for quick problem resolution that cannot be underestimated.

Gas metering made easy

Even if all multifunction gas controls employ the same operating principle, there are still substantial differences in design. Fundamentally, all devices work on the basis of the venturi nozzle. Like in an engine carburettor, the speed of the gas flow is increased by narrowing the cross-section. Here, preservation of momentum means that the pressure of the fast-flowing medium is reduced. While the carburettor uses this depression to draw in fuel, the gas control unit uses it to actuate a valve (Fig. 3). A highly sensitive match means that the right amount of combustion gas is always fed into the combustion air, and this is done purely mechanically.

Different systems are needed to precisely regulate heating systems of up to 80 kW, such as those that are commonly employed in single-family and multi-family homes. The fact that a controller for a blower burner needs a different design to an atmospheric burner, which works with much

Fig. 2: Cost-effective gas feed mixture by means of venturi nozzle: NRG 118 with venturi and gas fittings.

lower air speeds, is obvious. But even within each design, variations are possible with an additional electromagnetic valve control system. This makes safety, comfort and low-pollutant combustion possible in all load ranges and with different boiler designs.

Practice-orientated product range

The product range for the multifunction gas control division contains two main groups, the WhirlWind system and GasBloc.

The former is a fully integrated gas/air composite system that combines control and safety (Fig. 4, page 17). Despite the greater power density, it features a large modulation range, making it suitable for sensitive power adjustment. The GasBloc system

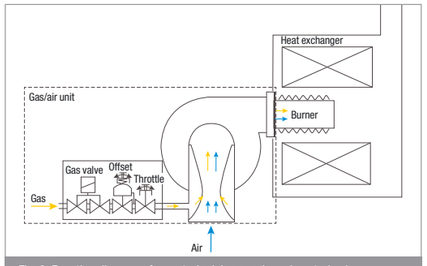

Fig. 3: Function diagram of a venturi mixing nozzle and control valve.

Eco-friendly gas heating systems need perfectly matched components:
Gas fittings, blower and control from a single source

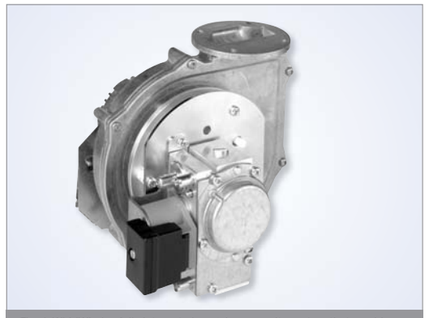

Fig. 4: WhirlWind, a fully integrated gas/air composite system that combines control and safety.

(Fig. 5) is also designed for single- or multi-stage or modulating operation of atmospheric burners or for premixing and blower-supported burners. Depending on the design, the ignition flame, the starting gas volume and other parameters can be calibrated to the boiler. All multifunction gas control units are compliant with EC type-examination certificates pursuant to the EC equipment directive.

Fig. 5: Multifunction gas control unit in GasBloc design.

For the modern, economical generation of heat in the household, gas heating will continue to set the standards in the future. Comfort, environmental protection and low costs are only possible if the gas metering is properly adjusted for the application concerned. A broad product range from a single source will help both users and manufacturers of gas heating systems to achieve the best possible match.

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Energy-saving EC fans contribute to enhanced efficiency:
A new generation of air/water heat pumps

A new generation of air/water heat pumps

Fig. 2a, image source Viessmann.

In Germany, there are some 17.5 million heating systems installed. Of these, less than 20 % can be considered to be state of the art from an energy perspective. The rest are antiquated and inefficient. Yet climate protection and reliable energy supplies demand the extensive, indeed comprehensive use of innovative technologies. This means that there is a great need for upgrading. At the same time, heat supplies in new buildings today demand concepts based on renewable energies instead of fossil fuels. For example, air/water heat pumps exploit the heat energy contained in the external air for heating and for preparing hot water. Today, modern EC fans make a major contribution to such systems being able to work extremely efficiently and therefore cost-effectively.

"Thanks to EC fans, heat pumps work efficiently and cost-effectively"

In principle, a heat pump works like a refrigerator. This extracts heat from within the food and transmits it to the outside. Air/water heat pumps extract heat from the ambient air and either transmit it to the heating system used in the house or apartment, or it is used to prepare hot water (see Fig. 1). In this field, today's air/water heat pumps are easily able to extract heat from the outside air, even at temperatures approaching -20° C. The use of modern technology makes it possible for the Vitocal 350-A with intermediate vapour injection to generate flow temperatures of up to 55° C for heating systems and 65° C for hot water preparation. This is

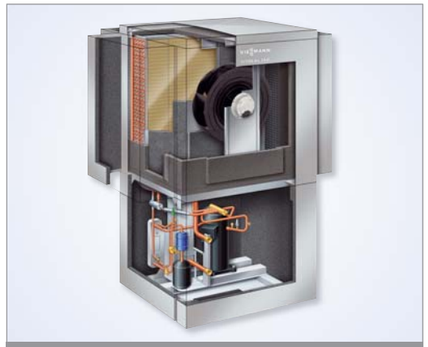

Fig. 1: Schematic illustration of how an air/water heat pump works (image source: Viessmann).

especially beneficial in older buildings, as the powerful air/water heat pumps can also be used as an energy-efficient upgrading measure for heating systems with radiators (energy-efficient also means eligible for subsidies).

Modulating heat pumps – regulated according to needs

For many years, the company Viessmann has been considered a specialist in the development of innovative heating technology. One example of this is the air/water heat pump series Vitocal 300-A and Vitocal 350-A, which are suitable for both indoor and outdoor installation as the same technology is accommodated in an appropriate housing for the site of operation (see Fig. 2a and 2b page 20). With a COP coefficient of 3.9 at 2° C ambient air temperature, the compact Vitocal 300-A achieves high annual performance figures, which ultimately has a positive effect on costs for the user. The COP (Coefficient Of Performance) is the ratio of thermal energy output to electrical energy input at a defined operating point. In other words, a COP of 3.9 means that nearly four times the amount of energy input is converted into usable thermal output. The ratio of heat energy output to the current draw of a heat pump heating system over a full year is known as the annual performance index (API). A further

performance indicator is the SCOP (Seasonal Coefficient Of Performance). In practice, these indicators mean that modern air/water heat pumps today work substantially more efficiently than their predecessors did.

Naturally, such improvements can only be achieved with a combination of know-how and a good portion of experience. For

Fig. 2b: Current developments in the field of air/water heat pumps. The powerful compact systems are suitable for exterior outdoor or indoor installation (image source: Viessmann).

example, an important issue during the redesign of the Vitocal air/water pumps was a control mechanism that continuously regulates according to actual need. The Vitocal 300-A uses Digital Scroll technology (familiar from air conditioning systems) to reduce losses within the heat pump (see Fig. 3). The heat pump can be operated at its optimal operating point for most of the time, when not much heat output is required, i. e. at relatively high ambient temperatures and when only moderate heating or hot water are needed.

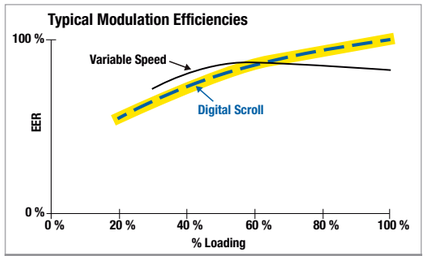

Fig. 3: Power control with Digital Scroll. Compared to inverters, efficiency at full load is enhanced. This is exploited in the control strategy (image source: Viessmann).

Other measures include the use of electronic expansion valves to optimise the operation of the evaporator. In addition, the fan used makes a decisive contribution to high energy efficiency. It is true that the compressor has a much higher electrical consumption than the fan, yet it is still worthwhile working with a fan that boasts maximum efficiency. For this reason, the new centrifugal fan "RadiCal" in GreenTech EC technology was chosen for the air/water heat pumps optimised for energy efficiency (see Fig. 4). These were developed by the fan and motor specialist ebm-papst.

Fig. 4: New centrifugal fan series "RadiCal" for use in ventilation and air-conditioning technology. The fan impellers are perfectly configured for the motor and the electronics to achieve a highly-efficient complete solution.

Energy-saving EC fans contribute to enhanced efficiency:
A new generation of air/water heat pumps

"The RadiCal allows the noise level of the fans to be reduced by a substantial 3 dB(A)"

New centrifugal fan series in operation: energy-efficient and quiet as a whisper

This new development is based on the core competences of aerodynamics, motor technology and electronics, and thanks to the use of modern EC motors, it is not only very energy-efficient, but also very quiet. The latter is certainly a key decision-taking criterion. Anybody using an air/water heat pump will have been confronted with the issue of noise development. Besides the compressor, the integrated fan is the second relevant source of noise, and this should work as quietly as possible. Here, remarkable success was registered in the redesign of the heat pump. The "RadiCal" allows the noise level of the fans to be reduced by a substantial 3 dB(A). In other words, two fans generate the same sound pressure as one used to. That is especially important during the night, when the exterior installation heat pump has to comply with the limits specified in DIN 18005 and in the relevant noise guidelines (in Germany the "TA-Lärm"). Here, the straightforward controllability of the EC fans is of course beneficial as the speed can easily be adjusted for the necessary air volume. Viessmann has fitted various speeds to the fans used in its air/water heat pumps to account for differing requirements. At night, the fan speed can be reduced even further to ensure that a both the user and the neighbours get a good night's sleep.

Compact energy saver

An important basis for quiet fan operation is the perfect interaction between the fan impeller and the motor and electronics. The latest findings in the field of fluid mechanics have caused the geometry of the fan wheels to be "radically" changed compared to earlier models. The innovative shape of the entire flow duct leads to a continual flow of air through the impeller, which greatly increases the aerodynamic efficiency of the fan (see Fig. 5). In addition, the interaction between the inlet nozzle and impeller inlet has been substantially improved. A decisive contribution

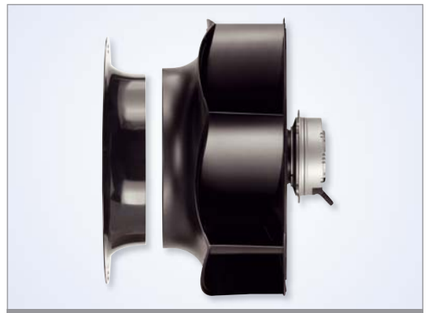

Fig. 5: The innovative shape of the entire flow duct leads to a continual flow of air through the impeller, which greatly increases the aerodynamic efficiency of the fan.

here is made by the materials used. The impeller is a hybrid construction of metal and plastic. This allows a good combination of stability and design freedom.

However, it is not only these aerodynamic improvements that have boosted the efficiency. The EC motors used in the fans are technically state of the art. Despite the integrated electronics, they are very compact and convince with excellent motor heat management. Air inlets in the rotor provide for optimum cooling. Even today, the "RadiCal" fans easily exceed the efficiency that

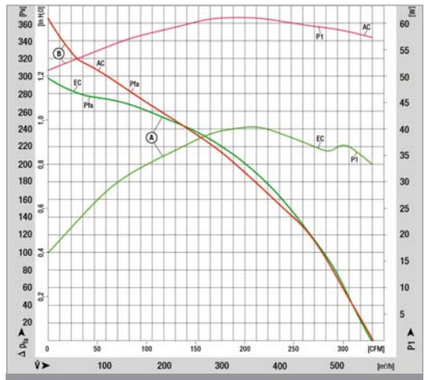

Fig. 6: "RadiCal" need substantially less energy than conventional AC centrifugal fans for the same air performance, and even today they exceed by far the efficiency standards that will be required in the future pursuant to the ErP directive (green curve: "RadiCal" with EC technology / red curve: conventional centrifugal fan with AC technology / P1 = Input capacity, Pfa = Air performance curve).

will be required in the future pursuant to the ErP directive (see Fig. 6). Compared to conventional AC fans, they consume up to 50 % less energy with half the noise level. And there are even more arguments that speak for EC technology. Because the motor in an external rotor design is located in the impeller, the fans are extremely compact and can be easily integrated even when space is very tight. The application described benefits from this. Air/water heat pumps, which are available for nominal thermal outputs of 9 kW to 18.5 kW, only need a small installation space and are suitable for space-saving corner mounting inside the house.

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Frequency inverter cooling calls for properly matched fans

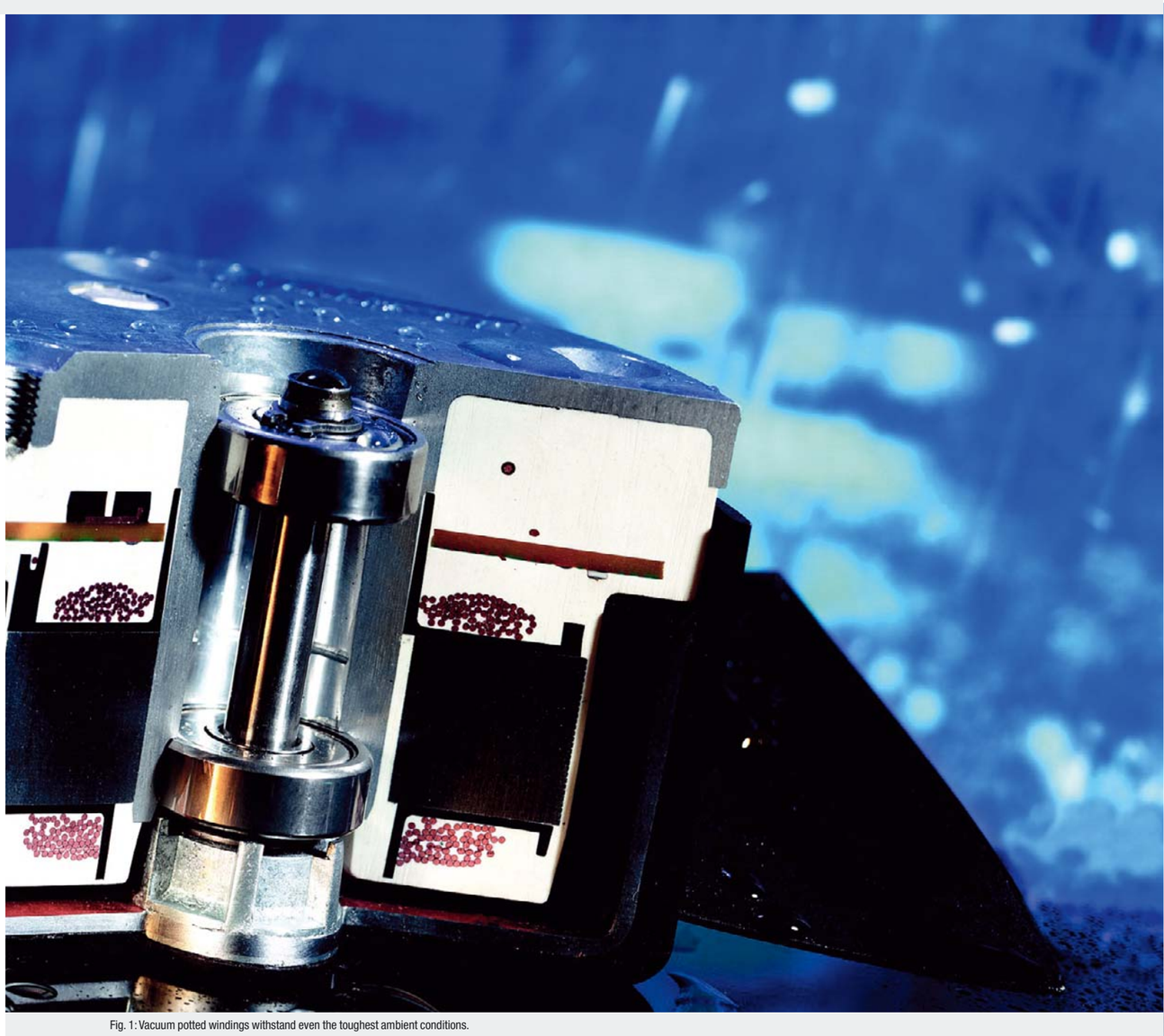
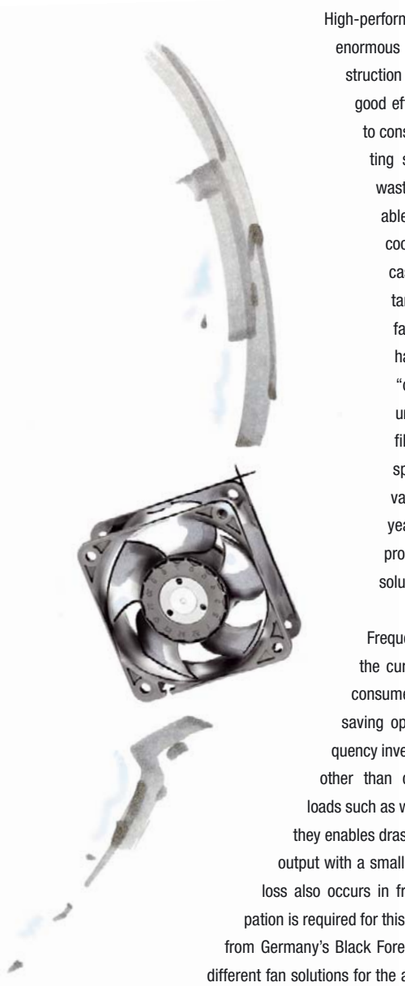


Fig. 1: Vacuum potted windings withstand even the toughest ambient conditions.

“Our product line ranges from the reliable standard model to customer-specific solutions”



High-performance semiconductors can switch enormous energy fluxes in a minimal construction volume. However, even with very good efficiency, the power losses add up to considerable amounts. In each operating state, reliable dissipation of this waste heat is required. As it is available always and everywhere, air is the cooling medium of choice in most cases. To make controlled and targeted use of the air flow, various fan concepts and design versions have proven useful. The dream of “one for all” will always remain unfulfilled – rather, it is important to filter out the best options for the specific application from the wide variety of options. In doing so, many years of experience and a wide product range help to present fast solutions.

Frequency inverters, which distribute the current flow from the power line to consumers as required, enable energy-saving operation of motors. However, frequency inverters are also used in applications other than drive engineering. For inductive loads such as welding transformers, for example, they enables drastic savings in weight and a higher output with a smaller construction volume. As power loss also occurs in frequency inverters, reliable dissipation is required for this as well. Fan specialist ebm-papst from Germany’s Black Forest region offers a wide variety of different fan solutions for the area of frequency inverter cooling. These range from the reliable standard model to customer-specific solutions. By request, the customer units are measured in our own test lab with regard to operating point, noise and air performance to attain optimum cooling.

Powerful basic version

For state-of-the-art compact fans from current production, certain characteristics are always required, regardless of the model and application. For example, the energy consumption is to be as low as possible. Good closed-loop speed control that allows the fan to be adapted to various operating states or customer requests is just as important as a long, reliable service life. Therefore, the fan specialists from Germany’s Black Forest region use state-of-the-art EC drives with additional options in their fans. Depending on the design, these electronically commutated motors are equipped with more or less extensive internal electronics and thus enable maximum efficiency in all operating states. As there are no more wear parts except for the rotor bearing, the service life for these drives can be greater than 100,000 hours. Optimised aerodynamics not only ensure higher air performance, they also decrease the operating noise level drastically; this is an important benefit in many applications. To adapt the drives to extreme ambient conditions, detail solutions can be used, such as encapsulated stainless steel bearings, water vapour-resistant, thick-film plastic insulation for the electronics board or, for the most stringent requirements, with PU plastic in vacuum potted windings (Fig.1, page 23). Therefore, the fans can withstand temperature fluctuations, moisture, splash water, dust, oil or salt loads, such as those encountered in coastal applications.

Requirements according to the specific application

Simultaneously, however, various frequency inverters also place individual requirements on the fans used. These can be classified roughly according to their application areas. For example, frequency inverters for general drive engineering, servo drives and solar inverters each impose different requirements on the thermal

Application-specific dissipation of waste heat required:
Frequency inverter cooling calls for properly matched fans

management than do welding inverters or particularly robust devices for rail technology. Depending on the application category, the cooling air devices must fulfil certain main requirements:

In solar technology: long service life, even for outdoor installation with large fluctuations of temperature and humidity. For installation within a protective housing, even high operating temperatures must not impair the function (Fig. 2). High efficiency of the system is likewise important.

In drive engineering and for welding converters: long service life, high air performance, compact design. Depending on where it is used, temperature fluctuations, dust, oil, and abrasive materials must not impair the function, even after years of operation. Rail technology imposes additional requirements for environmental resistance in addition to stringent demands for vibration and shock resistance.

Customer-specific solutions

Many special requirements for state-of-the-art fans can be met with minor modifications from the extensive range of products of the cooling experts from the Black Forest region. However, there are also some exceptions. In these cases, the company’s long-time expertise in the area of fan development shows its full potential. In individual cases, special measures can protect the drive motor from materials such as water, oil and salt. If the

Fig. 2: Efficient compact fans for high ambient temperatures.

conditions involve a large amount of suspended matter or dust and moisture, a dirt resistant surface coating with lotus effect can help (Fig. 3). Then, malfunctions due to clinging dust or oil deposits are a thing of the past. If the application imposes special demands for installation, familiar fan concepts can be integrated into custom-designed housings.

Though even standard EC fans offer a wide variety of different configuration options and monitoring functions, bus-controlled drive motors are also available for special cases (Fig. 4, page 26). In many cases, intelligent designs can react automatically to environmental triggers via connected sensors for temperature,

Fig. 3: Model 4400 with dirt-resistant coating (right) reduces deposits significantly.

Fig. 4: The S-Force centrifugal family for high pressure build-up with very good motor efficiency (up to 89 %) and high power density.

humidity, light/darkness detection etc. and thus relieve the burden on a higher-level control system.

As varied as the requirements of different frequency inverters are, off-the-shelf solutions already exist for many applications. With minor modifications, these models can be used for additional, more advanced applications. For the toughest requirements, customised solutions are available. If the user takes advantage of the fan specialists' expertise from the beginning of development, the most efficient cooling methods can be implemented.

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