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NEW IDEAS AT A GLANCE

ebmpapst

Editorial

"Emerge from the crisis with creativity and innovation"

Dear customers, partners and friends of ebm-papst:

The year of 2009 has been declared the European Year of Creativity and Innovation by the European Union. And how fitting this is in the current economic crisis, as we all want of course to emerge from the crisis stronger than before. The path to this aim is paved with more creativity and more innovation.

Orders received in the German mechanical engineering industry, according to research by the German Electrical and Electronic Manufacturers' Association (ZVEI), dropped in the first 8 months of the year by 43.7 % compared to the same period for the previous year. These are our customers for fans and, more critically, for drive engineering! At ebm-papst, we reacted to the challenges of the market with new products and leaner processes.

In this magazine, we report on our efforts to benefit from the crisis so as to develop innovative products in co-operation with our customers. Read the interesting articles about fans for centralised and decentralised air-conditioning systems, about condensate pumps for heat pump dryers, and about new EC motors that smartly complement the existing series. Most interesting of all, we showcase here our activities that led to the development of a new drive concept for electronically commutated internal rotor motors. The new ECI 63 series of electronically commutated internal rotor motors represents the launch of a new modular drive engineering line. Powerful motors with up to 100 % higher torque are the basis on which a wide variety of drive solutions can be built with IP54 protection, piece by piece, with gearboxes, brakes, absolute encoders and other encoders. Clever modular electronics designs, from the simple rotor position encoder to the powerful control system with CANopen interface, allow us to come up with a variety of sizes and function classes.

The IAA and MOTEK trade fairs have just come to an end. We look back at a very successful trade fair. We are greatly satisfied with the amount of real interest we produced and the expectation of very interesting post-trade-fair business. While the IAA reflected careful optimism in the automotive industry, MOTEK made a statement indicating that companies are regaining confidence and investing in continued improvements in productivity. It appears that we are beyond the lowest point of the crisis.

At the SPS/IPC/DRIVES trade fair in Nuremberg, Germany, ebm-papst is presenting their latest products. You are cordially invited to see for yourself how convincing our performance is.

I hope you enjoy reading the ebm-papst's tech.mag magazine.

Dirk Schallock
Managing Director
ebm-papst St. Georgen GmbH & Co. KG

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Fans for centralised and decentralised air-conditioning systems

Today, the field of ventilation and air-conditioning technology is characterised by three main requirements: the need to save energy, the increasing requirements for room air quality and the versatility of options for use, such as those for operating times and individual control. In this regard, selecting the fans used in the ventilation and air-conditioning units plays an essential role. To adapt the air performance, they should be as easy as possible to control. Because they are also usually operated with high duty cycles, considerable potential energy savings can be attained by selecting the right fan. By making use of the right technology, you can not only save energy, but also save a lot of money – both in centralised systems and in decentralised single-room air conditioning, which is becoming increasingly common.

Figure 1: Centralised air handling unit (Photo: Wolf GmbH).

Having to choose can be agonising. This proverbial wisdom also applies to choosing a building air-conditioning system.

This choice was not available in the past, when centralised air-conditioning systems dominated the market (Figure 1). Today, decentralised solutions (Figure 2, see page 6) for single rooms or smaller units of use, as they can be adapted to the wishes of individual users, allow detailed individual billing and, units integrated directly into the building facade do not need an elaborate duct system for air intake and exhaust. Whether centralised or decentralised, each system has its advantages and disadvantages that sometimes make it difficult to decide on an air-conditioning concept.

The choice: centralised, decentralised, partially centralised?

For a centralised solution, the comparatively large air handling units require significantly more space. One plant room per building or storey is mandatory; the branched network of air intake and exhaust ducts takes up additional space. However, this type of system has some advantages: Heat recovery and humidification, for example, can be implemented much more easily and effectively at a central location; maintenance work is easier to plan and execute. It is easier and faster to replace one central filter than to change dirty filters in a large number of single-room units spread out over a larger area. Partially centralised solutions with a central exhaust unit and decentralised intake air are an attempt to combine the features of centralised and decentralised systems and thus are sure to be a good solution for many buildings.

"EC motors consume much less energy at the same air performance"

Figure 2: Decentralised Facade Fan Coil Unit Type FVD for floor installation (Photo: LTG Aktiengesellschaft).

Depending on the use of the building, therefore, building planners and owners have to make a decision, which may not always be an easy one. Whatever the ultimate decision, when selecting the corresponding air-conditioning devices and the fans they contain, it is important to pay attention to the level of energy efficiency that can be attained. By no means is satisfying the requirements of the German Energy Savings Ordinance (EnEV) the only reason to do so. After all, one's wallet will also see a profit if as little energy as possible is used for building air-conditioning and the operating costs are correspondingly low.

EC fans: Energy-efficient and easy to control

In connection with energy-saving measures, it is no longer possible to get around the subject of EC technology. The electronically commutated motors of today's fans offer the ideal conditions for this (see text box): The integrated electronic control system allows their speed to be adapted continuously to the current requirements. Thus demand-oriented air-conditioning is attainable in all operating conditions. At the same time, EC motors work with high efficiency (Figure 3) and thus consume much less energy than conventional AC drives at the same air performance. Particularly for decentralised air-conditioning devices, using AC solutions makes little sense, as the dissipated energy of the small AC motors usually used in these situations is relatively high. EC motors with the same output have about one-half the dissipated energy.

Modern EC technology does not only provide savings when operated under full load. Even when operating under partial load, EC motors lose far less efficiency than asynchronous motors of the same output. There are other characteristics that make EC technology ideal for use in fans: It goes without saying that they feature practical activation options, for example via an analogue 0-10 V signal or a digital RS485 bus interface. In addition, the power electronics integrated in the EC motors are compatible with all common supply voltages; The air performance and efficiency are unaffected by frequency changes. This means that the same fan type can be operated on different power systems without further ado. Not only that, additional

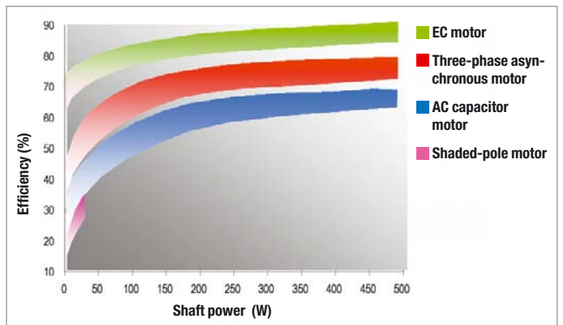

Figure 3: Comparison of the efficiency of EC and AC drives.

Choosing the right technology is essential:
Fans for centralised and decentralised air-conditioning systems

functions can be easily integrated into the motor electronics, e.g. for air flow or constant pressure control.

Central air handling units: External rotor design provides advantages

Thanks to the wide variety of EC fans currently available, these advantages can be used in a wide variety of applications in centralised, decentralised and partially centralised systems. Figure 4, for example, shows fans specially designed for use in centralised air handling units, which cover almost all conceivable applications with impeller diameters from 250 to 560 mm and drive outputs from 400 watts to 6 kilowatts. Air flows up to 10,000 m³/h with a corresponding pressure increase of up to 1.000 Pa are feasible here.

The external rotor design makes the fans highly compact. The electronically commutated motor is directly integrated into the impeller, which reduces the installation dimensions significantly (Figure 5). A belt drive between the motor and the fan, which is commonly used otherwise, is not necessary. This reduces not only the required installation space, but also the associated installation effort. Of course, this also means that there is less wear and tear, which keeps service costs lower over the long term. With respect to hygiene requirements,

Figure 4: EC fans for air handling units with air flow up to 10.000 m³/h.

too, it makes sense to use direct-drive EC fans instead of belt-drive fans, because the inevitable belt abrasion can have a negative impact on the air quality. Therefore, using EC fans in centralised air handling units is worthwhile, as in many cases this makes a redundant design unnecessary: For example, if one fan fails when three fans are run in parallel, the other two can be controlled so that the desired air flow is still attained. In conventional AC technology, a fourth unit would have to be provided to allow the required air performance in the event of failure.

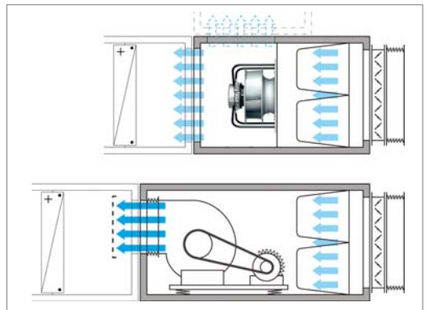

Figure 5: Space savings by using EC fans (top) versus systems with an AC fan and belt drive (bottom)

“Compact designs, energy-efficient and easy to control!”

Figure 6: Compact EC fan G3G146 for decentralised air-conditioning devices.

Compact designs for decentralised air-conditioning devices

For decentralised air-conditioning devices integrated into the building facade, the requirements are similar: They should be compact, energy-efficient and easy to control, allowing them to be adapted to individual requirements. Because the devices are installed directly in work or living spaces, their noise emission is an important consideration here. Figure 6 shows a fan type that fulfils these requirements ideally: The external rotor design of the EC motors makes the fans highly compact. The design of the forward-curved impellers provides good noise levels. At the same time, they enable sensorless air flow control, as there is a clear relationship between air flow, speed and power input (Figure 7). No additional electronics are required for control. All desired functions can be integrated into the power electronics of the motors, such as control of mechanical or motorised outside air valves. There are many reasons to use modern EC fans in ventilation and air-conditioning technology. Planners and owners should take this into account when selecting an air-conditioning concept, regardless of how they decide.

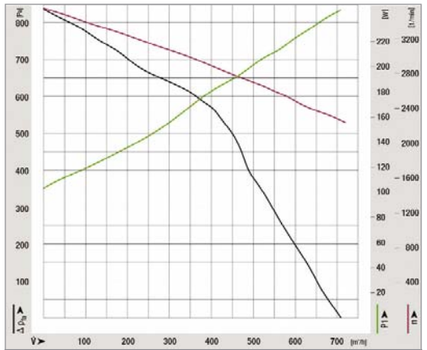

Figure 7: Sensorless air flow measurement for forward-curved impellers.

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Choosing the right technology is essential:
Fans for centralised and decentralised air-conditioning systems

Modern EC drives instead of conventional asynchronous motors

Asynchronous motors are still used as fan drives. The AC motors have a simple design because they require neither mechanical collectors nor electronics to supply power to the rotor. As a result, they are highly robust and reliable, but depending on the shaft power and design, achieve efficiency ratings of only about 20 % to 70 %. Open loop speed control, for example for demand-oriented performance adaptation or noise reduction, is laborious and requires additional components. Figure 8 shows the advantages and disadvantages of the various speed control options of AC and EC fans.

The more energy efficient alternative is the EC motor. In this motor, a magnetic rotor synchronously follows a rotary field that is generated electronically. Only the latest electronics have made useful implementation of this solution possible. EC motors behave like direct current motors and feature the same easy controllability. They operate with up to 90 % efficiency. These high efficiency levels mean not only better use of primary energy, but also less lost heat given off to the surroundings, which has a positive effect on the service life of the ball bearings used.

Features	AC							EC commutating electronics		
	Series resistance	Transformer	Speed stepping	Phase-angle control	Phase-angle control with sine filter	Frequency inverter	Frequency inverter with sine filter	Integrated	Integrated with switch power supply	External
Installation	+	–	+	–	–	–	–	++	–	–
Noise behaviour	+	++	–	––	–	–	+	++	+	+
Power input	––	–	–	–	–	+	+	++	+	+
Service life	+	+	–	–	+	–	+	+	+	+

Figure 8: Advantages and disadvantages of various speed options of AC and EC fans.

A new generation of EC motors

Photo: Güntner

Energy savings is currently a defining issue in the economy and industry alike. This also pertains to ventilation and air-conditioning technology. Here, selecting the right fan is critical for lowering energy consumption. State-of-the-art EC technology is indispensable in this regard, as the high efficiency of EC motors give them outstanding energy-saving performance and durability. Special technologies that reduce structure-borne noise also make them extremely quiet. The integrated electronic control system allows their speed to be adapted continuously to ventilation requirements. Thus it is no wonder that in accordance with the European energy efficiency directive, EC technology is designated as Best Available Technology (BAT). Particularly for large fans, however, technically sophisticated solutions are the exception rather than the rule. However, the first manufacturers are now beginning to introduce new generations of motors to the market that consistently implement the experience gained in past years.

Motor and fan specialist ebm-papst Mulfingen has enhanced the familiar EC motors (see text box 1, page 14) of the 150 series (Figure 1) by adding numerous new functions from which users in a wide variety of areas of ventilation and air-conditioning technology will benefit.

Figure 1: The EC motors of the 150 series have been enhanced by adding even more features. They are offered in 1.7 kW, 3.0 kW and now, also a 6 kW model for the first time.

Notably, the motors – which are offered in 1.7 kW, 3.0 kW and now, also a 6 kW model for the first time – are installed in axial and centrifugal fans (see text box 2, page 15). The advantages of the new generation of motors can thus be used in everything from outdoor applications to server rooms in the IT area. This means that users can benefit here from both the mechanical as well as the electrical and electronic improvements.

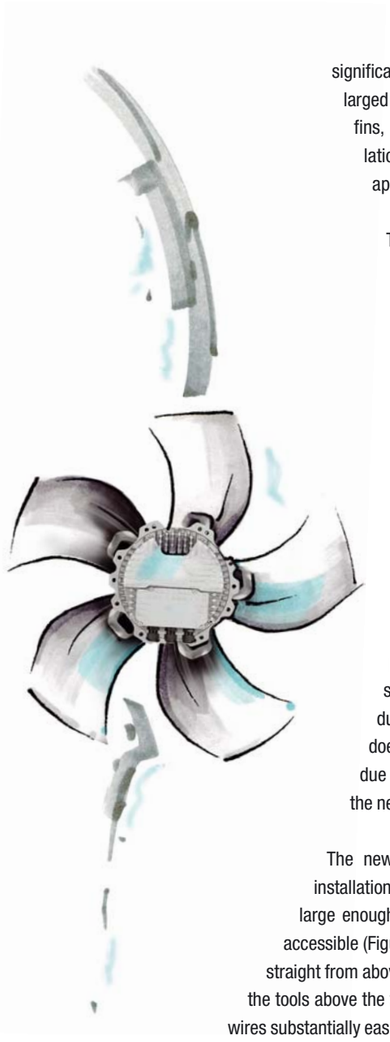
Optimised thermal management, moisture resistance and installation

Simply by looking at the new EC motors, it is clear that quite a bit of expertise has gone into their development, as the innovations already begin in the design. However, the attractive new design is by no means merely aesthetic purposes (Figure 2); it also improves the thermal management

Figure 2: The attractive new design is by no means merely aesthetic purposes; it also improves the thermal management significantly.

Consistently implemented real-world experience:
A new generation of EC motors

“New Design of the terminal box: easily accessible & highest moisture resistance”



significantly. The surface has been enlarged by installing additional cooling fins, which optimises the self-ventilation of the motor, even in difficult applications.

The mechanical design of the connection compartment has also been rethought. In doing so, two considerations were in the foreground: the highest possible moisture resistance and convenient connection options. To make the motors insensitive to the effects of the weather, the terminal box has been enclosed in the motor housing and the cover given an additional seal. It now forms a self-enclosed system that reliably fulfils the requirements of the IP54 type of protection. If, despite this, moisture should ever get into the motor – e.g. due to improper installation – this does not necessarily lead to failure, due to the protection implemented in the new motors.

The new design will be popular among installation technicians: the terminal box is large enough for the connections to be easily accessible (Figure 3). The strands can be inserted straight from above and there is room to manoeuvre the tools above the wire, which makes connecting the wires substantially easier.

Figure 3: The terminal box is large enough for the connections to be easily accessible.

New electronics design increases the range of function

The electronics design of the new generation of EC motors was likewise given a complete overhaul. The entire electronics are now on a single printed circuit board. In addition, because two processors share the work in the new solution, more computing power is available. This allows optimised commutation techniques to be implemented. At the same time, additional functions could be integrated. For example, communication tasks are carried out by the second processor, freeing up the actual “brain” of the electronically commutated motor for other tasks. The consistent separation between time-critical and non-time-critical processes also makes customer-specific adaptations easier.

The interesting additional features integrated into the new motors include different settings for daytime and nighttime operation, which can be called up at any time automatically or via a selector switch. The installation or service technician can configure parameters in the fan using a smartphone, PDA or laptop. The ModBUS software provides the necessary functions for this purpose to the

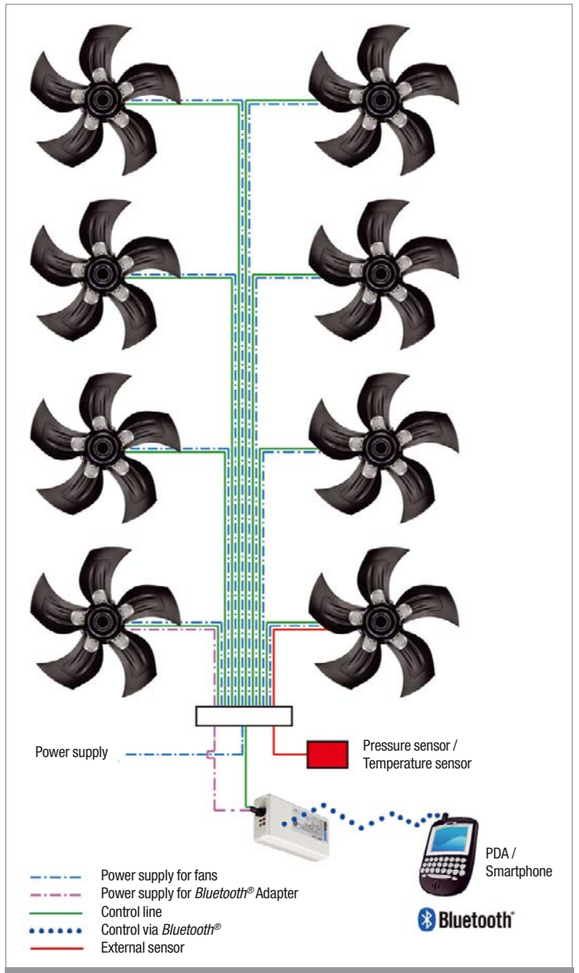


Figure 4: When many fans are used, networking and communication via a BUS system like ebmBUS or MODBUS RTU are practically indispensable.

bus-compatible motors. The MODBUS protocol stores information such as the internal motor temperatures, intermediate circuit power and, of course, the input signal, speeds etc.

For easy, intuitive operation of the motors and fans, ebm-papst offers corresponding software solutions, both for computers (EC Control) as well as smartphones and PDA (FanControl 3.0). Using these solutions, all fans connected via the MODBUS RTU (which is primarily used in industry) or ebmBUS (Figure 4) can be programmed, monitored and even remote-controlled wirelessly via Bluetooth. Configuration and diagnostic tasks can be carried out conveniently via computer for up to 255 fan groups with a maximum of 30 fans each. The software also supports the service technician if a ventilation or refrigeration system is set up with multiple fans: With the “Fan Clone 2.0” expansion, you can transfer previous settings to as many other devices as desired without any trouble and very quickly. You need only to read out the values of the one fan and copy it to the others. Of course, you can still start using the fan by just connecting the power supply and a 0-10 V signal – just as simply as an AC fan.

Versatile, robust and durable

The new EC motors also have many features that users will appreciate. For example, there are three additional digital inputs, for example for external sensors; if necessary, analogue input of the actual and set values is possible, and an external earthing option is also provided.

During further development of the new motor, the production process has also been improved. For example, the different variants do not come about until the last production station, which shortens the delivery times. It almost goes without saying that state-of-the-art

“EC technology is designated as Best Available Technology (BAT)”

components are used in the motors. The good fit of the individual mechanical and electronic subassemblies not only makes installation easier, but also makes the drives more reliable. Therefore, the new generation of energy saving EC motors will surely be adopted very quickly in many ventilation and air-conditioning technology applications, both indoors and outdoors.

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EC drives – high efficiency and effective closed-loop speed control

EC motors are, according to their principle, permanent magnet synchronous motors. In these motors, a magnetic rotor synchronously follows a rotary field that is generated electronically. Only the latest electronics have made useful implementation of this solution possible. This allows any desired operating speeds to be attained, even beyond the limits of 3000 rpm defined by the power frequency. The relationship between the voltage and speed, as well as that between the current and torque, is largely linear. At up to 90 %, the efficiency is significantly better than for usual asynchronous motors (Figure 5), at a size that is usually much smaller. The high efficiency levels mean not only better use of primary energy, but also less lost heat given off to the surroundings, which has a positive effect on the service life of the ball bearings used.

Consistently implemented real-world experience:
A new generation of EC motors

Axial or centrifugal fans?

Axial fans are perfect for moving high air volumes at low counterpressure. If the pressure drop in the device increases, its air flow rapidly decreases. In general, axial fans can solve many cooling tasks optimally. For applications that require a very high pressure build-up at lower air flows, however, centrifugal fans are the right choice (Figure 5). The air is sucked in axially, i.e. parallel to the driving axle of the centrifugal fan, deflected 90° by the rotation of the centrifugal impeller and blown out centrifugally. Thus the total air flow leaves the impeller at the outer diameter. The resulting higher kinetic energy of the air molecules generates a higher pressure than the axial blower, which has a circumferential speed limited by the impeller hub. For example, if an application requires a 90-degree deflection of the air flow or components, filters etc. obstruct the free air flow, centrifugal fans are more efficient than axial fans.

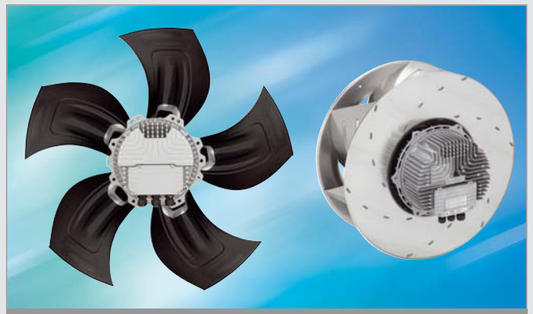

Figure 5: Axial fans are perfect for moving high air volumes at low counterpressure (left). For applications that require a very high pressure build-up at lower air flows, however, centrifugal fans are the right choice (right).

Condensate pump for heat pump dryers

Energy is becoming more expensive all the time. The only way to cut costs is to reduce consumption. Particularly for "white goods" such as clothes dryers, the energy used for water evaporation is enormous. In conventional exhaust air or condensation dryers with heating coil, the condensation energy used disappears into the environment immediately. One solution is to use a heat pump, which provides 50 % or higher energy savings. It uses the input heat energy multiple times, which saves money. Thus the new generation of dryers keeps money in your pocket over its entire service life. Because the functional principle has changed, innovations were required – even in what appear to be minor details. For example, the condensate pump also had to be adapted to the new requirements. Targeted optimisation allowed the developers to ensure long-term, reliable function with low unit costs.

Our pump solution: high level expertise in the details

Modern household appliances are becoming increasingly energy efficient. For the consumer, the actual efficiency is indicated by energy classes broken down by colours or letters. A leading manufacturer of durable household appliances has now set new standards for one of the largest energy consumers in the home, the clothes dryer. By using heat pump technology, the energy consumption decreases by 50 % and is reduced to approx. 46 % of the value required for efficiency class A. To attain this enormous reduction, it is necessary to consider some things that may appear to be minor details. Wet laundry always emits water vapour. However, water vapour from the clothes dryer should not reach the ambient air, as with current insulation techniques, it may increase the risk of mould growth. Therefore, for current condensate dryers, stringent demands are placed on what are known as condensate losses. This requires better seals at all locations that seal off the inside of the appliance from the outside. This includes the condensate pump, which feeds the water removed from the laundry into a collecting vessel or drainpipe. To solve this intricate problem, the appliance specialists worked with ebm-papst Landshut, the expert for small drives and pumps. Soon, an optimal pump solution was found that reflected a high level expertise in the details.

New technology

The energy consumption required to evaporate a certain quantity of water is determined by the laws of physics (see text box, page 20). This amount of energy cannot be reduced. However, the energy can be recovered and a large part of it fed back to the drying process. In this capacity, a heat pump works similar to a refrigerator. The moist, warm air from the laundry reaches a cold heat exchanger, and the water vapour condenses there (similar to condensation or ice formation in the freezer compartment). The dry ambient air cooled in this way now flows to the second heat exchanger, which puts back the heat energy that had previously been taken out of the air (corresponds to the rear side of the refrigerator, from which warm air rises). The required electrical output of the heat pump is much lower than that required by conventional appliances to replace the heat given off. As a result, the appliance saves energy and money.

Special vendor parts demand expertise – even in the details:
Condensate pump for heat pump dryers

However, this technology also brings new challenges. Because the air flows through two heat exchangers, the inside pressure in the clothes dryer is higher than for conventional devices. The positive system pressure provides the advantage of slightly improved heat transfer to the laundry, but also made it necessary to modify all seals in the appliance. They have to seal off the internal circulation reliably for many years and hold back moisture. All accumulated water must be specifically fed to the waste-water system and must not enter the room air. Features such as the newly designed condensate pump ensure that this is the case.

Current appliance solutions for energy savings often require intricate solutions

Customised pump solution

In addition to ensuring problem-free function and a long service life, the specifications for development included incorporating additional functions. In finding a solution, the ebm-papst experts first analysed the operating conditions: despite the filter elements installed in dryers, fine lint or hairs can get into the condensate. The necessary pumping height, at 1.5 meters, is not high, and the long-term flow rate is fairly low. Therefore, at first glance, only a small, low-power pump is required – unfortunately, these units clog too easily.

Therefore, the optimum solution proved to be a 20 W delivery pump, which can pump large quantities of condensate for short periods. The condensate accumulates in the sump of the condensate heat exchanger. After a certain operating time, the pump cuts in to pump out the "water ballast". Thus in approximately 20 years, the pump sees only about 1,500 operating hours. For the drive, the experts made use of the familiar shaded-pole technology. Though it requires more drive energy than EC drives, for example, it has significant advantages for this application area: the manufacturing costs are very low, with a long service life. In addition, the shaded-pole motor always develops a sufficient start-up torque when starting up from any rotor position. Only in this way is it possible to ensure that the pump starts up reliably, even if braked by an accumulation of lint or hair in the area of the pump rotor or shaft. The operating time for the appliance is 20 years, which means the pump must be ready for use for a long time. The sintered bearings of the pump have special lubricants that ensure a lubricating film at all times over the many years.

Figure 1: The drive motor of the condensate pump features high-quality bearings and seals.

Because the pump axis is vertical, the lower bearing, which bears the weight load, had to be specially designed for this purpose. A special disk attachment minimises abrasion on the face side of the bearing cap. Due to the higher internal system pressure, the shaft entry point was given a new, improved shaft seal (Figure 1).

Innovation was also required when selecting the housing material. For many materials, 20 years of use is a reason for possible failure. Plastics become brittle or are attacked mechanically or biologically, particularly when in continuous contact with water. Even with "normal" deposits on the float shaft, the integrated float switch must function reliably. Here, too, the specialists found a suitable solution (Figure 2). This was all the more important because the pump switch assumes a safety function. If the condensate tank is not emptied, the excess water flows back into the condenser sump. If the level rises to a critical value while the pump is running, the pump's level monitor switches the entire machine off. This also applies logically in the event of a clogged drainage line. In this way, disasters caused by water leaks are reliably prevented.

Figure 2: The pump housing with integrated float-type switch for pump start and emergency stop function features long-term stability and dirt resistance.

Current appliance solutions for energy savings often require intricate solutions that are not based on conventional solutions. With the necessary experience gained from many years of testing and many product series, if the drive specialist is integrated in a timely manner, an optimal detail solution can be found easily in most cases. This saves costs, during both development and subsequent production, without impairing the device function.

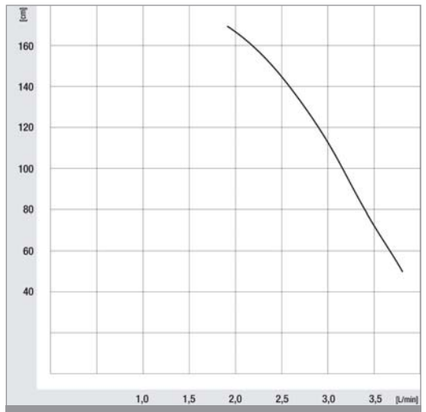

Figure 3: Pump performance data: Delivery head as a function of delivery volume.

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EC fans for school ventilation concepts

A quick explanation of physics and technology

Water is a very special fluid. Due to its internal structure, water has the highest evaporation enthalpy of all fluids (40.7 kJ/mol, corresponding to 2256 kJ/kg). This value is fixed and cannot be changed. In exhaust air and recirculating air dryers, for each kilogram of water, this amount of energy is lost to the exhaust air and must be resupplied. This does not include quantities of heat used to heat up the water until it evaporates – it has the highest heat capacity of all fluids, (75.366 J·mol-1)·(K-1) corresponding to (4.18 kJ·kg-1)·(K-1) or those contained in the hot air itself. Therefore, if the laundry contains a litre of water – about one kilogram – at least 0.63 kWh of energy (electricity) is required, not including other, mechanical losses.

If, on the other hand, the energy-rich moist, warm air is cooled off, the amount of energy it contains can be recovered and reused for the drying process. Due to the large amount of energy required for evaporation, despite the required drive energy for the compressor of the heat pump, about 50 % of the energy is saved. The electrical connected loads of about 1,700 to 2,000 W for heat pump dryers, compared to about 3,300 W for condensate or exhaust air dryers, underscore these theoretical values in real-world applications.

For Germany's federal and municipal governments, energy-efficient upgrades of public buildings are a central issue. One reason for this is legally binding directives and standards such as the German Energy Savings Ordinance (EnEV) and the EU Energy Performance of Buildings Directive (EPBD); another is economic necessity. After all, the German federal government spent some 650 million EUR for heat energy in 2007. Taking advantage of all potential savings is important. For upgrading school buildings, for example, billions of EUR in government spending has been approved in 2009. As highly flexible air-conditioning and ventilation systems for this application are now available on the market, energy savings and optimum room air quality can be attained at the same time. The EC fans used in the corresponding ventilation units make an essential contribution here.

Grohmann Lüftungstechnik GmbH (GLT) of Forchtenberg, Germany, offers its SLG series of ventilation systems, which are specially designed for upgrading classrooms and child-care facilities. These practical fresh-air solutions with heat recovery can be adapted to a wide variety of structural situations in a highly versatile manner (Figure 1). In this way, the compact, soundproofed and thermally insulated central ventilation units of various

Figure 1: Functional diagram of the SLG school ventilation device (Photo: GLT).

sizes can be housed either below the ceiling, behind encasements, standing in a corner of the room, integrated in a piece of furniture or in an adjacent storage room, for example (Figure 2). Design ducts feed the air intake and

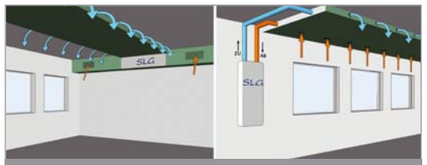

Figure 2: The compact central units can be installed almost anywhere in a space-saving manner, e.g. as ceiling or wall units. The air intake and exhaust ducts become a design element. Acoustical and lighting components can be integrated (Photo: GLT).

exhaust into and out of the rooms. This allows great freedom in how the ducts are designed. For example, acoustic elements and lighting panels can be adapted without any problems; the ducts can be finished in all RAL colours and are also available in stainless steel. Even the air intake and exhaust ducts on the building facade fulfil aesthetic requirements. This is ensured by parts such as attractively shaped outer panels (Figure 3, see page 23), which can be colour-matched to the rest of the exterior. Thus technology and aesthetics by no means have to be mutually exclusive.

Healthy climate with high energy efficiency:
EC fans for school ventilation concepts

"Technology and aesthetics by no means have to be mutually exclusive!"

Figure 3: In the outer panels, an integrated separating strip prevents a short circuit between the air intake and exhaust. The panels can be colour-matched to the building facade (Photo: GLT).

Fresh air for clear heads

The school ventilation systems work in a demand-oriented manner, adapting to the requirements. The ventilation is matched to the current use of the room, depending on the number of occupants and how they are using it. This is ensured by an integrated CO_2 sensor. At the lowest setting, the minimum base air exchange required for hygienic purposes is guaranteed. If the room air quality decreases (increasing CO_2 and IDA value), the air volume is increased automatically. However, the automatic control can also be based on the air volume of 15 m³ per person and hour defined in the German DIN 1946 or Austrian Standard ÖNORM H 6039.

Because the central unit works with a high heat recovery percentage of up to 90 %, exceptionally good reuse of exhaust waste heat is guaranteed. The heating of the intake air required when outside air temperatures are very low is provided either via the air mixture valve (discharge air mixed in) or an integrated hot-water heat register. If the feed and return of a heating plant are placed on the heat exchanger of the ventilation unit, depending on the design and calculation, no radiators for heat may even be necessary in the rooms. Optionally, the central units of the school ventilation systems can be equipped with an automatic summer bypass. Filter systems in various sizes guarantee a healthy room climate even when the outside air quality is poor, such as for buildings on streets with heavy traffic. The school ventilation systems are supplied completely ready to connect, with a preset weekly timer and Modbus interface for connection to all common building management systems; they conform to VDI 6022.

EC centrifugal fans save energy

To generate the respective necessary intake and exhaust air flows, two centrifugal fans are used in each of the central units. Part of the product range of motor and fan specialist ebm-papst Mulfingen, the fans are specially designed for use in ventilation and air-conditioning technology (Figure 4, see page 24). The complete series of these plug fans includes eight sizes with impeller diameters from 250 to 560 mm and drive outputs from 400 watts to 6 kilowatts. This covers almost every conceivable application in the area of ventilation and air-conditioning technology. The feasible air flows lie between 300 and 10,000 m³/h with a corresponding pressure increase of up to 1,000 Pa.

In the school ventilation systems, depending on the output of the central units, designs with air flows up to 1,600 m³/h ensure energy saving operation due to their high overall efficiency. Even today, the motors exceed the requirements of the minimum efficiency classes that are to take effect in January 2011. These are currently set forth in the EU Ecodesign Directive (based on the framework directive 2005/32/EC – Energy-using Products Directive). This was made possible by the selection of materials used, the well

Healthy climate with high energy efficiency:
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Figure 4: The fans are specially designed for use in ventilation and air-conditioning technology. The complete series includes eight sizes with impeller diameters from 250 to 560 mm and drive outputs from 400 watts to 6 kilowatts. This covers almost every conceivable application in the area of ventilation and air-conditioning technology.

thought-out design details and the state-of-the-art EC technology used with the drives.

Simple closed-loop speed control, high efficiency and quiet running

The integrated electronic control system allows the speed of the EC motors to be adapted continuously to requirements. The activation for demand-oriented operation is possible either via an analogue 0-10 V signal or a digital RS485 interface. Because the motors work with high efficiency of up to 90 %, they consume much less energy than conventional AC drives at the same air performance (Figure 5). However, these potential energy savings are realised not only when operated under full load, but also primarily when operated under partial load. When operating under partial load, EC motors lose far less efficiency than asynchronous motors of the same output.

Likewise very important in connection with the school ventilation systems is the noise level. Here too, EC drives are the better choice, because they do not produce any motor noise. 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 environment for the teachers and students.

Compact design, easy installation and long service life

Another advantage of the plug fans is their compact design. The electronically commutated external rotor motor is directly integrated into the impeller, which reduces the installation dimensions. The belt drive commonly used between the motor and the fan is no longer necessary. This reduces not only the required installation volume – always desirable for the central units made by Grohmann – but also the associated installation effort. At the same time, fewer wear parts are required, which keeps service costs low over the long term and thus saves money for the public purse.

In fans, not only the drive, but also the impeller is important. Aerodynamic improvements contribute to increased efficiency and reduced noise emissions. Here, even small details can have a great effect: For example, the optimised blade geometry with diagonal trailing edge improves both the aerodynamic performance and smooth running. The same is true for the nozzle contour implemented in this series. Previously, a standard pressure tap was integrated here to regulate differential pressure via a threaded nipple.

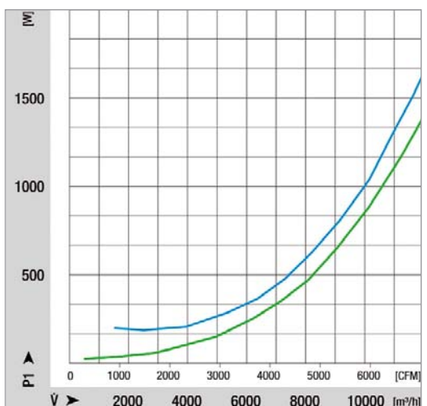

Figure 5: Energy consumption of an EC fan (green) compared to a frequency inverter-controlled AC fan (blue).

Optimised blade geometry improves the aerodynamic performance

The EC fans used in the school ventilation systems also feature an outstanding long service life: To achieve a low motor bearing load and withstand the long-term high circumferential speeds, the impellers with their backward curved blades are made completely of aluminium. The material is beneficial for the weight of the fans and at the same time offers a high measure of stability. The individual blades are welded on, which likewise adds to stability and service life. The fans are designed for a service life of more than 40,000 operating hours. That corresponds to a continuous operation of more than 4.5 years, operating under full load and at the maximum permitted ambient temperature. However, in the partial-load operation that predominates in school ventilation and the ambient temperatures common there, the service life is significantly higher.

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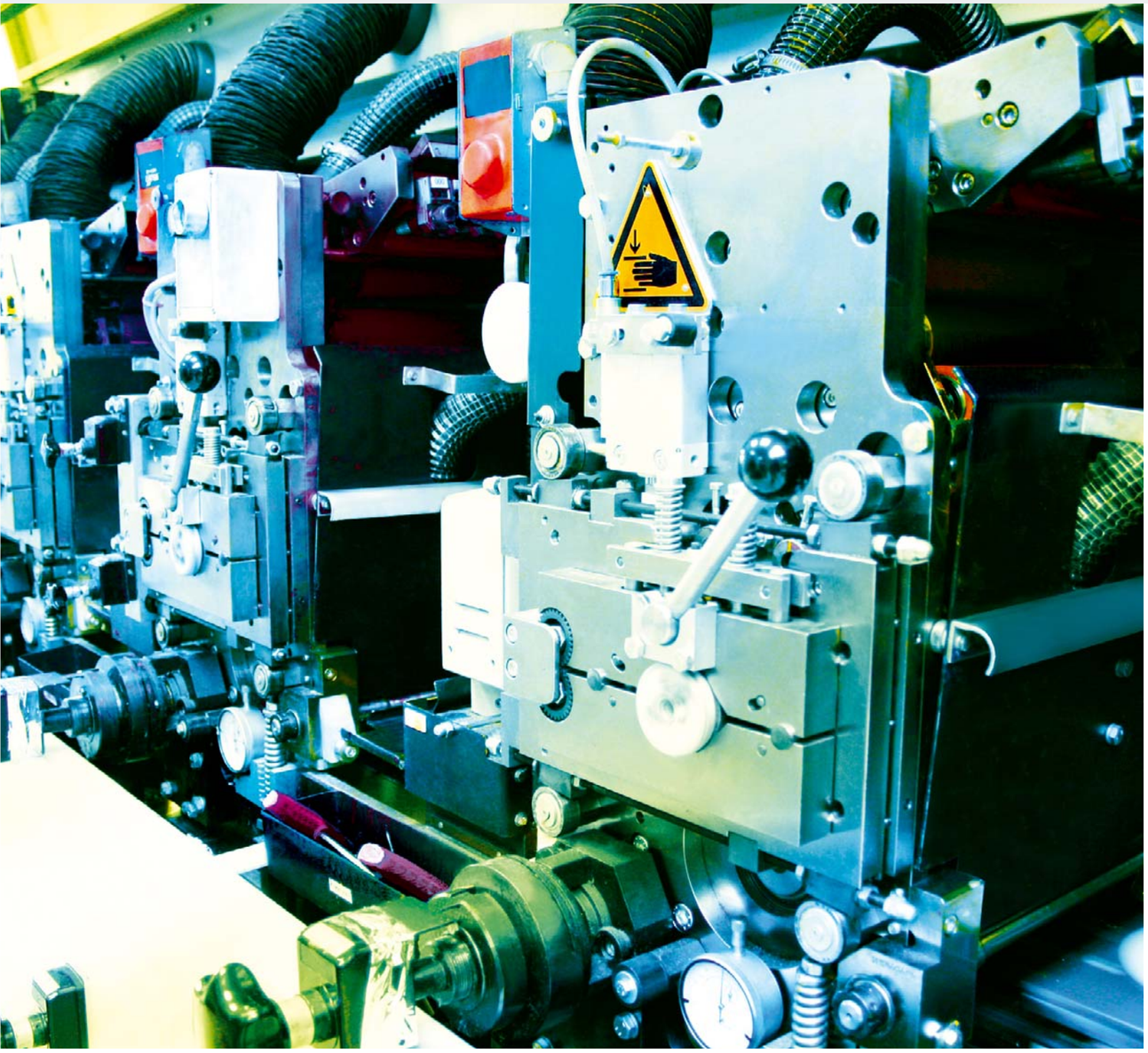
New ECI drive concept based on modular design



Complex drive tasks and individually programming can be combined

The vast multitude of possible drive applications and the huge variety of differing requirements result in great challenges when it comes to the versatility of modern drive systems. A large selection of motors with accessories was, until now, the key to tailoring drives quickly to suit customers' individual needs. A completely new approach now offers better customisation with faster availability. An entire drive range of new, electronically commutated internal rotor motors in a large variety of sizes based on the uniform principle of modular design. All modules, correspondingly equipped with communicative electronics, operate using a uniform implementation and programming interface. This helps to further decrease development and maintenance costs.

Customised drives are highly requested, and insofar as possible with uniform designs so as to minimise the stockkeeping of spare parts. Another very welcomed advantage is that it is now possible to implement extensions for new motor designs without having to make complex construction modifications to the system. In addition to these mechanical and custom-tailored characteristics, the ability to individually program the implemented drive is often requested, especially in the case of complex products or complex drive tasks. A uniform programming interface for such "communicative" designs saves vast amounts of time during the initiation period of implementation and maintenance. Drive specialist ebm-papst from St. Georgen, Germany, is now defining new standards with a modular concept for drive construction that meets these market demands. In the new series of electronically commutated internal rotor motors (ECI), drives of various performance classes with diameters from 32 to 80 mm will become available, one by one, complete with corresponding function modules. Each separate module, from the motor, to the gearboxes and brakes, to the rotary encoder and electronics, can be selected individually and combined to create the perfect system. Once chosen, all components are combined into a finished drive to meet the customer's demands.

Real-world applications

All motor, gearbox, electronics and accessory modules are built into a uniform, economically manufactured module case of aluminium. These modules are combined and mechanically sealed simultaneously in an ingenious process that requires just one step. As such, the drives, even in standard version, automatically have IP54 protection without the need of additional effort or expense.

Figure 1: ECI 63.40 K5 from the new modular drive line of electronically commutated internal rotor motors.

“Optimization of power density, torque and efficiency”

To keep the construction as compact as possible, the developers use a trick: Instead of giving each module a front and rear panel, they use the robustly designed intermediate panel of one module as the end panel of another. For example, while the front bearing of the motor rotor is located in its own module case, the rear side of the bearing is homed in the “floor panel” of the next module. This allows for easy and space-optimised integration of the brake and encoder modules with IP54. This approach reduces length considerably, with more length spared as more modules are added. To save more space, the various gearbox modules can, as necessary, be attached directly.

Powerful

To configure the entire range of diameters, from 32 to 80 mm, for optimum motor output and high efficiency, different design versions were developed for different sizes. The developers performed elaborate FEM calculations for each diameter to determine the optimum distribution of the magnetic flow density in the motor. High multi-pole motor laminations optimise power density, torque and efficiency in equal measure.

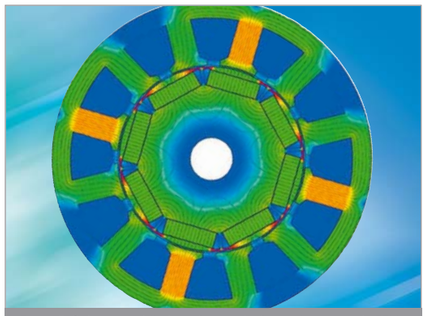


Figure 2: Optimum distribution of magnetic flow using elaborate FEM calculation techniques.

The first representative of the new family is the size 63 (outer diameter of the motor housing) with active lengths of 20, 40 and 60 mm. The attainable performance data are astounding: These dynamic powerhouses reach nominal torque up to 1000 mNm and output power up to 400 W with up to 90 % motor efficiency. The available nominal voltage is between 24 and 48 VDC, depending on the design.

A special connection technique is used so that each winding connection of the stator is through-connected to the electronics located behind it. This simple system provides simple and automatic assembly and reliable isolation, regardless of the quantity or lengths of the interconnected modules. For the rotor design, the neodym magnets are inserted using a reliable procedure into pockets in the laminated iron of the rotor. This makes them easy to install and resilient even to the toughest loads.

Auxiliary modules

The gear unit is located on the driving side of the motor module. Depending on the task, either compact planetary gears or angular gears can be installed. On the other side, many auxiliary modules can be implemented to carry out

Extensive modules for customised drive design:
New ECI drive concept based on modular design

the services you need, depending on the requirements of the application. High-torque brakes or high-resolution encoders can be interconnected as integrate modules. Furthermore, and either as an alternative or in addition to this, it is possible to connect such options using a shaft brought out on the B-side (rear side of the motor) in open-design form. The modules for the integrated functional elements always terminate with integrated electronics for the motor control system.

The new drive concept is well suited to industrial but also medical areas

Customised electronics

The concept for the design variants of the electronics module allows for up to four “performance classes”. Class K1 refers to a module that contains only the rotor position encoder and is designed for external commutation. The K3 module contains a complete basic package for block commutation, as well as a speed controller and safety functions (over-current protection, locked-rotor protection etc.). Variant K4 comes with additional basic equipment. It allows sinus commutation, which in turn allows the full potential of the motor to be utilised via field-oriented control up to speed 0, as well as speed and torque controller. As the high-end version, module K5 includes the basic features of the K4 plus extended electronics. This allows many additional control options. A CANopen commu-

Figure 3: ECI 63.20 K1 with angular gear and open-installed encoder HEDS 5500.

nication interface with several program modules in accordance with DSP 402 is also available. User-specific sequence programs can be created and stored via an implementation and programming tool and an interpreter that is runnable within the controller. These can take over the role of a small programmable logic controller.

The new drive concept is well suited to many areas of industrial automation, packaging and sorting machines, and applications in the textile industry. Likewise, this modular drive design can show its strengths in medical technology, laboratory instruments and many other applications. With the same basic construction, an existing system of this scalable and extendable range of drive

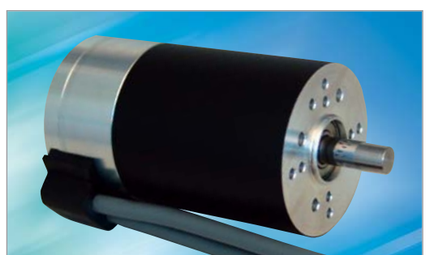


Fig. 4: ECI 63.20 K1 - the smallest representative of the new ECI 63 series.

“Our new drive concept offers substantial cost and logistics advantages!”

services can be upgraded easily without the need for complex modifications. The programming tool, which is uniform to all versions with electronics module K5, simplifies the implementation and later maintenance tasks for the user, thereby decreasing expenses throughout the service life. The high-level type of protection of the module drive also supplies a long service life without additional expenses even in rough environments. As such, the new drive concept is as versatile as any considerably more complex line-up of discrete individual drives, yet offers users and end customers substantial cost and logistics advantages.

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