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Technology from ebm-papst

SPECIAL ISSUE PART 2: **TRUE VALUES**

DISCLOSURE

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RadiPac = form + fit + function

People spend 80% of their lives in buildings. Air handling units control the purity, temperature and humidity of the air to create ideal human living conditions. Fans supply a specified volume of air at a defined pressure to maintain the required "atmosphere". That is the object of the exercise. In reality, a lot of supposedly constant parameters are in fact variables. There is no such thing as an all-purpose installation, as the local climatic conditions, the type and size of the building and the nature of the application concerned demand a sophisticated design and control strategy. Planning an air handling system involves performing detailed calculations to work out the most appropriate concept for the given situation. Characteristic data and design quantities are employed for dimensioning the ducts, the installation and the fan system. The air flow and operating profile form the basis for calculating the annual energy requirement and the efficiency of the installation - parameters which have to be documented to satisfy legal demands and for the owner of the building.

We analyse these factors together with our customers, the manufacturers of air handling units, to determine the optimum product-specific features for the fan system:

- Fans account for the majority of the power consumed by air handling units; the solution: EC technology integrated into an aerodynamically optimised impeller – nozzle module for maximum efficiency.
- Fans are part of the controlled system, the air performance has to be adaptable to requirements; the solution: EC technology with a networkable interface to the control system.
- Minimal air-borne and structure-borne noise levels through the use of an aeroacoustically optimised impeller – nozzle concept, possibly with FlowGrid and anti-vibration mounting module.
- Our RadiPac concept: Easy to integrate into the system thanks to its compact design with simple and safe installation.
- The RadiPac product range for all operating requirements; robust construction and reliable operation.

"Quality in a square" is not just a good motto for delicious chocolate, it can apply just as well to technical products.

ebm-papst can help customers secure their future success.

I hope this issue of the tech.mag will leave a lasting impression on all our readers.

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

An ongoing development process

Plug & Play centrifugal fans for ventilation technology

The technology involved with centrifugal fans for air handling units is constantly being enhanced - and not without good reason, given that users are demanding ever higher standards in terms of control and energy efficiency. Legal stipulations such as the EnEV (Energy Conservation Regulation) and the EVPG (Energy-related Products Act), known in Germany as the Ecodesign regulation, have greatly increased awareness in this respect (refer to "Ecodesign" box on Page 7). At the same time, economic considerations are also an important factor in the light of the rising cost of energy. After all, the higher the number of fans in operation, the more there is to be gained from energy efficiency.

Continuous improvement process ebm-papst, the motor and fan specialists from Mulfingen, have long since been committed to a process of constant improvement which in the final analysis is of equal benefit to both the environment and the financial interests of the customer. For instance, the centrifugal fans of the RadiPac product range (Fig. 1, Page 6) designed specially for use in air handling units have been the subject of ongoing enhancement in recent years, with particular emphasis on energy efficiency, noise reduction and handling properties.

State-of-the-art motors Consideration was first given to the motors employed. In the case of the external rotor GreenTech EC motors, recent developments have included improvements to the actuation electronics and the use of higher-quality stator plates to increase efficiency. The efficiency levels achieved by the energy-optimised motor, a mains-powered permanently excited synchronous motor (also known as BLDC or PM motor), are already far superior to the values required by

Fig. 1: The new-look RadiPac. The modification work mainly concentrated on the air inlet into the impeller, the positioning of the external rotor motor in the impeller and the blade profile of the impellers.

efficiency class IE4 as per IEC 60034-30. What's more, these external rotor motors operate with "simple", inexpensive and above all readily available ferrites. In other words they are not reliant on potentially problematic rare-earth magnets and yet still manage to attain efficiencies well in excess of 90% (refer to box on Page 7).

The successor: there is always room for improvement This product range is now nevertheless past its prime and – as already planned since 2010 – is being replaced by a successor model designed to set new standards in ventilation technology. The principle of company founder Gerhard Sturm, that every innovation and enhancement should be better than its predecessor, has once again been successfully put into practice. Experience has repeatedly shown that modern EC drives far surpass the conventional AC drives still widely used in air handling and air conditioning systems in terms of energy efficiency. It is however important not to forget that a fan always has to be viewed as a complete system made up of the impeller, motor, control electronics and housing. So the enhancement process has to encompass all aspects – from the electrical connection to the air outlet at the impeller and even the installation situation in the air handling unit – if the energy saving potential is to be used to its best effect (Fig. 2).

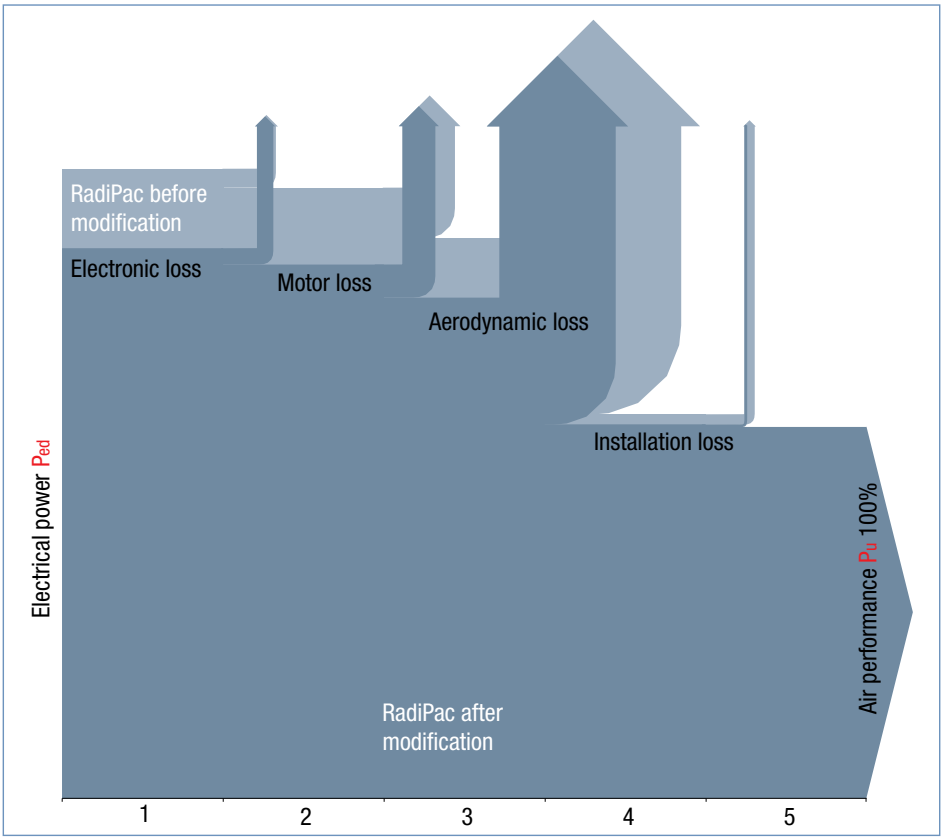


Fig. 2: The results of the optimisation process are impressive. All-in-all, modification of the motor and the flow machine brought about an up to 10% increase in the efficiency of the size 400 RadiPac fan.

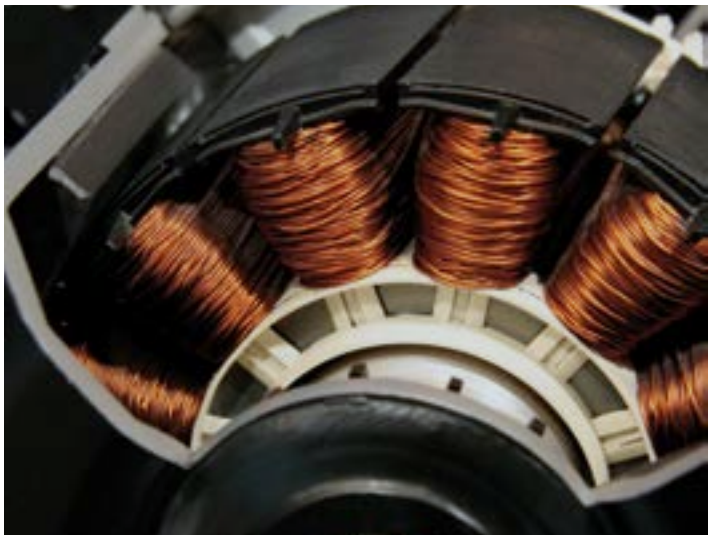


Fig. 3: External rotor motor with GreenTech EC technology: The rotor moves around the wound stator rather than in it and does not require the use of rare-earth magnets.

Ecodesign

The Ecodesign regulation for fans (EU 327/2011) specifies minimum efficiency requirements for fans operated by electric motors. The requirements first came into force in 2013 and became more stringent as of 01.01.2015. They apply to all fans with an input power between 125 W and 500 kW. A specified minimum efficiency level has to be attained based on the type of fan concerned. Calculation of the minimum efficiency values is described in this regulation. All GreenTech EC fans in the ebm-papst RadiPac product range far surpass the currently applicable requirements.

No dependence on rare-earth magnets

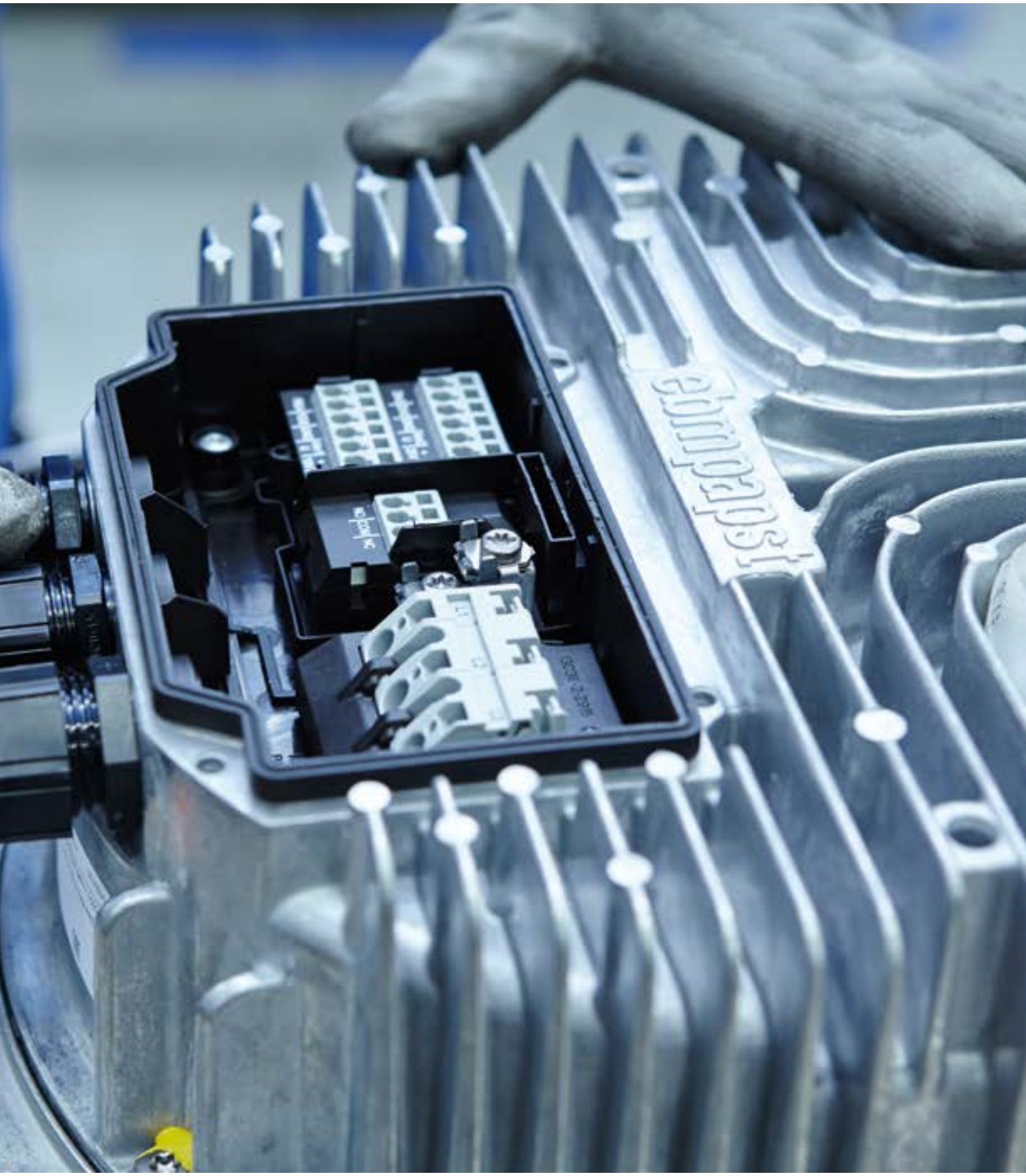
In external rotor EC motors, the stationary part of the motor, i.e. the stator and coils, is located on the inside and the moving part, the rotor with the permanent magnets, is on the outside (Fig. 3). The external rotor moves around the internal stator. This arrangement in itself makes it possible to achieve a higher torque (magnet volume, air gap, radius) with an external rotor than with an internal rotor with the same length of core, the same magnet system and the same magnet thickness (reduced magnet volume, reduced air gap, smaller radius). By making clever use of the degrees of freedom in the fan area, an external rotor motor employing hard ferrites can attain torques and levels of efficiency which can only be achieved by an internal rotor with limited degrees of freedom (volume, mass) using rare-earth magnets. As opposed to servo drives, there is no need for fan operation to be highly dynamic. On the contrary, a certain moment of inertia is desirable to obtain smooth start-up and acceleration characteristics. This means that it is no problem for GreenTech EC fans to manage without rare-earth magnets and use can instead be made of ferrites which are not just considerably less expensive but are also available at stable market prices on account of their availability.

A systematic approach

Improved flow machine

The efficiency of GreenTech EC motors leaves little to be desired. That said, a high motor efficiency level does not necessarily guarantee that the system as a whole will be just as efficient. Measurements have shown that the successful RadiPac fans still offer potential for improvement in this respect. Which is why the flow machine has now come under scrutiny again at ebm-papst. Following a detailed loss analysis and qualification process, the modification work mainly concentrated on the air inlet into the impeller, the positioning of the external rotor motor in the impeller and the blade profile of the impellers. With a view to improving the air flow (Fig. 1), the aim was thus to increase efficiency whilst at the same time reducing noise emissions. After all, the acoustic performance of a fan is considered to be one of the important features in most applications.

Fig. 1: The entire air flow in the AHU was taken into consideration for optimisation of the new RadiPac.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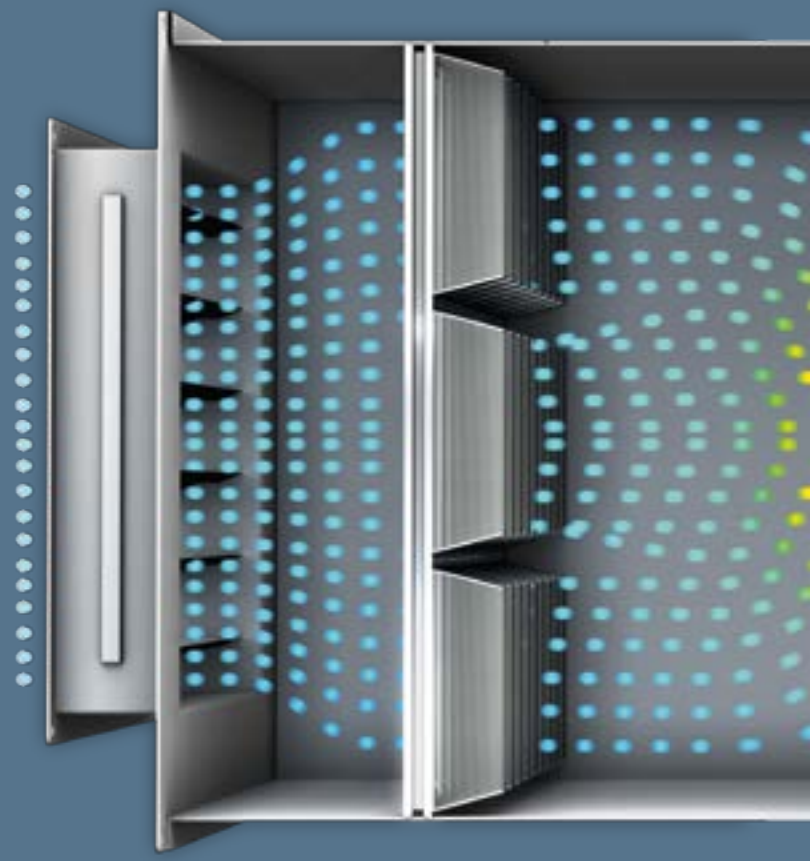
Air inlet grille – a useful addition Varying degrees of turbulence occur in the intake area of the fan due to the often confined installation space. Optimisation of the fan cannot compensate for such inflow disturbance. The turbulence arising from the installation situation can however be reduced by modifying or optimising the inflow of air to the fan, which also helps to keep down the associated annoying low-frequency noise. This was the reason for developing an optional special air inlet grille which has a straightening effect on the inflowing air (Fig. 2). The grille drastically reduces noise-generating disturbance in the inflowing air. Regardless of the building structure and the installation situation in the housing, the fans then attain noise levels comparable to operation under laboratory test conditions (Fig. 3).



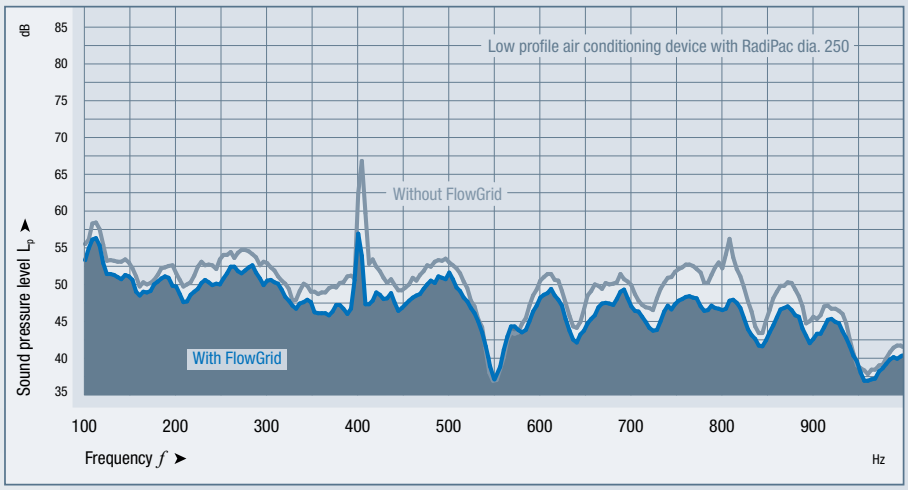


Fig. 2: FlowGrid air inlet grille for centrifugal fans.

Fig. 3: Convincing results: FlowGrid lowers the sound pressure level and distinctly reduces tonal noise.

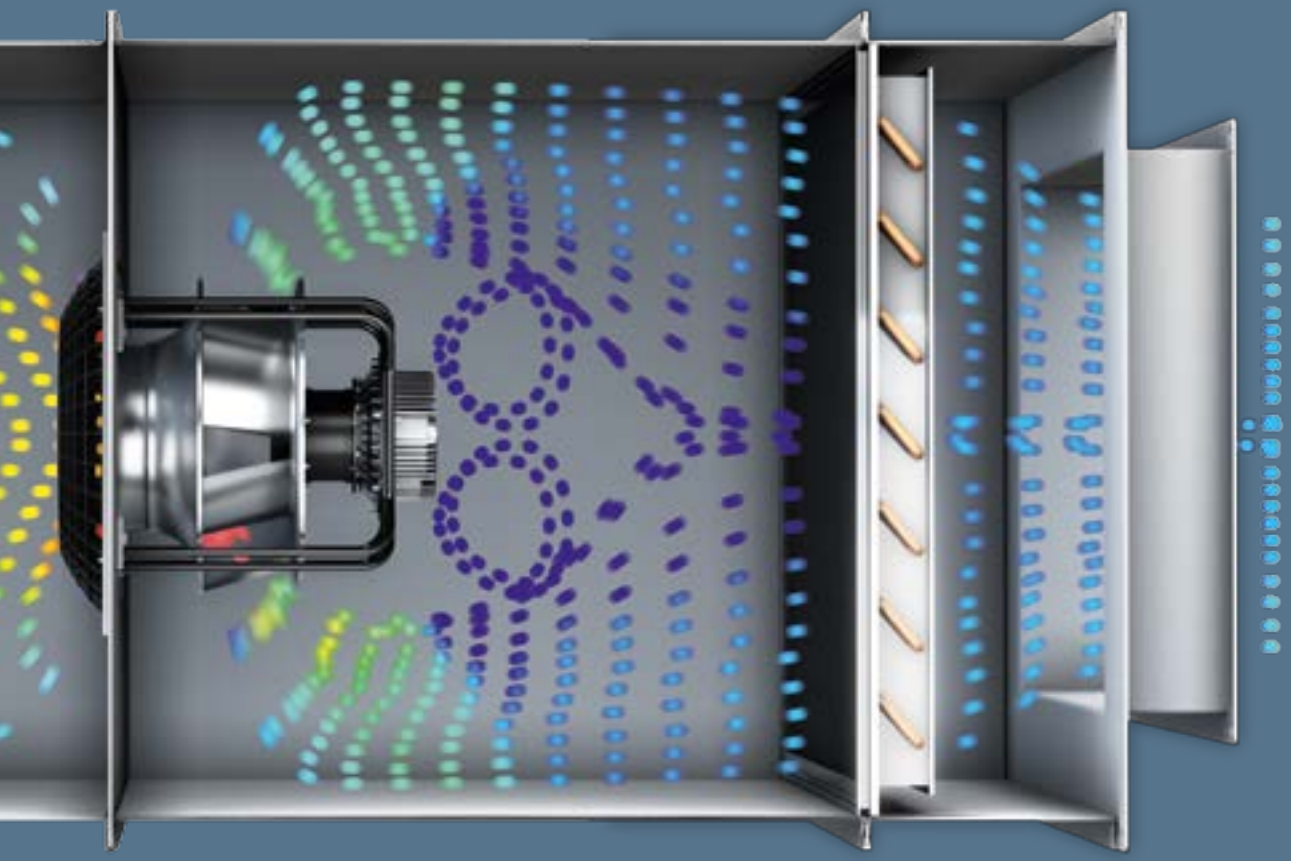


Fig. 4: The influence of the modifications on efficiency is determined by way of flow simulation. The outflow characteristics have been optimised.

Inlet nozzle An intelligent combination of components is the key to achieving good system performance. Which is why the inlet nozzle of the new RadiPac fans is designed to perfectly match the impeller with its aerodynamically optimised blade channel. This lessens turbulence right at the air inlet, thus reducing flow loss and at the same time eliminating one of the causes of noise nuisance. The transition from the inlet nozzle to the impeller cover plate has also been modified to produce a clearly defined gap flow. As a result the turbulence in the air flow, which would narrow the effective flow cross-section, is reduced at this point as well. This modification again adds to the efficiency of the system as a whole. An optimally positioned pressure tap for air flow measurement is also provided as standard, making commissioning easier for users.

New blade contour The mechanical design and aerodynamic properties of the new aluminium airofoil blades provide greater efficiency. The hollow profile of the blade keeps the weight of the impeller to a minimum whilst maximizing the rigidity. The extremely rigid impeller also permits high circumferential speeds.

Through-flow On account of the gentle rounding of the blade inlet, there is little inflow loss. The profiled contour guides the air flow through the blade channel with minimal loss before it leaves the impeller with hardly any turbulence thanks to the thin trailing edge. The specially shaped impeller base plate routes most of the outflowing air in axial direction. This reduces the deflection losses in the air conditioning device as well as the pressure drop when installed (Fig. 4). An added advantage is a lower noise level.

Optimised motor position The position of the motor in the impeller has also been altered to achieve a good compromise between the compact design of the fan unit as a whole and the best possible location of the motor in the impeller from an aerodynamic point of view. The centrifugal impellers are attached to the rotor, in other words directly to the "housing" of the external rotor motor. This particularly helps to reduce the axial dimensions whilst at the same time improving cooling, as the motor is cooled by the air conveyed by the fan. In addition, the entire rotating assembly made up of rotor and impeller is dynamically balanced in two planes at the production stage to ensure extremely low-vibration operation.

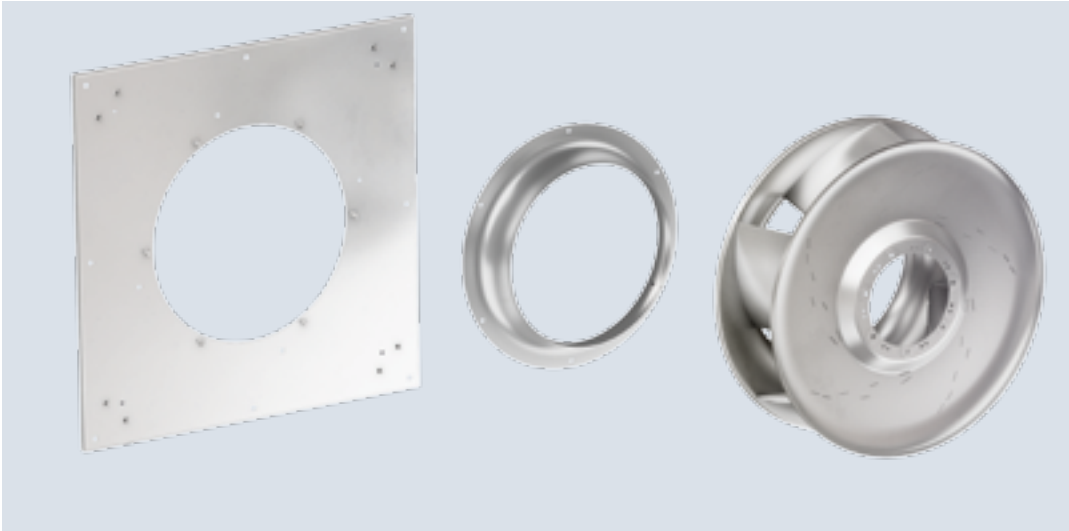


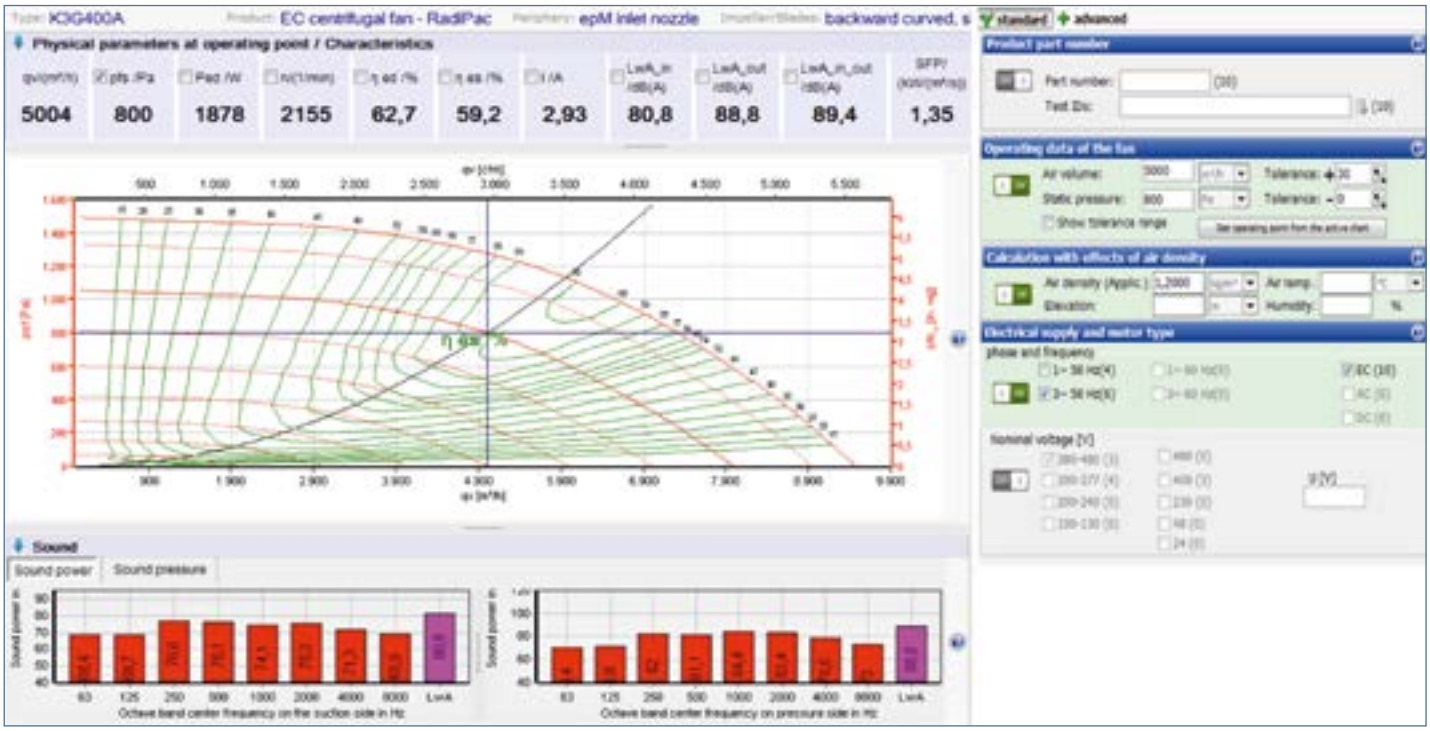
Fig. 5: For ebm-papst a fan is more than just an impeller. It is an optimised unit made up of at least the following components: Precision impeller with inlet nozzle, GreenTech EC motor and control electronics.

System concept rather than individual components There is yet another convincing aspect to the centrifugal fans. Alongside the high-performance impeller with inlet nozzle, a GreenTech EC motor and control electronics, the RadiPac product range for use in air handling units includes additional mechanical components (Fig. 5) to provide customers with complete ready-to-install fan units. In contrast to other concepts – employing asynchronous or PM motors for instance – users do not have to go to the trouble of purchasing, fitting, connecting and matching up individual motors, frequency converters and impellers.

Plug & Play What's more, there is no need for any additional electronic filters or screened cables with RadiPac fans, as the motor and the electronics integrated into the motor system are already perfectly coordinated and situated close together. External motor circuit-breakers are also superfluous. That's what Plug & Play for ventilation technology is all about. Our certified product selector (Fig. 6) permits the realistic modelling of the operating situations to be expected for a specific application on the basis of the measured performance data of the fan. Absolute planning reliability is thus guaranteed.

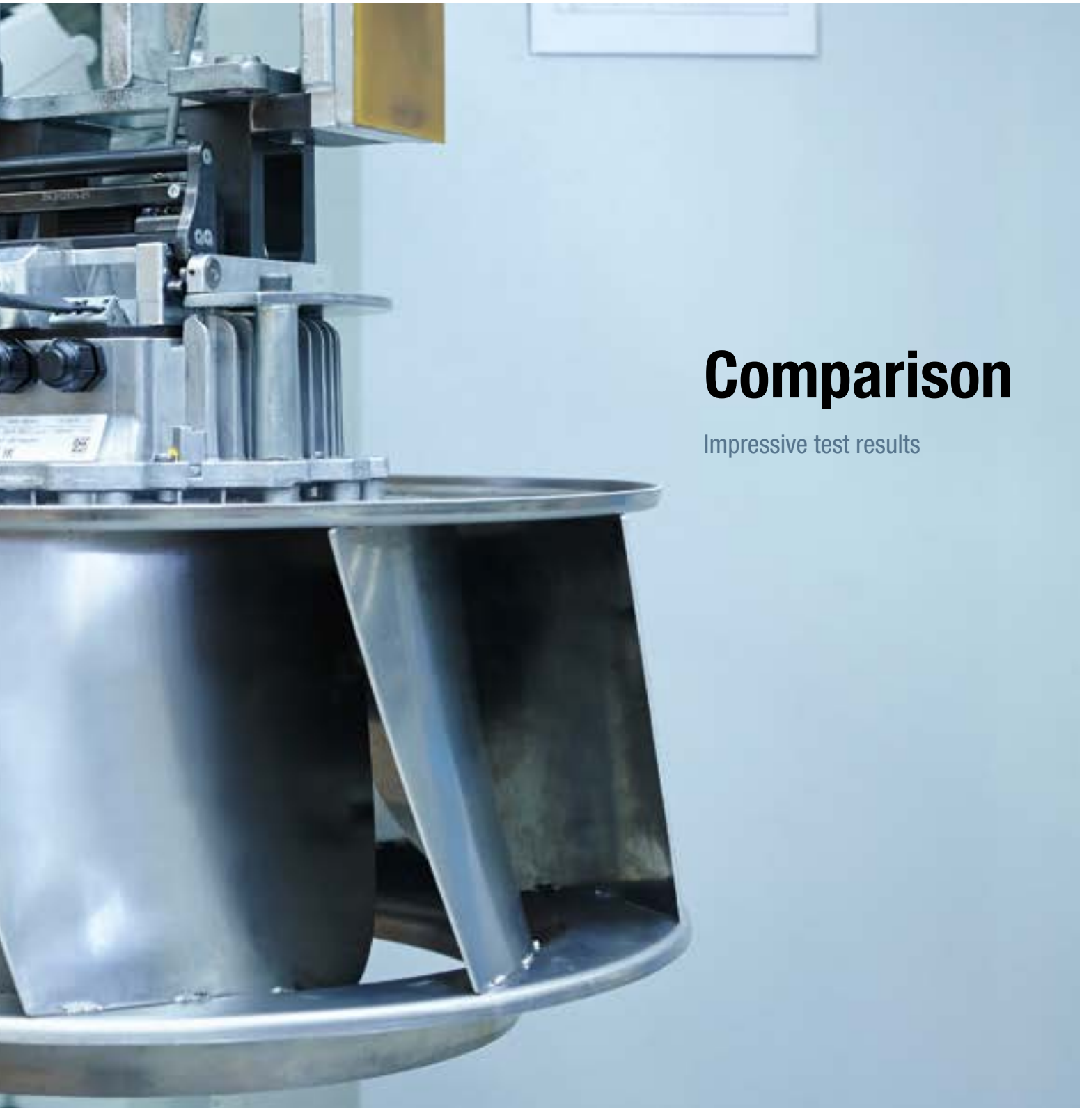
The infinitely variable speed control typical of EC motors also enables the fan performance to be exactly adapted to individual requirements. Either the standard 0-10 V DC/PWM input or the MODBUS-RTU interface can be used for communication.

Product selection made easy As an added feature and to help choose the right fan, the ebm-papst "Product selector" software with integrated "Black Box" module is available for incorporation into customer device configuration programs. With the new selection program, RadiPac fans can be picked out on the basis of the operating point. If there are several fans in the specified performance range, the aerodynamic and acoustic data displayed can be used to help choose and document the most suitable model. Another option available is calculation of the life cycle costs for the fans selected. As well as using the operat-



ing point, it is also possible to perform selection by way of the type designation. The data sheets can be created in pdf format and show not only the nominal data of the fan but also the performance data at the specified operating point together with the suction and pressure side sound power levels over the octave band. ○

Fig. 6: The product selector shows all the relevant fan operating data including an accurate record of the data in part load operation.



Comparison

Impressive test results

Certified test stand

As a certified manufacturer, ebm-papst fully conforms to the following criteria as specified for test stands by the guidelines of the AHU manufacturers' association: "An expert report/test report for fans will be accepted if testing was performed in accordance with the latest standard DIN EN ISO 5801:12-2010 (ISO 5801:2007 incl. corr. 1:2008) by a named test body on a suction-side chamber test rig and the component is manufactured without any modifications."

Certain test specifications must be observed for category A measurements with free inlet and free outlet.

Impressive test results The results of the optimisation process are impressive, as shown by the "old" versus "new" comparison in Figs. 1 and 2. All-in-all, modification of the flow machine brought about a more than 10% increase in the efficiency of the RadiPac fans At the same time the noise level dropped by over 3 dB (A). The extra efficiency is converted into higher air flows, in other words the new fans attain higher operating points.

The corresponding measurements were taken on an officially certified (TÜV) aeroacoustic fan test stand (c.f. text: Certified test stand) which permits the simultaneous recording of air performance data and noise values. This chamber or combination test rig consists of two low-reflection half chambers with high-impedance floor conforming to accuracy class 1 for acoustic measurements. Air performance measurements can be conducted at an air flow of up to 100,000 m³/h with a static pressure increase of up to 3,000 Pa.

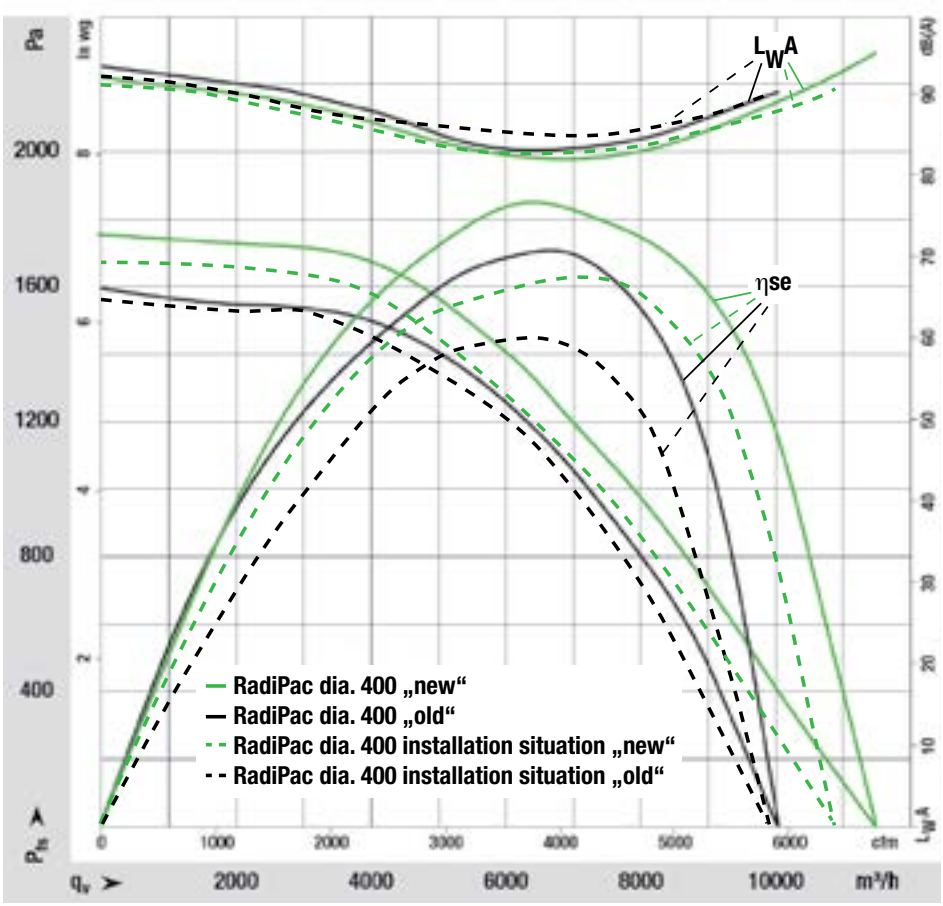


Fig. 1: The characteristic curves show the "old" vs. "new" comparison for size 400 measured on the certified test stand with free air and in installed condition.

Authentic operating conditions

The fans in an air handling unit operate in more or less confined spaces. This leads to a reduction in air performance which has to be taken into consideration when selecting the right fan. At ebm-papst allowance is made for the installation situation. For comparison measurements, the test fans are fitted in an AHU housing. Use was made of the dimensions 900 x 900 x 760 mm for size 400 fans. For size 560, the dimensions of the AHU housing were 1230 x 1230 x 760 mm. All the fans were centrally mounted in the AHU box.

The illustration shows the installation situation in the AHU on the test stand.

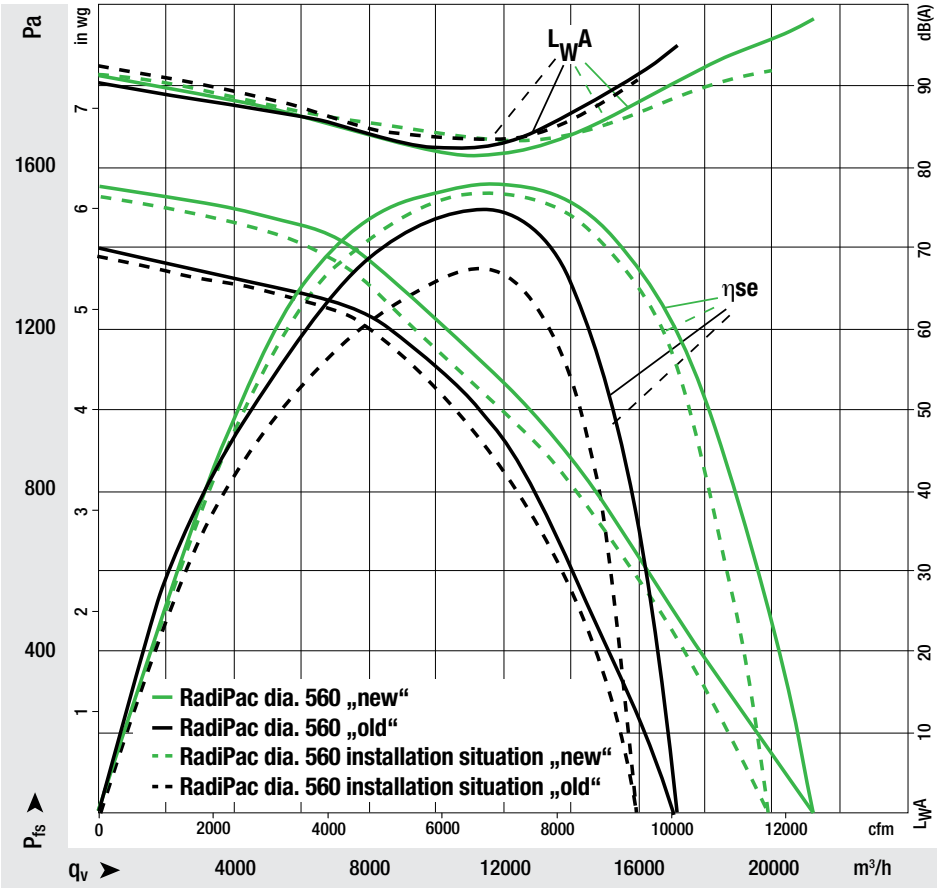


Fig. 2: The family of characteristics shows the "old" vs. "new" comparison for size 560 measured on the certified test stand with free air and in installed condition.

Authentic operating conditions

The fans in an air handling unit operate in more or less confined spaces. This leads to a reduction in air performance which has to be taken into consideration when selecting the right fan. At ebm-papst allowance is made for the installation situation. For comparison measurements, the test fans are fitted in an AHU housing. Use was made of the dimensions 900 x 900 x 760 mm for size 400 fans. For size 560, the dimensions of the AHU housing were 1230 x 1230 x 760 mm. All the fans were centrally mounted in the AHU box.

ebm-papst does not shy away from comparison with commercially available, highly efficient fan concepts and comes out well on top. The two sizes 400 and 560 were used for comparison and the measurements were taken in the same installation situation closely resembling real usage conditions (Fig. 3).

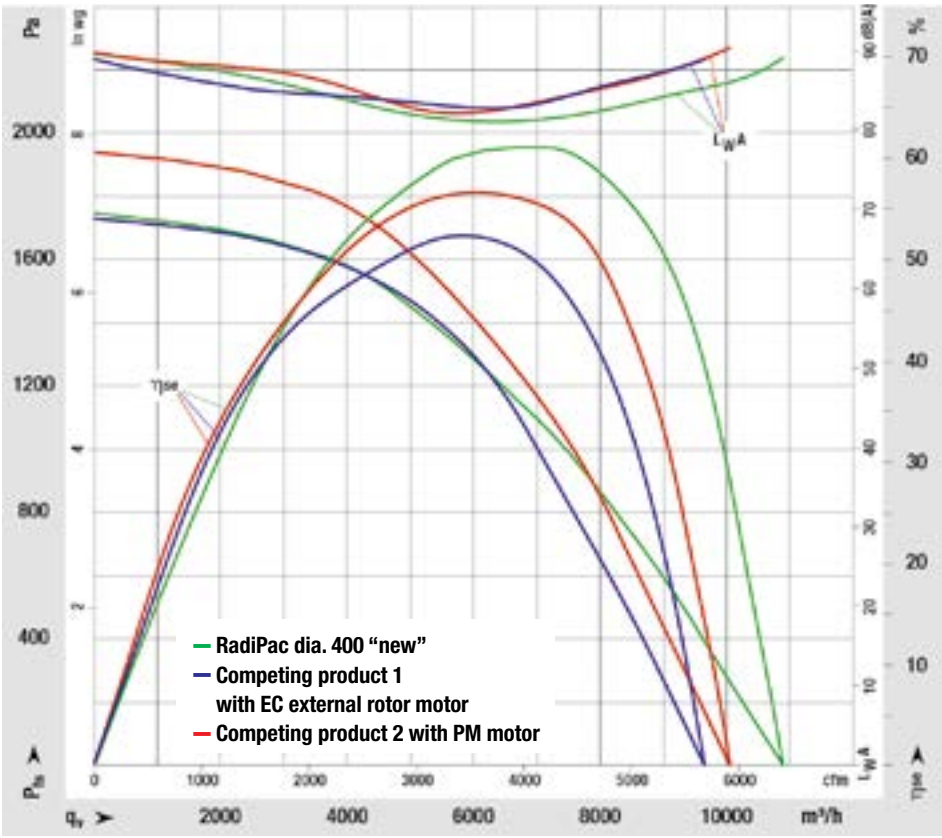


Fig. 4: Direct comparison of size 400 fans with competing products in installed condition. The installation situation is shown above.

Fig. 3: The illustration shows the installation situation in the AHU on the test stand.

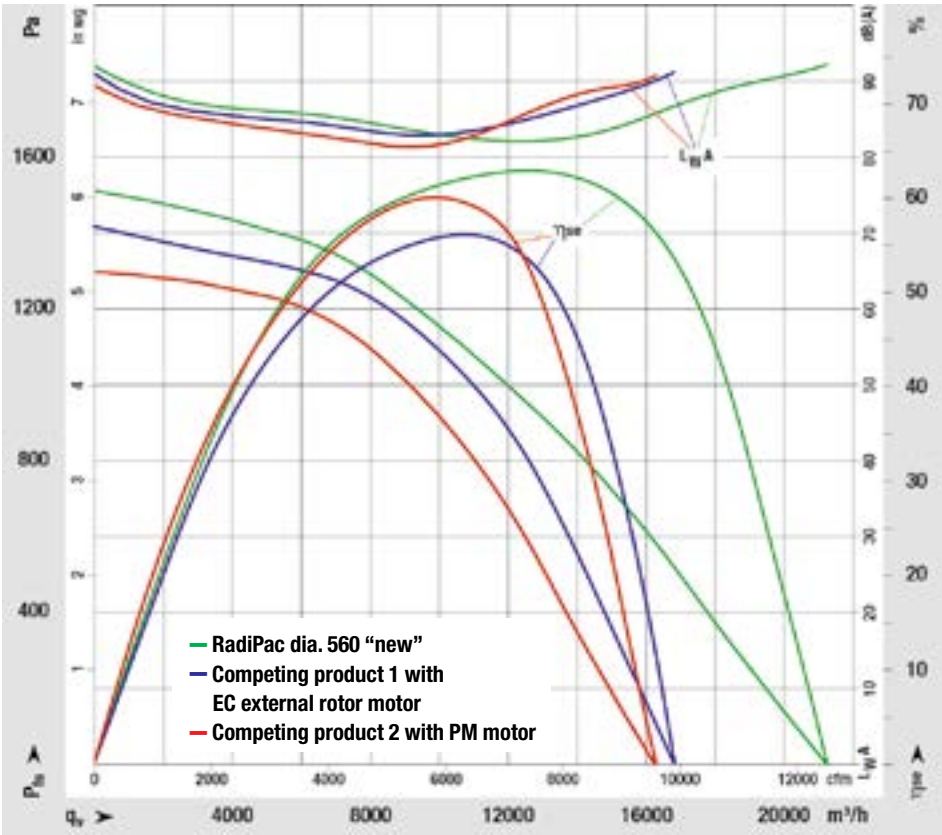


Fig. 5: Direct comparison of size 560 fans with competing products in installed condition. The installation situation is shown above.

The ebm-papst RadiPac (green curve) was challenged by:

– A manufacturer who also develops EC external rotor motors (blue) and
– A company which uses corresponding control electronics (red) with PM internal rotor motors (permanent magnet).

The diagram shows air performance, overall efficiency and noise generation. The characteristic curves speak for themselves.

DISCLOSURE

EC motors EC motors have not just proven their worth as a means of driving fans and pumps in buildings. More and more fans used for cooling switch cabinets and converters as well as in modern agriculture are being fitted with EC motors offering an unbeatably compact design and extremely quiet operation in addition to outstanding efficiency.

Technology EC motors are very similar to PM motors for example. Both types have a rotor fitted with magnets and the stator carries the excitation winding.

By virtue of their design, EC and PM motors are always superior to the widely used asynchronous motors (AC motors) in terms of efficiency. This particularly applies to applications involving low motor outputs and low speeds.

Attainable IE classes The efficiency levels currently achieved by the energy-optimised motor, a mains-powered permanently excited synchronous motor (also known as BLDC or PM) are far superior to the values required by efficiency class IE4 (as per IEC 60034-30).

Frequency converter operation ebm-papst EC motors already contain the necessary control electronics. This offers advantages in the event of EMC problems and the unit only has to be connected to one transfer point.

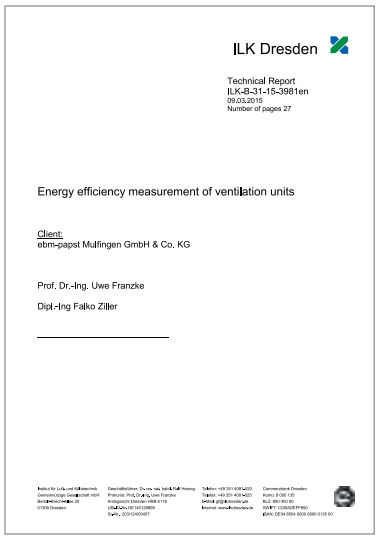
Typical applications EC motors have become established as drive units for fans in many areas, not just for use in buildings. The external rotor design is ideal for air handling applications, as the axial or centrifugal fan impeller can be mounted directly on the external rotor.

Worth noting The term EC motor is often used to refer to different concepts. However, as BLDC, EC and PM all describe motors with extremely similar properties, the name used is of no great significance – the important thing to remember is that: Genuine GreenTech EC motors from ebm-papst are designed to operate without potentially problematic rare-earth magnets.

System optimisation: An overall concept with potential In the power range below 10 kW, the use of efficient EC motors can reduce power consumption by well in excess of 10%. Savings of 50% and more are possible if this is accompanied by adaptation of the air performance to changing requirements, in other words by the use of speed control. EC motors in particular operate far more efficiently in the part load range than converter-controlled AC motors. Further savings can be achieved by optimising the air routing upstream and downstream of the fan. This is often not possible due to a shortage of space, which is where another outstanding feature of the new RadiPac impellers comes into play: The outflow of air from the impeller is directed in such a way that virtually no loss occurs when it is deflected into the main flow direction in an air handling unit. This illustrates the systematic approach adopted by ebm-papst when developing the new impeller generation.

All-in-all, modification of the flow machine and the motor brought about a more than 8% increase in the efficiency of the RadiPac fans. This can be seen from the difference between the green and black curves.

The full expert report of the ILK in Dresden can be viewed at: www.ebmpapst.com/ilk



ILK Dresden

Technical Report
ILK-B-31-15-3981en
09.03.2015
Number of pages 27

Energy efficiency measurement of ventilation units

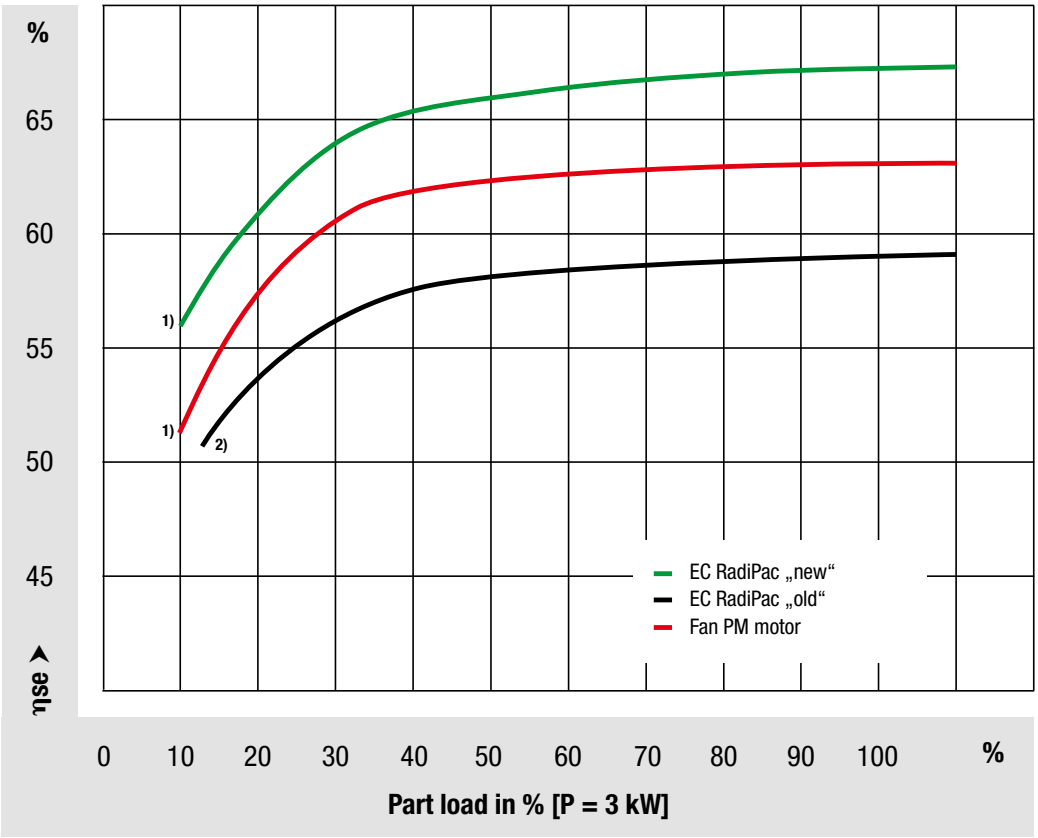
Client:
ebm-papst Mulfingen GmbH & Co. KG

Prof. Dr.-Ing. Uwe Franzke

Dipl.-Ing Falko Ziller

Measured by the ILK in Dresden!

Size 400 centrifugal fans measured in an air handling unit



Comparison of first and second generation size 400 RadiPac. The results were taken from the expert report 1) ILK-B-31-15-3981a (dated 09.03.2015) produced by the Institute of Air Handling and Refrigeration (ILK) in Dresden and 2) our own laboratory measurements. For more information on the study please visit www.ebmpapst.com/ilk

Not just for ventilation technology

The new RadiPac fans will be available in sizes 250 to 560 in autumn this year, thus making efficient, compact and quiet plug-and-play fans available for many applications, not just for ventilation and air conditioning units but also for cooling electronics such as the inverters in wind-power stations.

Cool air for solar parks: John Mylonas, Sales Engineer at Helcoma, and Zois Parthymos, Application Technology specialist at Gnettle, stand in front of a protective container.

Cooling down the container

Greece is discovering the value of its sunlight as a resource. To cool the electrical equipment in solar parks in that country, Gnettle is using GreenTech EC fans.

Greece's brilliant sunshine is not just a tourist attraction. The 300 sunny days per year also pay off in another respect: the country long ago discovered its immense potential as a production site for solar energy. Since last year, the Greek government has been intensively subsidising the construction of solar parks in order to strengthen this new branch of the economy.

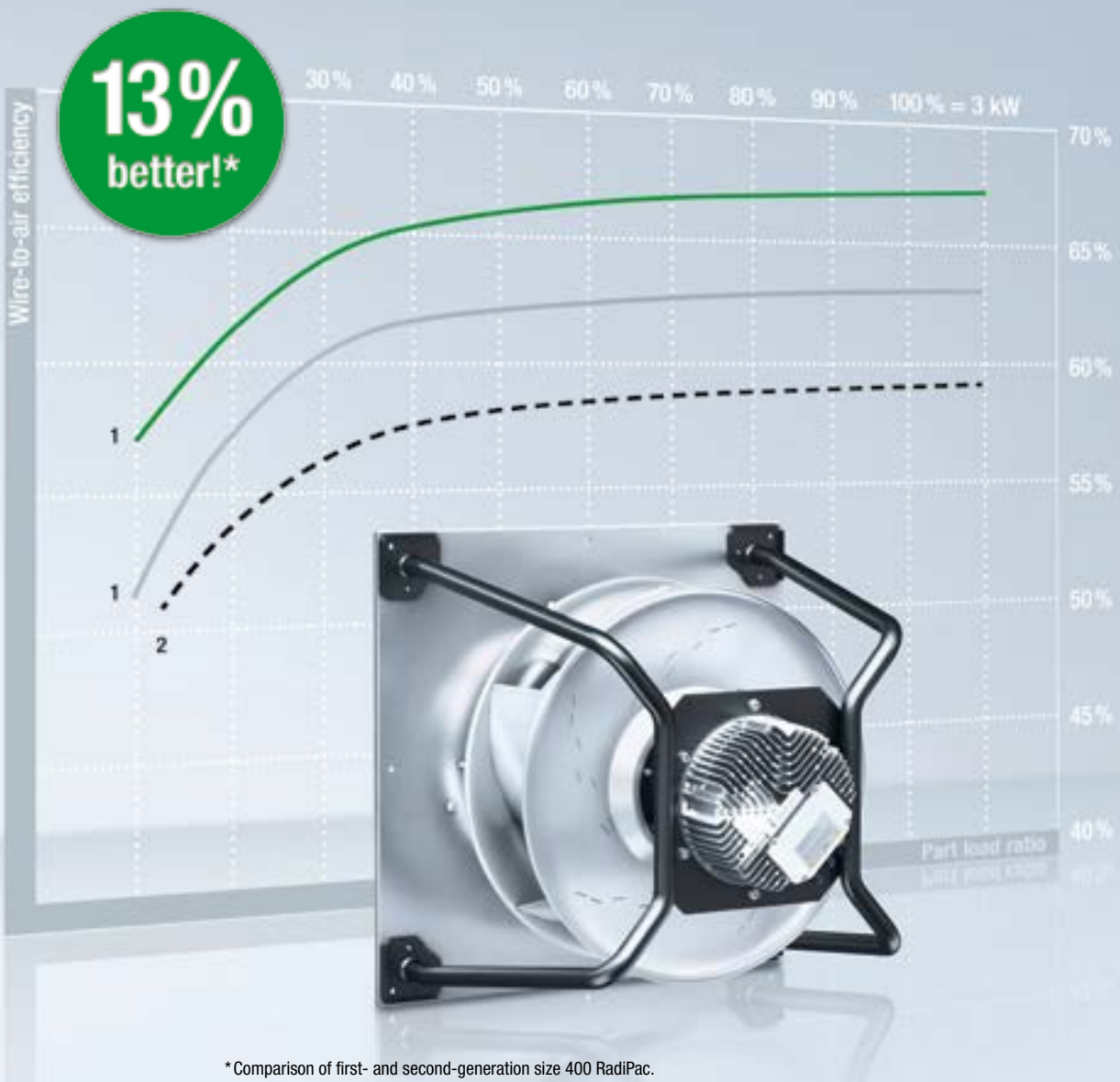
Gnettle has recognised this trend and, since January 2012, has been producing protective containers for the electrical equipment in solar parks. The white structures contain all necessary components for bringing the energy from the photovoltaic system to the mains power supply as electricity, for example transformers and power converters.

Smart solution However, the strong Greek sun also heats up the container. So that the heat outside and the heat given off inside by the electrical system do not impair the operation of the equipment, the containers have to be cooled. Usually, this job is done by a relatively low-efficiency split climate control system. However, Gnettle has decided in favour of a smart, energy saving solution; fans with GreenTech EC technology now ensure the proper temperature. Plug fans bring outside air into the container, while an axial fan disperses the heated air to the outside. In co-operation with Helcoma – ebm-papst's representative in Greece – Gnettle not only attains much higher air performance than with split climate control systems, but also saves energy.

Reacting flexibly "However, lower power consumption was not the only factor that led us to decide in favour of EC," says Nikos Kazantzis, Head of Systems Engineering at Gnettle. "The most important thing was that all of the components for controlling the speed are already integrated into the fan, allowing it to be programmed easily." This is particularly important for this application, as the fans have to react flexibly to both the changing outside temperatures and the variable electricity production and the resulting variable amounts of heat given off. After just one year on the market, the ECcooled protective containers from Gnettle are already online in eight solar parks, which together attain an output of nine megawatts.

RadiPac supplies the container with the air it needs.

A cut above: the new RadiPac.



*Comparison of first- and second-generation size 400 RadiPac.
The results are [1] from the ILK-B-31-15-3981a technical report (dated 9 March 2015) by the Institute of Air Handling and Refrigeration (ILK) in Dresden and [2] our own laboratory measurements. For more information on the study, see www.ebmpapst.com/ilk

Leading the way: The new RadiPac, our highly integrated plenum fan system, is the new standard for air handlers, as confirmed by ILK Dresden*.

– Compact motor
– Variable speed drive
– MODBUS control
– Airfoil impeller
– Custom inlet cone
– Rugged mounting structure

More information at **www.ebmpapst.com/radipac**

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The engineer's choice