tech.mag

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NEW IDEAS AT A GLANCE

ebmpapst

Editorial

All from one source: „Products, service, and innovation“

Dear ebm-papst customers, partners and friends,

With the beginning of 2007 seeing our technological magazine „tech.mag“ being issued, let us pause a moment to look back on the past year, a quite successful 2006.

During the last year, we here at ebm-papst Mulfingen once again managed to expand our product lines significantly. You, our customers, can now get the complete line of axial fans up to 1000 mm in diameter and the complete line of centrifugal fans up to 710 mm in diameter from a single source. What is more: all fan sizes are also available both with AC or EC motors. Incorporating our extremely quiet EC motors helps you to not only save substantially in terms of energy costs, this also contributes enormously to protecting our environment.

The development of our large fans has set new standards on the fan market. Taking less than two years from start to maturity for serial production, our highly motivated teams managed to apply state-of-the-art calculation and computation programmes to designing more than 20 new impellers and more than 15 motors to match these new impellers. In doing so, our R&D teams accomplished to vastly improve the acoustic performance – compared to some rival products, our fans generate more than 50 % less noise.

Of course, having excellent lab equipment at our disposal makes R&D work a lot easier. Here at ebm-papst Mulfingen, we have just set up a new chamber test station that is truly unique and seeks its rival worldwide. So we are now in a position to carry out aerodynamic and acoustic measurements at one and the same time. This results in drastically reduced measuring times, thus saving cost-intensive and valuable development time.

The real advantage of this innovative test station, however, lies in the fact that we can now measure the acoustic performance and aerodynamic characteristics of your units fitted with our fans, allowing us to optimise both in close co-operation with you. There is no doubt about it: customer service is very dear to us, and this investment simply makes sure you, our customers, get even better service from us.

As you can see, for us here at ebm-papst, innovation and customer service are not just eye-catching slogans - they are our reality.

Hoping you thoroughly enjoy this latest issue of our „tech.mag“.

Wilhelm Reinhardt
Head of Product Development
ebm-papst Mulfingen GmbH & Co. KG

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Mature design reduces overall installed size and noise emission:

New generation of gas blowers

As far back as at the end of the Eighties, gas blowers were developed for modern heating systems, known today as „condensing boilers“ and widely used due to their good energy efficiency. The gas blowers are placed right in front of the burner to blow in the gas-air mix. As in other fields of application, heating too tends to go for more and more compact units. At the same time, design aspects play a more and more important part in the specifications, as heating units are increasingly installed in the living quarters themselves, e.g. as integral part of kitchen furniture. Now, compact gas blowers taking all these specifications into special account are launched on the market. Radically new design principles are at the heart of this new development.

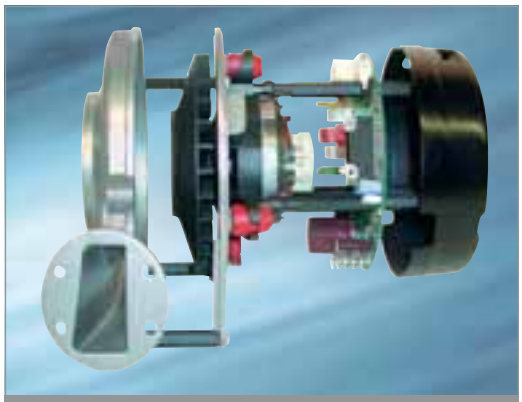

Fig.1:The new NRG118 gas blowers were specifically developed and designed for use on pre-mixing gas-condensing boiler units with capacities of up to 30 kW.

The new NRG118 gas blowers ebm-papst Landshut, the specialist for drives, fans and blowers, had ready for serial production in early 2006 (fig. 1), were specially developed for use with premix condensing boiler units with capacities of up to 30 kW (fig. 2). The centrifugal blowers are mounted in a sturdy die-cast aluminium housing, and their dimensions - 160 mm in height, 160 mm in width, and 90 mm in depth - are very compact. Compared to the preceding types, size could be diminished by ca. 20 %. What is more, the new centrifugal blowers also operate extremely quietly and reliably. These are advantages one can - not only because of the favourable cost/benefit ratio of the blowers - make use of in other applications, too, for instance in gas-fed automatic cookers in industrial-sized kitchens. Even the printing industry has by now begun to use these blowers to for fanning out the sheets of paper. As they are designed as modules, the blowers can be easily adjusted to even more individual customer specifications without elaborate modifications.

New design details with amazing effect

When developing the new gas blower line, there was a clear definition of design specifications. Apart from the reduced installed overall size, attention was to be paid to better balancing options. After all, well-balanced blowers significantly reduce noise emission and result in quieter heating systems, as both the circulation pump and the gas blower are the main source of noise in gas-condensing boilers. At the same time, the new design was aimed at making it possible to optimally adjust the blowers to the requirements of automated production in order to be able to offer the user high quality at a still favourable cost/performance ratio in future.

„Good cooling capacity and low overall installed size are no longer mutually exclusive!“

Fig.2: Compared to preceding types, size could be reduced by approx. 20 %.

Motor with multi-functional bearing cap

Based on these specifications, quite a number of constructive changes were made to the existing line, e.g. to the motors: The driving force behind the gas blowers is a single-core, electronically commutated DC internal-rotor motor (BG36-3). The main difference to the preceding types lies in the fact that it no longer needs two bearing caps but just one (Fig. 3). As multi-functional and central component, it houses the maintenance-free ball bearings and the springs needed for their positioning, as well as the sealing for the shaft exit, the stator, the motor screws, the anti-vibration mount and the motor support needed with horizontal shaft position.

Fig.3: The bearing cap serves as multi-function and central component.

As for material, a fibreglass-reinforced plastic was finally chosen. The consistently symmetrical design and a die-cast tool especially designed for this component make both sure the material does not deform and that the ball bearings are optimally aligned in the patented reception bores. Extensive practical tests have proven this. Even with extreme temperature changes between 20 °C and 130 °C, no mechanical distortion could be measured. Mechanical stability was proved via shock tests in different load directions with 30 g.

Diameter of cooling blades reduced by half

Apart from the compact motor design with only one bearing cap, other measures were taken to make sure the overall installed size could be significantly reduced in comparison with the preceding types. With the new design, for instance, part of the bearing system is immersed, so to speak, in the blower. Moreover, the cooling concept was redesigned, too. Active cooling of the blower motors is a definite must with most motor designs. After all, their power density is of such a high degree that winding, bearing and electronic components would overheat in the specified duty point. His is why cooling blades are normally pressed onto an elongated motor shaft, naturally causing the required overall installed size to be increased.

With the new gas blower, however, the cooling blade was integrated in the overall installed size of the stator and the PCB (Fig. 4). It is positioned in such a way as to make sure it blows the air directly onto windings and stator, which – with the new design – is only covered by the bearing cap on one side anyway. This allowed a reduction in the diameter of the cooling blade from 65 mm to a mere 33 mm. And as the cooling blade is also positioned on the same level as the PCB, the new design helps to generate a second air flow cooling the components on the PCB. Good cooling capacity and low overall installed size are therefore no longer mutually exclusive!

Balancing in two planes: substantially lower operating noise

As heating units and boilers are more and more often operated in the rooms themselves, there is a growing need for extremely low noise generation and emission. For a blower to operate quietly, this means minimizing any potential imbalance. It does not suffice to just produce and mount the rotating components such as impeller, rotor and cooling blade to a certain grade of imbalance. It is far more

Mature design reduces overall installed size and noise emission:
New generation of gas blowers

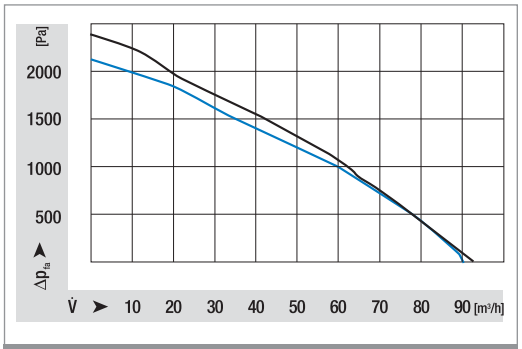

Fig.4: Air performance curve of the new gas blower
(blue: 24V, black: 230V)

effective to balance the entire rotating system in two planes once it is assembled. Here, too, the new motor design with only one bearing cap offers vital advantages:

The integrated cooling blade forms the first plane and is designed in such a way as to allow balancing weights to be integrated, too. The backward curved impeller serves as second balancing plane. If needed, any potential imbalance can be corrected here via minimal milling off, as the impeller is made of plastic. The periodically rising torque coming with the single-core DC motor design does not impair the balancing process, as the rotating system is driven externally during the automatic balancing. It is totally unproblematic to mount the stator afterwards. This way, the corrupting influence of the single-core DC motor on the measuring values is eliminated. The operator profits from this sophisticated balancing process in two ways. For one thing, the blowers are significantly quieter than specified in VDI 2060 (quality gradient 6.3); and, secondly, the increased running smoothness goes soft on the bearings. This has a direct impact on the service life of the blowers.

Minimal leakage rates: Liquid sealing instead of O-ring
The new centrifugal blowers comply with the specifications of protection type IP 20 and are approved by the DVGW (German association of gas and water engineering /Deutsche Vereinigung des Gas- und Wasserfaches). One of the development highlights proved to be the new liquid sealing replacing the conventional O-ring. The liquid sealing which is used in the automotive industry as windscreen sealing, for instance, effectively reduces leakage rates. All specifications as to insulation class F are complied with. And for applications requiring a pressure sensor for controlling the gas volume, there is an inlet provided on the housing. The permitted temperatures of the flow medium are 80 °C maximum.

In different designs, the new gas blowers operate either on 24 V DC or 120 V AC respectively 230 V AC (at 50 or 60 Hz each). They can thus be easily used in units produced for export. Long-term tests with the manufacturer prove the high reliability of the new blowers. The first samples have by now managed more than 40.000 operating hours without any defects or failures. Right on schedule, serial production started in January 2006.

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Diagonal fans cool supercomputer in Jülich, Germany

Today's supercomputers enable simulations of complex processes in biology, chemistry, physics and climate research. Since March 2006, Germany's Jülich Research Center has made the JUBL supercomputer – the fastest in the country – available to scientists. Its high computing power enables better insights for materials research, nanotechnology and investigation of new energy sources. Just supplying power to this monster computer is a difficult technical challenge. Since the JUBL is not exempt from the law of conservation of energy, the heat given off by its thousands of processors must be dissipated effectively. A specially designed ventilation system, in which electronically controlled diagonal fans provide the necessary cooling air, ensures problem-free operation.

Fig.1: The new supercomputer in the Jülich Research Center.

Germany's Jülich Research Center is a world-renowned research establishment and the largest multidisciplinary institute of its kind in Europe. Its computers are networked with those of other research centers in Germany. To expand its own computer capacity – which is available not only to those in-house, but also to 200 research groups throughout Europe – it installed the new JUBL (Juelich Blue Gene/L) from IBM. This supercomputer can handle up to 46 teraflops per second, thus reinforcing the research center's primacy in the field of computer-intensive research (fig 1). Powerful computers are particularly indispensable to researchers for developing new molecules in chemistry and medications in medicine, and for environmental simulations such as the spread of pollutants in groundwater. Complex simulations are also the current required standard in nanoelectronics, for example when developing new ultrathin magnetic layers for high-performance hard drives. In virtually every field, research at the highest levels would be virtually impossible without massive computing power and the infrastructure required for operating these computers. The new computer reinforces the research center's activities in the field of scientific computing – which, along with theory and experiments, is the third pillar of research.

Massively parallel

To attain this high level of computing power in a cost-effective manner while keeping the energy requirements reasonable and manageable, today's manufacturers use what are known as parallel computers. In these computers, thousands of individual processors – in the case of the JUBL, a grand total of 16,384 – work on the same problem simultaneously. Despite the use of energy-saving chips, such a large number of processors give off a vast amount of heat. Therefore, for optimal processor networking and thermal management, the computer is made up of modular components. Two processors sit on one chip; in turn, each board has eight chips. 128 boards make up one

„The VarioPro drive makes the fan self-monitoring!“

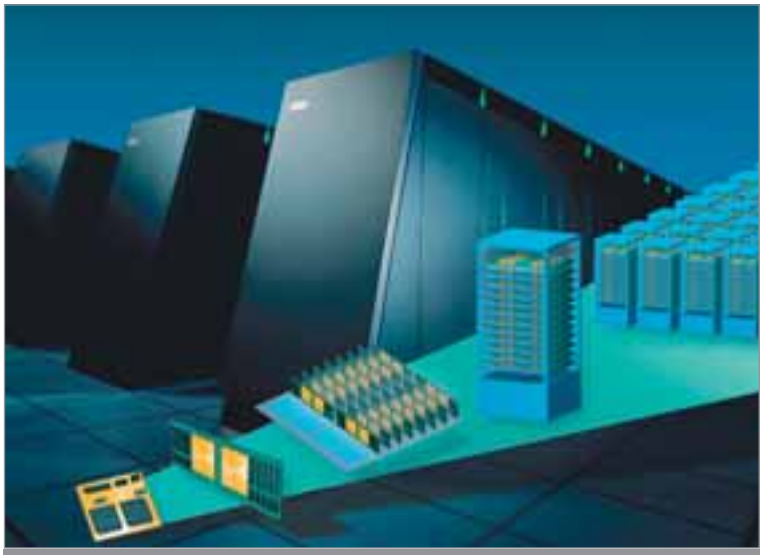


Fig.2: Modular design: the cabinet contains 128 boards, each with 8 dual-processor chips.

Fig.3: Fan trays with 3 diagonal fans each and control board for higher-level communication.

rack. The rack is housed in a cabinet that also contains the ventilation ducts and fans (fig 2). With this high performance in an extremely tight space, reliable dissipation is needed for the large amount of heat that is given off.

Thermal management - aerodynamics

This dissipation is provided by the supercomputer's 80 fan tray modules, which feature integrated temperature monitoring via an NTC sensor. In each module, three fans from fan experts ebm-papst in St. Georgen, Germany provide the necessary air flow (fig 3). The cooling system monitors and controls the fan trays via an I^2C bus and a control board. The control board, in turn, triggers the three fans via a PWM signal. The modules need to be hot-swappable for service work. This requirement, along with the component density in the cabinet, places particularly stringent demands on the fans used. High component density means high counterpressure in the unit, which normal axial fans are not capable of handling. However, the space-saving arrangement of the fans in the modules does not permit the use of centrifugal fans. For just such cases, fan specialist ebm-papst from Germany's Black Forest region has developed its series of diagonal fans. They combine features of both axial and centrifugal fans. The air flow rate largely corresponds to that of the axial fan. However, like centrifugal fans, they can provide a larger pressure increase of the air they move. Therefore, the principle is particularly well suited for supplying cooling air in complex, densely integrated electronic devices.

...and function

The requirement for trays to be hot-swappable poses an additional challenge: when one cooling module is removed, all of the others keep working. The remaining cooling modules generate over-pressure. When the new tray is inserted, the air flow generated by the overpressure activa-

tes the fans – which are not yet connected to the power supply – counter to the direction of air flow. Thus the fan hub must first be braked, then brought up to nominal speed before it can start moving air. This is too much for conventional fan drives. Using VarioPro electronics with adjusted software easily meets this requirement.

Because the impellers of the diagonal fans, due to their design principle, produce a rearwards conical stream of air, larger control boards can be used. Thus the wide variety of characteristics offered by the VarioPro drive, with its integrated, programmable control electronics, are also available to the fan. After the modules are swapped out, the integrated control center, made up of the microcontroller and EPROM, brakes the impeller to a complete stop during the start phase. It is then accelerated with a higher starting torque in order to overcome the system flow. This makes the start-up phase substantially shorter. In the pressure range from 90 to 160 Pa, the fan then moves between 260 and 130 m3/h, with a service life of about 40,000 h (60 °C) to 70,000 h (20 °C). In operation, the controller continuously monitors the fan for deviations and is responsible for communication with the control board. This relieves the control board and the higher-level computer unit from the actual task of controlling the fan. Since each fan contains its own controller, the system has a high level of redundancy – an important security advantage.

Diagonal fans enable problem-free, space-saving retrofitting for difficult cooling tasks with increased flow resistance in the unit. Because they feature higher pressure than axial fans with practically identical installation dimensions, they can be easily upgraded or retrofitted if the cooling requirements increase. The VarioPro drive makes the fan self-monitoring; the improved motorized possibilities, such as brake operation and heavy load start-up, expand the range of applications even further. This drastically reduces the design and stock-keeping costs.

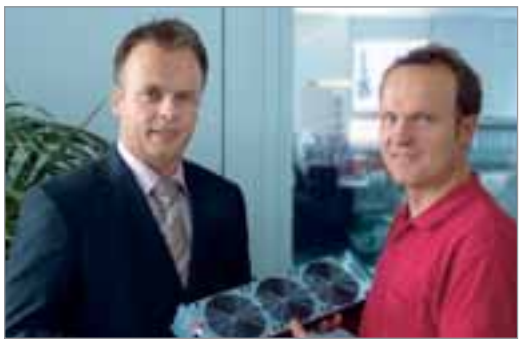
The diagonal fan principle

A diagonal fan uses both the „paddle effect“ of the fan blades, which is familiar from axial fans, and the centrifugal acceleration principle of centrifugal fans. The advantage of this arrangement is that it provides largely the same air flow as common axial fans, while simultaneously providing higher pressure build-up. This makes it easy to overcome high counterpressure without modifying the design of the unit. The most important feature of a diagonal fan is its conical rotor hub. The fan sucks the air in mostly axially. The hub, which is in the form of a cone-shaped shell, has a small cross-section in the intake area. The diameter increases towards the pressure side. The associated higher circumferential speed of the blade tips at the outlet also means higher centrifugal acceleration of the air (fig 4). Thus the flow path is adapted to the aerodynamic processes. Even at the same size, more energy is transferred to the air, and the attainable pressure increases. Vortex generation is minimized by the conical shape of the impeller. Therefore, the fan runs very quietly, even at high speeds or high pressure build-up. However, this requires precision work:

„The fan runs very quietly thanks to the aerodynamic optimization“

Fig.4: Design and aerodynamic function of the diagonal fan.

When the impeller diameter increases, the circumferential speed also increases towards the outside. The lower circumferential speed at the hub means that the blades must have greater curvature in order to sufficiently accelerate the air. This curvature must continually decrease towards the outside in order to prevent air replacement and vortex generation. (This effect is familiar from aviation: a slow glider has greatly curved wings, while fast jets have relatively flat wings.) The air thus moved via the blade profile and centrifugal acceleration exits the fan in a diagonal, oblique direction towards the outside. This results in a compact fan with relatively high air flow with high pressure build-up. Despite this, it runs very quietly thanks to the aerodynamic optimization.



Bachelor of business administration Thomas Brodbek
Head of Sales and Marketing fans (left)
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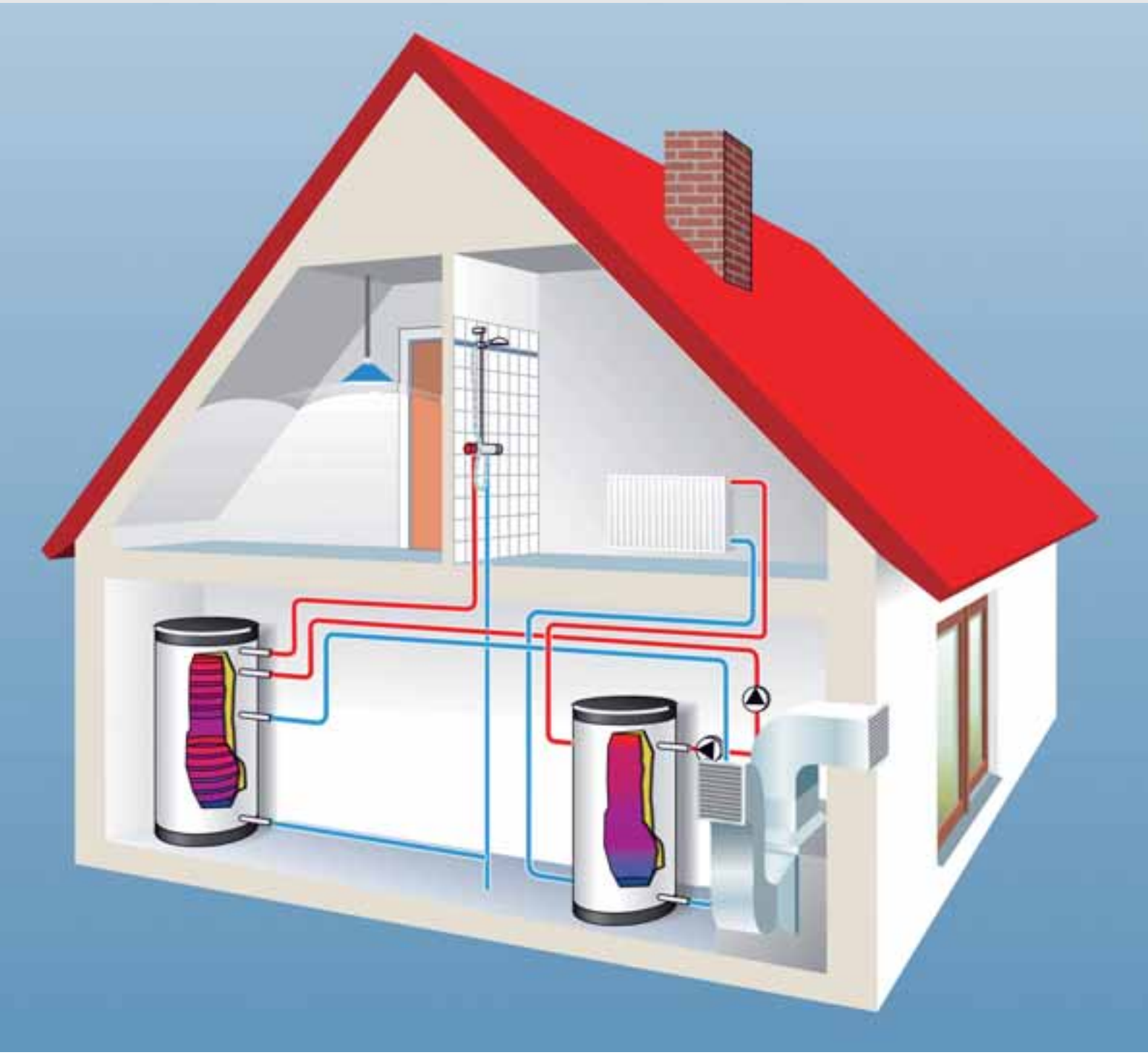
Key Account Manager (right)
ebm-papst St. Georgen GmbH & Co. KG

Quiet, economical and reliable to plan



„Air-water heat pumps absorb energy from the air around them.“

Heat pumps are among the heating technologies with a guaranteed future. There are systems for new buildings and for redevelopment. Of growing importance in this context is the air-water heat pump. In conjunction with this solution, modern EC fans offer decisive advantages especially when it comes to home modernisation. This also applies when taking the new building energy report.

Air-water heat pumps absorb energy from the air around them. For this, fans have to provide air exchange above the evaporator, which is either installed directly on the heat pump or, as split solution, with the unit mounted outdoors. Both system configurations are compact and quick solutions, especially when it comes to replacing an old boiler in a mono-energetic or supplementing it in a bivalent way.

„EC motors – They are the most economical solution on the market!“

The number of boilers in old systems in acute need of redevelopment in single family and apartment houses is estimated to be in a six- to seven-digit range. And despite the fact that investors are still reluctant about it, they are perforce called to look for energy-saving alternatives within the next one to two years in order to simply not risk their property losing too much in value all of a sudden.

Energy of building certificate creates new impulse

After all, what experts have so long been waiting for is finally going to become legally effective: January 2008 will see the introduction of the energy of building certificate. Having fought hard about its scope, the German Federal Government finally agreed on it in late October 2006. The model agreed on gives owners of buildings erected since 1978 the choice between declarations oriented either on demand or usage. For those buildings erected before 1978 and containing less than 5 apartments, the demand-oriented declaration is mandatory. The energy of building certificate is considered to turn into the new quality criterion on the property market and is meant to result in better market transparency when it comes to existing buildings. What it is all about is to make the future user of a home to be rented or purchased aware of the energy consumption that needs to be taken care of. Economical apartments and houses will therefore be rated as being more valuable in future.

As for energy, the biggest share by far goes into generating heat for both heating and hot water supply (see fig. 1). This is why it really pays to invest here in order to save more henceforward. A study presented by the German Federal Association for HVAC, energy management and environ-

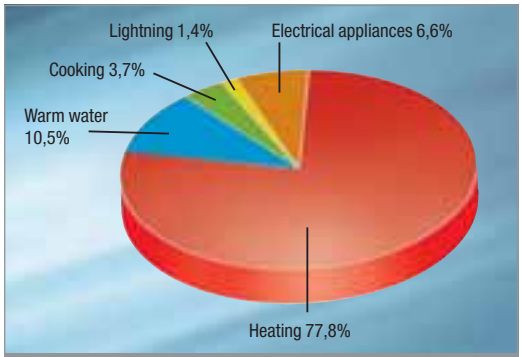


Fig.1: Distribution of energy costs (in %)

Different heating technologies and their quantities:		2005	2020
Condensing boilers (fired with natural gas, biogas and fuel oil, bio oil)	quantity/a	350,000	1,000,000
Wood-fired boilers: tiled stoves, fireplaces, flue-heaters (additional heating units) boilers (main heaters as central heating)	quantity/a quantity/a	220,000 30,000	110,000 200,000
Solar plants: collector surface, annually installed Number of annually installed plants (size 8 m²)	Mio. m²/a quantity/a	0.95 119,000	5.6 705,000
Heat pumps (mostly electric heat pumps for detached and semi-detached houses)	quantity/a	30,000	100,000

mental engineering (BDH) in Cologne a few months back documents that energy savings of up to 30% can be attained until 2020 if only state-of-the-art heating technologies are implemented on a broader basis more quickly, if regenerative energy sources are more widely used, and if heat insulation is enforced. In order to achieve this, two „lighthouse projects“ were started. One such action package contains, among other things, doubling of gas-condensing boilers, in combination with solar plants and the use of renewable energy such as biomass, solar heaters, and ambient heat that can be made utilised via heat pump systems (see table).

Heat pumps for existing buildings

A few figures may illustrate the growing importance of heat pumps. According to the German Federal Heat Pump Association (BWP), there was an increase in the sale of system variants for the German market by 150% in 2006. In absolute numbers, this translates into more than 35,000 sold heating pumps and about 8,000 sold heat pumps for water for domestic use. For 2007, the same growth rate is expected.

Service water is provided using air-water heat pumps. About 30 % of the heat pumps used in heating systems also use air as heat source. For 2006, this adds up to about 20,000 plants, and if we take sales figures to remain constant this year, we have about 30,000 air-water heat pumps sold in Germany alone.

The reason this prognosis tends to be rather conservative in medium term lies in the fact that there is an enormous bottleneck in the installation of ground probes for the most effective and best-selling brine-water heat pumps at the moment. Too few (competent) drilling companies that also charge extremely high prices – this is a great obstacle for potential sales. It is small wonder, then, that air-water heat pumps are turning into a promising alternative with an additional advantage to boost: their footprint is extremely small, and their optimal use is in mono-energetic or bivalent operation. This means that they use electric power to drive the compressor, the fans and the electric direct heating. Or heating during the few extremely cold days is not covered directly via electricity, but via a second source of energy (oil, gas, wood, etc.).

Air provided by EC fan

There are two variants of air-water heat pumps: indoor and outdoor installation (see fig. 2, page 16). With indoor installation, external air is sucked in and exhausted via two channels. With outdoor installation, the evaporator takes the form of a split unit and is outdoors, with the coolant passing indoors via pipeline. The BDH graphics illustrate both functions. Service water heat pumps form

„The greatest plus of EC motors in view of the owner – running smoothness“

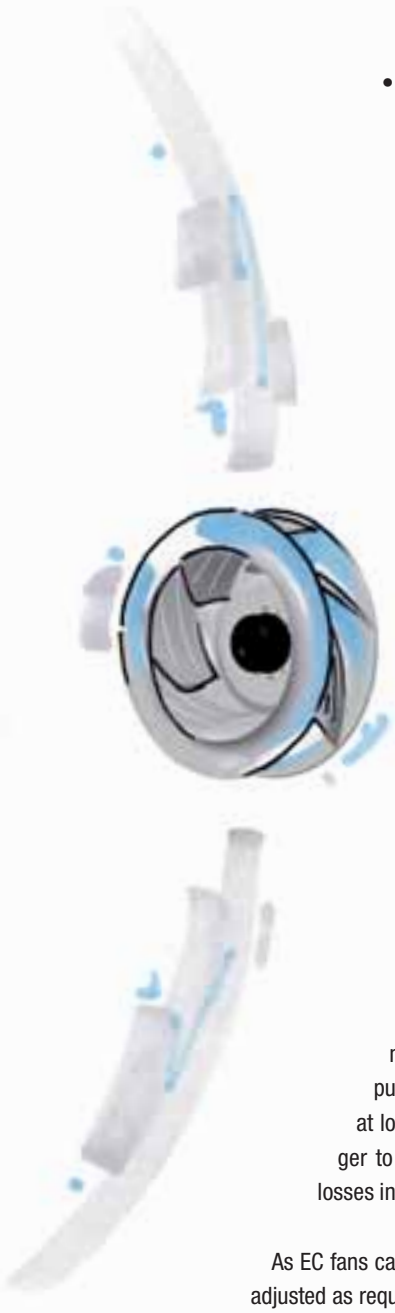
Fig.2: Air-water heat pump installation. Quelle: BDH/Solarpraxis AG

a special category and are normally operated inside a building, directly using the ambient air there. What all systems have in common, though, is the fact that they need a fan to transport the required amount of air. In most cases, these fans are lined up in sucking mode, and both centrifugal and axial fans can be employed. Reflecting the broad range of heat capacities needed for apartments and houses, the range of fans meeting these requirements has to be quite comprehensive. The specialist for fans and motors, ebmpapst Mulfingen GmbH & Co. KG, has therefore completed their product lines of centrifugal and axial EC fans for air-water heat pumps (fig.3). From now on, units with diameters ranging from 710 mm (centrifugal) respectively 1000 mm (axial) can be used, thus allowing for airflows of up to 20.000 m³/h across the entire portfolio. The EC motors used play an important part in this, especially from the point of view of the owner:

- They are the most economical solution on the market
- They offer maximal running smoothness
- Their speed can be adjusted to meet actual demand and ambient conditions.

Yet unit manufacturers and installers profit from this technology for the following reasons:

Fig.3: Example of an ebm-papst centrifugal fan in size 630 with matching EC-motor for low speeds
(left: front view, right: back view)



- Significantly lower logistics expenditure due to large scope of one fan type
- One fan that can be used for different voltage supplies (worldwide)
- Compact design
- Minimum wiring expense with simple speed control
- Integrated open loop control functions

The greatest plus: running smoothness

Whenever an air-water heat pump is used, there is one issue that always ranks high in the list of specifications. This is quiet operation. The only real source of noise emission is the fan, really. In the dead of night, this becomes rather obvious once the permitted maximum levels according to DIN 18005 and TA-Lärm (Technical specification noise) have to be observed inside the building, but especially outside the building. At night, the maximum noise emission is restricted to 35 to 40 dB(A) in residential areas. There is one way of reducing noise emission without losing out on heat pump capacity: Large fan impeller diameter at low speed and adjusting the heat exchanger to the fan. This makes for lower pressure losses in the evaporator.

As EC fans can be controlled, their speed can be easily adjusted as required without having to switch off the heat pump. This is illustrated by the graphics. The operating point of the fan in this example is reached at 5500 m³/h and pressure of 125 Pa at about 600 revolutions (Fig. 4). Sound pressure level in this operation mode is at 57 dB(A). Simply reducing the speed by 100 revolutions brings down the SPL by 4 dB(A). With an AC fan, such adjustments could simply not be made without taking further action.

From the operator's point of view, smooth running and economical EC operation (more details in the info box) are certainly the most decisive factors. For plumbers and manufacturers of heat pumps, additional factors come into play. EC fans are very compact, as the motor is inside the impeller. Moreover, EC technology can – without requiring any modifications – be used with any voltage supply, in single-phase operation at 200 to 277 Volt, with 50 and 60 Hz, and also in three-phase operation between 380 and 480 Volt, 50/60 Hz.

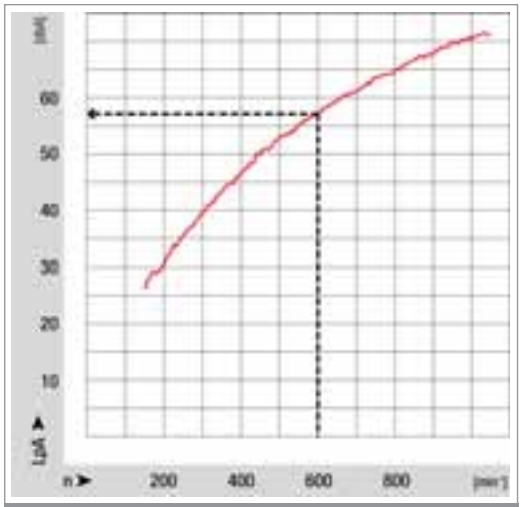


Fig.4: Acoustic performance of an ebm-papst centrifugal fan in size 630 across speed

„EC motors are self-regulating“

The following little example illustrates the logistic advantage: Whereas a heat pump manufacturer had to use 450, 500, and 560 AC fans with 4, 6 or 8 poles, he can now cover the entire operating range with one single size 500 EC fan. For this reason, only a few fans of a fan line are needed to meet practically all requirements, whether for new units, for maintenance or in the refitting sector – all over the world. By now, ebm-papst can cover a broad range of applications with a number of fans. On top of it all, EC motors cannot overload (for instance with frozen heat transfer agent), as they are self-regulating.

Optimal air-water heat pumps with EC technology

Everything considered, modern air-water heat pumps are going to have an increasing impact on heating service water and heating systems in Germany and Europe. In doing so, new systems use modern parts and components to full advantage. They are quiet, of compact build, can be easily used for redeveloping, and they save energy. And optimal results are achieved whenever air exchange is left to our equally pioneering EC technology.

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Module 1
EC - AC comparison

Compared to AC motors, EC motors have been certified to be far more efficient. At identical air performance, they need significantly less electric energy than comparable motors in AC design, thus increasing the service life of a heat pump. The illustration here shows the comparison between an EC and an AC fan in the same duty point of 5500m³/h at a pressure of 125 Pa. The result: The difference in power input is about 200 W. At an estimated operation period of 2,000 hours annually, and with energy costs estimated at 0.17 €/kWh, this translates into savings of almost 70 €. In addition to this, less electricity used results in a reduction of CO_2 emissions, which is yet another contribution toward climate control.

Module 2
Increasing demand for air as source of heat

Air-water heat pumps deduct the required energy from the outside air. They can be operated between +30 to -20°C. As a drop in outside temperatures leads to lower heating performance, the heat pump is most often realised in single-energy or bivalent operation in order to keep investment costs down. Air-water heat pumps have a number of advantages: simple installation, inexpensive source of heat, no approval procedures, no special requirements as to lot size, no outside contractors (e.g. civil engineering firms) needed to realise plans. Investment costs of an air/water heat pump are significantly lower than those needed for a comparable plant using geothermal collectors. In winter, air-water heat pumps operate with a relatively cold heat source. This is why a little bit more energy per year is needed to power such a plant. Despite this, the simple system has led to 54% of all heating systems using heat pumps in Switzerland today, for instance, are designed as air-water heat pump plants. Exhaust air from buildings or industry can also be used as heat source. If a constant heat source of high temperature level is available, high power ratings can be achieved.

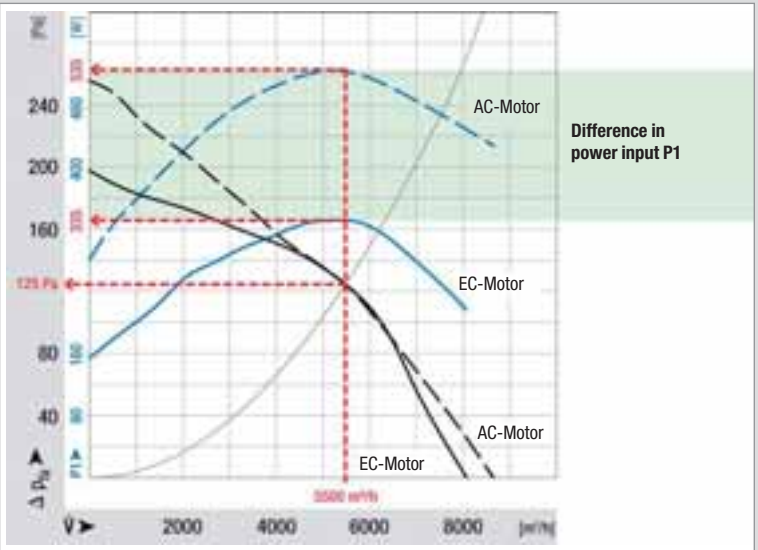

Fig. to module 1: Difference in power input

Air-conditioned seats for commercial vehicles

The number of jobs that require long hours of sitting is increasing at a steady pace. As this number increases, so does the number of people who suffer from back problems. For this kind of work, ergonomically adapted seats are all-important. Though we normally associate these problems with office workspaces, it is not only office furniture that places strain on the back. For example, truck drivers and farm, construction, and industrial equipment operators often sit for long hours while working. In these lines of work, additional stress factors come into play; vibrations and strong temperature fluctuations make life hard on the back. Clever designs for damping vibrations and for air-conditioning provide relief for these problems. However, good designs are only practical when they can be put into use with the right components. For example, the fans used must be able to cope with harsh ambient conditions inside the vehicle.

The Grammer company specializes in developing and manufacturing driver and passenger seats. Components and systems for interior vehicle equipment are also part of their product portfolio. The Maximo series of driver's seats are designed as a retrofit system to be suitable for use in industrial trucks and in middleweight to heavyweight tractors (fig. 1). The right seat can be selected based on individual needs. With its electronic adjustment to the driver's weight, adjustable damping action, various suspension settings and active seat ventilation, the Maximo Evolution offers the highest level of comfort possible (fig. 2, see page 22). Considering that moisture and temperature fluctuations have the most long-term impact on the health of your back, then this equipment package – developed especially for industrial truck drivers and tractor operators – is not an over-the-top luxury. For example, during a five year period, a career driver spends around 8,000 hours sitting in the driver's seat. That equals an entire year of uninterrupted sitting.

Proper ventilation for the health of your back

Seat ventilation alone does not prevent back problems. Many ventilation systems bring the driver into direct contact with cooling air. If the driver is sweaty, for example, the cool air can have unpleasant consequences. Anyone who has ever experienced discomfort caused by catching a draft while perspiring can relate to this problem.

To prevent this problem, the cooling system in the Maximo Evolution is configured so that the passengers in the vehicle do not come into direct contact with cooling air. For one thing, the system works preventatively: even when the weather is hot, the seat is pleasantly cool, which prevents perspiration in the first place. However, should the surface of the seat become moist again – for example, when a perspiring driver sits down – the moisture is wicked away in several stages. A textile fabric with excellent moisture wicking properties draws heat and moisture from the surface of the seat into its interior. Activated carbon fabric below the surface of the seat creates a

Fig.1: The Maximo series driver's seats are designed as a retrofit system to be suitable for use in industrial trucks and in middle-weight to heavyweight tractors.

„Centrifugal fans deflect the air flow direction by 90 degrees“

Fig.2: Active weight adjustment, adjustable damping action, various suspension settings and active seat ventilation offer the highest possible level of comfort.

temporary moisture barrier. Beneath the activated carbon fabric, there is a zone of active ventilation. Air ducts and fans draw warm air and moisture into this ventilation zone (fig. 3). The opening of the air duct is placed in an area on

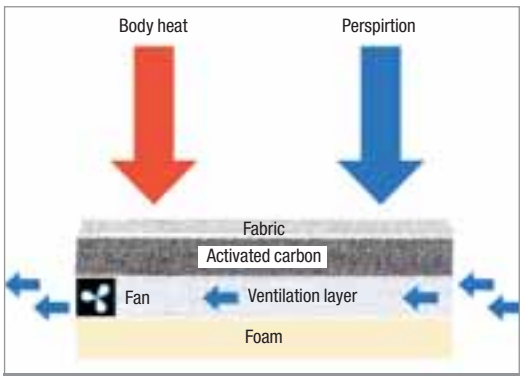

Fig.3: Diagram of the seat design: A clever system dissipates heat and wicks away moisture from the seat surface.

the vehicle seat that does not come into contact with the driver. Although the seat fabric is permeable to air, the resistance provided by the fabric prevents the air blown by the fan from actually passing directly through the upholstery of the seat.

Choosing the right fan is critical

To ensure that the entire cooling system functions properly, the fans must work reliably, even under harsh conditions. Therefore, the seat manufacturers decided on fans from ebm-papst. Our fan specialists are supplying two brushless direct current centrifugal fans (BLDC fans) from the RV 40 series – one for the seat cushion and one for the backrest (fig. 4). The commutation electronics are fully integrated into these fans, which are driven by electronically commutated external rotor motors. Electronic reverse polarity protection and locked rotor protection offer additional safety. The scroll housing and impeller are made of fiberglass-reinforced, halogen-free plastic.

The RV 40 offers many advantages for seat ventilation. Because of their structural shape, centrifugal compact fans can transfer more energy to air molecules. The current in these fans always leaves the impeller at the outer circumference, and thanks to the higher circumferential speed at the impeller, it has a higher level of pressure. If you need higher pressure with lower air flow, as is the case here, this is the fan for you. For seating ventilation, centrifugal fans offer an additional structural advantage that comes to bear when installation conditions are extremely tight: they deflect the air flow direction by 90 degrees. The air is sucked in axially and blown out radially. Because of the way the system operates, centrifugal compact fans are highly suited for being adapted to air ducts. This means that the fan does not necessarily need to be built into the area where warm air or moist air develops. On the contrary,

designers have the flexibility to put it just about anywhere in the seat.

The demands on cooling systems in vehicle seats are considerable. The particular challenge for ebm-papst's development engineers was to develop an extremely quiet and durable fan that could cope with the extreme loads that occur in the seat area, as well as adjust to the stress caused by temperature and vibrations in commercial vehicles. With its time-tested BLDC motor technology and careful adaptation of all of the ventilation components, Grammer is providing a reliable cooling module for commercial vehicle seats.

The right fan for every requirement

The type of vehicle and the type of air-conditioning needed are among the most important considerations when choosing the right fan. If, as described above, you would like to implement a seat ventilation system with air ducts, then centrifugal compact fans are the ideal solution. For ventilation systems without air ducts, axial compact fans are the ideal solution. They offer high air flow with moderate pressure build up. ebm-papst offers an entire array of products that are also suitable for this application. The fans can work in exhaust or intake modes

Fig.4: DC centrifugal fans meet the need for high pressure build-up with lower air flow and also deflect the air flow by 90°.

depending on your needs. And of course, these fans are not just for cooling – they can also be used for distributing heat when controlling the climate inside vehicles. Centrifugal compact fans are also well-suited for tight installation conditions; for example, they are used for heating the head room in convertibles. In short, there is virtually no vehicle climate-control application for which our fan specialists cannot offer a solution.

EC motors for vehicles

Today, modern passenger vehicles and commercial vehicles are equipped with a multitude of de-centralized drives. Seat ventilation, active steering boosters, and electronically-controlled gear-boxes are just a few examples of the array of applications. These applications are just as varied as the demands made on the motor by work-related motion. Safety and service life are the first and foremost priority. Electronically commutated direct current motors (also called EC or BLDC motors) fulfill these needs perfectly. The rotor bearing is the only component that is subject to mechanical wear; therefore, a service life of 40,000

„ebm-papst EC motors leave nothing to be desired!“

hours is the rule rather than the exception. The drive lasts for the life of the vehicle, even when put to commercial use for years. Thanks to electronic control, the drives can be well regulated, and they have proven to have a high level of efficiency – typically, from 70 to even far beyond 80 %. Electromagnetic compatibility also plays an important role in mobile applications. Here, too, EC motors are the solution of choice. Thanks to integrated electronics, it is entirely possible to connect the drive directly to the vehicle's internal bus. Furthermore, the safety functions in the engine control system, which can be linked with external data, allow the system to monitor itself. This is how localized intelligence relieves strain on the bus and all other control unit computer components. Whether used as a high-torque external rotor motor, a dynamic internal rotor motor, a tiny air sensor drive of only 9 mm in height or a powerful 200 W servo drive, EC motors can meet any and every requirement.

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Big axial fans premiering with single-piece plastic rotor

Innovation by simplification:
Big axial fans premiering with single-piece plastic rotor

„The new concept: a monolithic system instead of many individual parts“

EC-motors are increasingly the first choice when it comes to finding energy-saving and quiet drive solutions for fans, even with higher performance ranges and larger diameters even up to 1000 mm. This was made possible by groundbreaking new technologies and findings in the field of magnetic materials, the development of electronic components and, last but not least, new and low-noise commutation approaches. Another innovation may speed up this process even further: newly developed single-piece rotors made of high-performance plastics make powerful, EC-driven axial fans substantially more attractive. The most important keywords in this context are the significant reduction in weight, redundant varnishing – especially important when taking environmental aspects into account-, improved quality due to the fact that fewer individual components are needed, sensible use of raw materials such as aluminium and steel, and an optimised overall energy balance.

In terms of fan drive, external-rotor motors have proved to be especially useful, as the impeller can be directly mounted onto the rotor. In principle, this simplifies the fan design, yet it is still rather a complex operation in practical terms: as conventional rotors require a series of individual components, their assembly necessitates a lot of comparatively diverse processing and production steps (fig 1).

The new concept: a monolithic system instead of many individual parts

When conventionally built, every single blade has to be made of sheet steel or die-cast aluminium individually. With larger fans, this translates into five to seven pieces. Each single piece has to be welded onto the metal bell of the rotor or mounted with screws. The bushing taking up the shaft has to be mounted, too. Usually, welding it in is all it takes. And last but not least, varnishing also has to be taken into account. So far, there has been no alternative to the processing as described here, and it is also very cost-intensive in terms of components and manufacturing. Moreover, specialised knowledge and a superbly working quality assurance are essential for this kind of processing. This complicates production, and the

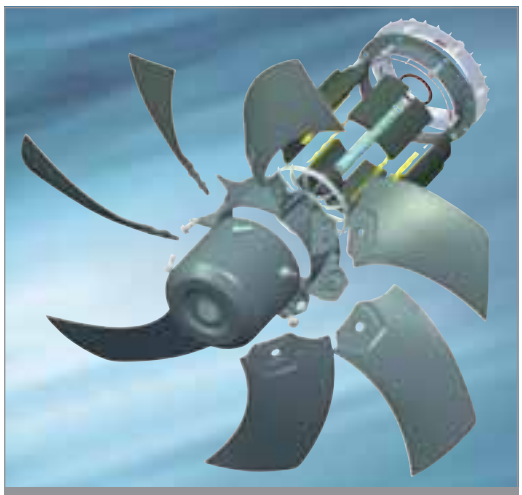

Fig.1: As the design of a metallic rotor requires a series of individual components, comparatively many and diverse processing and manufacturing steps are needed.

Innovation by simplification:
Big axial fans premiering with single-piece plastic rotor

Fig.2: General design of the plastic rotor manufactured in one single production step.

exploding prices for raw materials such as aluminium and steel make matters even worse.

With their new rotors for EC fans in the performance range of up to 1 kW, ebm-papst Mulfingen as leading manufacturer of motors and fans has opted for a pioneering approach: as a worldwide premier, the new rotors for EC axial fans with diameters ranging from 500 mm to 650 mm are made from high-performance plastics and in one piece. The design of the single-piece die-cast plastic part is shown in figure 2. The inserted steel strip serves as magnetic closure device, replacing the drawn steel bell. It also holds the magnets. Once the bushing for the shaft inserted into the form together with the pressed-in shaft, the rotor is die-cast in one single step. The magnets are well protected against the required high temperatures, both by the magnetic closure device and the cooling provided for by the tool.

Side effects: robust, corrosion-proof, and quiet

Compared to conventional approaches, the die-cast plastic part simplifies production substantially, as the number of necessary assembly steps is reduced. Nothing has to be screwed on, adjusted or welded any more. The material has other advantages, too, such as its high integration potential. Die-casting takes into account things like cooling fins or structures making sure the sealing for IP protection can be easily mounted. Balancing pockets can also be easily integrated. As soon as the complete rotor is balanced in two planes, they can take up balancing clips if needed. The result: better balancing quality – and thus lower noise emission – within even shorter time.

Yet the new design came with other advantages as well: compared to conventional metallic models, the aerodynamic performance of the rotors improved, greatly due to the fact that while sheet metal parts can only be bent and stamped, plastic can be easily formed into three-dimensional profiles. In doing so, even the winglets known from aerospace can be taken care of. These winglets reduce undesirable airflow between rotor and housing. This enhances efficiency and noise performance of the fan.

Another factor contributing to lower noise emission is the good damping effect of the plastic; thanks to special reinforcement, it compares well to the metallic material conventionally used, even though it weighs substantially less. And even without special varnishing, the plastic rotors are very corrosion-proof, e.g. with salt water or salt mist. As the plastic used is UV-resistant, even direct sunlight has no negative effects. These aspects are especially important for air-conditioning and refrigeration. The fans used in condensers here (figure 3, see page 28) are normally put to work outdoors, having to brave the elements unprotected.

Powerful simulation and computational tools: Optimisation of impeller geometry via CFD

The new plastic rotors offer a number of advantages that users can enjoy, yet they were a big challenge for the R&D engineers. However, thanks to their expertise, know-how and state-of-the-art development tools, the project could be realised smoothly. After all, ebm-papst has long since invested in technology enabling their expert staff to calculate fan performance on the PC well in advance.

„This numerical flow simulation is becoming more and more important“

Fig.3: A typical field of application for EC fans with plastic rotor is refrigeration and air-conditioning. The fans, used on the condensers here, are normally set to work outdoors and unprotected and have to weather the seasons.

Specialised computational tools working closely together in data networks are the basis for this. With the new plastic rotor, it took hardly a year from starting the project to the first die-cast part coming from the serial tool.

In optimising the impeller geometry, the most important tool proved to be CFD (Computational Fluid Dynamics) (figure 4). This numerical flow simulation is becoming more and more important, as the sophisticated computational functions and modes make it possible to do without many of the work steps usually required in the course of developing a product. Without CFD, for instance, a great number of cost- and time-intensive experimental loops are needed. Prototypes have to be assembled, measured in the air performance test rig, evaluated and, with the trial-and-error principle in full force, modified time and again until the specifications are met. Here, simulation saves a lot of time, as far fewer prototypes are needed. Moreover, far more variants can be analysed and evaluated, as simulations based on 3-D models can be far more speedily processed than prototype assemblies and ensuing measurements.

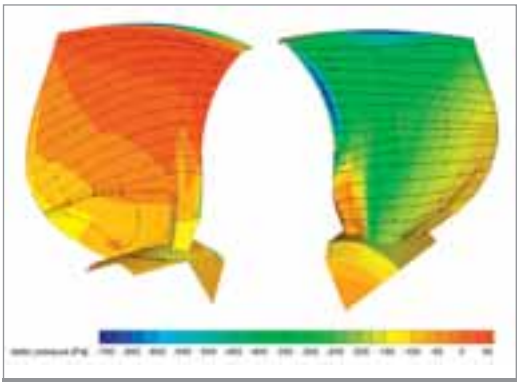

Fig.4: The CFD-shot shows the distribution of static pressure and the flow lines of the shear forces applying to the blade surface. On the left is the pressure side, on the right the suction side.

In order to take advantage of this when developing the new plastic rotor, the design data for a new impeller were transferred to the CFD-tool and then re-calculated. Reviewing the result of the computation, the design engineer could clearly see where the impeller required further modification. The ensuing simulation checked the modifications as to their effectiveness and efficiency. As soon as the computation had yielded a satisfactory result, the prototype could be assembled. Modern technology helped to save time here, too.

Quick way to maturity phase: „Rapid Prototyping“ and Moldflow analysis

Based on the CFD results, a prototype of the impeller was manufactured using the so-called Rapid-Prototyping. I.e. existing data were directly translated into a component – without manual handling. The plastic rotor, for instance, can be organised layer by layer from formless or form-neutral material using physical and chemical effects. This prototype can then be extensively measured and reviewed. Only when all targets and objectives have been met is it time to deal with the tool. This was first optimised on the PC, too, using the so-called Moldflow analysis.

Important results yielded by the Moldflow analysis are, for instance, the optimal shot point, filling properties and the optimal configuration of the tool cooling system in order to minimise shape distortion. State-of-the-art FEM calculations served to optimise both the sturdiness and the materials used. They also yielded results as to required amounts of plastic material and allowed optimisation. Only after all computational results complied with the targets and objectives, a test tool was produced and a prototype of the plastic rotor was injection-moulded. For

fine-tuning, the prototype was then gauged. In order to be able to compare it to the 3-D model of the CFD simulation, it was also scanned in. This comparison between the electronic image of the prototype made in the test tool and the 3-D model (fig. 5) served as the basis for the final modifications, which of course took also into account visual aspects. After all, the design engineers wanted to come up with an attractive and pioneering design. As soon as all targets were met, the serial tool was released and production could be started.

Fig.5: The comparison between the electronic image of the prototype made in the test tool and the 3-D model serves as basis for the final modifications.

„Our design engineers also wanted an attractive design!“

Within very short time and – compared to conventional approaches – at lower expense, ebm-papst has once again managed to push EC technology for axial fans. These powerful fans are not only going to conquer the refrigeration and air-conditioning market, they are also set to take many other fields of application by storm.

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