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NEW IDEAS AT A GLANCE

ebmpapst

Editorial

“Together with you, we develop energy-efficient and innovative products for the world market”

Dear customers, partners and friends of ebm-papst,

The current year, 2008, has been marked above all by the exchange rates and exorbitantly rising costs of raw materials and mineral oil. Therefore it is important to maintain markets through new developments and innovations, to continue expanding and above all to defend against cheaper Asian competitors. German mechanical engineering in particular is a very good example of how this can be realised.

Germany leads the world in developing renewable energies and in photovoltaics. Due to political support, photovoltaics has gained acceptance above all in Germany, Spain, Korea, China and increasingly also in the USA and offers corresponding growth prospects in all other parts of the world.

We at ebm-papst look to the future with optimism and are certain that we are ideally situated, above all with our energy-saving products, which already account for 60% of our turnover. At the Chillventa trade fair held in October in Nuremberg, the new trends in refrigeration technology for the future will be presented. We are delighted to be able to present to the market, together with our customers, new energy-efficient and innovative solutions for evaporators, condensers and air coolers as a complete system. The segment for heat pumps in the air/air and air/water area will also profit from this technology and realise lucrative COP values for the end consumer. Implementation of the new HyBlade® series presents a very large challenge for AC and EC fans, which has led to a substantial improvement of fan technology with respect to noise levels and efficiency.

This year ebm-papst has invested over 80 million EUR in new products and locations. Together with our reference customers we have succeeded in developing 60 innovative products for various markets and establishing these as industry standards in corresponding devices. This will continue to be the focus of our attention. Worldwide, we have a chance only if we develop innovative and global products for the world market and produce and install where our customers are.

At this point we wish to give you our heartfelt thanks for your partnership and the trust which you have placed in us until now. We look forward to our continued good cooperation. Rest assured that even in the future, ebm-papst will provide competitive prices with the best quality and the best service, so that you can be successful with your products in the world market.

I hope that you will enjoy reading our new magazine, tech.mag, and that it will provide you with many new and interesting ideas.

p.p. Alfred Müller
Sales Manager Germany
ebm-papst Mulfingen GmbH & Co. KG

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HyBlade® sets new standards for axial fans

Image 1b: HyBlade®- axial fan in EC technology

External rotor motors have proven to be particularly well suited as fan drives, as the impeller can be attached directly to the rotor. This simplifies the design of the fans and makes the units relatively compact. These benefits are valued by industries, including refrigeration and air-conditioning technology, that favour large axial fans, for example to blow air through heat exchangers for cooling systems. However, the requirements are increasing continuously, even in the area of fan technology. The highest possible air performance with the lowest possible noise is surely among the most important requirements. The numerous others include efficiency, optimum corrosion protection, light weight, environmentally sound manufacturing with a good energy balance and, last but not least, aesthetic requirements for the design.

HyBlade® blades, a concept well established

Keeping up with users' wants and needs is a constant challenge. The large blades made of steel or aluminium sheet or die-cast aluminium that are most commonly used for large axial fans place narrow constraints on design engineers. Naturally, the monolithic blades with uniform plate thickness limit design options. Moreover, sheet steel has to be coated to provide appropriate corrosion protection for outdoor applications. Exploding raw materials prices are another challenge – in this case, particularly for aluminium – and require cost-conscious, but above all responsible and conservative use of raw material resources.

New blade geometries and material structures

In light of these facts, it is only logical that motor and fan specialist ebm-papst of Mulfingen, Germany, has worked intensively to develop new blade geometries, materials and component structures. ebm-papst can be proud of the results. At the Mostra Convegno 2008 trade fair in Milan, held from 11-15 March, 2008, a complete series of axial fans equipped with what is known as HyBlade® blades (image 1a) was presented. And this concept is well established – so ebm papst will present at the Chillventa in Nuremberg this autumn a complete HyBlade® range also in energy-saving EC technology (image 1b). The optimised blade geometry and hybrid material structure allowed the noise behaviour and efficiency of these fans to be increased considerably.

Image 1a: HyBlade® fan with 630 mm blade diameter in AC technology

“Winglets reduce unwanted air flow”

In the world of technology, hybrid structures are a combination of different elements. The distinctive feature is that each of the combined elements are functional solutions on their own and, when put together, provide desired positive characteristics.

Real-world examples of such hybrid systems can be found in a wide variety of areas. Hybrid material structures, for example those made of plastics and metallic alloys, have already become commonplace in automotive engineering, and are currently used in aviation and gas turbines. Now, for the first time, they are defining new standards in axial fans. In this area, hybrid components can unite material properties that appear contradictory at first glance. Examples include the high strength of a metallic material with the light weight and design freedom of plastics, where each material is used according to its specific strengths, thus complementing each other optimally.

Two become one

The basic structure of the new HyBlade® series is easily understood (image 2). A carrier of high-strength, corrosion-resistant aluminium alloy is sprayed with a jacket of a special, fibre-reinforced plastic. The metallic carrier absorbs the mechanical forces during operation and ensures a long-lasting connection to the rotor. The plastic gives the blade a shape that is optimised according to aerodynamic criteria. While sheet metal parts can only be punched, bent or stamped, using plastics, it is easy to create three-dimensional profiles. Winglets, familiar from the aviation field, can also be used here. They reduce unwanted air flow between the circumferential blade and wall ring. This improves the efficiency and noise behaviour. At the same time, the good dampening behaviour of the plastic helps to reduce noise. Overall, fans equipped with the new HyBlades® are significantly quieter than models with conventional sheet metal blades (image 3). At the same time, the plastic jacket has a positive effect on the fan's total weight, particularly where monolithic die-cast aluminium blades have been used previously (e.g. 800 mm fan impeller). Of course, this reduces fuel consumption when transporting the fans to the location where they are used. The weight savings are

Image 2: Basic structure of the HyBlade® blades: a carrier of high-strength, corrosion-resistant aluminium alloy is sprayed with a jacket of a special, fibre-reinforced plastic

Combination of metals and fibre-reinforced plastics:
HyBlade® sets new standards for axial fans

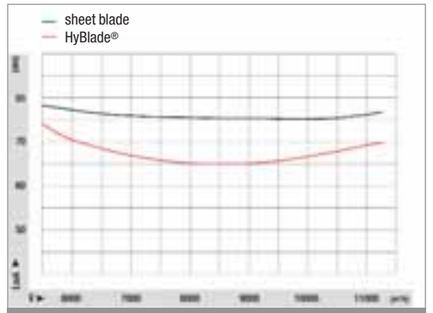

Image 3: Comparison of noise behaviour of the new HyBlade® blades and conventional sheet metal blades

Image 4: Test rig at a company

just as noticeable as those provided by transporting PET beverage bottles instead of glass bottles.

Another very important environmental factor is that much more primary and secondary energy is used in creating the raw material and subsequent processing to create finished blades. The electrical energy used to create 1 kg of primary aluminium is approximately 15.4 kWh, which does not include the amount of fuel used. (Source: Werkstoffeffizienz: Einsparpotentiale bei Herstellung und Verwendung energieintensiver Grundstoffe. German Federal Ministry of Economics and Technology). On the contrary, 1 kg of plastic requires only approximately 1.8 to 1.9 kWh. (Source: European Commission JRC, EU dated Oct. 2006). This clearly shows that an innovation does not at all necessitate additional expenditure of resources. On the contrary, it helps to lower environmental impact and significantly reduce the amount of primary and secondary energy used.

Tried and tested

The technical advantages of hybrid technology have been proven in long-term tests in a wide variety of conditions (image 4 and image 5). These included, for example, temperature change tests (-40 °C/+80 °C), shock tests, or long-term tests under real-world operating conditions. The HyBlades® passed these tests with flying colours, proving features such as their UV resistance to extreme solar radiation. The new hybrid blades are also unharmed by saltwater or salty air. They are corrosion-resistant, even

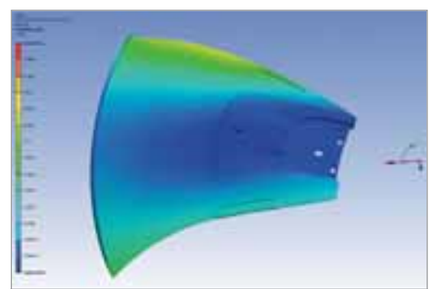

Image 5: The FEM calculation indicates deformation in operation

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“Developers and users value an attractive, trendsetting design”

without coating. Last but not least, visual considerations can be included in the styling of the blades. After all, developers and users value an attractive, trendsetting design. Because the new development allows both EC and AC motors to be used, numerous application areas benefit from the higher air performance and lower noise of the hybrid blades – not only in refrigeration and air-conditioning technology, but in numerous industrial areas. Thus ebm-papst Mulfingen has again succeeded in setting new standards in fan technology.

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Using TRIZ for a successful product

In developing the HyBlade® blades, ebm-papst Mulfingen used the TRIZ method. This "theory of inventive problem-solving" describes an empirical, highly systematic approach to innovation based on the wealth of experience of 2.5 million patents. An important component is the 40 innovation principles with recurring solution approaches that have resulted from patent research. Two of these have been consistently implemented in the new development of the fan blades. The first is innovation principle 3 (local quality): The different parts of a system should fulfil different functions (Source: TRIZ, Der Weg zum konkurrenzlosen Erfolgsprodukt). The second is innovation principle 40 (composite materials): Replace a homogeneous material with a composite one (Source: TRIZ, Der Weg zum konkurrenzlosen Erfolgsprodukt).

Axial fans in EC technology

Image 1: A new generation of forklift trucks: vehicles of the Linde H14-20 series not only consume less fuel, but are also faster than their predecessors, e.g. when unloading trucks.

“The advantages: high efficiency, low energy consumption and accurate control”

Today, ergonomics and energy efficiency have become important catchwords, and this is also true in the mobile equipment industry. Forklifts are a great example. Forklifts may well be the best known power-operated industrial trucks and do their job all over the world in a wide variety of industries, some even in extreme operating conditions such as outdoor use. State-of-the-art forklifts distinguish themselves especially in their high performance with simultaneously lower energy consumption. New motor cooling concepts have contributed to these achievements.

In Spring 2007, Linde Material Handling introduced the new diesel and LPG forklift series H14 to H20 (image 1, see page 9). The agile forklift trucks with load-bearing capacities between 1.4 and 2.0 tons now supplement the successful 39x series with small and low-end trucks. Target groups for the new models are “heavy users” at trucking companies in particular but also those in the building materials, beverage, chemicals, and plastics industries. The vehicles are fast, require little maintenance and use up to 12 percent less fuel than the previous versions. These improvements were attained in large part through Linde's direct-drive hydrostatic transmission and motor technology that is perfectly adapted for forklift trucks. Of course, this also includes cooling systems for these powerful LPG or diesel combustion engines. Here, the manufacturer relies on a new concept. The previously used conventional hydraulic fans or Visco fans have been replaced with accurately controllable electric fans (image 2). The axial fans are installed directly on the heat exchanger and operate as so-called forced air fans. In other words, the fan forces air intake over the heat exchanger.

Controllability guarantees demand-oriented motor cooling

Motor and fan specialist ebm-papst Mulfingen has developed a customised solution for this application area that offers a long list of advantages in practical use: high efficiency, low energy consumption and accurate control. The basis for these improvements is provided by the modern EC drives that are used with these fans. EC stands for “electronically commutated”. There is no mechanical commutation via carbon brushes from the stator to the rotor, i.e. the drives operate practically wear-free. In addition, they can be easily controlled. The necessary electronics have been integrated into the motor and communicate directly with the control system of the forklift. With this technology, demand-oriented motor cooling is completely unproblematic. Every conceivable operating state can be taken into account, e.g. for diesel vehicles it is required to burn off the soot filter in certain intervals; of course, the motor cooling must react accordingly. Across the entire speed range, the efficiency of these drives is significantly better than that of previous conventional solutions. They achieve approximately 90 percent efficiency. This means that the fans themselves produce only very little extra heat, while also making the best possible use of primary energy. Power consumption is only 195 W and the load on the vehicle electrical system is relatively low. Relatively low cable cross-sections are sufficient, which has a positive impact on the cost of vehicle electrical wiring.

Low noise emission and high air performance

The new series of forklift trucks stands out not only due to their energy efficiency, but also because they run exceptionally quietly. The respective values are about 75 dB for diesel-powered vehicles and 73 dB for LPG forklift trucks. The noise the driver is exposed to has been reduced by 3 dB for the diesel version, and by 4 dB (A) for LPG forklifts.

A new concept for forklift cooling:
Axial fans in EC technology

Image 2: A new concept for motor cooling. The previously used conventional hydraulic fans or Visco fans have been replaced with accurately controllable electric fans.

So two forklifts of the new series driving next to each other are just as loud as one of the predecessor models.

The motor cooling fans used also contribute to this favourable noise balance. Their impeller consists of high-strength plastic and the impeller's geometry has been optimised according to aerodynamic criteria with the help of state-of-the-art CFD simulation tools. These features improve noise behaviour and efficiency. The noise level is from 4 dB to even 7 dB lower than that of comparable design versions. The good dampening behaviour of the plastic material used also helps achieve favourable noise emission values. At the same time, the fans deliver up to 6 percent more air than conventional systems. Reliable cooling is thus possible even with higher motor output. The increased air performance also positively influences the aforementioned energy balance.

Tough ambient conditions in worldwide use

Forklift trucks are intended for worldwide use and must operate reliably even in tough operating conditions, such as those on docks and in foundries or cement works. A forklift truck is a piece of equipment that is usually cleaned frequently and intensively using tools such as steam or high-pressure washers. Regardless of humidity, dust pollution or temperature effects at the site where the vehicles are used, the service life of forklift trucks exceeds 20,000 hours.

Every chain is only as strong as its weakest link, and consequently all components of the vehicle must be able to withstand the same requirements. The motor cooling fans used can meet these stringent requirements with ease. The fans have been designed to last for double the number of operating hours without any problems and their operating reliability is not impaired by tough ambient conditions. Innovative design details and carefully selected materials are the prerequisites for these characteristics. The plastic material used for the impellers, for example, is extremely durable and – even without additional varnish – corrosion-resistant, e.g. for salty air. Due to UV stabilisers contained in the plastic, direct solar radiation during outdoor use does not have any harmful effects. Shock and vibration resistance has also been designed to meet stringent requirements. Thus, nothing stands in the way of worldwide use in all climate zones.

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Power fans for high-performance electronics cooling

Reliable heat dissipation is an absolute must for modern high-performance electronics. Discrete power electronics or computer components, such as those in servers, are composed of many individual heat sources. Each component part has a different waste heat flow, for which dissipation is necessary. Particularly when the waste heat flow fluctuates greatly (standby/full load), uniform cooling of all components is difficult. Previously, this required large fans that required a substantial amount of space.


Image 1: Fan family S-Force

Heat dissipation through air cooling is a complicated subject. Many individual "secondary conditions", such as the type of flow (turbulent or laminar), pressure drop due to cooling ducts or fixtures in the cooling air flow (filter, upstream components), etc., make cooling using a central air supply difficult. Using a fan installed directly on site, many of the usual resistances in cooling operation can be bypassed. An individual fan with highly variable output for each subassembly or device specifically adapts the air volume to the local heat and air flow. With this fact in mind, fan expert ebm-papst developed a completely new generation of fans. The S-Force fans stand for targeted high-performance cooling where necessary and a wide air flow bandwidth for standby or normal operation (image 1).

Wind of change

The new cooling concept replaces the previous philosophy of "large air flow = large fan" with small fans with variable speed. Previously, fixtures in servers or industrial equipment, such as welding inverters, frequency inverters, brake resistors or outdoor equipment in the telecommunications area, were supplied by central fans regardless of their actual amount of heat. Today, the components are cooled by individual fans or upstream fan trays. With their wide air flow bandwidth, the new S-Force high-performance fans meet the requirements for a discontinuous heat flow. If short or long-term peak heat levels, the fans increase the cooling air flow accordingly. This provides targeted dissipation of enormous amounts of energy in a small space. The greatest advantage of this is that despite their much higher blower output, the new fans are very compact. The advantage of today's electronic components – their high power density per unit of volume – is not defeated by a voluminous air flow.

Compact high performance

Achieving the objective of high performance in a standard size requires substantial improvements in the fan design. In the foreground are motor technology, aerodynamics and electronics – three components without which it would be impossible to obtain the desired air flow bandwidth. Thus all mechanical parts of the fan generation have been newly developed from the ground up and adapted to the more stringent requirements. Five sizes are available, with diameters

New generation of compact fans features unmatched performance data:
Power fans for high-performance electronics cooling

“The new models achieve a performance increase of about 500 percent”

Image 2: Impeller with winglet blades

from 80 x 80 mm to 172 mm and air performance from 190 to 950 m³/h (free-flowing), with pressure build-up of up to 1200 Pa. Even before each prototype was designed, computer simulations ensured precise calculation of the critical parameters. Then, all components of the fan were tested on the test rig at nominal speeds of up to 14,000 rpm. Particular attention was paid to the design of the impellers and blade profiles and the venturi housing (image 2). A connection and shape of the fixed links between the motor and housing improved the strength of the entire fan.

The ball bearings, which are specially designed for high speeds, make a critical contribution to the excellent service life of the new fans. Additional reinforcements on the housing minimize the physical structure-borne noise excitation at maximum speeds. To provide the necessary drive energy at the new impellers, the fans are also equipped with 3-phase multipole motors, which likewise have been newly developed. Their 6, 8, 10 or 12-pole magnetized rotor units, together with the 9-slot stator pack, provide significant optimization of the magnetic circuit. Therefore, depending on the design, the new motor attains peak power of over 300 W. This means a performance increase of about 500 percent compared to the predecessor models. Here, too, reliability is of the utmost importance.

Because extremely high speeds and temperatures can also cause increased wear, ebm-papst has equipped the motors with speed-dependent, targeted self-ventilation. Every detail of the inside air flow of the motor is adapted to the stringent requirements (image 3). Thus despite the higher speed, these fans easily attain the same long service life of previous standard types.

Electronically commutated drives always have an edge when it comes to service life, energy savings or power output of fans. Likewise, in the control center of the S-Force fans, all settings are adapted to the new requirements. Instead of steep switching flanks, a “soft” commutation decreases structure-borne noise excitation; speed monitoring and closed loop speed control allow constant air flow with minimal energy consumption. The integrated operation monitoring and microprocessor-controlled motor management for software-controlled fan operation allow optimum individual integration of the fans into a comprehensive cooling concept, even for the largest computer systems.

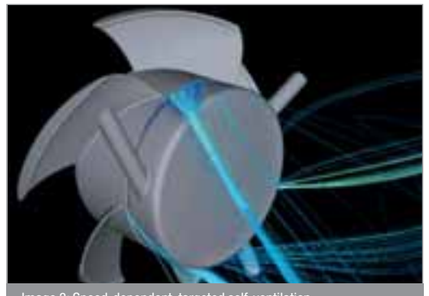

Image 3: Speed-dependent, targeted self-ventilation

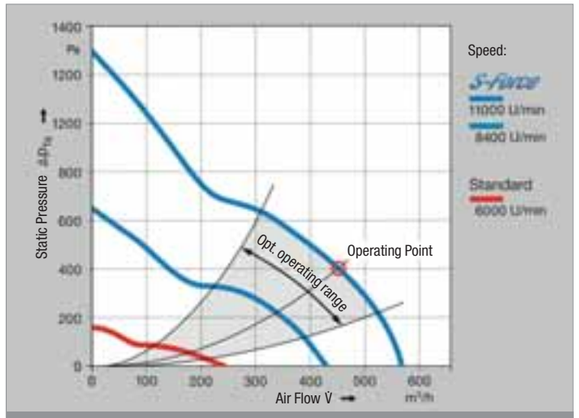

Image 4: Typical air performance curves compared to the predecessor model

Modern electronics and sophisticated aerodynamics, in conjunction with housing and bearing rigidity improved by computer simulation and new materials, enable completely new high-performance fans to be manufactured with remarkable air performance and pressure values (image 4). They enable efficient cooling of tightly packed electronics components, thus drastically reducing the space required for cooling. The more compact dimensions and higher reliability mean less space required, for example in server rooms, and better handling for inverter welding units and thus more economical work.

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Double inlet fans in EC technology

In air-conditioning and ventilation technology, compact fans with forward curved blades are in widespread use due to their relatively high air performance with small dimensions. Typical examples are found in air handling units, the air curtains frequently installed in the entrance areas of department stores, in laminar flow ceilings (e. g. operating theatre) or the fan coils used in many hotel rooms. In these applications, using other fan designs would be out of the question due to the installation space, which is defined by the design of the unit. Because until recently, corresponding EC motor-driven fans with forward curved blades did not exist, users had to live with the low efficiency levels and complicated control of the conventional AC drives on the market. All of that has now changed.

Nobody seriously doubts the importance of saving energy wherever possible. Implementing energy savings in the fans used in air-conditioning and ventilation technology is particularly effective, as these are often operated with high duty cycles. As a result, high motor efficiency makes a pronounced difference – not only in terms of reducing environmental impact, but also keeping money in the end user's wallet. Until now, however, few useful solutions could be found among fans with forward curved blades. These fans in their typical scroll housing are very popular in this application area because they provide relatively high air flow at high static pressure, all while taking up little installation space. However, the energy-efficient EC technology that is used in many other fans could not be used before now. The combination of EC external rotor motor and free-running centrifugal impellers with backward curved blades, which actually provides optimal efficiency and energy consumption, cannot usually be integrated into the existing design of the unit due to the discrepancy in geometric dimensions. Therefore, switching over to modern energy-saving technology necessarily meant a complete redesign of the unit – a time and cost-intensive step that, understandably, scares many off.

Conversion without changing the design

Motor and fan specialist ebm-papst Mulfingen understands this problem. It has now developed a complete series of double-inlet, direct-driven fans with forward curved blades in efficient EC technology. Without changing the design of the unit, this allows a conversion from a conventional fan with asynchronous motor to modern energy-saving technology (image 1, see page 18).

Because the electronically commutated external rotor motor is directly integrated into the impeller, even the installation dimensions are reduced. The belt drive commonly used between the external motor and the impeller is no longer necessary. This reduces the fan dimensions – always desirable for ventilation and air-conditioning technology – as well as the associated installation effort. Of course, this also means one less wear part, keeping service costs low over the long term. Depending on the motor type used, the double-inlet fans with state-of-the-art EC

(Source: Weiss Klimatechnik GmbH)

Image 1: Converting from conventional asynchronous motors to modern EC motors is possible without changing the design of the unit (left: conventional technology with belt drive, right: new technology with EC motor).

technology cover almost every conceivable application area. You can choose between eleven sizes with drive outputs between 85 W and 3 kW (image 2). Thus a customised solution is available for virtually any application, including compact air handling units, air curtains for doors and gates, fan coils, air heaters for factory buildings or as a cooling fan for forced cooling of power converters, generators, laminar flow ceilings or telecommunications systems.

Converting to EC technology provides many advantages

In every case, switching to EC technology quickly pays off for the user. The improved efficiency of the motor provides immediate energy savings of between 20 percent and 50 percent, depending on specific operating conditions such as the load range and duty cycle. The electronically commutated motors work with up to 90 percent efficiency, thus attaining significantly higher values than most voltage-controlled asynchronous motors, which have typical efficiencies of between 30 percent and 60 percent. The different curves in image 3 illustrate a comparison of the power consumption of controlled AC and EC fans. For example: At the operating point 1,000 m³/h and 155 Pa, the consumption of the EC fan is only 115 W. The AC fan, on the other hand, requires 175 W. In addition to the significant energy savings, switching to EC technology provides a whole host of other advantages. Because users in the field of air-conditioning and ventilation technology place particular value on low noise and the most energy-efficient operation, EC fan drives offer an ideal solution. In addition to the low energy consumption, improved noise behaviour is one of their most important features. The electromagnetic circuit of the motors has been designed for just this purpose. Combined with the optimised commutation technique, it was possible to drastically reduce vibration noise and structure-borne noise. The “motor hum” of voltage-controlled asynchronous motors, which is particularly unavoidable in partial-load operation, has been completely eliminated. Of course, installing and wiring the speed controller also becomes unnecessary. This eliminates potential sources of faults, as the EC fans are connected directly to the mains.

Continuous closed loop speed control or automatic air flow control

All of the power electronics are integrated into the motors. They are triggered by the control unit, which is also integrated into the motor. This allows the fans to be continuously adjusted according to the values measured by the external sensor. The set values for the speed, and thus for the air volume, can be configured either via the PWM or 0-10 V input or via a 4 to 20 mA signal. If you need to change the speed manually using an adjusting knob, simply connect a potentiometer. The necessary supply voltage is provided by the integrated motor electronics directly via an electrically isolated voltage output. Thus the closed loop speed control helps to reduce the noise emission and save energy, as the fans only ever have to provide the air volume that is actually required.

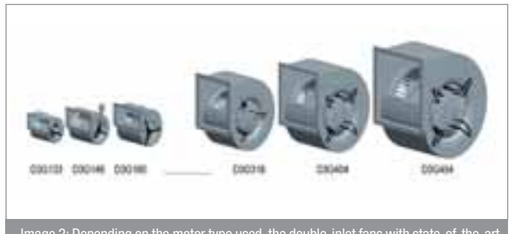

Image 2: Depending on the motor type used, the double-inlet fans with state-of-the-art EC technology cover almost every conceivable application area. You can choose from eleven sizes that cover the power range from 85 W to 3,000 W.

A practical feature for many air-conditioning and ventilation technology applications is an additional option for adjusting the air performance to the actual requirements. Up to three air flow stages can be programmed in “Constant Flow” mode. If the system resistance changes, for example due to clogged filters, the fan compensates by switching to constant air flow (image 4, see page 20). Image 4 shows the control set to a constant air flow of 2,000 m³/h.

Simply connect for robust performance

However, these are not the only advantages of EC motors. The integrated power electronics are compatible with all common supply voltages; depending on the motor type, either 230 V for single-phase AC or 380 V to 480 V for three-phase current supply. The frequencies may vary between 47 Hz and 63 Hz. The air performance and efficiency are unaffected by frequency changes. Compared to asynchronous motors, this drastically reduces the number of variants. Use in fairly rough ambient conditions is likewise not a problem. The motors fulfill the requirements of IP54, and thus are insensitive to dust deposits and splash water. Permitted ambient temperatures may range from -25 °C to +40 °C. The large three-phase versions can be networked, enabling you to implement “intelligent” fan systems. The corresponding interfaces, such as RS485 and 0 to 10 V output for a master slave operation, are integrated at the factory.

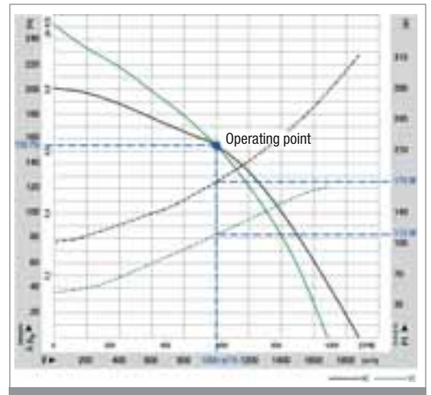

Image 3: The characteristic diagram shows the curves of a blower with an impeller diameter of 180 mm, both with EC motor (green) and with AC motor (black).

Energy savings, convenient control and low noise:
Double inlet fans in EC technology

“EC fan drives: low energy consumption and improved noise behaviour”

Identically sized EC drive replaces shaded-pole motor

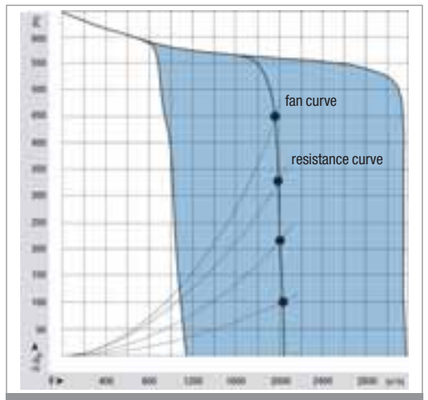

Image 4: Characteristic diagram of a type D3G318 EC fan in “Constant Flow” design.

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“Energy savings of up to 70 percent are practicable”

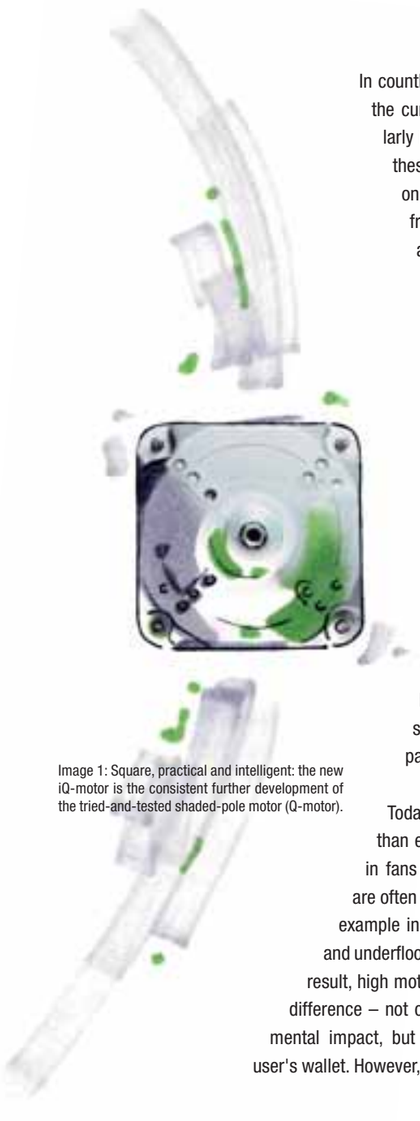

Image 1: Square, practical and intelligent: the new iQ-motor is the consistent further development of the tried-and-tested shaded-pole motor (Q-motor).

In countless fans, shaded-pole motors are the current state of technology, particularly if low power is required. Because these motors can be operated directly on the AC voltage mains, they are frequently preferred for household appliances. One typical application area is fans for convection ovens. However, shaded-pole motors – often known as Q-motors – are also used as an inexpensive standard drive for small axial and centrifugal fans in many refrigeration and air-conditioning technology applications. The asynchronous motor’s typical smooth running, maintenance-free performance and long service life have also contributed to the widespread use of this motor type. However, there is also an important disadvantage: because of their design principle, shaded-pole motors work at comparatively low efficiency.

Today, saving energy is more important than ever. Implementing energy savings in fans is particularly effective, as these are often operated with high duty cycles, for example in refrigerated cases, bottle coolers and underfloor convection heating systems. As a result, high motor efficiency makes a pronounced difference – not only in terms of reducing environmental impact, but also keeping money in the end user's wallet. However, higher efficiencies also mean that less waste heat is given off into the surrounding area. This results in additional energy savings, as less energy must be generated for the cooling process in the first place.

Consistent further development: from the Q-motor to the iQ-motor

However, finding a suitable alternative to the widespread Q-motors and their low efficiency was not easy. Relatively high purchase prices and the fact that such models are not well suited to the application area made the search even more difficult.

Motor and fan specialist ebm-papst Landshut understands this problem. To replace Q-motors, it has developed a new EC motor that is no different on the exterior from the tried-and-tested shaded-pole motors. However, the EC technology on the inside has a significant effect on the efficiency (see text box). This allows immediate energy savings of up to 70 percent. At the same time, the integrated electronics provide intelligent open and closed-loop control options that conventional AC technology lacks.

The newly developed product, called the iQ-motor, is mechanically and electrically compatible to the “old” technology, which allows the motors to be easily interchangeable. Likewise, axial impellers with diameters of 154 to 254 mm can be installed on the new iQ-motor. The same holds true for the mounting flange, the wall ring and the guard grille. The mains cable is all that is necessary for the electrical connection. The motors are designed for rated voltages of 115 or 230 V at a power frequency of 50 Hz or 60 Hz. The maximum power output is 10 watts.

Energy-savings potential for small axial fans:
Identically sized EC drive replaces shaded-pole motor

It pays to switch

Switching over to the new motor technology is worthwhile whenever the old shaded-pole motor fails or energy savings are desired. The switch pays off for both the environment and the user, as the following example calculation shows: in a small supermarket, 40 Q-motors work that have 200 mm impellers and a 34° incline. The energy savings with iQ-motors in this case is 70 percent, which corresponds to 7.5 MWh per year. For the environment, this value means that 4.4 fewer tonnes of carbon dioxide are produced. However, users profit as well. If we assume an electricity price of 15.0 Euro cents/kWh, they save 1,100 Euro a year.

The switch pays off for both the environment and the user

Of course, similar savings can also be attained in many other applications. In addition to refrigerated cases and convection ovens, the typical application areas of the new fan generation include cooling compressors, underfloor convection heating systems and all others that require small fans. This also includes industrial areas, such as textile machines.

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EC drives – high efficiency and effective closed-loop speed control

EC motors are, according to their principle, permanent magnet synchronous motors. They have the same behaviour as direct current motors. Their idle speed depends solely on the applied voltage and the number of windings of the stator winding. This allows any desired operating speeds to be attained, even beyond the limits of approx. 3000 rpm defined by the power frequency. The relationship between the voltage and speed, as well as that between the current and torque, is largely linear. Their efficiency is significantly better than for usual asynchronous motors, at a size that is usually much smaller. Depending on the motor design and power, the efficiency is from about 65 to over 90 percent.

ebmpapst

A new generation of motor forced air ventilation systems

Three-phase standard motors are normally cooled via an impeller that is installed on the motor shaft. This type of cooling works only for uncontrolled motors that are operated at full speed. Speed-controlled motors such as servomotors therefore require forced air ventilation. Forced air ventilation guarantees speed-independent, constant cooling of the electric motor. The outstanding features of this new generation of motor forced air ventilation systems include a high protection class, low noise and high air performance.

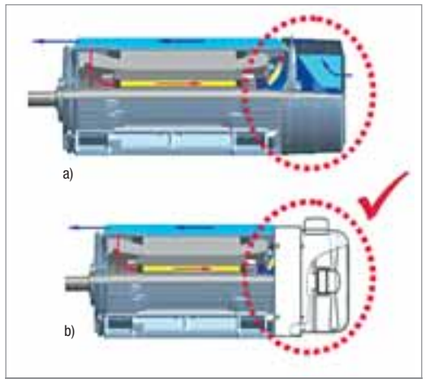

Image 1: (a) Impeller directly on the motor shaft, (b) Motor with built-on forced air ventilation

Electric motors are often operated at variable speeds via frequency inverters, i.e. the motors must produce high output, even at very low speeds. Self-ventilation via a synchronously running impeller (image 1a) on the drive shaft is no longer sufficient in this case. A forced air ventilation system (image 1b) is the solution to this problem. It consists of a fan hood with a fan, which is completely independent of the motor to be cooled and is powered by its own motor. A forced air ventilation system of this kind supplies a continuous air flow that ensures sufficient cooling of the motor for all operating conditions.

Internal rotor technology with a well thought-out sealing system

Motor forced air ventilation systems have been a part of motor and fan specialist ebm-papst Mulfingen's successful product line for several decades. Now, it has implemented the know-how gained over the years in a new series. For the first time, ebm-papst also offers motor forced air ventilation systems for controlled motors with an internal rotor design (image 2, see page 27). The advantage of the new series is its IP 66 protection, i.e. the motor forced air ventilation systems are completely dust and water jet-proof. This means that they can be used without any problems even in extreme ambient conditions, for example, if installations are cleaned regularly, if operated at a location that is very dusty or if the motors are installed outdoors. Image 3 (see page 26) shows the basic structure of the new series.

The motor package is very compact and is sealed by means of a newly developed sealing system. The plastic impeller with the injection-moulded metal socket is press-fitted onto the shaft. This ensures the greatest possible operating reliability throughout the entire service life, which according to the manufacturer's specifications exceeds 30,000 operating hours. Long-term experiments have confirmed this information.

“Motor and hood – a compact unit”

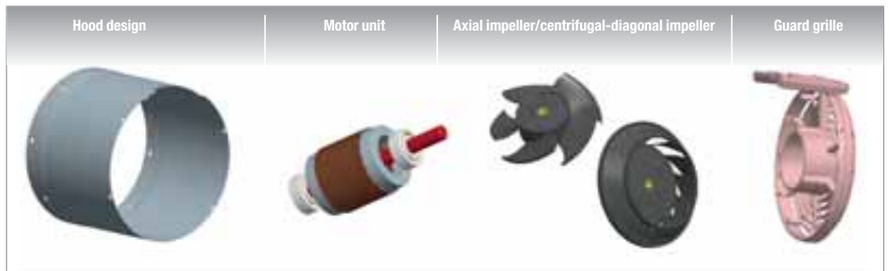

Image 3: Overview of the components of a forced air ventilation system

Carefully selected materials and a well thought-out design

The materials used for other components have also been selected very carefully. The guard grille, for example, consists of durable die-cast aluminium; the terminal box for electrical connections is integrated. The hood design also guarantees excellent durability. It is straight-bead welded of Zincor sheet metal and can easily be adapted to customer-specific needs. Systems for special customer applications can be made available within two weeks. This way, the motor and the hood of the forced air ventilation system become a durable, compact unit that also meets aesthetic requirements.

The new AC forced air ventilation systems are offered in eight sizes and are suitable for motors with shaft heights from AH63 to AH200. (For Germany, the respective mounting dimensions are defined in the standards DIN 42673, 42676 and 42677.) In order to achieve optimum air performance for every size and the specific application, the smaller versions of the forced air ventilation systems are operated with an axial impeller, while centrifugal-diagonal impellers are used for forced air ventilation systems that have motors of size AH100 or larger. Image 4 shows a comparison of the different design versions.

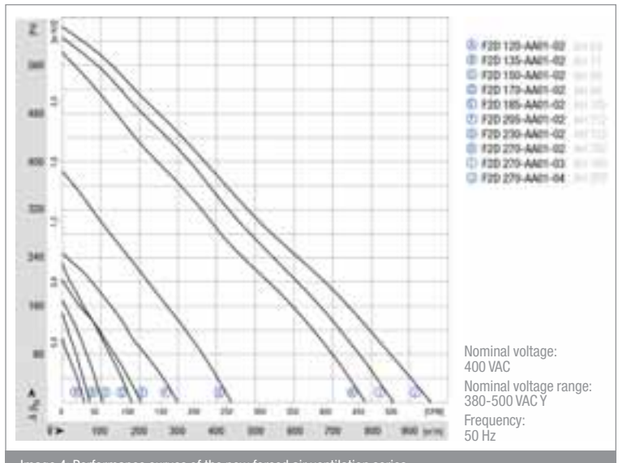

Image 4: Performance curves of the new forced air ventilation series

IP66 protection and high air performance:
A new generation of motor forced air ventilation systems

Image 2: New AC fan for forced air ventilation with IP66. The outstanding features of the fans include high air performance, low noise emission and long service life.

Optimised according to aerodynamic criteria

All the impellers are made of high-strength plastic and have been optimised according to aerodynamic criteria. For example, winglets – familiar from the field of aviation technology – are used to minimise unwanted air flow between impeller and housing. This improves the efficiency and noise behaviour of the forced air ventilation systems. According to recent test results, motor forced air ventilation systems provide on average up to 6 percent more air than existing systems; to be more specific, that value means an increase in air performance of up to 16 m³/h. Reliable cooling is thus possible even with higher drive output. At the same time, the noise level is up to 7 dB lower than that of existing motor forced air ventilation systems. Due to the noise reduction, it is now easier to comply with noise protection regulations.

Of course, the good dampening behaviour of the plastic material used, which happens to also be extremely durable, helps to achieve the lower noise emission. The plastic impellers – without varnish – are very corrosion-resistant, for example if exposed to salt water or salty air. Even direct solar radiation during outdoor use does not have harmful effects, because the plastic material that is used is UV-resistant.

Designed for worldwide use

Thanks to their wide voltage input, the robust motor forced air ventilation systems are suitable for worldwide use. Design versions for star and delta voltage are available for input voltages of 220 to 500 VAC at a power frequency of 50 Hz and for 220 to 575 VAC at 60 Hz. The systems can also be connected to a single-phase AC power supply. Motor forced air ventilation systems with the so-called Steinmetz circuit are suitable for input voltages between 230 and 277 VAC at a power frequency of 50 or 60 Hz. For all variants, the electrical connection not only can be carried out via the terminal box, but upon request also via a plug (guard grille, without terminal board).

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ebmpapst

It pays to save energy

Example from real life

Motor forced air ventilation systems with IP66 protection

Kurt Meier Motor-Press GmbH (KMMP) in Kalefeld, Germany, is already using the new series of forced air ventilation systems. Mario Limburg, the department manager responsible for design and technical sales of forced ventilation units at KMMP commented on the relationship as follows: "We have already been doing business with ebm-papst Mulfingen for more than 20 years. The new forced air ventilation series with internal rotor motors and IP66 protection was developed in response to constantly growing customer requirements. Today, they are the ideal addition to the IP54 forced air ventilation systems, which have a very flat design and external rotor motors." The design versions with IP66 protection are also suitable for use in rough ambient conditions. In addition, ambient temperatures of up to 70 °C are permitted.

"Since the US and Canada are important markets for us, we especially welcomed the fact that the new motor forced air ventilation systems already have UL/CSA approval for insulation class F," Limburg says. "The expenditures associated with applying for certification would hardly be sustainable for a small business like us." Since the Kalefeld-based company purchases the motors for its own motor forced air ventilation series from other manufacturers, it has not really been possible to enforce specific certifications up until now. "When we obtained UL/CSA approvals, they were usually for insulation class A only. For higher voltages, however, temperature problems are inevitable," Limburg adds. When it comes to international use, the motor forced air ventilation systems from Mulfingen can play to other strengths also. An especially important example is the wide range of input voltages between 380 to 575 VAC. In South Africa, where KMMP has its own subsidiary, 525 V power systems are oftentimes the norm.

But there are still more new product features of the motor forced air ventilation systems that KMMP finds very valuable. "The interchangeable frames, meaning the mounting adapter and hood, offer our customers high versatility," Limburg explains. "Thanks to our modern sheet metal processing facilities, we are able to produce and deliver all custom installation dimensions for the sheet metal adapters within one to two weeks." It is possible to integrate special diameters, different lengths, manual ventilation slits, special bores, etc. into the hoods – both for individual items and entire series (image 5). "Due to the special blade design that allows high air performance and minimises noise at the same time, we are in a position to provide technically advanced solutions for any modern application," Limburg concludes.

Image 6: Hoods and mounting adapters offer a high degree of versatility (Photo: Kurt Meier Motor-Press GmbH)

Image 1: Air curtain (Photo: Tekadoor)

Modern EC fans in air curtains: It pays to save energy

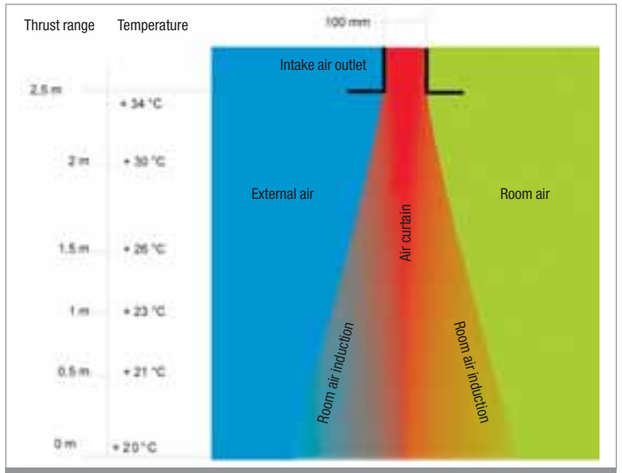

Image 2: Air stream and shielding (Photo: Tekadoor)

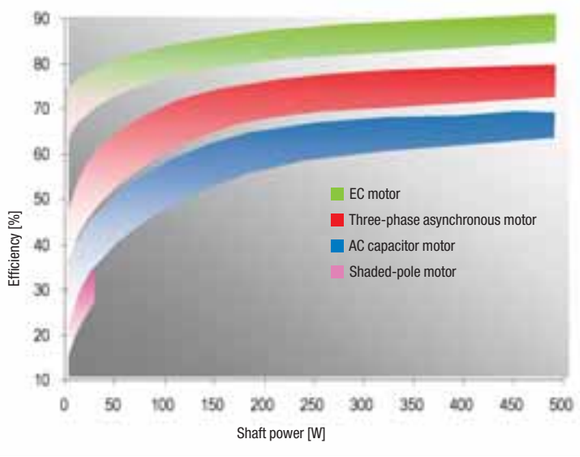

Image 4: Comparison of efficiency

Saving energy and using it as efficiently as possible is the key to a more environmentally responsible future. In today's world, this statement has almost become a truism. Still, it is often not consistently implemented in our daily actions. Many people shy away from the investment costs associated with new energy-saving technology. That reaction is understandable, but incorrect – lower energy consumption of an electrical device will typically yield substantial savings over the course of its service life. As a result, higher purchase prices are usually amortised quickly; thus switching to modern energy-saving technology will ultimately not only benefit the environment, but also help keep money in the consumer's wallet. This pleasant side effect of modern energy-saving technology influences all areas of life – private households as well as industry, trade and commerce. Air curtain systems, which can often be found in the entrance areas of industrial buildings, supermarkets, department stores or public facilities, are a good example to illustrate this point.

Today, there is growing acceptance of the use of air curtains. The air curtain's adjustable air stream divides two thermally different zones and prevents thermal mixing. In the optimal configuration, the room temperature remains constant or there are only minimal fluctuations, draughts can be eliminated or at least significantly reduced, and heating energy consumption is decreased. Image 1 shows an air curtain that is part of the product range offered by Tekadoor of Langenfeld, Germany. Air curtains with the Coanvara Flow blow-out system (see text box, page 32) are suitable for upright or suspended in-line mounting, and thus can easily adapt to the respective spatial requirements in various entrance areas and work very efficiently. They achieve very homogenous air streams and shielding (image 2), good thermal output and require a relatively small amount of energy to do so. According to the manufacturer's information, these air curtains allow for energy savings of up to 40 percent compared to similar systems when heating air. Now, however, additional potential energy savings have become available for air curtains.

Image 3: EC centrifugal blower D3G146-AH50-14 for use in air curtains

The air flow of the air curtains is generated by three to seven fans that are aligned side-by-side depending on the size of the system. The latest generation of systems is now also available with energy-saving EC fans. Motor and fan specialist ebm-papst Mulfingen has developed dual inlet EC centrifugal blowers especially for this application area (image 3). The EC motors used operate at very high efficiencies of about 90 percent. "This means that the end user will see substantial savings (up to approx. 40 percent compared to the conventional technology) in energy costs – particularly considering that air curtains are operated with relatively high duty cycles," explains Martin Aaldering, Managing Director of Tekadoor. "The somewhat higher purchase price for air curtains that are equipped with EC fans will often pay for itself within just a few months – depending, of course, on the size of the system." Switching to energy-saving technology thus pays off quickly and benefits not just the environment, but also the end user, such as the supermarket, department store or industrial facility.

Modern EC drives instead of traditional asynchronous motors

Previously, only the so-called "asynchronous motors" have been used with air curtains. They have a simple design because they require neither mechanical collectors nor electronics to supply power to the rotor. As a result, they are robust and reliable, but only achieve efficiency ratings of about 50 percent (image 4, see page 30) depending the configuration. Open loop speed control, for example for demand-oriented performance adaptation or noise reduction, is laborious and requires additional components.

The more energy efficient alternative is the "EC motor". The abbreviation EC stands for "electronically commutated", as there is no mechanical commutation via carbon brushes from the stator to the rotor. EC motors are, according to their principle, permanent magnet synchronous motors. They behave like direct current motors and feature the same easy controllability. Their idle speed depends solely on the applied voltage and the number of windings of the stator winding. This allows any desired operating speeds to be attained, even beyond the limits of approx. 3,000 rpm defined by the power frequency. The relationship between the voltage and speed, as well as that between the current and torque, is largely linear. Across the entire speed range, their efficiency is significantly better than that of conventional asynchronous motors. Of course, the improved efficiency results in much better use of primary energy and thus in substantial savings that can be calculated fairly easily. The annual cost savings is the product of power savings, energy costs and run-time. The example calculation below illustrates the matter.

„The purchase price will pay for itself within just a few months“

Reduced operating costs, quiet operation and reliable function

The measuring results of direct comparisons between the use of conventional AC technology and EC technology are more than clear. In a cold/hot air door curtain with four blowers running at free air approx. 3,135 m³/h are achieved. The input capacity differs by 350 W (AC = 920 W, EC = 570 W); in other words, the power savings corresponds to approx. 40 percent. If we assume a daily run-time of 12 hours (as for example, in a department store) and 306 days per year, this results in power savings of 4.2 kWh per day and ventilation unit. For three entrances or three cold/hot air door curtains, for example, that would mean 12.6 kWh and 3,855.6 kWh accordingly. The result are annual cost savings of 578.34 EUR (assuming the electricity price is 0.15 EUR/kWh). These savings add up to a large amount considering the many units used worldwide.

At the same time, the user benefits also from the other features of EC technology. For one, EC fans run exceptionally quietly. There is practically no motor noise across the entire speed range. The typical resonance levels associated with asynchronous motors operated with frequency inverters or “phase noise” have been eliminated since a different operating principle is involved. Of course, the impellers, which have been optimised according to aerodynamic criteria, also contribute to the lower noise emissions. Other features of EC fans, such as the relatively long service life of well over 40,000 operating hours, good controllability and alarm output, have shown to have positive effects in practical use. This substantially reduces the maintenance intervals, resulting in significant cost reductions for the end customer. For EC fans, the motor speed can be adjusted via a control interface, which provides a very convenient option for demand-oriented performance adaptation. The air performance of the air curtains can be perfectly matched to the specific ambient and operating conditions. Therefore, switching to energy-saving fans is not only easy on your wallet and the environment, but also offers better operating convenience.

The Coanvara Flow blow-out system

The air curtains are based on the “Coanvara Flow blow-out system," which is a multiple nozzle system with specially shaped vane profiles and a blow-out angle that can be adjusted by up to 40° in both directions. The individual jets are combined into an extra-wide air stream. The design harnesses the Coanda effect, which states that an air stream will tend to follow the curvature of a convex surface rather than depart from it and continue moving in the original direction of flow. The selected long vane profiles of the air curtains simultaneously function as flow straighteners. The back pressure generates homogenous air streams with remarkable levels of shielding and heating.

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