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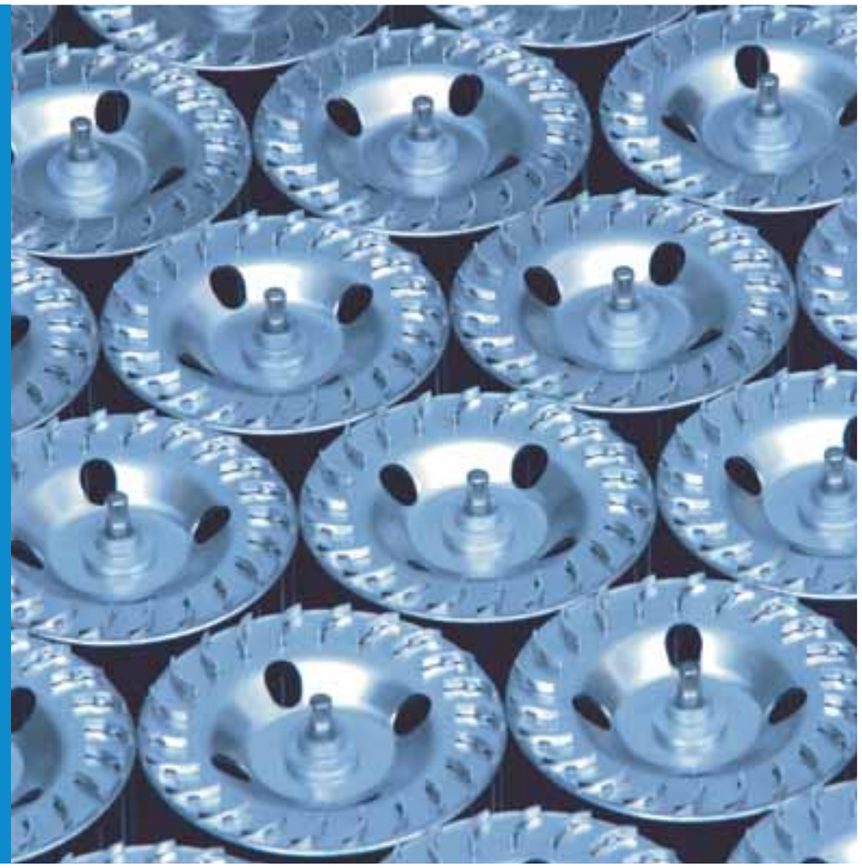
NEW IDEAS AT A GLANCE



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Editorial

The basis:
„Open communication, fair co-operation, passion and commitment"

Dear ebm-papst customers, partners, and friends,

The success we enjoy as company is the market response to our current product range and our quality standard. New applications, new technologies, and new specifications are the driving force for continuous change that we, together with our customers, are asked to accept in order to assert our position in global competition every single day.

The main factors for our success have always been:

- Optimal product utilization in the customer application
- Reliable function of our products
- Customer-oriented product range with appropriate standardisation
- High degree of innovation focussing on benefits for our customers
- … and last, but not least, competitive prizing

What are the tasks and objectives arising from this?

- Professional handling of customer projects: Clearly – in co-operation with customer – defined project objective, well-timed tying in of suppliers and production, and project progress oriented on deadlines and target costs
- Future through progress: Innovation in the sense of progress, i.e. keeping what is tried and tested and continually improve and add something new.

Open communication and fair co-operation with our customers, our suppliers and, of course, also here in house, combined with "passion and commitment" so necessary in R&D are the basis for successful action and business. Success provides us with the necessary security and self-confidence to positively shape our future.

This edition of our tech.mag gives you an idea how ebm-papst evidently helps to bring about a reduction in CO_2 emission with products based on our core competences aerodynamics, motor technology, and electronics. Having improved the efficiency of fans, pumps and electric drives, and with these products used in billions of applications in the field of refrigeration, ventilation and air-conditioning, in heating, systems engineering and appliance technology, as well as in motor vehicles, we see a tremendous amount of electric power being saved. Despite the slightly higher primary costs of products using this technology, a commercial benefit is gained in a very short time due to savings in operating costs. We are certain that politics and common sense will help to boost this technology and help to implement it thoroughly with promotions and provisions.

May this edition of our tech.mag. bring you new insights, information and ideas!

Dr. Bruno Lindl
Managing Director R & D
ebm-papst

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Decentralized electric drives in the automobile

Nicolaus Otto used a fixed coupling of crankshaft and camshaft in his engine because there simply was no alternative. Generations of engineers adopted this simple yet inflexible solution to drive countless auxiliary and ancillary units. In the process, the size of the engine's gear, chain and belt mechanism became more and more overwhelming as the emphasis on comfort and safety features increased. Today, this historically-rooted concept stands in the way of new technical solutions and optimum aerodynamic design. The remedy is to use state-of-the-art decentralized drives. Electronically controlled EC motors can power a variety of safety and auxiliary functions in the vehicle. The space problems and laborious inspections of belts, tensioning rollers etc. are a thing of the past; the compact local drive saves space and requires little maintenance.

Image 1: The conventional, cluttered mechanical solution.

Decentralized control modules for the brake assistant, engine management, the climate control system, and chassis stabilization are already being used to control a variety of functions in the vehicle. However, virtually all of these functions still obtain drive energy for controlled operation from auxiliary units that are mechanically coupled to the engine, either directly or indirectly (image 1). This holds an enormous potential for new developments and cost savings – of which automakers and automotive suppliers are making increasing use, one of the reasons being more stringent emissions standards. Motor manufacturer ebm-papst of St. Georgen, Germany is also taking part in this trend. New concepts in the area of small drives open up a wide range of applications for decentralized drives in vehicles.

State of the art of technology

Until now, only a few functions in a car have been powered by decentralized drives. Usually, these have been units with very simple movement sequences or functions that need to work independently of the main engine. The chief examples are windshield wipers, power windows and ventilation.

Even these things, however, are often still centralized; for example, it is still common to distribute fresh air throughout the vehicle through a conduit system by means of a single, large and loud fan. As a result of design necessities, the use of individual drives for window lifts, seat adjustment, and blowers for the climate control system or in the radiator fan has continued to advance. However, inflexible brush motors have been used almost exclusively. What is also often lacking is an intelligent control system to monitor the functions and avoid overloads. Also, simple on/off switches for the radiator fan do not allow the coolant temperature to be controlled according to the engine load and fuel consumption.

Evolution in automotive peripherals: Decentralized electric drives in the automobile

“An EC motor lasts for the entire lifetime!”

State-of-the-art solutions

Most energy-consuming systems are used only for short periods or only occasionally used at full load. Therefore, a mechanical coupling to the main engine always has two significant disadvantages. The first is that the speed of the internal combustion engine varies and, along with it, its capacity. Secondly, the output of the drive and the power demand of the units frequently differ. For both reasons, a mechanical coupling is seldom very effective from an energy standpoint. Examples of other systems which, unlike most others, receive full power at all times are the coolant pump and the hydraulic power steering pump. These typical power-hungry systems are mechanically linked to the main engine. Because these systems are driven at their maximum power from the first moment the vehicle moves, they are very inefficient in their energy balance. From an emissions standpoint, these drives are also highly disadvantageous.

However, by switching over to electronically controlled EC motors as the power source, the available power from the engine can be decoupled from the power demand of the units. If the motors are electronically commutated, the only remaining mechanical wear component is the bearings. Today, many tens of thousands of operating hours at full load are the standard; an EC motor lasts for the entire lifetime of a car.

Ideal auxiliary drive

The properties of today's EC motors make these drives ideal for all automotive applications in which compact, easily controllable power is required. The functional principle is quite simple: a synchronous motor with internal or external control electronics that generate the necessary rotary field – usually 3-phase – from direct current. The motor behaviour corresponds to that of the direct current motor, so that in this respect also, the designation of electronically commutated DC motor is justified. (The motor is also known as a BLDC motor, short for brushless direct current).

These motors can be precisely controlled in all load and speed ranges. For example, 4-quadrant operation – accelerating or braking in both directions of rotation – is possible without any problems. It is precisely these properties that allow use in many automotive applications, which require both an acceleration and a braking mode. Unlike hydraulic components, this does not require any additional components such as reversing valves or return springs. Thanks to the rotary field, which is always optimally controlled, the torque can be adjusted easily, an important point for overcoming high breakaway torques and subsequently controlling to position. Furthermore, these motors feature very high efficiency due to the optimal magnetic flux control.

Real-world applications

Initial efforts at decentralization are already evident in premium-class vehicles. For example, a power steering system using an electric motor and a modulation gear (image 2) is currently in production, as are power steering systems with electric motors instead of hydraulics. Power steering in particular places extreme demands on the drive motor. For its entire service life, it must withstand changing speeds between 0 and 6,000 rpm. Unobtrusive power steering requires both a sensitive mode, almost like a step motor (minimal corrections for improved directional stability) as well as a rapid change mode, as demanded by rapid changes in rpm in typical parking situations, not to mention support for dynamic driving situations (slalom course). In a vehicle application, the motor is constantly under stress in 4-quadrant operation.

Image 2: Already in series production: highly dynamic power steering motor.

An integrated rotary encoder with a rotation angle accuracy of less than 1% ensures that motor and control electronics receive the exact data they need.

Fans and miniature blowers with intelligent EC drives are already established technology. These are used primarily in vehicle electronics cooling, but also in the comfort area for seat ventilation (image 3), climate control sensors, single-seat air-conditioning and as auxiliary blowers in large quantities. Controlled radiator fans and electric coolant and motor oil pumps are also on the market. They expand the possibilities of engine management and help to reduce consumption and harmful emissions.

Some EC motor applications are limited to trucks and/or prototypes, and will take a bit longer to be used in cars. These include drives that replace the conventional fixed mechanical coupling for drives or brakes, thus integrating them into a driving management system. These include gearbox actuators, the electrically activated clutch or a controlled oil separation and exhaust gas recirculation or exhaust cleaning systems that use urea/water solution. Other promising planned uses for EC motors include adaptive headlights, automatic brake lining adjustment when the vehicle is started, and electrohydraulic leveling or active chassis systems.

Image 3: Active seat ventilation for maximum seating comfort in cars and commercial vehicles.

“For developers, this provides greater flexibility and more leeway for design!”

Image 4: In the laboratory – fans that make it here will last the car's entire lifetime.

Image 5: Modern automotive EC motors: as diverse as the requirements.

Inner values

Thanks to today's miniature electronics and new, high-energy magnet materials, the decentralized drives can be custom-tailored to every application. They easily withstand shock and vibration loads, even over 10 g, for long periods. Just as importantly, they withstand other environmental influences, such as a wide temperature range (-40 to +120° C) or temperature shock, and have high chemical and mechanical resistance (image 4).

In addition to meeting purely mechanical demands, the drive also needs to automatically monitor safety-related functions. The integrated electronics for motor activation can already fulfill other tasks with ease. For example, torque and speed control are no problem, nor is an error message output or integrating the drive into the vehicle's bus system. With this compact solution, the motor replaces the responsible computer(s); it is a plug-and-play system that configures and monitors itself after installation. Compact internal or external rotor motors in many sizes, each with specific advantages, allow the actuator to be optimally adapted to the individual drive technology (image 5).

They also have significant advantages over gear, belt or chain drives in terms of service life and low maintenance. Direct electrical drive allows the hydraulics commonly used today to also be omitted.

In the future, state-of-the-art EC drive motors will be the interface between flexible electronics and relatively rigid mechanical peripherals. Used as a decentralised, local actuator, they allow the drive power to be finely tuned to match requirements. Furthermore, they are capable of self-monitoring as an intelligent drive and carrying out safety functions, thus opening up completely new control possibilities to the vehicle management system. For developers, this provides greater flexibility and more leeway for design and individual adaptation.

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Safe component “Made in Germany”

As the patron takes great delight in washing down the first sip of his fresh draught beer, he does not even notice that a little something has reliable done a good job: the centrifugal immersion pump inside the dispensing equipment. Thanks to its untiring work, the beverage maintains the correct temperature from tank to tap. A new generation of the German manufacturer ebm-papst now offers operators of dispensing equipment a host of valuable benefits.

Condensed water is dripping off the ice-cold draught faucet of the brewery. The landlord has just drawn five pints, and orders for more are in hand. This is a scene typical of what went on in thousands of gastronomic locations, beer gardens, or the many organised street parties, World Cup parties and other open air events throughout Germany during last year’s hot summer months. To make sure the liquid gold is served the guest at the required temperature all year long, reliably technology has to be used. And in order not to have the beverage drop in temperature on the very last metres just shortly after the beer cooler and up the faucet, special centrifugal immersion pumps are used for cooling the pipes the beverage flows through.

What the pump does

From the beer barrel or steel keg to the glass, beer has to travel a long way. In doing so, a temperature of 4° C may not be exceeded. For this reason, it passes the beverage cooler or chiller first. This is normally housed in the cellar or in another distant location. Inside the beverage cooler, there is the cold water quench, and inside this is one cooling coil for the coolant coming from the refrigeration plant and a second one for the actual beverage. The chiller serves as heat exchanger, absorbing heat from the beverage and passing it on to the refrigerant. Submersed in the water quench of the beverage cooler is the centrifugal immersion pump. Its function is easily explained: On one side, there is the electric motor serving as drive. On the other side, connected with the motor via a long shaft, is a round cylinder containing the actual centrifugal pump. At the very end of the shaft, a little propeller is put on that works just like a ship’s propeller.

Two main tasks are accomplished

As tapping at the dispensing point has to be at a uniform low temperature, and as the maximal temperature of 4° C may simply not be exceeded, the supply pipe between cooler and dispensing point – usually between 10 and 15 metres long – has to be also cooled. This is known as the secondary beverage cooling. In gastronomy, the centrifugal immersion pump is better known as cooling line pump or column pump. This means that the pump does not deliver the beverage (therefore not designed to meet food technology standards), but rather it delivers cooling water taken from the water quench of the beverage cooler. Cold water is sucked in via a piston ring at the pump, passes a plastic hose coiled around the beverage line right up to the faucet and then back into the cooler. Thus the cycle is closed. In expert circles, the coiled appearance of the hose package has earned it the affectionate term “python”.

New centrifugal immersion pump for beverage dispensing equipment:
Safe component “Made in Germany”

“The operational reliability and efficiency were improved”

Image 1: New centrifugal immersion pimp made by ebm-papst.

The second task of the pump has to do with the propeller. In order to ensure an even vertical temperature distribution in the beverage cooler, the cold water is permanently circulated in the cooler via rotation. This has a positive side effect: ice is prevented from forming on the cooling coil carrying the refrigerant.

The new generation is coming from Mulfingen, too

A further development of the pump generation as described has been launched on the market by ebm-papst Mulfingen GmbH & Co. KG, the leading manufacturer of motors and fans. Improvements of the new centrifugal immersion pump of the P2E070 line are down to details (image 1).

As with the existing type P2E076, the proven size 68 ebm-papst motor is used. The apparent change is the design of the motor housing, now in encapsulated form. The top part is made of high-quality reinforced fibre thermoplastic resin to protect the pump from mechanical and thermal stress.

The bottom part is made of hydrophobic and dimensionally stable thermoplastic resin ensuring the exact and permanent positioning of the impeller in the housing. This has led to an improved operational reliability and efficiency. Moreover, the heat introduction of the running motor into the quench has been reduced, as the stainless steel bracket has been replaced by the high-quality plastic design. In operation, the external-rotor motor is protected mechanically. Potential damages to the lines caused by its rotation are thus also avoided on the beverage cooler.

And especially in winter, the new pump is of additional usefulness, as the new encapsulated motor design does not create air turbulences, so almost no evaporating surface water can get from the cooler into the ambient air. The benefit lies in the eliminated need to refill water in order to avoid malfunction or failure. On the other hand, in summer, the cooler will not overflow, which is what can happen with condensing water from the “humid” ambience.

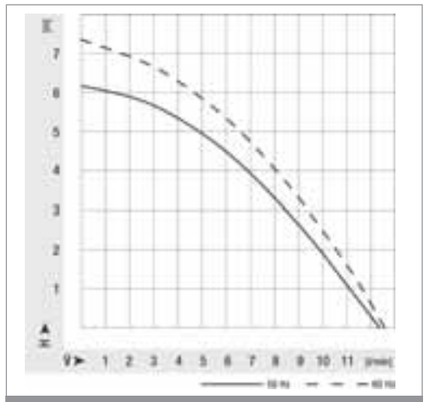

Image 2: Delivery rate characteristic of the new pump.

“The new centrifugal immersion pump saves energy costs”

So far, centrifugal immersion pumps have been based on the so-called AC technology and are not speed controlled. For beverage coolers in the high-end segment, however, EC applications are also possible, as they allow the pump to be speed controlled. This would have the additional benefit of being able to realise a speed night sink mode for times when no actual tapping takes place, yet cooling has to be performed anyway to prevent ice from forming on the coiling coil. This optional mode has the operator save even more on energy costs.

“Customer-specific adaptations can be realised more easily”

Due diligence lies with the operator

On July 1, 2005 the beverage dispensing equipment regulation was suspended. So far, due diligence for operation and hygienic state and use of the dispensing equipment has been lying with the operator. In its DIN 66650, the “standard committee on beverage dispensing equipment/Normenausschuss Getränkeschankanlagen” has been recommending ever since to cleanse tapping armatures, faucet and beverage lines for beer at least every seven days. The duty pf the operator also extends to the safe operation of the plant. With defects and deficiencies, fines or even tougher sanctions are to be incurred. So it really pays off to make beverage dispensing equipment and its components safe to operate and reliable in operation. Modern centrifugal immersion pumps provide this safety. Their modular mechanical design makes it easy to adapt the pump to individual requirements:

- Immersion depth can be altered by pump leg length and shaft length variation
- Customer-specific adaptations can be realised more easily by simply exchanging the mounting plate.
- Cable exit and position of terminal box can be fitted in 4 x 90° stages.

With this, even replacing or exchanging older models is no problem. And this makes sure that every landlord or dispensing equipment supplier is on the safe side, even if operating conditions are not statutory.

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Stable combustion, even with fluctuating gas quality

New type of electronic controller for gas blowers:
Stable combustion, even with fluctuating gas quality

"The new LambdaConstant electronic combustion controller optimises combustion"

Image 1: The new LambdaConstant electronic controller for premix burners automatically detects the gas quality and controls the composition of the gas-to-air mixture accordingly.

The liberalisation of the gas market obligates gas providers to pipe gases from various manufacturers through their networks and, in the event of supply bottlenecks, to mix gases from different supply regions. Though this requirement ultimately benefits the consumer, it also has disadvantages. Fluctuations of gas quality demand different proportions of gas and air in the burner. If they are not adapted, this could lead to unwanted noise, increased pollutant emissions or reduced heating capacity. The solution to this is modern electronic controllers.

Attaining an optimum and environmentally sound combustion process in modern gas heaters an adapted gas-to-air ratio is required. This ratio is known as lambda. A lambda value of approximately 1.3 is ideal for an optimal combustion process. The currently standard premix burners, which work with corresponding values, ensure flame temperatures of under 1300° C and thus low nitrous oxide values.

The limits of mechanical systems

Though the correct mixture ratio can usually be attained without any problems using mechanical control systems, as long as the combustion-related marginal conditions do not change. However, control with the conventional gas-to-air mixture becomes difficult or impossible when different gas qualities are involved. Depending on the supply region, for example, the nitrogen content of natural gas can vary considerably. Though the gas providers have agreed on certain limits, the fluctuation range remains substantial. Thus, depending on the origin of the gas, expensive and laborious adjustment and measuring tasks would be required to keep the lambda value roughly constant for a pneumatic mixture. This is not feasible in real-world conditions. As a result, undesirable side effects have to be taken into account when using mechanical processes for gas-to-air mixtures, such as reduced heating capacity with increased pollution and overall "dirty" combustion.

Switching from high-calorific natural gas (known as E gas) to low-calorific gas (L gas or even LL gas) also reduces the heating capacity in the double-digit percent range if the gas-to-air mixture ratio is not adjusted accordingly. The location of the heating unit also plays an important role. Due to the decreased air pressure, the higher the unit is located above sea level, the lower the heating capacity will be, even at the same gas quality. At the same air flow of the combustion air, the supplied air mass decreases, the combustion-related oxygen quantity decreases, and the heating capacity decreases along with it.

Electronic control based on air mass flow and flame temperature

The new LambdaConstant electronic combustion controller (image 1), introduced by ebm-papst in Spring 2007, prevents these problems from the outset. The microprocessor-controlled system detects the quality of combustion. Regardless of the installation location and the heat requirement, a closed-loop control system optimises combustion automatically. How this works in practice can be understood quite easily (image 2).

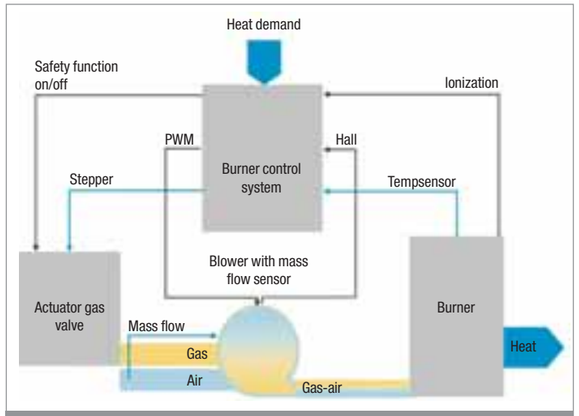

Image 2: The principle of the electronic gas-to-air ratio controller with LambdaConstant.

Three values are important for controlling and thus optimising the combustion: the heat requirement, the air mass flow and the gas quality. First, the mass flow of the combustion air is adjusted according to the heat requirement. After all, this mass flow is proportional to the desired output. The required mass flow meter, in this case a thermal anemometer, is directly integrated into the fan.

However, to attain the optimum gas-to-air mixture ratio, it is also necessary to know the composition and quality of the gas. Measuring this value directly using corresponding sensors is a laborious process, requiring expensive instruments. There is, however, a practical alternative. To measure the gas quantity required depending on the combustion quality, one can use a characteristic feature of premix burners. At the same heat load and excess air (i.e. the same lambda value), all gases in the same family have identical temperatures at the burner under identical marginal conditions. In accordance with the regulations of the German DVGW (German Technical and Scientific Association for Gas and Water), this gas category includes all natural gases as well as methane, butane, and propane-air mixtures. This allows lambda control depending on the temperature at the burner and the mass flow of the combustion air. The curve in image 3 shows the relationship between the temperature and the air mass flow. Thus, the excess air can be kept constant over a heating unit's entire modulation range, from the minimum to maximum load. This guarantees an optimum combustion process under all conditions for the new "electronic mixture".

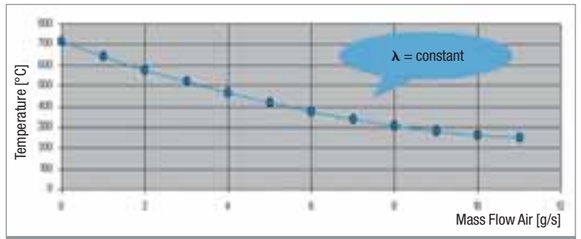

Image 3: Typical of premix burners: A direct relationship exists between the temperature at the burner and the supply of combustion air.

Reliable function and wide control range

The electronic control is extremely compact and can be combined with virtually all gas-tight radial fans of the ebm-papst group. This means that premix burners with rated outputs from approximately 10 kW up to the megawatt range can benefit from the new control system. The modulating gas valve does not require expensive parts such as membranes. The brushless, electronically commutated DC drives used in the fans guarantee reliable operation over many years.

The good control options allow the heating capacity to be perfectly matched to the specific heat requirements. While pneumatic gas-to-air controllers usually allow a control

"The good control options allow the heating capacity to be perfectly matched"

range of only about 1:4, control ranges of up to 1:10 are conceivable with the electronic gas-to-air ratio controller. The following example illustrates the benefits this provides. If the current outside temperatures result in a low heat demand, a premix burner designed for a rated output 20 kW could, in an extreme case, provide a constant heating capacity of 2 kW. This drastically reduces the number of burner starts; in an ideal case, it drops to almost zero, increasing the efficiency of the system with lower harmful emissions. The optimised combustion process makes the electronic controller highly beneficial, providing advantages to consumers and the environment alike.

Ulrich Geiger (left)
Project Team LambdaConstant

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EC fans putting pressure on the market

The most economical solution for handling air: EC fans putting pressure on the market

"Fans are the most important components and the heart of the entire operation"

According to a study commissioned by the EU, airconditioned buildings are about to double in area by 2020 in Europe alone. At the same time, the benchmark for energy-saving system solutions has been set higher and higher. In order to help solve this climatic Gordon knot, using EC fans for handling air in centralised air-conditioning plants or home ventilation is the most promising solution.

In building management, air-conditioning and ventilation systems are and will always be an essential part. From the passive house with home ventilation providing the mandatory air renewal up to large-scale airports, administrative building complex or hospital. In many instances, ventilation or air-conditioning plants are responsible for providing the enclosed spaces with air via extensive supply and discharge ducts. Alone the costs for handling air here can constitute up to 70% of the total costs for operating the air-conditioning or climate control system. As heat recovery units, respectively heat/humidity-recovering units are increasingly used in air-conditioning systems this ratio is even further increased, mainly due to the fact that pressure loss is in parts considerably higher here. What is absurd is that there are now cases where the additional costs for handling air easily exceed the actual cost for the heating energy saved.

Pressure losses and resistances

Research results of existing plants covered by the "BOLKA I Forschungsvorhaben"[1] (research project) revealed that the central unit and the fan have a decisive impact on the energy requirement. The central unit in most cases consists of a fan for moving air and the component assemblies for air treatment. With various building types that were investigated, pressure losses in the central unit made for 60% of the overall pressure loss (including the losses on the fan). Electricity demand for ventilation in administrative buildings, for example, is approx. 18%. In this, the fans have the biggest share. This shows that selecting a fan requires careful consideration (image 1).

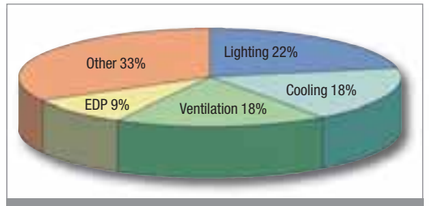


Image 1: Electric energy consumption in office buildings.

Energy input in handling air is not only determined by the pressure losses of the duct system, but also by the pressure losses inside the ventilation unit and the efficiency of the fans that are used. Within the unit, the heat exchanger for heat recovery is a main cause for flow resistance - approx. 50 Pa – as are the installed filters. The discharge filter in filter class G3 causes a pressure loss of approx. 16.2 Pa. Outside air is also filtered with filter class G3, additionally with F7. For the G3 filtering process, the pressure loss is 16.2 Pa, and for F7 the pressure loss is 95.3 Pa. This just shows that a substantial part of the costs for handling air in home ventilation units is incurred by heat exchanger and air filter. With air-conditioning plants, these resistances are even markedly higher, as complex duct systems of additional components such as radiator grille, sound mufflers or filters cooling and as bigger air volumes both for air supply and air discharge are involved[2].

1: Research project BOLKA "Bestimmung des Energiebedarfs zur Optimierung von Luftkanalsystemen Raumluft-technischer Anlagen" (Determining energy demand to optimise air duct systems of air-conditioning systems) (AiF-Nr.: 13269/BG), Universität Stuttgart - Lehrstuhl für Heiz- und Raumlufttechnik, Technische Universität Dresden, Institut für Thermodynamik und Technische Gebäudeausrüstung Bereich Technische Gebäudeausrüstung; August 2004

What the standards say – SFP value

The energy saving targets as specified in the European guideline "Energy Performance of Buildings Directive (EPBD) 2002/91" are implemented in Germany per energy-saving directive and other standards and guidelines. For ventilation and air-conditioning plants, the most important standard is DIN EN 13779 "Lüftung von Nichtwohngebäuden – Allgemeine Grundlagen und Anforderungen an Klima- und Lüftungsanlagen" (Ventilation of non-residential buildings – General basics and specifications for air-conditioning and ventilation plants), as reported by the Fachinstitut Gebäude-Klima e.V., one of the few organisations in Germany involved in standardisation.

SFP value in W/(m³/s)		
Category	Air-conditioning unit / AHU	Per fan
SFP 1	<1000	<500
SFP 2	1000 bis 1500	500 bis 750
SFP 3	1500 bis 2500	750 bis 1250
SFP 4	2500 bis 4000	1250 bis 2000
SFP 5	4000 bis 6000	2000 bis 3000
SFP 6	6000 bis 9000	3000 bis 4500
SFP 7	>9000	>4500

Table 1: Specific fan capacity (supply and discharge air) as per DIN EN 13779.

Air volume flow	Unit class 1 Without thermo dynamic air treatment	Unit class 2 With air heating treatment	Unit class 3 With additional functions
[m³/h]	[W/m³/s]	[W/m³/s]	[W/m³/s]
2000 to 5000	2700	3300	3800
5000 to 10.000	2500	3000	3600
10.000 to 25.000	2300	2700	3300
25.000 to 50.000	2000	2500	2900
Exceeding 50.000	1900	2300	2700

Table 2: (source: VDI 3803)

DIN EN 13779 defines the so-called SFP classes (Specific Fan Power). Throughout Europe, the SFP has become a parameter for the power input of a fan per m³ of handled air volume (unit: W/[m³/s]). This SFP value is therefore an (energy) index for the quality of optimised air handling. Reducing pressure losses and leakage air amounts and using efficient fans helps to also reduce the fan power input, thus optimising the SFP value.

Table 2 shows maximum electric power input for air handling in air-conditioning plants according to VDI 3803. With combination units for air supply and discharge, the limits apply to each partial volume flow.

When it comes to energy costs for an air-conditioning unit, the cost distribution of the fan has to be carefully considered, too. The design of efficiently working centralised air-conditioning and ventilation appliances thus relies on the reduction of investment, operating and maintenance costs.

The fan at the heart of the air-handling operation

Air-conditioning plants contain at least one, in most cases two or more fans which are the most important component

2: The figures are taken from presentations held at the FGK-Symposium "EnEV 2006 für RLT-Anlagen" (Energy-saving directive 2006 for air-conditioning systems), March 2006 as well as the FGK-Symposium "Wohnungslüftung" (Home ventilation), October 2005.

The most economical solution for handling air: EC fans putting pressure on the market

"EC motors made by ebm-papst even exceed the specifications!"

and at the heart of the entire operation. The fan is responsible for:

- Conveying a certain volume flow through the air-conditioning plant and generating a pressure increase overcoming the flow resistance of the plant.
- The best possible efficiency. Thus, fans are the most important component and play a decisive role in determining the amount of energy consumption respectively the SFP value.
- Only causing minimal noise emission.

Energy costs for an air-conditioning unit are roughly made up as follows:

- 20-30% cooling demand/cooling load
- 30-50% heating demand/heating load
- 30-50% fans

EC technology – always the best choice

This leaves the question what fan is the right fan for these applications. As is sometimes the case, the answer is closer to hand than expected. DIN 1946-part 4 says: "Free-running impellers without scroll housing are to be preferred", and VDI 6022 recommends "For hygienic reasons, fans respectively fan drives are to be used with which it can be safely assumed that there is no deterioration of air quality caused by belt abrasions; free-running impellers without scroll housing or V-belt drive with flat belts are to be preferred", and the Association of air-conditioning unit manufacturers has the following to say in the directives 1 and 3 on "General requirements with air-conditioning plants: "Fans with backward curved blades are to be preferred". The preliminary European standard prEN 13053-6.3.1 states: "Energy-saving motors in class EFF1 are recommended." And VDI 3803-5.3.5 says: "The use of free-running impellers at total pressures <1500 Pa is recommended. […] Fans without belt abrasions (especially free-running ones) are recommended".

All of these requirements, even up to best SFP values indicating highest efficiency, have their answer in the line of fans driven by motors in EC technology as offered by ebm-papst Mulfingen, the specialist in motors and fans. EC motors made by ebm-papst even exceed the specifications for class EFF1 motors in terms of efficiency – and this by a wide margin (image 2). The comprehensive and complete new line in EC technology comprises speed-controllable centrifugal fans with diameters ranging from 250 to 560mm. With this, air flows for home ventilation units as well as centralised and decentralised air-conditioning

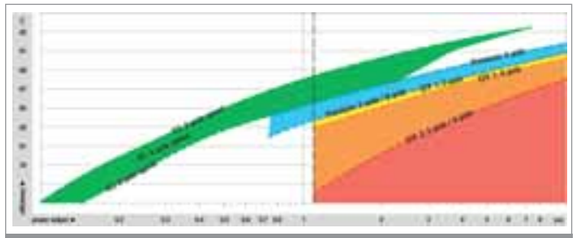


Image 2: Classification of efficiency of different motor types.

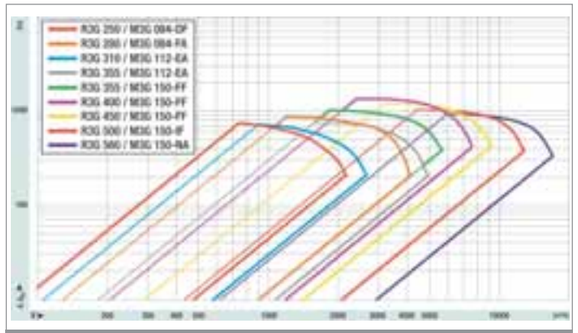


Image 3: The line covering airflows from 300 to 10 000m³/h.

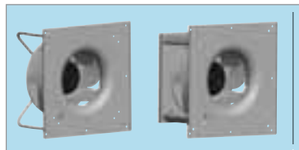


Image 4: EC fans as Plug & Play variants.

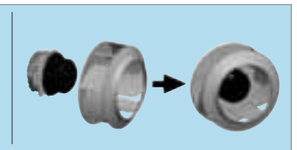


Image 5: Compact design, as motor is integrated in the fan.

plants between 300 and 10,000 m³/h can be covered (image 3). The compact modular units consist of a motorised impeller and the appropriate inlet nozzle with integrated pressure sensor spot. Alternatively, ready-to-install modules are also available (image 4).

As the EC fans are speed-controllable, it is possible to adjust the airflow via 0-10 V signal to what is actually needed. At the same time, an ebm-Bus interface RS 485 allows for the fan to be networked with the centralised unit or the building management system. And wide voltage input 200-277 V, 50/60 Hz respectively 380-480 V, 50/60 Hz makes the units compatible with all conventional power providing systems throughout the world. And the pressure sensor lets you choose between constant airflow and constant pressure control.

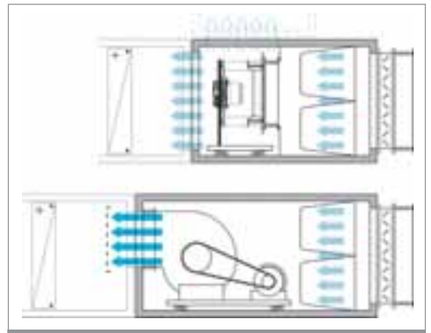


Image 6: Comparison in size reveals just how much space can be saved in the overall system by using EC fans (top: using EC technology, bottom: conventional system).

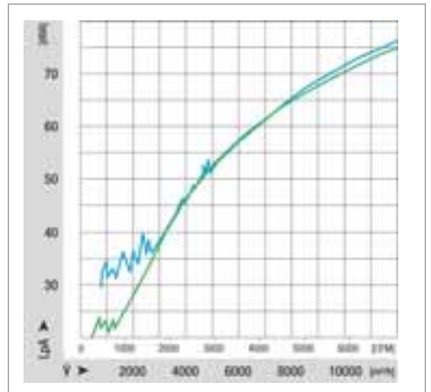


Image 7: Acoustic comparison of an EC motor (green) with an AC motor with frequency inverter (blue).

EC technology also makes for the most compact design on the market, as the external-rotor motor is situated right inside the welded aluminium impeller (image 5).

Very often, space-consuming fan systems are used made up of double-inlet centrifugal fans driven by V-belt AC

motors and controlled via frequency inverter. A comparison of size (image 6) reveals just how big the potential savings can be when using the compact EC centrifugal fans. More and more manufacturers of centralised air-conditioning units have a discerning eye for space-saving unit dimensions – a modular design is increasingly favoured for transport reasons – and this strong benefit is also attractive for planners and plant engineers.

Comparing these two systems, EC technology offers another decisive advantage: acoustic performance under partial load. Whereas frequency inverters often cause irritating noise, EC fans run almost silently (image 7).

Since the beginning of 2007, ebm-papst has been offering a new selection programme to help you find the right unit. This programme is available either as independent software or as DLL module. It can be ordered directly from ebm-papst. Calculations prove that EC fans in ventilation units are the solution with lowest energy consumption and highest efficiency in the market – guaranteed!

Dipl.-Ing. (FH) Andreas Salig (left)
Project engineer / Domestic Sales

Dipl.-Ing. (FH) Uwe Sigloch (right)
Head of Project management / Sales Europe
ebm-papst Mulfingen GmbH & Co. KG

Module 1: EC is "State-of-the-art"

Compared to AC motors, EC motors have a clearly proven higher efficiency. At identical air performance, they consume considerably less energy. For fans, this is an ideal option. Other than with AC technology, an EC motor is used as fan drive featuring an electronic control device, the so-called commutation electronics. Per design principle, these motors are synchronous ones, have no slip and therefore no slip losses; this is an advantage over conventional asynchronous motor systems with voltage or frequency control. Thanks to their commutation electronics, EC fans can be continuously controlled. This means that their rotational speed can always be specifically adjusted to the requirements of the air-conditioning plant or the process. The compact fan unit is a result of integrated power electronics together with the vital EMC components, line filter, motor protection, as well as open and closed loop control functions in the motor. Compared to conventional technology, this takes up far less installation space. Moreover, no additional installation work or an extra switch cabinet is needed. Installation mistakes are thus easily eliminated.

The most economical solution for handling air: EC fans putting pressure on the market

"Using efficient motors could reduce electric power consumption by 15 percent"

Module 2: BMU and ZVEI recommend economical electric drives

In industry and trade, there are considerable potentials to use energy more effectively and thus consume less energy. Climate protection profits from this, as do companies by having costs reduced. In industry alone, 20 - 40% of the energy consumption could be saved by 2020, and this at conditions making real economical sense. In industry, about two thirds of the electric power consumption are for electric drives. Using electronic speed controls and efficient motors could reduce this consumption by 15% – this translates into the power output of three to four power plants, exceeding 4,000 Megawatts. This potential is to be tapped. A current ZVEI market research on "Energy-saving with electric drives" revealed figures that the BMU brochure "Energy efficiency – the intelligent source of energy" (Energieeffizienz - die intelligente Energiequelle) expands on. This BMU brochure summarises the various options, also including ventilation, air-conditioning and refrigeration engineering. Repeatedly, the use of speed-controlled and economical motors is strongly recommended.

Module 3: Efficiency study for building technology

The research project Sanirev 2 sponsored by the German Federal Ministry for Economy and Technology provides a decisive basis for implementing the EU directive on the total energy efficiency of buildings. In this research project, vital approaches for balancing buildings with ventilation and air-conditioning plants were established and are to be integrated in the current standardisation process. Part 1 of the report deals with describing an approach for calculating the effective energy requirement for heating and cooling of a building zone, based on the approaches to calculate the heating energy demand. Part 2 describes a parameter model that can be used to calculate the effective energy requirement of an air-conditioning plant. The third part deals with the practical realisation in the context of DIN V 18599. This three-part research report "Sanirev 2 – Energetische Bewertung von Gebäuden mit Raumlufttechnischen Anlagen" (Sanirev 2-energetic evaluation of buildings with air-conditioning plants) has now been published by the Fachinstitut Gebäude-Klima (FGK) in the context of the FIA project – Forschungs-Informations-Austausch (research, information-exchange).

Product design for high-performance fans

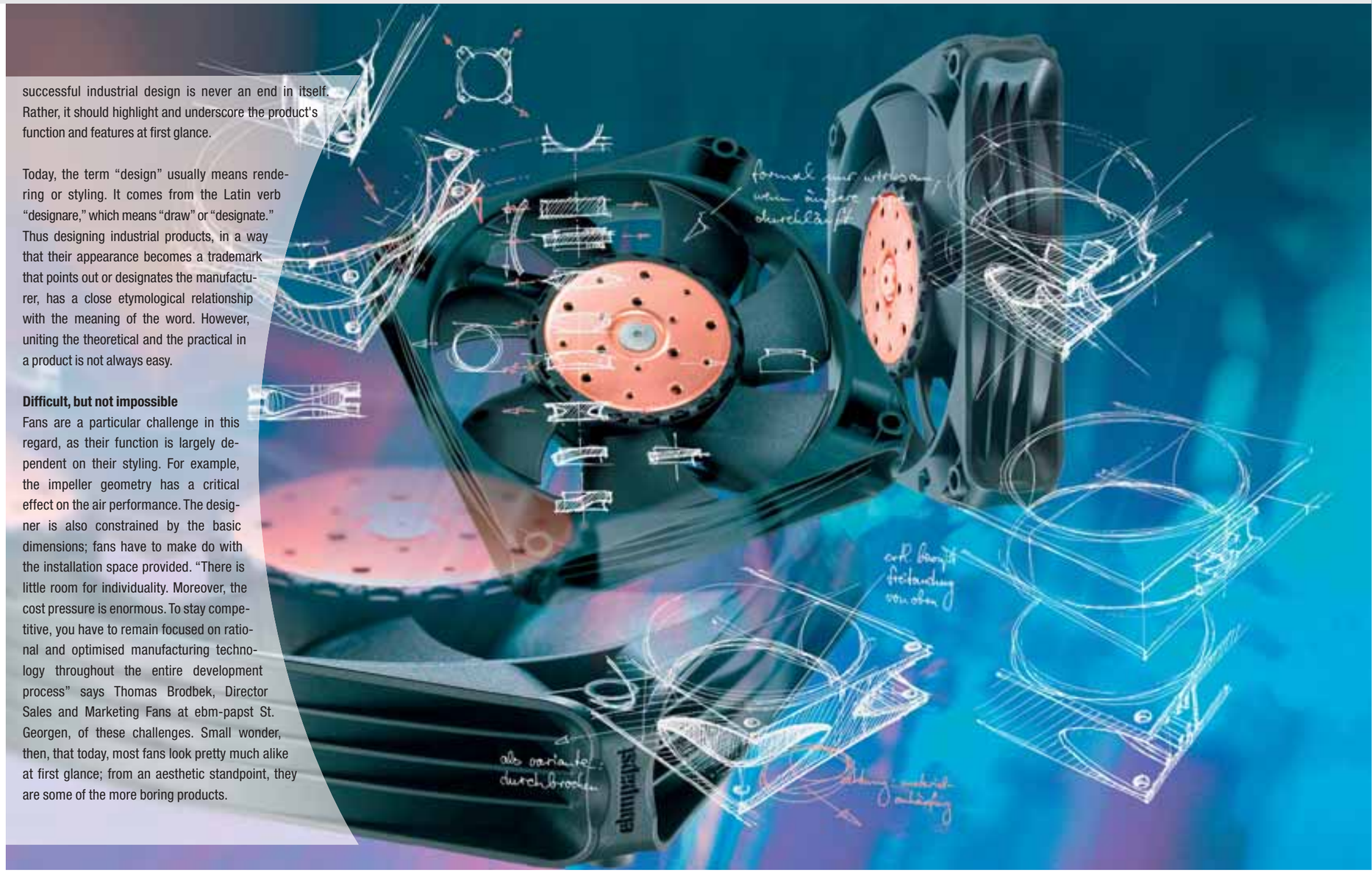
High-quality product design offers manufacturers the ability to stand out from the competition. Like a company logo, styling and clever details can enhance a product's recognition effect, make its function clearly visible at first glance and highlight its features. With the new 4400 FN fan series, ebm-papst St. Georgen has succeeded in doing exactly this. With blower outputs up to 225 m³/h, the compact fans not only are the most powerful in their class, their clever design elements also make them look the part. The visible metallic rotor, with its distinctive hole pattern, visually conveys how powerful the fans are. Rounded edges and ribbed structures on the housing provide a harmonious appearance. Because the new design takes into account the manufacturing technology requirements of mass production, the compact fans feature an outstanding price-performance ratio even after the designer makeover. They are available now in 12, 24 and 48 V DC versions.

Humans experience their environment with their senses; they see, hear, smell, taste and touch. This also applies to their interaction with modern technology, even if in this area, it is the function – performance data, dimensions and the like – that is most important. Still, aesthetics and the senses play a role when making a selection, particularly when choosing from products that are technically almost equivalent. Therefore, high-quality product design offers manufacturers the ability to stand out from the competition. Like a company logo, styling and clever details can enhance a product's recognition effect. However, successful industrial design is never an end in itself. Rather, it should highlight and underscore the product's function and features at first glance.

Today, the term "design" usually means rendering or styling. It comes from the Latin verb "designare," which means "draw" or "designate." Thus designing industrial products, in a way that their appearance becomes a trademark that points out or designates the manufacturer, has a close etymological relationship with the meaning of the word. However, uniting the theoretical and the practical in a product is not always easy.

Difficult, but not impossible

Fans are a particular challenge in this regard, as their function is largely dependent on their styling. For example, the impeller geometry has a critical effect on the air performance. The designer is also constrained by the basic dimensions; fans have to make do with the installation space provided. "There is little room for individuality. Moreover, the cost pressure is enormous. To stay competitive, you have to remain focused on rational and optimised manufacturing technology throughout the entire development process" says Thomas Brodbek, Director Sales and Marketing Fans at ebm-papst St. Georgen, of these challenges. Small wonder, then, that today, most fans look pretty much alike at first glance; from an aesthetic standpoint, they are some of the more boring products.



“Aesthetic and technical qualities – a successful symbiosis”

Despite this, when accomplished design engineers and creative designers work closely together, even fans can lose their anonymity and become unmistakable designer objects. This benefits manufacturers and users alike – as the senses, in addition to rational considerations, contribute to the purchase decision. Everyone prefers an attractive product to one that appears generic. In its new fan series, drive and fan specialist ebm-papst, based in St. Georgen, Germany, proves that successful product design can do more than just make the product visually appealing and distinctive. In the 4400 FN series of compact fans (see text box), the design also underscores its characteristic features (image 1). It is a successful symbiosis of aesthetic and technical qualities.

Image 1: Product design for fans. The unusual styling makes the high-performance fans unmistakable. The visual details also underscore the characteristic features.

Underscoring the characteristic features

For example, the designers used clever tricks to make the fans look “quieter”, reflecting the lower noise emissions of the fans in practical use. Brodbek explains the concept this way: “The redesigned, rounded mounting plates make a contribution, as does the ribbed structure on the fan housing.” This gives the housing (image 2) a harmonious appearance rather than a boxy one, making it much more pleasing to the observer than those of most fans. At the same time, the ribbed structure also serves a functional purpose: “The ribs ensure that the housing is stable, despite its unusually thin walls”, Brodbek explains. The impeller geometry, with its sickle-shaped blades and winglets, also contributes to a harmonious appearance while at the same time optimising the blower output.

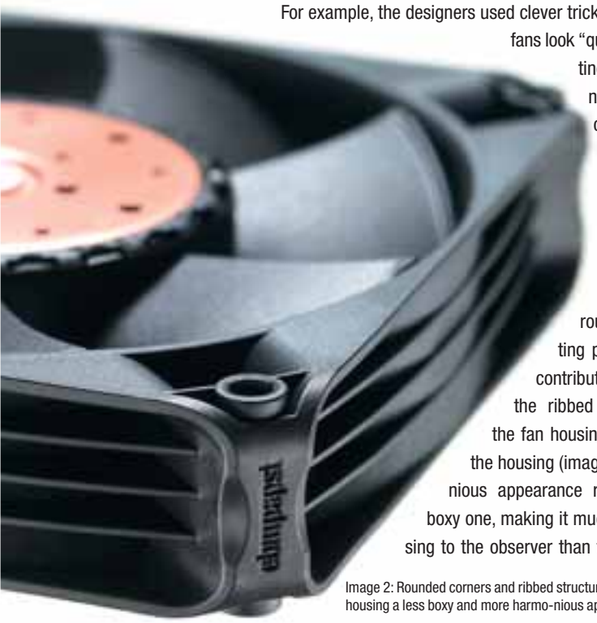


Image 2: Rounded corners and ribbed structures give the housing a less boxy and more harmo-nious appearance.

Another important design element that makes the fans unmistakable is the visible metallic rotor can with its distinctive hole pattern. “This visually dominant component is an effective way for us to convey the fans’ high level of performance”, explains Brodbek. Thus the results of the fan design are attractive indeed. The close cooperation of design engineers and designers took into account the technical considerations of mass production during the entire development process. Therefore, with its new fan series, ebm-papst not only sets standards from a technical and aesthetic point of view, the attractive fans also feature an outstanding price-performance ratio.

A successful symbiosis of technology and aesthetics:
Product design for high-performance fans

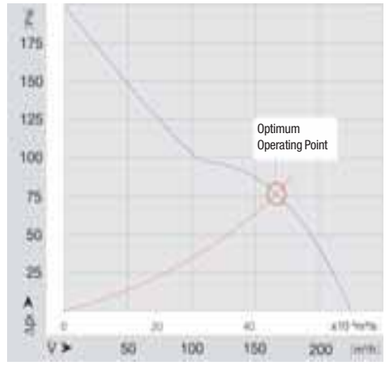


Image 3: The new fan type is the most powerful on the market in this size. Even at high counter-pressure, it supplies a large air flow with a low operating noise level.

Powerful fans get a makeover

The most outstanding feature of the 4400 FN series of high-performance fans is not their successful design, but their output. With slim and trim dimensions of 120 x 120 x 25.4mm, the most powerful version has an output of 170 m³/h at the optimal operating point and a pressure build-up of 75 pascals. And free flowing – without counterpressure – it attains an output of 225 m³/h. Thus the new fan type is the most powerful on the market for its size (image 3) and supplies a large air flow, even at high counter-pressure, with low operating noise. The electronic equipment is equally outstanding. Even in the basic version, reverse-polarity and locked-rotor protection are standard. All common alarm, tachometer and speed control functions are available as options.

Typical application areas for these powerful packages are in IT or telecommunications servers, control boxes in automation and process technology, and the food industry. The new compact fans are available now in 12, 24 and 48 V DC versions.

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Director Sales and Marketing Fans
ebm-papst St. Georgen GmbH & Co. KG

Quiet-running family of products with the lowest torque pulsation

For industrial systems and devices, compact motors that provide high performance while taking up very little space are in high demand. Whether in automation, the printing industry or in packaging systems, long service life, even when running at full capacity, is always important. EC motors are particularly well suited to this area. They have excellent dynamic features and a high level of efficiency. They continue to work even under adverse conditions and are the product of choice in today's market when it comes to reliable and powerful drives with compact dimensions and an excellent price-performance ratio.

Image 1: Fully automated manufacturing of ECI 63 series.

Modern plant and machine designs place a focus on decentralised intelligence and decentralised drives. When it comes to performance and service life, a localised drive provides substantial advantages over mechanical power distribution from a central drive. Powerful, maintenance-free EC motors are ideal for this task. To be able to offer users powerful, optimally stepped drives, the motor specialists at ebm-papst in St. Georgen have developed a new family of EC motors. Building on the standardised dimensions and flange measurements of brush motors already on the market, our specialists implemented an optimal drive system by taking into consideration the special requirements for flexible and especially durable industrial motors.

Technical refinement

The requirement for manufacturing the new ECI 63 motor series was a uniform system configuration that allows the drives to be produced on a fully automated production line, with 100% process monitoring during each step of the manufacturing process. The most important part of this process for the development engineers was not just the quality of the manufactured product; the performance characteristics and system capability of the drives also held precedence (image 1). For the motors themselves, it was important to come up with a design that allows for sensitive movements almost like those of a step motor, as well as a rapid change mode to dynamic run-up. The drive should also be able to cope with continuous alternation in 4-quadrant operation without a problem. The innovative solution realised in the new motor series builds on the principle of a 3-phase permanent magnet synchronous motor with an internal rotor design for electronically commutated (or, in a few cases, sine-commutated) motor operation. The active components consist of a 6-slot stator and a 4-pole rotor. The concentrated stator winding has low copper loss, and because it does not require coil crossover, it is not only robust, but also cost-effective to manufacture. A targeted air gap extension (image 2) in the rotor surface reduces the motor detent torque to a minimum.

Highly dynamic, 3-phase internal rotor motor for industrial applications:
Quiet-running family of products with the lowest torque pulsation

"The new family of EC motors offers high performance without taking up a lot of space"

In addition, foregoing all types of oblique parts in the stator and rotor results in significant technological advantages.

Rod-shaped SE permanent magnets made of neodymium iron boron material are embedded in the plated rotor stack. Thanks to the pockets in the rotor plate, the magnets are permanently held in place and are suitable for high speeds without the need for additional safety measures.

An additional challenge for the motor developers was attaining the lowest possible torque pulsation, both when the motor is energised and when de-energised, and a very low running-noise level. Many years of experience in developing and manufacturing complex EC drives, and using the most modern design and simulation software, are prerequisites for effective motor optimisation. Suitable analytic and numeric calculation programs, and making calculations based on the finite element method, allowed the torque pulsation to be reduced to a minimum. Endurance tests under extreme conditions and stress tests on all of the components of the motor complete the development phase.

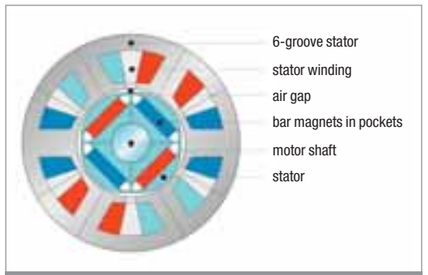

Image 2: Targeted air gap extension for optimum concentricity.

Real-world applications

The new family of drives consists of three platform motors with an output of between 85 and 270 W at a nominal voltage of 24 V (image 3). The dimensions of the drives vary only in length. The diameter is always a uniform 63 mm. The smallest, which is 85 mm in diameter, is extremely compact. At 100 mm and 135 mm overall length, the two larger models in the family are very compact.

At the factory, we make sure our motors meet the IP 40 system of protection. The motors are designed so that they can be equipped with encoders and brakes. Digital operating electronics customised for driving these motors are available. This allows customers to choose the drive that is precisely suited for their application: either a pure drive component, meaning a motor with integrated sensors for the customer's existing control system, or the complete drive package – ready to connect and equipped with all of the necessary components.

Image 3: The optimally stepped 63 series: The right motor for every type of drive.

Currently available accessories for the motors include single and double-stage planetary gears with reduction ratios of 5:1 and 30:1 and a max. nominal torque of 14.8 Nm (higher torques can be provided upon request). To provide optimum service life, the gearbox output shafts are equipped with double ball bearings, and all gearbox components are adapted for the performance potential and durability of EC motors.

Systems offered include both the optical impulse transmitter for the speed sensors and electromechanical brakes. DRIVECONTROL, the external operating electronics from ebm-papst, provide optimum activation and closed-loop speed control of these motors.

The new family of EC motors offers high performance without taking up a lot of space. Sensitive operation, similar to that of a step motor, and highly dynamic acceleration, is not a problem for this motor design. Thanks to high-performance gearboxes that have been adapted specifically for EC motors, the drives can cover a wide variety of applications, and they offer an attractive alternative to inflexible main drives. In addition, making the technological switch from brush motors to EC technology creates entirely new opportunities for more flexible and dynamic applications.

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