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NEW IDEAS AT A GLANCE

The engineer's choice

ebmpapst

Editorial

"ebm-papst – innovative and customer oriented"

Dear customers, partners and friends of ebm-papst,

The efficient use of energy and resources is a declared global objective for the decades ahead. In Europe, the first tier of the ErP Directive is set to come into effect at the start of 2013. In the USA, standards have been laid down in EEBA and ASHRAE and in China, efficiency targets are defined in the current five-year plan. The tasks facing the research and development departments of the ebm-papst Group are thus clearly stated: competitive products which are energy-efficient in operation and resource-saving in production.

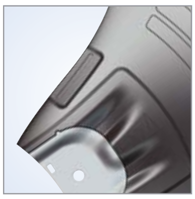
Only the integrated consideration of the efficiency chain from the motor through the aerodynamics of the fan to the optimal installation in the customer's appliance can lead to efficient operating characteristics. Our GreenTech EC technology permits air performance to be called up according to requirements using either standard or customised interfaces. The special motor drive guarantees high levels of running smoothness at efficiencies of up to 90 percent. Our use of composite materials for axial, diagonal and centrifugal blowers with a diameter approaching one meter is truly groundbreaking. Here, we have exploited the advantage of design to innovatively increase efficiency by around one third. At the same time, we have reduced noise emissions by up to 6 dB. One example is our new RadiCal line of centrifugal fans. At this year's Mostra Convegno and Chillventa exhibitions, we will present a trendsetting innovation for axial applications. We also offer our customers technically competent support in the aerodynamic and acoustic optimisation of their final applications, including in the use of our products.

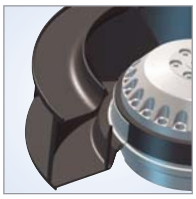
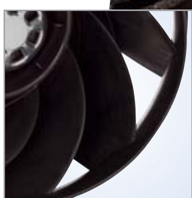
With our GreenTech label, we confirm energy efficiency in operation. The efficiency of our EC products already exceeds the stipulations of the second tier of the European ErP Directive 2015. The first step towards the resource-saving manufacturing of products has been taken with the start of series production of the ESM fan, whose housing is made of a composite material using renewable raw materials. We shall continue to systematically pursue this goal – independence from conventional materials.

Offering the customer cost benefits in his assembly, no losses due to efficiency and no increases in noise due to maladjustment of the motor-impeller-vent combination – that is what our modular range offers. Practical electrical connections and straightforward integration into the control system of the customer's application of interfaces that enable air performance to be called up in accordance with what is actually required make efficient operation possible. Moreover, more than 3000 individual approvals in accordance with UL, CSA, CCC, GOST, VDE as well as the standard CE Declaration of Conformity for Europe permit our customers to use our products all around the world. May I wish you many sustainable impressions when reading this issue of tech.mag.

Dr. Bruno Lindl
Managing Director Research and Development
ebm-papst Group

Content



Development trends in fan technology

“The new generation of GreenTech EC motors are just as compact as conventional AC motors”

The much-used term of the day “efficiency” describes the ratio of output to the input needed to generate it. This is by no means restricted to energy efficiency. In fan technology, the focus is certainly on maximum efficiency, not least in order to satisfy the ever stricter future directives. Energy-efficient EC technology is increasingly the technology of choice. However, just as important in fan development is material efficiency. The buzzwords in this context are bioplastics and material-saving design elements that perform several functions, reducing the total number of components and manufacturing steps. Easy-to-install plug-and-play solutions instead of many individual parts also boost efficiency. In practical use, they make it substantially easier for the user to work with the technology.

Fan efficiency has become a central issue in ventilation and air-conditioning technology. This is encouraged not only by the statutory basis created with the Energy Conservation Directive, but also by increased environmental and cost awareness on the part of the user. Against this background, it is no surprise that energy-efficient EC technology is increasingly being employed in all areas of application. And yet today, “asynchronous motors” are still state of the art as fan drives in ventilation and air-conditioning applications. And they are so because the tried and tested AC motors are compact and straightforward in their design as they are powered directly from the AC or three-phase current supply. Neither mechanical collectors nor electronics are needed to power the rotor. They are robust and reliable. However, EC motors achieve a much higher degree of efficiency than AC motors, and this will be essential in the near future with an eye on the requirements of the Energy Conservation Directive. That makes it important to allow the user to change over to EC technology easily. The latest developments in ventilation technology reflect this.

Straightforward changeover to EC technology

For example, the motor and fan specialist ebm-papst Mulfingen has developed a new generation of GreenTech EC motors featuring integrated commutation and drive electronics, and which are just as compact as conventional AC motors. On both axial and centrifugal fans, the original AC motors can now simply be mechanically exchanged for a new EC design (see figure 1). The exceptionally high efficiency of GreenTech EC motors – up to 90 % – can be enjoyed without having to make design modifications to the customer’s application (see figure 2, page 6). Operating costs are reduced and

Figure 1: Despite the integrated commutation and drive electronics, the new GreenTech EC motors (right) are just as compact as conventional AC motors (left), making a simple mechanical exchange possible. (photo: ebm-papst)

the low energy consumption reduces the impact on the environment. At the same time, the drives impress with their quiet running, which is especially beneficial for equipment used in domestic appliances. The key to this is an especially low-noise commutation which is precisely adapted to the EC motor.

EC motors are by principle synchronous motors actuated by permanent magnets. The magnetic rotor synchronously follows an electronically generated rotating field. This allows any random operating speeds to be realised, regardless of the power frequency used. However, this development represented a great technical challenge to accommodate the electronics needed by GreenTech EC motors in the limited space available. Apart from the miniaturisation and optimisation of the electronics, mechanical compatibility was also a necessity. This includes, for example, modifying the complete motor design in line with the AC motors and adopting the mounting flange.

"GreenTech EC motors impress with their quiet running"

Optimisation potential in material usage and manufacturing

When designing the new GreenTech EC motors, great value was attached to sustainability and to resource-conserving manufacturing. There are several details that contribute to this. The single-piece rotor with pressed-in shaft

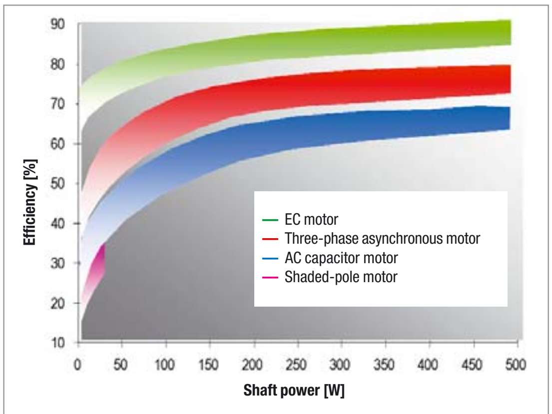


Figure 2: EC motors achieve efficiency of up to 90 %. (photo: ebm-papst)

reduced the number of manufacturing steps. Multifunction components mean fewer individual parts are needed. Specific heat elimination and comparably short bundles of laminations in the motor help to reduce material. The smaller amount of material used saves energy during manufacturing.

The sealing of the electronics also plays an important role here. Instead of the flange solutions that used to be common, featuring various O-rings, the electronics case has been given an elastic sealing component. The housing flange comprises two separate plastic components. The hard component (aluminium) boosts stability, provides a receptacle for the motor and helps to cool the motor, plus it also acts as a cover to protect the integrated electronics. The soft, injection moulded elastomer component provides for sealing compliant with IP55. The terminal connector is already integrated. This reduces the number of parts and at the same time guarantees long-term protection for the electronics. The complete motor is robust, insensitive to shock and impresses with its reliability and long service life.

“By using plastic materials it is easy to create three-dimensional profiles”

Plastics and composite materials

There is also optimisation potential to be exploited with respect to boosting the efficiency of the fan blades. This relates firstly to the fluid mechanics, and secondly to the choice of materials. The large blades made of steel or aluminium sheet or die-cast aluminium that are most commonly used for large axial fans place narrow constraints on design engineers. Naturally, the monolithic blades with uniform plate thickness limit design options. Moreover, sheet steel has to be coated to provide appropriate corrosion protection for outdoor applications. In addition, costs for raw materials, in particular for aluminium, are rising, making a responsible and conservative use of raw material resources necessary. Robust plastic materials thus offer numerous benefits for fan blades: While sheet metal parts can only be punched, bent or stamped, it is easy to create three-dimensional profiles with plastics. Winglets, familiar from the aviation field, can also be used here. These reduce unwanted air flow between the circumferential blade and housing. That improves efficiency and noise behaviour. At the same time, the good damping behaviour of the plastic helps to reduce noise and weight.

Depending on what is needed with respect to strength and application, different materials can be used for the fan blades. A typical example of this is the HyBlade® fan blade (see figure 3), which substantially improves noise and efficiency on large axial fans. Here, an aluminium inlet can withstand the mechanical forces during operation and ensures a durable connection to the rotor, while the plastic encapsulates the carrier structure, giving the blade its optimised aerodynamic shape.

Biomaterials reduce environmental impact

An equally important issue in fan development today is the use of natural raw materials. For example, by 2015 ebm-papst will have replaced 15 % of all the plastics it uses in its products with sustainable materials. Work on this is progressing with great success. The first “bio-fan”, on which the wall ring is made of a wood/plastic composite, has already been built. Properties such as durability and temperature stability are equally well

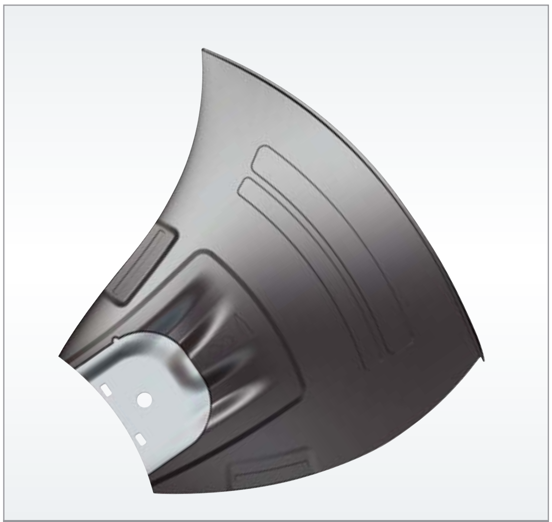


Figure 3: Basic structure of the HyBlade® blades: a carrier of high-strength, corrosion-resistant aluminium alloy is sprayed with a jacket of a special, fibreglass-reinforced plastic. (photo: ebm-papst)

“The ‘bio-fan’ from Mulfingen started series production at the beginning of 2012”

fulfilled as compliance with all current technical specifications. Corrosion is not a worry with this material combination and the damping properties are exceptionally good. Among users, the idea of biomaterials is met with a positive resonance and the “bio-fan” from Mulfingen started series production at the beginning of 2012 (see figure 4). In the future, other sustainable materials are sure to be used in fan technology.

System solutions not individual components

Extremely specific boosts in efficiency are realised by a completely different development focus: complete system solutions, plug-and-play appliances which, in contrast to many individual components, are easy and practical to install. One example of these are the EC motors described above, which are available as complete solutions with impellers and housings for specific applications. The user thus has a ready-to-install fan solution (see figure 5, page 9). Apart from the installation and logistical benefits, this also has substantially better efficiency as all the individual components are optimally configured to one another (motor, electronics, impeller).

Multifunctionality for high flexibility in assembly

A textbook example of a practical system solution is the so-called filter fan. These are well suited for economically dissipating heat loads from switch cabinets or electronics enclosures. The patented mechanical design of these specially developed diagonal fans impresses with many details: their housing comprises two multifunctional shells. In one half of the housing are the inlet vents, guard grille and spacers for the filter mat. In the other half is the rear guard grille and the motor support. Between the two parts is the connector terminal with integrated wire ducting. A bayonet coupling allows the fan and the filter housing to be joined in four different positions. This allows a different cable outlet positioned every 90 °. No extra tool is needed for this. The same thing applies to changes in the direction of air flow. Here, all the user has to do is to release the bayonet coupling on the diagonal fan, turn the fan unit through 180 ° and lock into place again (see figure 6, page 9).

These examples show that many different aspects have to be taken into account in modern product development. Besides energy efficiency, which really ought to be a matter of course by now, material efficiency and function play key roles. At the same time, it is increasingly important to design the best possible product the user and his application, and to make a practical system solution available, preferably a plug-and-play appliance.

Figure 4: The fan with a “biomaterial” wall ring complies with all current technical specifications. (photo: ebm-papst)

“The direction of air flow can be changed simply by turning the fan unit”

Figure 5: Ready-to-install complete system in GreenTech EC technology. (photo: ebm-papst)

Figure 6: Mechanical details on the fan housing make assembly easier. For example, the direction of air flow can be changed simply by turning the fan unit. No extra tools are needed to do this (photo: Rittal)

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Energy-efficient centrifugal fans in fan coil units

Hear nothing. Feel nothing. See nothing. A good climate control system is one that the guest doesn't even notice. It should work quietly and without causing draughts. Its controls should be self-explanatory and straightforward. Yet in practice it is often a different story. Even in high-class hotels unacceptable climate control systems are installed. And yet good air conditioning is an important feel-good factor for guests. And choosing the right product can save you real money!

Figure 1: Example of a fan coil unit (photo: GEA Air Treatment)

"A climate control system is an important parameter for guest satisfaction"

Trouble-free and cost-effective operation is an important requirement for a climate control system. Yet there is often a droning sound behind the panelling. This is no longer state of the art. The climate control system lives a lonely life. Nobody's interested in it so long as it's working reasonably well. The problem often starts with the very installation. The investor or proprietor of the hotel is responsible for procuring the air conditioning equipment. But as a rule he will only consider the procurement costs in his calculation. Follow-up costs are irrelevant. That is a problem for the operator. A dilemma!

Here, it is worthwhile for the hotel operator to insist in the contract that he doesn't have any "energy guzzlers" forced upon him. The lion's share of the costs do not come from procurement, but rather from operation. Then there is the fact that a climate control system is an important parameter for guest satisfaction.

Important constituent components of a climate control system are the fan coil units (see figure 1). Here, the motor and fan manufacturer ebm-papst has developed a solution that sets new standards with respect to cost efficiency. The broad product range of nine different fan models has been conceived to provide a model for all commonly used blower convectors and for practically all room sizes. These new fans employ GreenTech EC technology, are energy-efficient and quiet-running. As a rule, upgrading will pay for itself within eighteen months to two and a half years.

The right equipment will save you money

Rising energy costs and stricter legal regulations contribute to the fact that the comprehensive consideration of buildings in terms of their efficiency is playing an ever more important role.

"Fan coils from ebm-papst: low-noise, compact and easy to install as a plug-and-play solution"

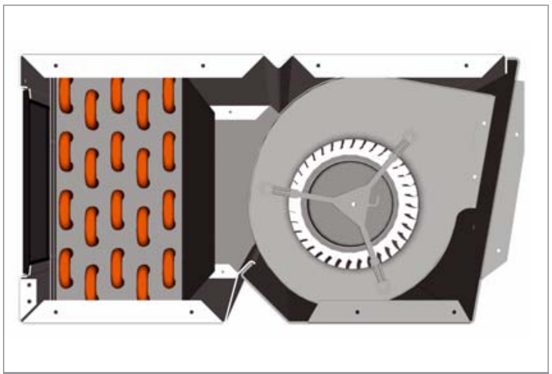

Figure 2: Using the fan, air is guided past the heat exchanger, which provides heating or cooling of the room air. (photo: Fa. Chiller)

In particular in new buildings, but also in renovation work, energy efficiency and "life cycle costs" (LCC) are increasingly important in the decision-making process when choosing appliances and components. High energy savings potential can be attained if the right technology is used in ventilation and air-conditioning technology, such as climate control systems, where the fans run almost around the clock.

Fan coil units are part of a central air conditioning system and have the task of cooling or heating the air using the air-recirculation procedure. They belong to the group of air-to-water air conditioning units, and their principle function is easy to understand. Depending on requirements, heated or cold water flows through the built-in heat exchanger. Using the fan, air is guided past the heat exchanger, which provides heating or cooling of the room air (see figure 2). Fan coils are usually located close to where people are. That means strict requirements with respect to comfort. Low-noise performance across the entire operating range is a key criterion in decision making. Today, this is achieved using intelligently arranged and aerodynamically optimised fans. ebm-papst has developed different types of quiet and energy-efficient fans for fan coil applications. These fans in GreenTech EC technology deliver air volumes up to 2,200 m³/h in the power range between 40 and 250 watts (see figure 3a + b). All versions are specially designed for low-noise operation. They are very compact and are easy to install as a plug-and-play solution. The fan is mounted on the exhaust flange and connected using a plug system. The plastic materials used are light, yet durable and sound absorbent.

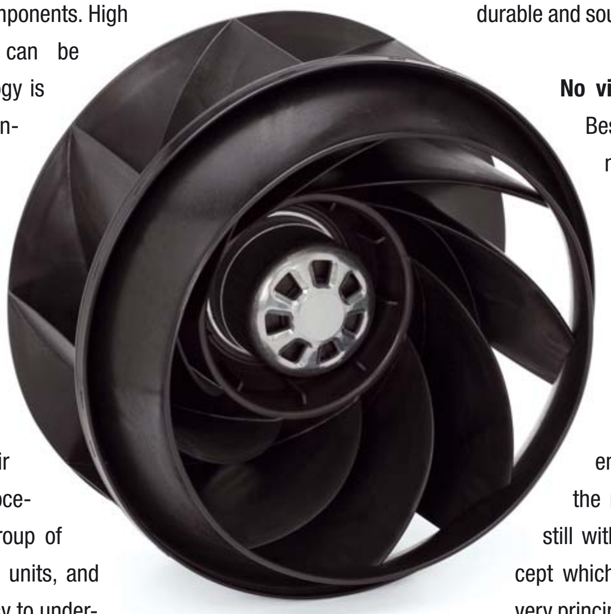

Figure 3a: Energy-efficient GreenTech EC fans for use in fan coils (photo: ebm-papst)

No vibrations – quiet operation

Besides the noise of the air, the noise generated by the motor plays an important role, especially at low speeds (partial-load range), i. e. with smaller air volumes. For this reason, it is essential for this component to be optimised. This is done by enhancing the decoupling of the motor and housing, or better still with a sophisticated motor concept which eliminates vibrations by its very principle, preventing it from exciting vibrations in its immediate surrounds.

Motors with this property include, for example, so-called EC motors (EC stands for "electronically commutated"). In principle, EC motors run synchronously, have no slip and so no slip loss – an advantage over conventional asynchronous motor systems with voltage or frequency control. Asynchronous motors driven by a frequency inverter, particularly under partial load, produce resonance noise that results in the typical unpleasant motor hum.

"The GreenTech EC solution pays off after a short time"

Because EC motors also work with great efficiency, they also consume substantially less energy than conventional AC drives. These potential energy savings are not only realised when the motor is operated under full load, but also primarily when it is operated under a partial load, i. e. when the speed is controlled according to current temperature requirements. EC motors then lose far less efficiency than asynchronous motors with the same output. The payback period for the fans with more efficient drive can be easily calculated by making a comparison between EC and AC fans running at the same operating point, with an assumed operating time of 5000 h/a and energy costs of 0.15 euro/kWh for a period of 10 years. The graph in Figure 4 illustrates the total (accumulated) operating costs of an AC fan (red line) running with a standard speed control. The intersection of the two lines shows when the GreenTech EC solution (green line) has paid for its own procurement.

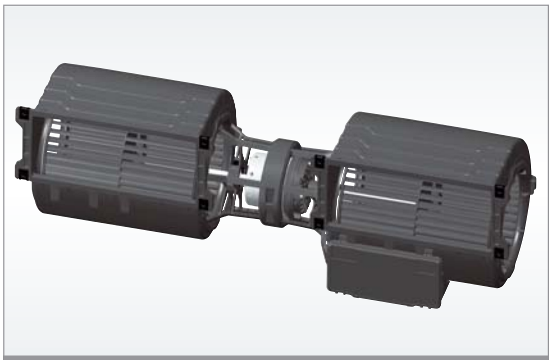

Figure 3b: Energy-efficient GreenTech EC fans for use in fan coils (photo: ebm-papst)

Ideal for renovations

Efficient centrifugal fans from ebm-papst in fan coil units provide for greater comfort by controlling the air volume precisely according to requirements. They work very quietly, especially at low speeds, and make substantial energy savings with the high efficiency of the EC motor. Even for existing installations, fans that are already installed can easily be exchanged for new energy saving GreenTech EC fans due to the simple plug-and-play solution. So state-of-the-art tech-

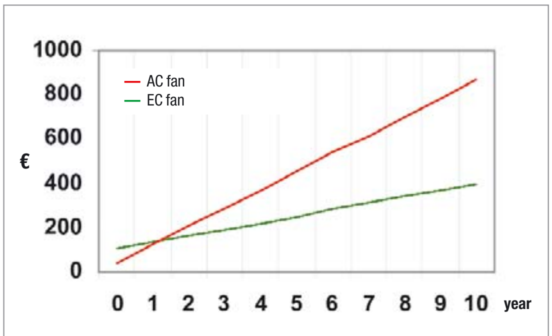

Figure 4: Accumulated cost development – "pay-off" time (photo: ebm-papst)

nology proves once more to be simply the better choice – in terms of energy savings as well as for comfort.

Further information under www.hotel.ebmpapst.com

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Laboratory practices and computational theory for service life comparisons

Statistical failures for fans are being calculated differently:
Laboratory practices and computational theory for service life comparisons

“A test lab is an important support for the entire computational concept”

Service life is one of the most important characteristics for a product. This is particularly true for electromechanical components like fans. However, the manufacturers of such devices use very different specifications for specific numeric values for service life. Even if the same terminology is used, one statement is not necessarily comparable with another depending on the calculation techniques that are used.

For long-lasting products such as fans for cooling electronic components (see figure 1), a realistic evaluation of service life of those electromechanical components is an important deciding factor for users. However, manufacturers cannot test for decades before the customer receives the product. This is why the fan specialists from ebm-papst St. Georgen in Germany’s Black Forest region rely on combining a theoretical approach, where empirical values have a large influence, and practical values measured in its own endurance test laboratory. Other manufacturers use different computational and test procedures. Since the results are not directly comparable, such specifications must be evaluated properly. Also it must be known what statements are really hidden behind the numeric values.

Test practices in the laboratory

A theory is only worthwhile if its predictions are confirmed in real-world applications. For this reason, a test lab is an important support for the entire computational concept. In the Black Forest test lab (see figure 2, page 17), the respective test procedures and cycles for various applications are run in dust and salt spray chambers by Weiss Umwelttechnik; environmental tests are carried out in temperature and climate-controlled cabinets made by Vötsch and CTS. In addition, there are also test cabinets and a temperature chamber for normal long-term tests under thermal load and equipment for vibration tests. Tests that at first glance appear extreme for fans, like the salt spray test, are important for example to reliably predict the service life in applications such as telecommunications on a sea coast (e. g. transmission module cooling). Heat tests emulate use in deserts or very warm industrial environments. A test for temperature durability goes through a pre-defined number of hours in cold and hot profiles, which were also defined in advance. Without failing, a fan also needs to be able to cope with days of intense solar radiation and nights with cold equalizing winds with negative temperatures. For the thermal shock resistance test,

Figure 1: A wide range of centrifugal and axial fans fulfil highest requirements – also regarding service life. (photo: ebm-papst)

"Drives are tested in long-term fatigue tests – some are running almost 30 years in continuous operation"

a specific drive, for example, must prove its endurance by passing the tests including electrical function testing in increments of 5 °C from -40 °C to +120 °C. Depending on the application, it may be very hot and splashes of water can cause abrupt cooling. This is simulated by a temperature shock induced with a gush of water. The drive is heated to 110 °C and cooled with a gush of water at 0 °C in 3 seconds. This is repeated approximately one hundred times. Afterwards, the housing, seals and function must all conform to requirements.

Figure 2: Test candidates in the test lab; they undergo the endurance test at 40 °C and 70 °C until they break down. (photo: ebm-papst)

Meaningful results

Long-term fatigue tests last many years. The so-called "marathon fans" are test specimens, a portion of which have been running in a temperature cabinet since the early 80s, interrupted only by being moved. The data extracted from more than 30 years of continuous operation are combined with data from other tests for the current life span calculations. The independent Austrian Centre of Competence for Tribology (AC²T) also examined some of the continuously operating units that are still working. A type 7650 fan with a 201,900 h run-time (23 years) and a 4850 N fan (figure 3a, 3b) with 170,500 h (19.5 years) were examined, each of which ran at 40 °C. An 8412-GL example with 125,600 h (14.3 years) at 70 °C was also included. The analysis findings confirmed the in-house service life evaluation. Together with the influences from new manufacturing processes, new materials and lubricants as well as

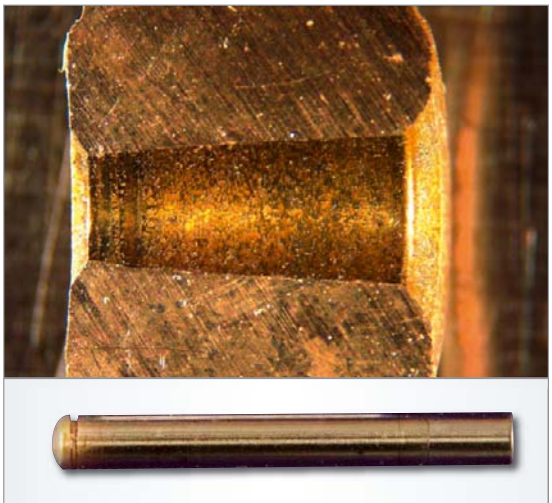


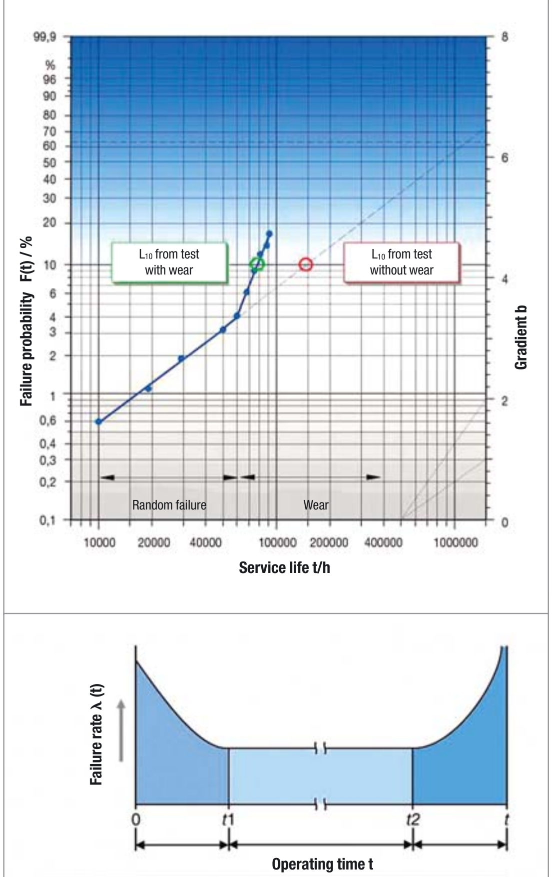
Figure 3a, b: Almost 20 years of continuous operation and no measurable wear, 3a (top) sleeve bearing in a cross-section and 3b (bottom) fan impeller shaft (photo: ebm-papst) other components, a complete concept results, which replicates actual conditions during a fan's lifetime with exacting precision.

Theory needs practical relevance

Service life and reliability (see text box, page 20) are two common values, which in general cannot be converted into each other. The reason for this is the weighting of classic failure performance for components. This performance means that a relatively large number of components could fail at the start due to faulty parts or installation errors. This part of the failure probability can be reduced drastically by testing and "burning in" (test running) the new parts before delivery. In the subsequent period, the devices that pass the test endure long operating times with only a few, random failures. Towards the end of service life, wear then becomes noticeable and the failure rate increases again. This failure rate can be shown quite well graphically using a so-called Weibull evaluation and a bathtub curve (see figure 4). The steep drop-off of the early failure rate is followed by the long, stable phase of random failures, which slowly transitions to the steeply increasing phase of wear-related failures towards the end. Additional influences such as increased temperature, vibration or shock and chemical reactions (cleaning agents or disinfectants, dust, salt, dust, steam, etc.) influence the failure rate and the shape of the curve as well.

"External influences can heavily impact the service life of devices"

In order to limit the testing period, often a larger number of devices are operated for a short time (typically 6 months to a year). Then the service life is extrapolated from the result using different methods. However, this result provides incorrect



Error type	Premature failure	Random failure	Wear failure
	b < 1	b ≈ 1	b > 1

Figure 4: The bathtub curve (bottom) and Weibull evaluation (top) provide a quick overview of service life and reliability. (photo: ebm-papst)

"Long-term experience are absolutely necessary for such practical evaluations"

results for fans, since service life can be determined only if the test already includes cases of wear as well. Otherwise, the values for failure will normally be too high and the service life information that is obtained is too optimistic.

Since external influences heavily impact service life, these can be used to generate premature ageing, for example by running tests with increased temperatures or temperature changes or temperature shocks. This shortens the actual testing period drastically. The disadvantage of such an approach compared to an actual long-term fatigue test is the effects of the temperature influence – which are often impossible to measure realistically – and retroactive projection of that influence to normal operating temperatures. Thus, a temperature drop of 10 to 15 Kelvin is assumed to result in a doubling of service life for many computational models. If this "extrapolation" is applied multiple times (e. g. with a test at 70 °C or higher and specifications of service life at less than 40 °C), then unrealistic service life values approaching absurdity will soon result. Despite similar results in an accelerated service life test, the service life information of various manufacturers can differ by a large factor. Thus, a conservative estimate of all influencing factors is essential for realistic specifications. However, long-term experience and constantly

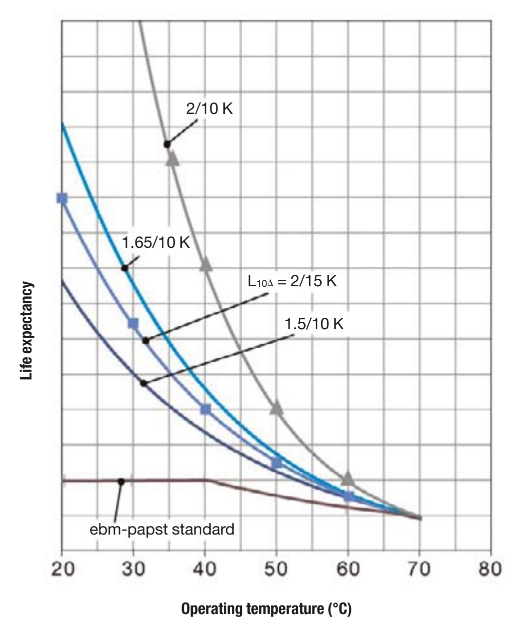


Figure 5: Influence of acceleration factors used by various manufacturers on the calculated expected service life (photo: ebm-papst)

optimised arithmetic operations are absolutely necessary for such practical evaluations (see figure 5).

The Black Forest region fan experts take these variations into account during evaluation by providing three different specifications for service life in the catalogue. The first two values are related to an in-house measuring standard, which is improved constantly by intensive, long-term service life tests in ebm-papst's own test lab. For this, the test fans are operated at various temperatures until they fail. Thus, demonstrable service life values for both L10 (40 °C) and L10 (Tmax, usually 70 °C) result, which very closely reflect failure performance in real-world applications. In order to offer the user a simpler comparison, a third value is used: expected service life. This value, identified as L10Δ, is based on the calculation methods frequently used throughout the fan market in general.

Fundamental data supported by statistical evaluation must be verified continuously through long-term tests. Manufacturers with traceable testing operations, which have accompanied production for years, can gain an advantage by providing realistic values. In this case, even individual tests for stringent requirements under the assumed conditions are often not a problem.

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Service life or reliability

Service life and reliability are two terms that are often used and equally easy to mix up. Service life, often abbreviated to L10, specifies a period in hours during which up to 10 percent of the devices will have failed. A L10 of 100,000 h, for example, means that 90 % of tested devices have reached this run-time. In contrast, reliability is specified with the value Mean Time Between Failure (MTBF). Since fans normally cannot be repaired, a more apt designation would actually be MTTF (Mean Time To Failure). Despite this, MTBF has become the expression that is most commonly used. Statements regarding MTBF values only apply during the planned period of validity (e.g. usable service life). The failure rate can increase significantly after that due to signs of wear. A MTBF value of 1,000,000 h (more than 110 years) means that if 1,000 devices were running at the same time, one of them would fail every thousand hours, i.e. every 42 days (1000 h * 1,000 = 1,000,000 h).

Efficient GreenTech EC fans adapt to the application conditions:

Not just hot air

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Today, solar air collectors working with vacuum tubes are a particularly practical solution when it comes to the efficient exploitation of solar energy. Their basic structure is comparable to a thermos flask filled with air. In contrast to conventional systems which use liquids to collect and transfer the heat, air does not freeze, it is available everywhere, and it cannot leak out, causing damage to the collector circuit or the building. For domestic hot water and central heating support employing vacuum tube solar air collectors, a fan draws the heated air through a heat exchanger. The design of the centrifugal fans has been modified to take account of the fact that the installation space required for this application is somewhat tight on account of the design of the collectors, plus the fact that site of operation can be exposed to very high temperatures, depending on the amount of solar radiation it receives and on the heating requirements of the system. That allowed innovative GreenTech EC technology to be integrated, guaranteeing an energy-efficient and quiet operation of the application.

"GreenTech EC technology guarantees an energy-efficient and quiet operation"

Kollektorfabrik GmbH & Co. KG, based in March-Buchheim, Germany, does not employ liquids as the heat transfer medium in its "Sun-Storm" range of solar air collectors, but rather air in its vacuum tubes. Such a vacuum tube (see figure 1) consists of two glass tube, one inside the other and joined at one end. At the other end, the tubes are closed. Between the tube is a vacuum. This design has numerous benefits for the application.

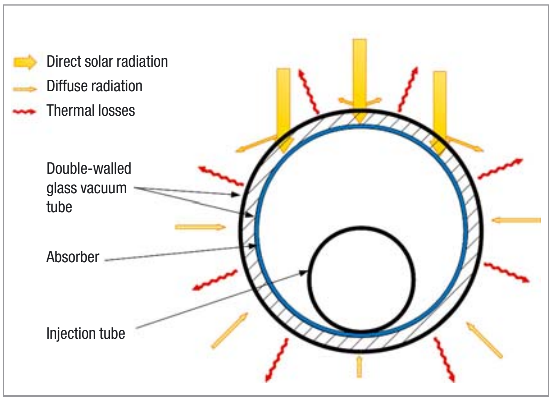

Figure 1: Structure of a vacuum tube (photo: Kollektorfabrik)

The vacuum tube and its benefits

The good insulating properties of the vacuum allows the solar collector to work with great efficiency, as very little heat is emitted to the surroundings. The vacuum tube is easy to touch. Its outside temperature is a pleasant 45 °C, even though the interior temperature can be as hot as about 230 °C. This property is especially beneficial in the winter. At very low ambient temperatures, the good insulation allows temperatures of over 100 °C to be reached inside the "Sun-Storm" collector. Cold air is introduced through a thin aluminium injector pipe. This is heated up on the absorber surfaces inside the "thermos flask". That guarantees reliable and highly efficient heat transfer. This is beneficial in many different applications, e. g. in processes that directly require warm air. These include for example air pre-heaters in controlled ventilation systems, air heating, for example in industrial halls, *"The Sun-Storm collector is suitable for domestic hot water heating systems with central heating support"*

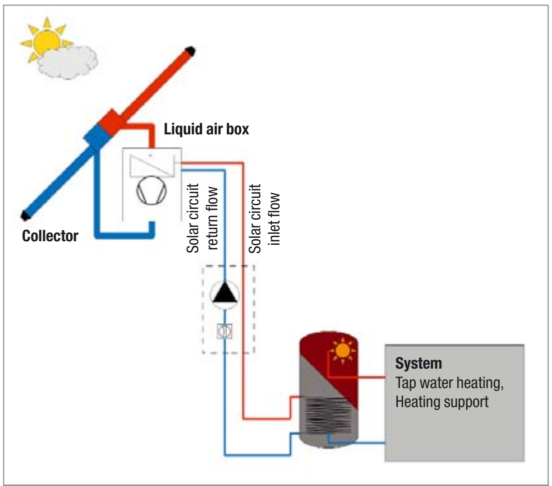

Figure 2: Schematic illustration of a domestic hot water system with central heating support (photo: Kollektorfabrik)

Figure 3: Sun-Storm collector on the flat roof of a single-family home (photo: Kollektorfabrik)

sports halls, leisure parks, hot air generation for saunas or paintshops, and numerous industrial drying processes and solar cooling systems with open ventilation circuits.

The "Sun-Storm" collector can also be coupled to an air/water heat exchanger to heat up fluids to over 120 °C (see figure 2), making it eminently suitable for domestic hot water heating systems with central heating support. The fact that the "Sun-Storm" collector is recognised as eligible for subsidies in many different schemes such as the "Renewable Energies" program of the KfW and for the market incentive program of the BAFA is a further argument for its use. Different variants with different dimensions ranging from 9 to 30 m² and the option of combining several systems together to create a total area exceeding 1000 m² mean that the collectors are equally suitable for detached houses and multi-family homes (see figure 3) as they are for schools, office buildings, swimming pools, fuel stations, sports halls and industrial halls, to name just a few.

Tailor-made fan for the heat exchanger box

To ensure that the heat exchanger and fan harmoniously fit into the design of the vacuum tube solar air collectors, the Sun-Storm design engineers have developed a so-called liquid-air box (see figure 4), which despite its compact dimensions accommodates both heat exchanger and fan. This places

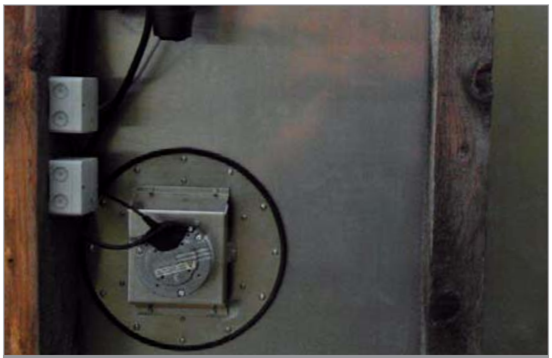

Figure 4: The liquid air box (viewed from the rear) with heat exchanger and fan impresses with its compact dimensions. (photo: Kollektorfabrik)

"The engineers from ebm-papst have the necessary expertise for customer-specific solutions"

special demands above all on the fan. These could only be resolved with a specially modified design. Not only were compact dimensions required. The electronics of the GreenTech EC fans also had to be protected against the high temperatures encountered at the heat exchanger.

Not least for that reason was a centrifugal fan from the motor and fan specialist ebm-papst selected. As a pioneer in the field of modern GreenTech EC technology, the engineers from Mulfingen have the necessary expertise for customer-specific solutions that can be integrated into just about every application. For the liquid-air box application, the impeller was not mounted directly on the rotor in the usual manner, but rather on the extended shaft (see figure 5). This protects the motor against the high temperatures encountered inside the box. That enables the benefits of energy-efficient EC technology to be used in this application

Energy efficiency and intelligence

In contrast to AC technology, an EC motor is used to drive the EC fan. This is equipped with an electronic control device, the so-called commutation electronics. In principle, these motors run synchronously, have no slip and so no slip loss – an advantage over conventional asynchronous motor systems with voltage or frequency control. Because EC motors also work with great efficiency, they also consume substantially less energy than conventional AC drives. These potential energy savings are not only realised when the motor is operated under full load, but also primarily when it is operated under a partial load, i. e. when the speed is controlled according to current heat requirements. EC motors then lose far less efficiency than asynchronous motors with the same output.

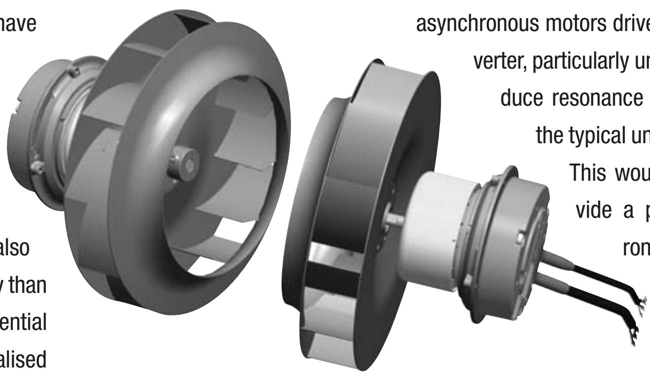

Figure 5: Innovative GreenTech EC technology adapts itself to the application. On this centrifugal fan, the impeller is not mounted directly on the rotor in the usual manner, but rather on the extended shaft. (photo: ebm-papst)

Simple to control and quiet in operation

The EC motors that power fans feature an integrated electronic control system that allows the speed of the fan to be adapted precisely to what is actually required. In the application described, actuation for requirement-orientated operation is realised with either an analogue 0...10 V signal or a PWM signal. The fact that the motors can thus work hand in hand with all the other standard control systems that are normally found in solar technology is also appreciated by the "Sun-Storm" collectors. To allow the motor and fan to be monitored, an additional pulse is emitted every revolution at the tach output.

Also extremely important in association with solar collectors is noise development, as the units are installed directly on the roof. Residents and neighbours are not to suffer from noise disturbance. Not in the house, nor on the patio or balcony. Here too, EC drives are the better choice, because the motors produce practically no noise (see figure 6, page 25). In contrast, asynchronous motors driven by a frequency inverter, particularly under partial load, produce resonance noise that results in the typical unpleasant motor hum. This would certainly not provide a pleasant living environment. Users of the solar collectors have nothing to fear here. The solar systems equipped with GreenTech EC fans

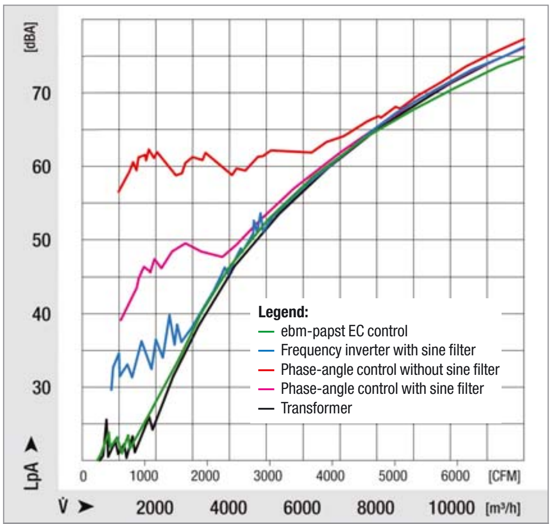

Figure 6: GreenTech EC fans also score with respect to noise development. They are much quieter than AC solutions with the same output. (photo: ebm-papst)

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are pleasantly quiet in their operation, producing practically no noise either in the house or on the patio or balcony.

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