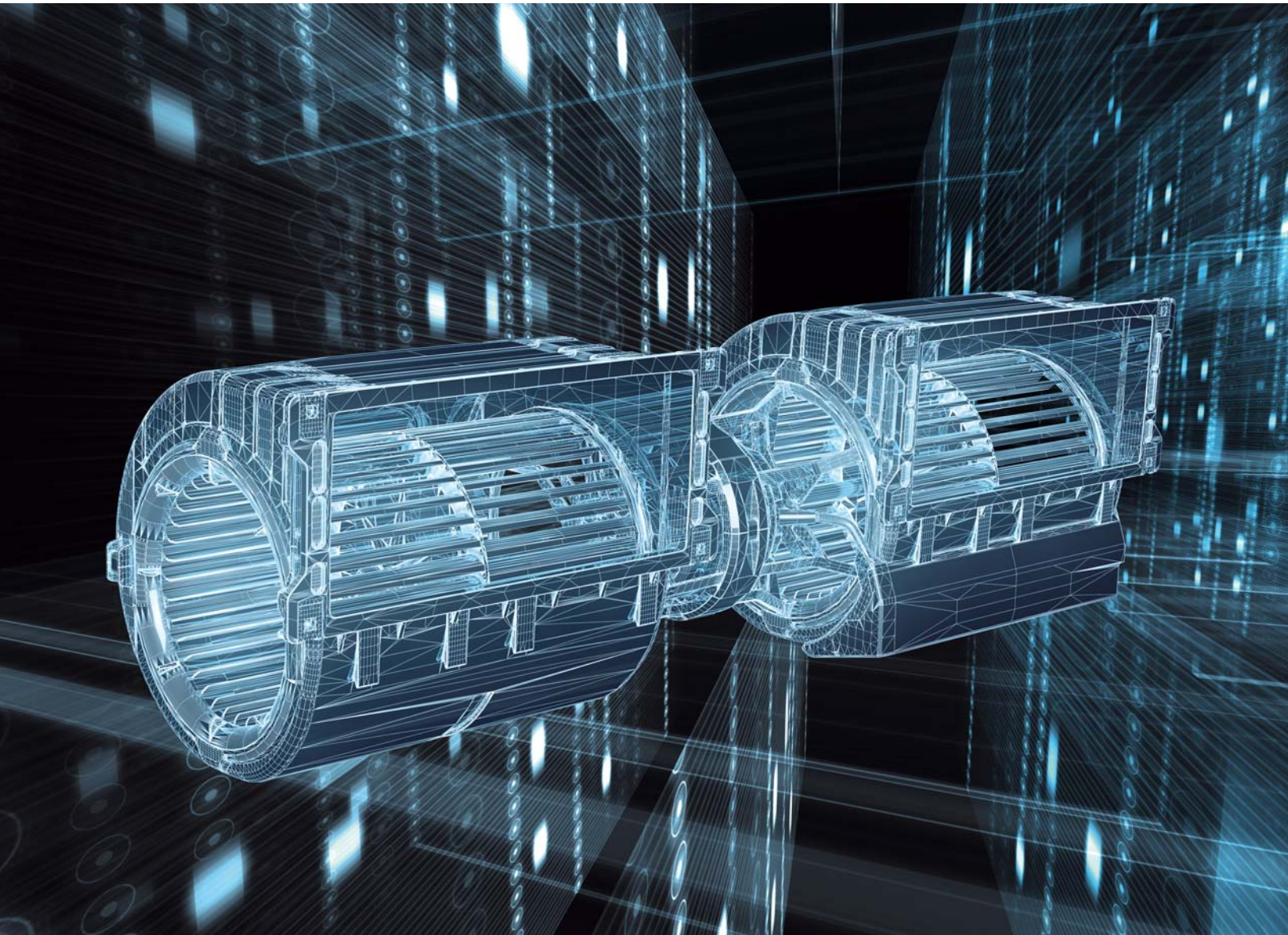
02°2013

techmag°

Technology by ebm-papst



techmag°

02°2013

“We offer our customers truly plug-and-play products”

We have long since become accustomed to electronic systems providing us with assistance in all sorts of everyday activities and even influencing our way of life. This has been a constant process, leading to more and more improvements in all areas. Progress in the field of electronics means that, for example, we can always stay in touch wherever we are and our cars make less of an impact on the environment thanks to enhanced performance and reduced fuel consumption. Over the course of time, the incorporation of electronics has also brought about significant changes in the fan industry. The real breakthrough for electronically commutated GreenTech fans however only came about once the ebm-papst Development Department had found a way of inconspicuously accommodating the added complexity introduced into the overall system by the use of electronics. The electronics are integrated into the motor and do not take the form of a separate component. A modern GreenTech EC fan, as used for example in the RadiPac range described in this issue, has more than 100 parameters which are optimally pre-set at the factory. This means we can offer our customers truly plug-and-play products. There is absolutely no need for complex wiring and the coordination of individual components such as the frequency converter and the motor. Precision control of the motor is implemented every millisecond and almost imperceptibly by the electronics. The complete absence of resonance points makes it possible to achieve outstanding efficiency levels and great versatility over an even broader speed setting range. This versatility is also reflected by the RadiPac design.

Despite all efforts to make electronic systems as simple to handle as possible, the potential they offer can only be fully exploited if users also have more in-depth knowledge. In the long term, competent working with the electronic functions in the system will be the key to company success. This is already apparent in other areas. It is now no longer possible to perform automotive service work without the ability to read out an engine control unit.

We shall be continuing to promote the use of electronics in fans. So we hope you will accompany us along this road and help us carry on shaping the future. In this spirit I trust you will enjoy reading this electronics-packed issue of our tech.mag. Keep on flying the electronics flag!

MBA Dipl.-Ing., Dipl.-Ing. (FH)
Thomas Sauer, Development Manager
for Product Area B
ebm-papst Mulfingen GmbH & Co. KG

Peace and quiet at a pleasant temperature

Hotel air-conditioning: new state-of-the-art system saves up to 70 % on energy consumption

Figure 1: The air-conditioning systems of the newly built Hotel Abasto near Munich are equipped with energy-saving GreenTech EC technology.

For many hotel owners, air-conditioning systems are often a necessary evil: while they may ensure optimum room temperature, they also use a lot of energy and their noise can prevent guests from getting a peaceful night's sleep. In hotels for example, the average operating time of fan coils is currently around 80 %, compared to around 40 % in office buildings. The Abasto Hotel in Gernlinden, near Munich, has got to the root of the problem and now uses a new generation of fan coils – to the satisfaction of all parties concerned. Thanks to the highly efficient GreenTech EC fans, rooms can be cooled blissfully quietly to the guest's preferred temperature using 70 % less energy.

The Abasto Hotel opened in mid-September 2012 around 30 km from Munich, in the district of Gernlinden (Figure 1). The 31 modern rooms have been fitted out to the latest standards, and that includes the air-conditioning. For the hotel's owner, Robert Rentzsch, who is himself a trained heating installer, the new system fully realises his vision for perfect air-conditioning.

Lower noise and energy consumption with increased comfort Both the guest rooms and the "Farmhaus" restaurant in the basement are equipped with the latest air-conditioning technology from Kampmann GmbH, based in the German town of Lingen (Ems). Fan coils known as "Venkons" are hidden behind the ventilation slits (Figure 2, page 6). The hotel guests cannot see them but they can certainly feel their effects. When the guest checks in at reception, the booking software transmits the starting signal to the Venkon. By the time the guest goes to unlock the door, the room will have been cooled or heated to room temperature (21 degrees Celsius). If the guest wants the room to be warmer or cooler, they can amend the temperature up to three degrees in either direction via the Ka-Control control device. The unit does not make any noise. Describing an experience that nearly every hotel guest will be familiar with, Rentzsch recalls "I have been in many hotels where the air-conditioning got on my nerves. When you actually have a unit in the room that both heats and cools and is practically inaudible it really makes your stay much more comfortable." In order to make this feeling of comfort the standard in noise-sensitive applications, Kampmann has developed a system design for its fan coils specially for applications in hotels. In order to fulfil the tough requirements for low noise, the

air-conditioning specialist has sought cooperation with its chosen high-performance partner ebm-papst. At the heart of the Venkon is a centrifugal blower, and this is produced by fan manufacturer ebm-papst based in Mulfingen, Germany (Figure 3a, page 6). When Kampmann developed the latest generation of the Venkon, the key factors it looked at were space requirements, noise level and power consumption. Ulrich Budde, Sales Manager for Kampmann in southern Germany and Austria explains that "The crucial factors for us with the fan coil was that the motors would have a particularly low noise level and that there would be a high level of control in the lower speed range." Both factors are inextricably linked; hotel air-conditioning systems employ the lower speed range because it offers the lowest noise levels.

Continuously adjustable – for greater satisfaction The lower speed range is also the range with the greatest potential for energy savings. Standard AC motors only offer incremental control, whereas modern GreenTech EC motors are continuously adjustable across the entire speed range. Even at low speeds, the high level of energy efficiency of the EC motors brings benefits, as the motors are supplied with an input of 0-10 V. The GreenTech EC centrifugal fans are available

Kampmann GmbH

This company headquartered in the town of Lingen an der Ems in the region of Lower Saxony (Germany) develops, produces and sells systems for heating, cooling and ventilation, always employing state-of-the-art technology for its products. The technology leader employs around 700 employees in 15 branches. The collaboration with the fan manufacturer ebm-papst has been going strong for more than 30 years.

Hotel Abasto

The hotel to the west of Munich was opened in September 2012 and offers 31 rooms for guests as well as its "Farmhaus" restaurant.

www.abasto-hotel.de

Figure 2 (left): GreenTech EC blowers from ebm-papst in a fan coil unit from Kampmann – invisible to the guest but indispensable for the air-conditioning system.

Figure 3a: The K3G146 energy-saving EC centrifugal blower from ebm-papst ensures a pleasant room temperature while remaining blissfully quiet.

Figure 3b: RadiPac centrifugal fans such as the R3G355 used in the Airblock C, with aluminium-welded impeller and energy-saving EC technology have an especially space-saving construction as compared with belt-driven motors.

as single, dual or triple fans with a power of between 40 and 250 W, to suit the room size. In all sizes, they offer energy savings of up to 70 % and noise reduction of up to 5 dB(A). Thanks to the plug-and-play solution, existing units can also be retrofitted without a great deal of work (Figure 4).

ebm-papst's product range includes EC fans in the power range 400 W - 12 kW for ventilation and air-conditioning technology (VACT). The RadiPac range (Figure 3b) with aluminium-welded impellers and integrated control electronics enable a design that saves on space compared to models with belt-driven motors. The resulting space saving also facilitates installation and start-up. The intelligent control electronics of the GreenTech EC centrifugal fans enable a number of different automation and management tasks to be implemented via MODBUS. Major savings can be made on the electrical operating costs thanks to the ability to control the GreenTech EC centrifugal fans based on actual requirements.

Benefits of a decentralised system The hotel's owner, Robert Rentzsch, explains that "For me, the energy-efficient EC motors were a crucial determining factor, because I had designed the entire building with a view to keeping the operating costs as low as possible."

The hotel owner has installed 40 Venkons in the Abasto Hotel: 31 in the guest rooms and nine in the restaurant. Heat is provided via a heat pump with 45 °C flow temperature, and cooling is provided using ground water. The highlight of the system is that heating and cooling takes place actually inside the room itself; the ventilation unit under the roof merely provides fresh air and recovers 81 % of the heat from the air extracted from the room. Standard centralised units heat and cool the air centrally and then distribute the air around the building via air ducts. The Airblock C ventilation unit (Figure 5) manufactured by Kampmann using GreenTech EC fans now only supplies the fresh air – the decentralised Venkons inside the hotel rooms are operated individually. The unit is therefore very compact and the supply air ducts can also be made smaller. As a result, transport losses are also greatly reduced.

For Robert Rentzsch, the factor of whether a system is decentralised or not is in itself no insignificant matter: "For heating installers, space is always a major issue." This is because centralised systems necessitate ducts with large cross-sectional areas. Rentzsch has managed to install the system with just 30 centimetres of intermediate ceiling at the Abasto Hotel. With a centralised system he would have required up to 80 centimetres – dead space that would only have increased costs. "I was convinced straight away that we should be heating and cooling the air where it is actually going to be used", says Rentzsch.

The operating costs at a glance "I believe that the concept we have here is the best possible solution for hotel applications", claims Ulrich Budde with conviction. He is also pleased about the increased level of controllability. If the air quality is OK, the system simply provides heat or cooling as required; if the temperature is OK, the system simply provides ventilation.

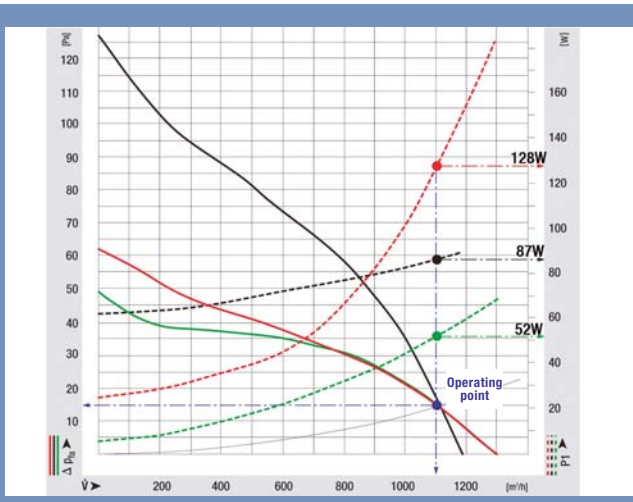


Figure 4: At the example operating point of 1100 m³/h, the green characteristic curve shows the clear energy saving of up to 60 % made by the K3G146 GreenTech EC blower (52 W power consumption) in comparison to standard AC centrifugal fans (black characteristic curve: 87 W power consumption, red characteristic curve: 128 W power consumption).

LEGEND

- *ebm-papst EC*
- *ebm-papst AC*
- *Competitor AC*

However, it is not always easy to communicate the best solution. Although at Abasto Hotel the investor is also the user, and therefore close attention was paid to the operating costs. "As a general rule, investors look above all at the investment costs and the minimum legal requirements", says Budde, explaining the market situation. A key factor is the life cycle costs over the entire service life.

The minimum requirements are also becoming more stringent: the European Union's Energy-Related Products Directive demands a much higher level of energy efficiency. Air-conditioning devices with GreenTech EC technology help with compliance as they already go significantly beyond the requirements. What is more, buildings equipped with high-quality technology with a long service life fare much better on the real estate market. Finally, guests are much happier when they can stay in a hotel room with blissfully quiet air-conditioning technology; they will be more likely to come back for another stay and will spread the word.

Conclusion The successful use of GreenTech EC technology in this hotel application clearly illustrates just how much this technology has to offer hotel owners in comparison to a standard air-conditioning system with AC motor and incrementally controlled winding. Firstly they benefit from the reduction in noise thanks to the EC motor, which is up to five decibels quieter – for the human ear this equates to a reduction in the overall noise impression of almost half. Secondly, they can reduce energy consumption by up to 70 % thanks to the high-performance, continuously adjustable control functionality across the entire range. Hotel owners save on energy costs, architects and building planners benefit from a future-proof solution and guests can finally have a more peaceful night's sleep. ○

Figure 5: In ventilation and air-conditioning systems such as this Airblock C system from Kampmann, R3G355 fans with GreenTech EC technology from ebm-papst reliably supply fresh air.

Author is engineer Wolf-Jürgen Weber, Regional Sales Manager for ebm-papst Mulfingen

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

Concepts for quiet-running axial fans

Noise emissions during the operation of fans and air conveying systems

Noise emissions are a significant factor with regard to the operation of fans and air conveying systems. The conflicting aims of achieving top performance, high efficiency, compact design and a hardly noticeable noise level can best be reconciled by developing fans with as low a sound power as possible whilst at the same time optimising the system as a whole. The generation of noise is influenced by the design, the number of fans and the drive system employed, the fan operating status and the system used to convey the air. Individual effects can often be identified as the main cause. In such cases specific action can be taken to successfully minimise the noise level.

Selection criteria It is not unusual to select fans on the basis of purely geometrical criteria. The speed is then adjusted as long as necessary to achieve the required performance. Depending on the fan installation situation, design and type of drive, this may give rise to substantial noise emissions. Different fans in the same system or identical fans in different applications exhibit different acoustic behaviour. To cover the broadest possible usage spectrum, fans should have a low overall noise level and should not be affected by changes to the geometry of the installation situation. In a first step, an aerodynamic design was selected to permit a performance similar to that of the existing generation but at considerably lower speeds. The basic design was then further optimised with the aim of obtaining the broadest possible operating ranges with a low noise level.

Definition of the operating range The first stage in the design of a fan involves defining the envisaged operating range, in other words the spectrum of possible applications for which a given fan is primarily intended. Air conveying systems can be represented as resistance parabolas (system impedances) in a pressure/flow rate diagram. If more air is conveyed, the back pressure increases quadratically. To convey the air, use is made of fans designed such that the point of optimum efficiency is ideally on the system impedance curve. For flow simulation, the Navier-Stokes equations for incompressible flows are solved numerically; the acoustic quantities are determined by way of the Lattice Boltzmann equations. The aerodynamic designing of compact fans employing modern flow calculation methods is described in detail in [2] for example.

As the speed increases, the fan curve shifts along the system impedance curve, however the shape of the characteristic does not change. To the left of the optimum operating point, the flow on the blades breaks down, efficiency decreases and the aerodynamically induced noise emissions increase. Figure 1 (page 10) shows the characteristic curves of three different fans with identical external dimensions. All the fans have five rotor blades and were designed for a similar maximum pressure. The preferred operating range of each fan is on or to the right of the corresponding system impedance curve (Figure 1).

Whereas fan 3 is designed for higher flow rates, the performance characteristic curves of

fans 1 and 2 are similar. Fan 1 however requires a 30 % higher speed than the two other versions. According to [1], the total sound emission level of a fan is influenced by the internal and external turbulent flow field, the design and size of the fan as well as the rotational speed of the rotor. Fans accordingly tend to be quieter when turning at low speeds than at high speeds. For a fan to achieve the same performance at a lower speed the blades have to be designed for higher aerodynamic loads, which may adversely affect the flow field and thus the acoustic properties. In addition to the basic aerodynamic design, certain aerodynamic components of the fan are optimised for minimal sound emission to counteract this effect. Figure 2 (page 11) shows the sound power levels of fans 1 and 2 if the speed of fan 2 is altered such that it attains the same performance characteristics as fan 1 (Figure 2).

The differences in the right portion of the characteristic curve amount to as much as 10 dB. The sound power spectra at the acoustically optimum point for fan 2 reveal that fan 2 has a considerably smaller blade passing frequency com-

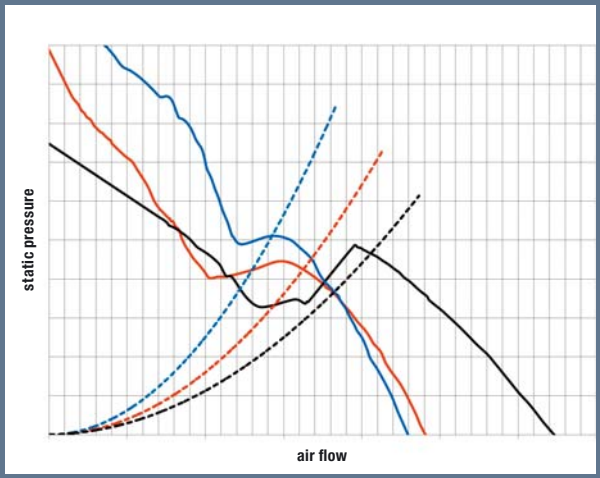
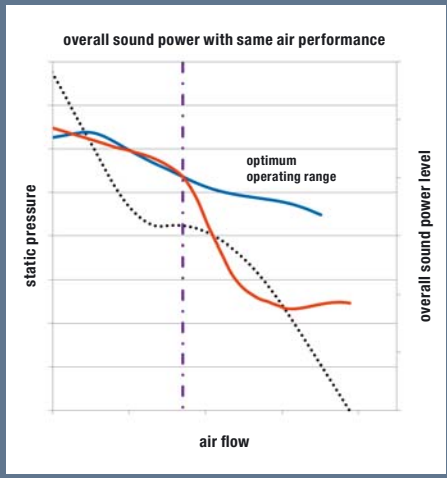


Figure 1: Operating range of three axial fans with identical external dimensions

LEGEND

- *optimum operating range fan 1*
- *optimum operating range fan 2*
- *optimum operating range fan 3*



ponent and reduced noise components in the higher frequency spectrum. With axial fans, the blade passing frequency in particular is considered to be a nuisance. This frequency is calculated from the number of rotor blades and the speed. As both fans have five rotor blades, fan 2 has a slightly lower blade passing noise than fan 1. By re-designing the entire fan (rotor blades, guide vanes, air routing in the housing), it was possible to reduce both the blade passing noise and higher-frequency noise components. The higher-frequency components of the noise spectrum can be reduced by making certain changes to the rotor blade. This includes the use of winglets at the blade tips to influence the blade tip vortex and trailing edges on the suction side of the blades to alter the turbulent flow along the blades (Figure 3).

Aerodynamic efficiency Winglets affect the behaviour of the blade tip vortex formed by the rotation and difference in pressure on the blade suction and pressure sides. An increase in the aerodynamic efficiency of the individual blades resulting from an improved flow permits a reduction in speed and thus has a positive influence on the noise level. Altering the dynamics of the blade tip vortex will also change its noise characteristics. The design of the trailing edge on the suction side of the fan blade alters the position at which the flow breaks down, with a noticeable effect on both efficiency and acoustics. The design of the winglets, trailing edges and all other flow components is part of the overall aerodynamic concept. Although this method yields ideal results, it involves having to find an optimum solution for each particular type of fan. Computer-based optimisation algorithms provide assistance for this process. Each point in the diagram corresponds to a fan geometry. The values were determined for the design point in each case. A Pareto front forms, along which the optimum sound pressure and aerodynamic efficiency points are distributed.

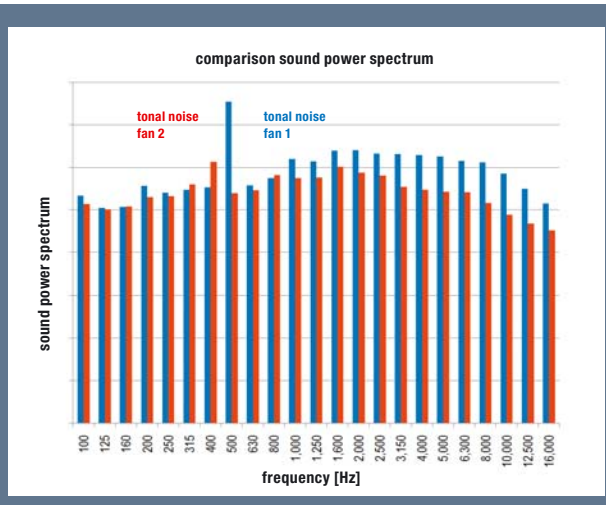
The sound power level of axial fans increases with increasing aerodynamic load (expressed by the aerodynamic efficiency). Whether or not this can be generalised will have to be clarified in the course of further investigations, as all the geometries generated have different performance curves with only the design point being the same. The next step involves constructing prototype samples, taking acoustic and aerodynamic measurements and comparing the results to those forecast. The acoustic calculations were performed using a new Lattice Boltzmann method [4] in which the frequency range was restricted to 5 kHz in this case to save time. There is a very high level of coincidence between the simulation and experimental results. The shape of the frequency curve is very accurate and the individual amplitudes differ by only a few decibels. Deviations only occur in the lower frequency range. These can be attributed to the imbalance of the manually balanced test sample.

As illustrated by figure 3, the sound power of a fan depends on the operating point, in other words the back pressure and the air volume demanded by the application. The acoustics of the system as a whole are also influenced by the local

Figure 2: Sound power (left) and spectra (right) of two axial fans with identical external dimensions operated in the same way

LEGEND

- *fan caracteristic curve*
- *fan 1*
- *fan 2*



inflow conditions. For example, a fan may have a low blade passing noise under ideal conditions but this may be amplified in an unfavourable installation situation [5]. A non-uniform flow developing immediately upstream of the inlet (e.g. as a result of fitted components causing the formation of vortices which strike the impeller) will give rise to blade passing noise. Such an effect can be alleviated by way of suitable flow routing or the use of grilles to break up these coherent structures and create a more homogeneous turbulent inflow.

There is a need to develop ever quieter fans to satisfy increasing requirements and the demand for more and more compact system designs. Lower speeds and aerodynamic components such as winglets and trailing edges can help to achieve this development goal. Adaptation to the system as a whole is however often required to obtain ideal results. Operating and installation conditions can have a significant effect on the acoustic characteristics of the entire system.

Figure 3: Flow of an axial fan with winglets (left) and trailing edges Series fan (right)

Author is engineer Michael Schmitz, Head of Central Research and Development at ebm-papst St. Georgen

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

Bibliography

[1]: L. Bommes, J. Fricke, K. Klaes, Ventilatoren, Vulkan Verlag, 2002

[2]: M.B. Schmitz, G. Eimer and H. Schmid. Design and Test of a Small High Performance Diagonal Fan. Proceedings of ASME Turbo Expo 2011, Vancouver, Canada

[3]: M. Stadler, M.B. Schmitz, P. Ragg, D.M. Holman and R. Brionnaud, Aeroacoustic Optimization for Axial Fans with the Lattice-Boltzmann Method, Proceedings of the ASME Turbo Expo 2012, Copenhagen, Denmark

[4]: M. Stadler, M.B. Schmitz, W. Laufer, P. Ragg, Inverse Aeroacoustic Design of Axial Fans Using Genetic Optimization and the Lattice-Boltzmann Method, Proceedings of the ASME Turbo Expo 2013, St. Antonio, USA

[5]: M. Sturm, T. Carolus, Large Scale Inflow Distortions as a Source Mechanism for Discrete Frequency Sound from Isolated Axial Fans, Proceedings of AIAA Aeroacoustics 2013, Berlin, Germany

Making use of optimisation potential for cooling

Applications for EC fans in the data centre

The catchword "Green IT" is on everyone's lips now – energy-conscious behaviour is indispensable these days precisely in conjunction with the indispensable cooling in data centres. Particularly in light of ever-increasing computing power, it pays off to switch to energy-efficient fans. State-of-the-art EC technology can contribute a lot to this, for example, by sparing the environment and the operator's wallet.

There is no end in sight to the growth of data centres. Trends such as mobile Internet, cloud computing and Internet TV require ever-higher outputs, since the volume of data is continuously rising. As a result, data centres have turned into considerable energy consumers. As early as 2008, commercial data centres in Germany were using around 10 terawatt-hours of electricity, which corresponded to just under 2 % of the overall energy consumption. This value will increase even more in future if data centre operators and people responsible for facilities and IT departments do not invest in thermal optimisation. Real-world applications show that 35 to 50 %, thus about half of the energy demand of a data centre, is required for the cooling alone. Herein lie enormous potential energy savings, especially

for air-conditioning technology. Now there are state-of-the-art data centres that operate with a PUE (power usage effectiveness) value of approximately 1.1. The PUE value describes the ratio of energy demand by the actual IT hardware and the overall energy consumption of a data centre. Thus this key figure is a measure for the efficiency of the non-IT-relevant environment, in particular, of air-conditioning technology. In the case of conventionally operated data centres, the PUE value should be about 1.9, that is, nearly half of the overall energy consumption is not used for the computing power and therefore does not serve the actual purpose of a data centre.

Low energy consumption by means of free cooling The palette of cooling options for data centres is wide-ranging. This is necessary because there will be no universal solution in the future either. After all, structural conditions have just as much influence on the selection as the technology used or the climatic conditions at the location. Therefore local cooling concepts, such as a direct server cooling system in the rack, are just as appropriate as concepts for cooling entire data centre areas or even the entire building complex with a central unit. To do this, operators of data centres are increasingly relying on what is called free cooling. It operates without energy-intensive chillers and uses the data centre's ambi-

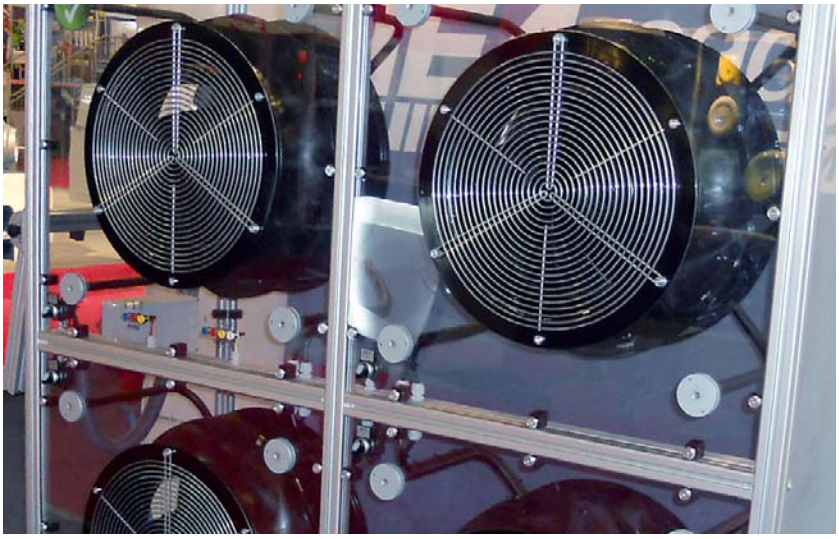


Figure 1: Free cooling in the data centre. The central component is called a fan array; this is a trade fair exhibit.

ebm-papst offers energy-efficient concepts with a wide selection of suitable fans

ent air. An important role is played, for example, by multiple fans operating in parallel, which provide for the defined intake and exhaust air flows within the building. Such "fan arrays" can be put together in practically any size and arrangement to achieve an ideal adaptation to the respective conditions (Figure 1). The modular design makes the systems scalable, and the user can choose whether to use multiple small fans or fewer large fans.

EC technology brings advantages ebm-papst is the world market leader in the field of EC technology and has been represented for many years in the area of data centre cooling. The fan specialist has propelled this field forward and, on this basis, is offering solutions for energy-efficient concepts with a wide selection of suitable fans. The new "RadiPac" product line (Figure 2) combines high flexibility provided by the frame design with maximum output, precisely for applications requiring a moderate operating pressure. Flow rates of up to 35,000 m³/h per fan are possible here. Depending on the desired operating point, however, other fans from the comprehensive product range of the Mulfingen-based specialist lend themselves to the task. The "RadiCal" series (Figure 3), for example, was developed based on the core competencies in fluid mechanics, motor technology and electronics. The RadiCal centrifugal fans feature particularly low noise emissions and reveal their strengths especially well in the low pressure range. These centrifugal fans are currently available in the sizes 133 to 630 with drive outputs between 35 W and 3 kW. The attainable flow rates reach up to 15,000 m³/h per

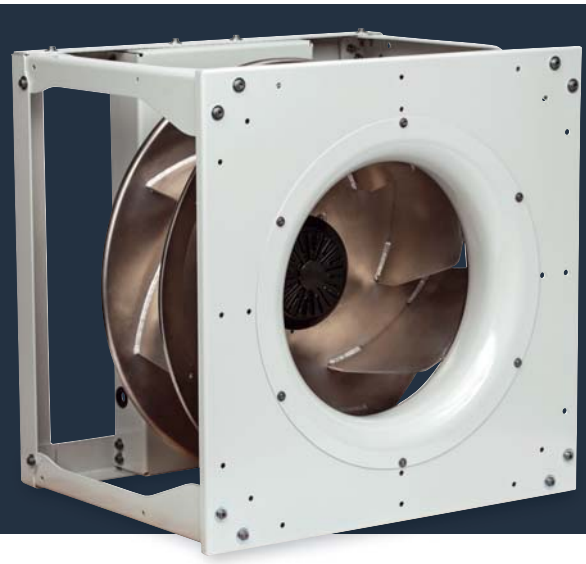


Figure 2: The RadiPac series is available with a drive output from 500 watts to 12 kilowatts in outer diameter sizes from 250 mm to 1,250 mm.

fan. Whether operating under full load or especially under partial load, both fan series operate with high efficiency and are exceptionally quiet.

Controllability, bus networking, redundancy and long service life Another advantage is the compact dimensions of the fans. The electronically commutated external rotor motor is directly integrated into the impeller, which dramatically reduces the installation dimensions. The electronics integrated in the drives are not only ideally matched to the EC motors used, they can also be controlled with either a 0-10 V analogue signal or digitally with a MODBUS interface. For the fan arrays in which many fans are used in parallel, the bus networking offers advantages: From making configurations during commissioning to performing service, alarm diagnosis and maintenance, dealing with the technology becomes substantially easier if the technician can use a central computer to access the fans. Moreover, by means of the MODBUS interface the fans from ebm-papst can be integrated into a BMS (Building Management System) or DCIM (Data Center Infrastructure Management). This interface makes the motor speeds continuously variable. which provides a very convenient option for demand-oriented performance adaptation. Thus the air performance of the fan arrays can be perfectly matched to the specific ambient and operating conditions of the data centre. At the same time, it is easy to incorporate the necessary redundancy in the event of a fan failure. The speed of the "neighbouring fans" is increased so that the same air flow is maintained. ○

Figure 3: The "RadiCal" centrifugal fan for applications in ventilation and air-conditioning technology. The impellers of the fans are matched perfectly to the motor and electronics to attain a high-efficiency total solution.

Author is Daniel Lemke, Market Management at ebm-papst Mulfingen

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

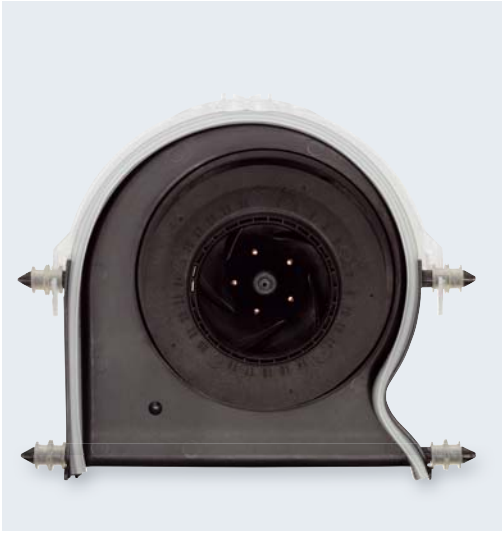
Highly efficient centrifugal compact fan for household appliances

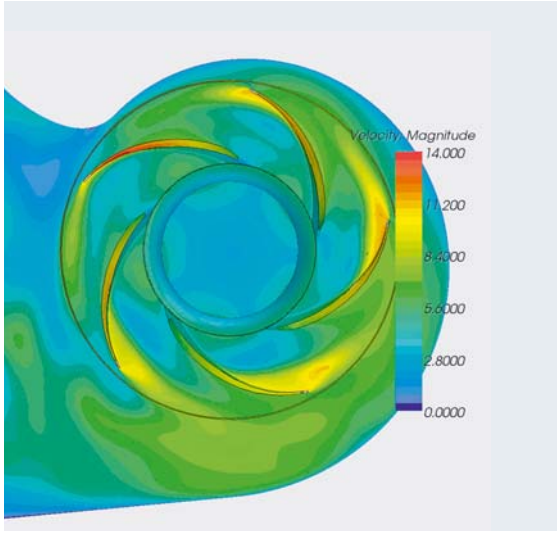
Fans are being used in modern refrigerators and freezers in increasing quantities

Forced air circulation can increase the efficiency of the heat exchanger and with this, it is possible to use a special compact heat exchanger, which would not function with natural convection alone. In addition, the temperature distribution in the device can be adjusted by targeted distribution of cold air, creating the perfect storage conditions in terms of temperature and humidity. The forced air circulation inside the device also prevents air moisture from condensing on the equipment parts and stored items.

Best possible level of device efficiency at minimum power consumption To achieve the best possible level of device efficiency and therefore to minimise power consumption, every component must be optimised and particular attention must be paid to how the individual components

Figure 1: Completed fan and CDF model. The direction of rotation in the model is the opposite of the completed fan and the minimum distance between the impeller and housing has been increased in favour of noise emissions. There are pockets at the fan inlet for balancing weights, which are used to guarantee that the fan runs with low vibrations.





The geometry is modified until the current moves through the fan with as little noise and loss as possible

interact with one another. In fans that are located inside the device to be cooled, energy is not just used to drive the fan; the motor heat generated by the fan must also be included in the overall thermal balance. The third crucial design parameter for household appliances is the noise emission. This must be kept as low as possible, as noise is an important quality factor.

Design specifications for the fan can be derived from these basic conditions. In the instance described, the requirements led to a new centrifugal compact fan being developed, which, with an input capacity of around one watt, achieves a maximum efficiency of 22 %. The aerodynamic components have been especially designed and perfected for their application. The impeller and worm gear unit have been designed in unison so that an ideal interaction between the individual components can be guaranteed as early as the design phase. A low circumferential speed for the impeller was very important in this process, as it results in low noise emissions. In line with the aerodynamic and aeroacoustic configuration, a motor that produced particularly low levels of structure-borne noise has been designed and adapted to the required speed and torque.

The aerodynamic components have been entirely designed with modern, three-dimensional computational fluid dynamics (CFD). These were used in the refrigeration unit in a much earlier state of development when defining the requirements for the fan. In the course of the development, the reaction of the fan to the noise behaviour was also evaluated by means of simulations. For this, the incompressible Navier Stokes equations involving friction are solved for the given fan geometry. The geometry, i.e. the design of the blades, current cross-section and housing geometry, are modified until the current moves through the fan with as little noise as possible and with as little loss as possible. More details of the design process and the description of the experimental devices used can be found in Schmitz, et. al., Design and Test of a Small High-Performance Diagonal Fan, Proc. IGTI 2011, Vancouver.

Rapid prototyping In the next state of development, the components of the fan are built in a rapid prototyping procedure, the motor is integrated and the entire unit is evaluated with regard to air performance and acoustics. The operating point of the fan is within the range 30-40 m^3/h. In this range, the pressure build-up in the fan corresponds to the system resistance of 15-25 Pa. The fan achieves an overall efficiency of around 20 %. This means that one fifth of the electrical energy is converted into current energy. For a fan of this size and performance level, this is a very good figure, particularly when one considers the compromises that have to be made.

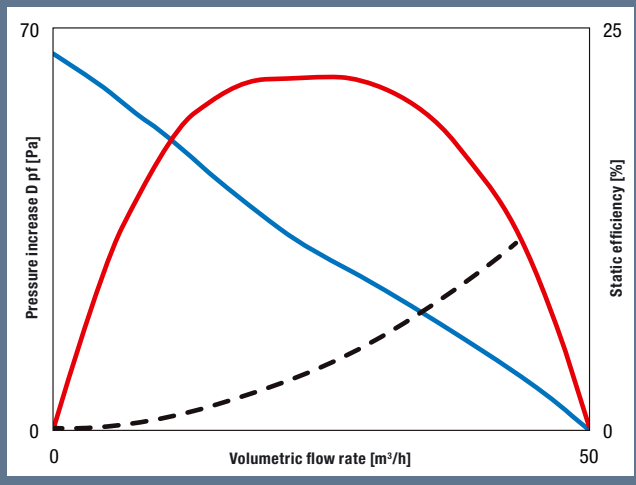


Figure 2: Aerodynamic power data of the fan unit

LEGEND

- *characteristic curve of air performance*
- *static efficiency including motor and control electronics*
- *system resistance curve of the cooling application*

To achieve a higher level of efficiency, the gap between the rotating and static components must be kept as small as possible. However, if the gap is too small, there is a danger of the refrigerating unit freezing, which is why a minimum gap size must be adhered to. The smaller the distance between the casing tab and the impeller, the more audible the aeroacoustic interactions of both components. These contradictory requirements mean that compromises have to be made and the compromises needed for good acoustics were determined in experiments using prototypes.

Authors are engineer Michael Schmitz, Head of Central Research and Development at ebm-papst St. Georgen and F. Cifrodelli, M. Malisi, R. Pradel as well as A. Feinauer from BSH Bosch and Siemens Hausgeräte GmbH

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

Gas valve automatically optimises combustion

Variations in the gas mixture no longer a problem

Although modern gas heating systems operate efficiently and ecologically, new concepts are, nevertheless, called for in view of rising energy prices and more diverse raw material sources. For reasons of cost and to avoid shortages, gas is now increasingly being obtained from new suppliers. This can result in fluctuations in the gas composition, which in turn requires complex adjustment of the gas mixers to the particular calorific values of the gas currently being supplied in the case of conventional gas heating systems. A new gas valve with stepper motor control and electronic actuation now performs automatic adaptation to the quality of the gas. This permits rapid set-up of the heating system and at the same time avoids subsequent extra costs resulting from changes in the gas quality.

Similarly to a car engine, a heating system only provides optimum performance when operating with a narrowly defined air-to-fuel ratio. In the case of natural gas, the so-called Lambda value (the gas-to-air ratio) is in the region of 1.3. The nitrogen content fluctuates considerably depending on the gas field and the amount of biogas fed in. Conventional mechanical mix regulators cannot provide compensation for such fluctuations and so have to be re-adjusted. By contrast, the new gas valve F01 from ebm-papst Landshut offers a convenient way of dealing with the problem of adjustment to different gas qualities: Electronic control obviates the need for manual setting. An ideal, economical, and ecological combustion process is always guaranteed.

Natural gas from a variety of sources As a result of liberalisation of the gas market, gas companies are now obliged to allow other suppliers to pump gas through their networks. Potential shortages are avoided by mixing gas from various fields or feeding in biogas. The calorific value of the resultant gas mix often fluctuates considerably despite the limit values agreed upon by the gas companies. The consequence of this for the combustion process is that the amount of combustion air required has to be adjusted. In practice, switching from high-calorific (so-called H gas) to low-calorific natural gas (L or even LL gas) for instance results in heat output losses of a double figure percentage magnitude if the mixture ratio is not adapted accordingly. This is

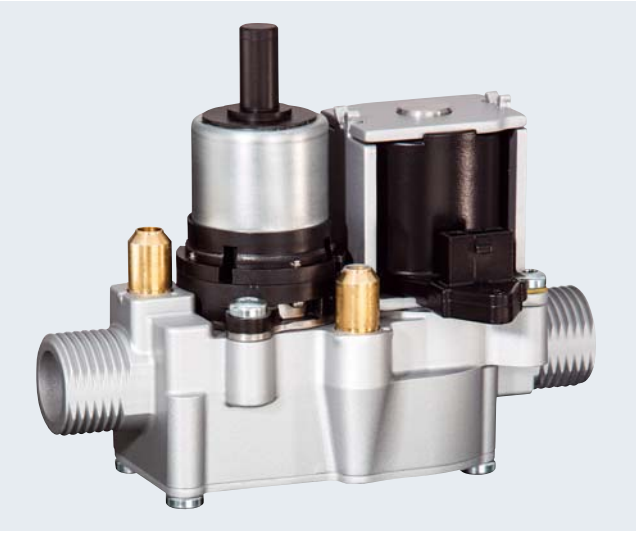
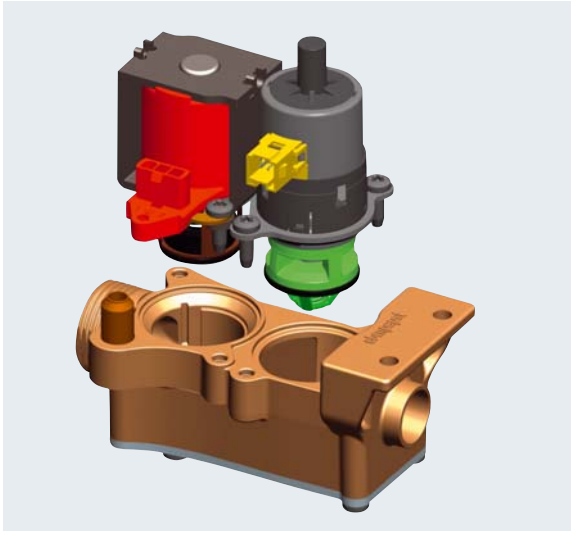


Figure 1: Link between gas and control system, the new gas valve F01

Figure 2a: Modular Design: Safety module and stepper motor module (top) and housing (bottom)



The new gas valve also simplifies the commissioning of gas heating systems

also associated with an increase in the pollutant emissions of the heating system. A conventional gas and air modulation system with mechanical/pneumatic control is not able to accommodate such fluctuations and manual adjustment is, therefore, always necessary. By contrast, the new electronic combustion control system provides constant automatic regulation by way of the gas valve (Fig. 1) to ensure optimum fuel utilisation.

Electronically controlled The microprocessor-controlled system registers the combustion quality and ensures optimisation regardless of the installation location and the amount of heat required. This is based on three important parameters: Heat requirement, air mass flow, and gas quality. The air mass flow is set on the basis of the amount of heat required, as it is proportional to the output. A mass flow meter integrated into the fan measures the air throughput. With standard pre-mix burners, the composition of the gas can easily be detected thanks to a particular property of gases: Given identical thermal load and excess air (same Lambda value), all the gases within one gas family exhibit identical temperatures at the burner. This permits reliable regulation of optimum combustion with a constant Lambda value as a function of the temperature at the burner and the combustion air mass flow. Depending on the heating system concerned, the excess air can, thus, be kept constant over the entire heater modulation range. This does, however, presuppose accurate and rapid regulation of the gas flow as specified by the electronics.

Gas valve as actuator To be able to react accordingly to the information received, the new gas valve F01 is equipped with a stepper motor. The deterministic behaviour of the motor – one pulse corresponds to one step – simplifies the control action with no detriment to accuracy and safety. In practice, the new valve permits a control ratio of 1:10 as opposed to the standard 1:4 provided by pneumatic modulation to date. The valve reliably regulates gas quantities in the range between 1 and 40 kW rated output. In extreme cases this control capacity makes it possible to reduce the heat output from 20 kW rated output to just 2 kW heat output for example if only minimal heating is required. Frequent burner start-up is, thus, avoided. Shorter shutdown times increase the efficiency of the heating system whilst at the same time reducing pollutant emissions.

The modular gas valve (Fig. 2a, 2b) combines proven safety technology with a modern electronically compatible actuator, the stepper motor with pressure regulator. The design is simple: Downstream of the safety valve, the gas flows to the valve disc. This is precisely raised or lowered by the stepper motor as specified by the control sys-

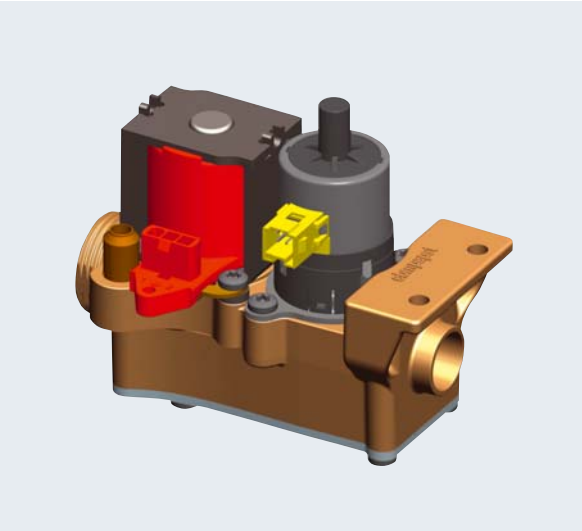


Figure 2b: Modular Design: Safety module, stepper motor module, and housing (assembled)

tem, thus, accurately metering the flow of combustion gas. The new gas valve also simplifies the commissioning of gas heating systems. Constant monitoring and adjustment not only provide compensation for fluctuations in the calorific value of the combustion gas. The system also automatically senses the altitude of the installation location and accordingly adjusts the quantity of gas and the combustion air flow required. There is then no need for time-consuming heating system setting work on site.

Author is Enno Vrolijk, Program Manager Heating at ebm-papst Landshut

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

techmag 02°2013

Imprint

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

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

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

www.ebmpapst.com

Responsible for content:
Kai Halter

Editor:
Katrin Lindner

Layout and production:
Scanner GmbH, Künzelsau

Concept:
pr+co GmbH

Photography:
ebm-papst,
fotolia.com:
S. 9 © triocean
S. 13 © senticus
S. 16 © sergey02
S. 20 © Mihalis A.

Print:
Druckerei Ziegler GmbH + Co. KG

FSC www.fsc.org
MIX
Papier aus verantwortungsvollen Quellen
FSC® C012935