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Special Edition • September

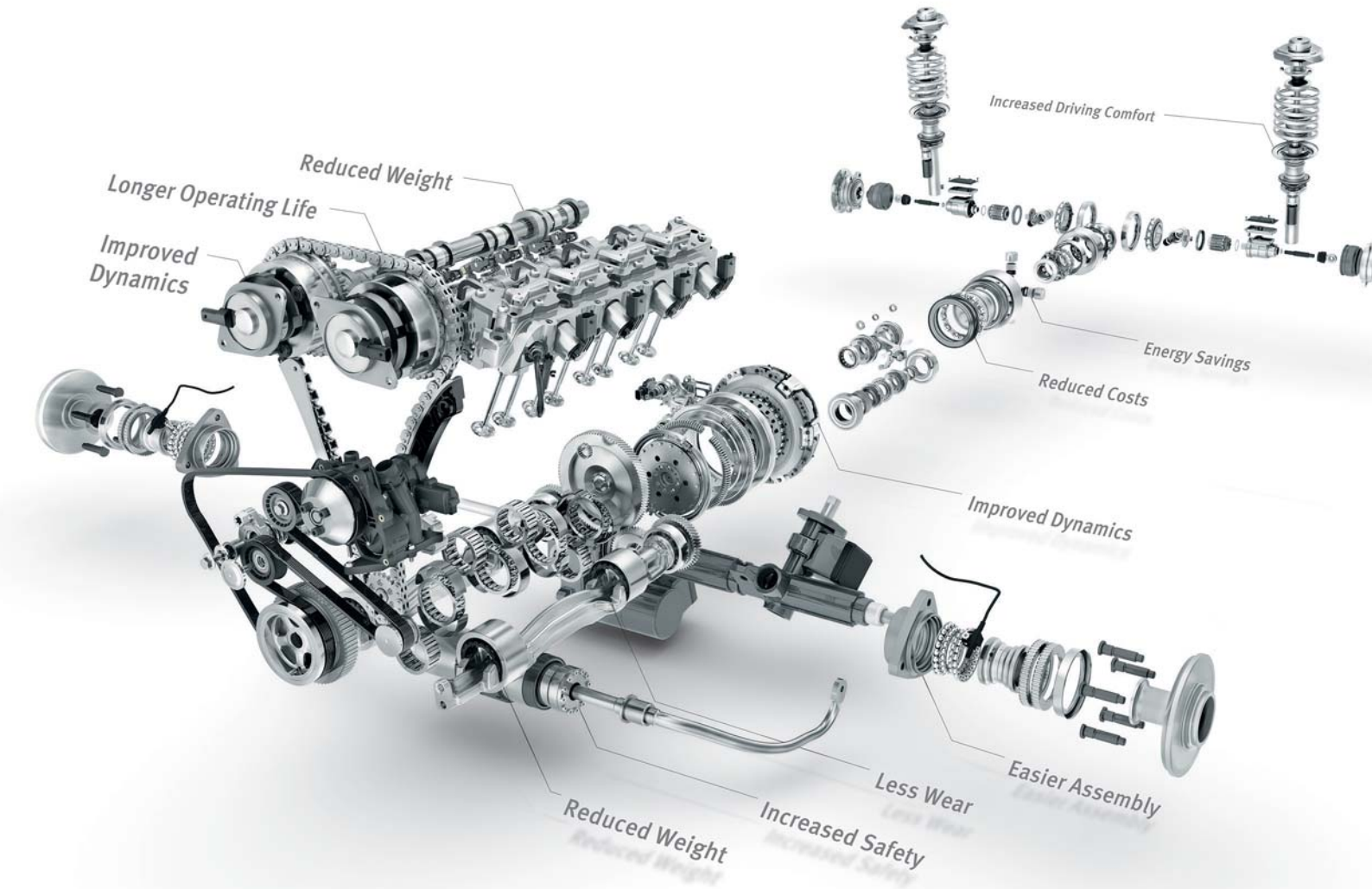
AUTOMOBIL INDUSTRIE

SPECIAL

CO_2-REDUCTION

Customized Hybridization

Vogel Business Media



Progress
is a Matter of Detail

From the engine to the transmission to the chassis, our engineers analyze every detail of the automobile system. The many ideas we get from this analysis are translated into innovative products created by working closely with manufacturers. In everything we do, our main objective is to increase the performance, safety, and economy of today's automobiles.

Our ability to respond quickly to specific requirements is what makes us a renowned partner for the automobile industry. But it is our in-depth understanding of systems that has made us successful. That is why we will continue to focus on systems in the future – with uncompromising attention to detail.

Click to enter and explore the world of Schaeffler Automotive: **www.schaeffler.com/Automotive**

LuK INA FAG SCHAEFFLER

THERE ARE MANY WAYS TO ACHIEVE THE SAME GOAL

JÜRGEN GORONCY,
CHIEF REPORTER
»AUTOMOBIL INDUSTRIE«

Every month, self-appointed luminaries – especially from the political sphere – can be heard proclaiming new solutions for environmentally friendly and "sustainable" drive trains. This sometimes makes it difficult to maintain a clear head and a steady hand when developing marketable solutions for future CO_2 regulations. In this field too, a "not only/but also" is more constructive than the categorical "either/or" – despite what the environmental scaremongers might believe. After all, there are many ways to achieve the same goal.

With its diversification strategy, Schaeffler is demonstrating that the conventional internal combustion engine must be further optimized in order for it to be used as the basis for effective hybrid drives. From start-stop systems that allow an increasingly wide range of functions and hybrid drives in various designs through to all-electric drives, the drive technology specialists from Herzogenaurach and Bühl have products and systems ready for volume production and work together with their customers to develop solutions for tomorrow and for the future. The focus here is always on a goal: 95 grams of CO_2 per kilometer.

This Special provides information about the options for customized hybridization that Schaeffler has to offer.

SPECIAL

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Verlag
Vogel Business Media GmbH & Co. KG,
Max-Planck-Str. 7/9, 97082 Würzburg

Postadresse
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97064 Würzburg
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http://www.vogel.de

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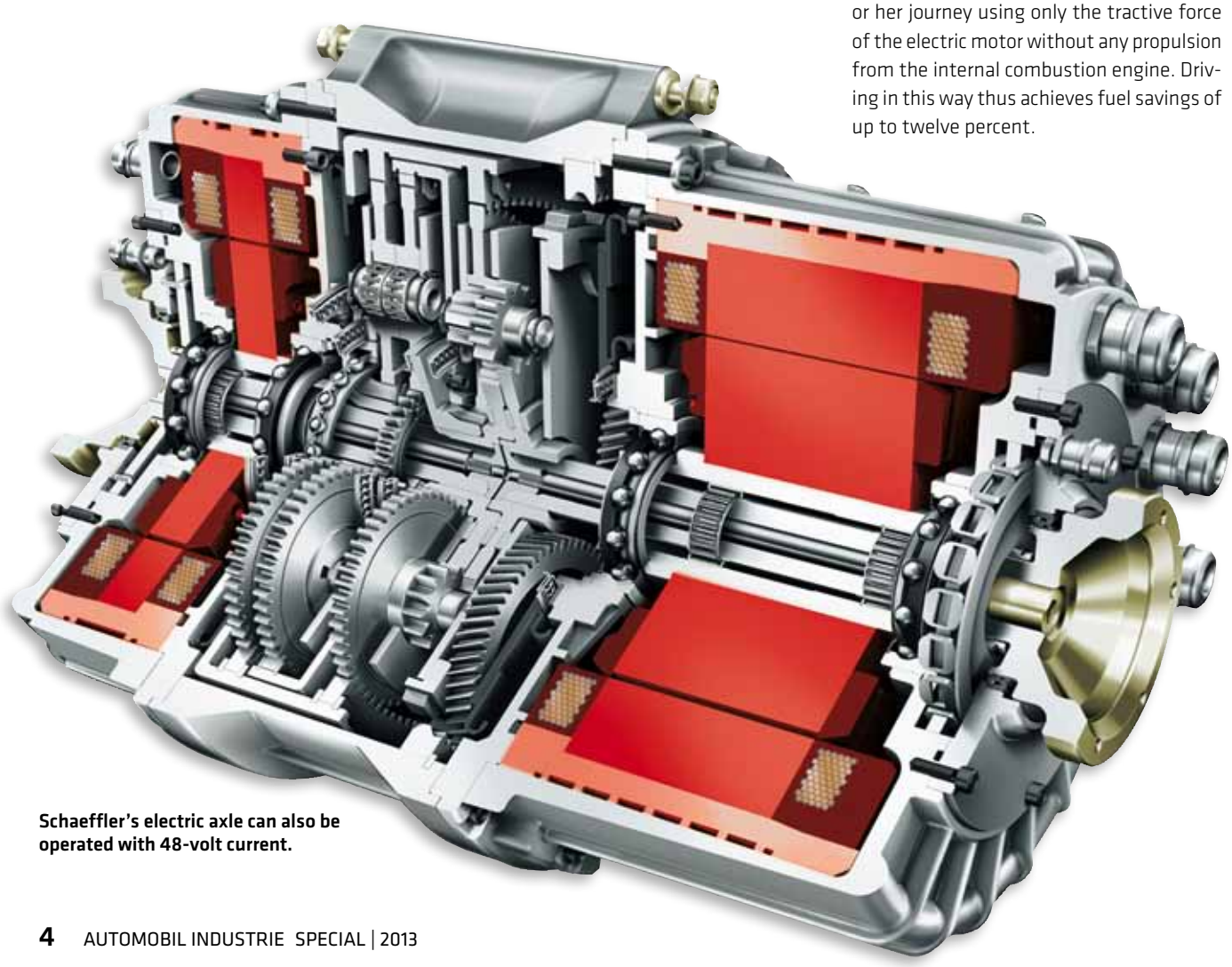
THE VOLTAGE IS RIGHT

The increasing electrification of the drive train compensates for the intrinsic weaknesses of the internal combustion engine and utilizes additional potential for efficiency. However, electric boosters, actuators, and control systems often require high levels of electric power, either briefly or permanently. It is no longer possible to achieve this using existing 12-volt on-board electric systems.

The separation of high-voltage consumers in a separate 48-volt electric system is a solution to this problem. A high-efficiency 48-volt generator delivers approximately twelve kilowatts of power and is thus a significantly more high-powered solution than its predecessors, which delivered only three kilowatts. The advantages of a second, higher voltage level are not to be dismissed. Firstly, the additional outlay with 48-volt systems remains straightforward because special technical safety and qualification measures are only mandatory for voltages of over 60 volts. The lower electrical currents also mean that the 48-volt on-board electric system does not have any high requirements in terms of electromagnetic compatibility.

Secondly, the additional power that is available also offers potential for new comfort, safety, and efficiency-related functions. On the drive side, for example, the internal combustion engine can be expanded to form a mild hybrid drive. Recovery of kinetic energy, electrically-assisted driving, short-distance driving using only electric power, and the "sailing" function are just some of the keywords. For example, BMW has determined that, by driving economically, a driver can "sail" for up to half of his or her journey using only the tractive force of the electric motor without any propulsion from the internal combustion engine. Driving in this way thus achieves fuel savings of up to twelve percent.



Schaeffler's electric axle can also be operated with 48-volt current.

IMAGES: SCHAEFFLER

"Schaeffler has also identified the potential for efficiency offered by hybridized drives with 48-volt components, and we already have a number of solutions available for these", said Schaeffler CTO Prof. Peter Gutzmer in his assessment of the technology's market opportunities. Technologies for drive assistance on which focus is being placed include electrical camshaft phasing, hybrid modules, axle drive solutions, and electromechanical torque vectoring units. In addition, Schaeffler is also researching an entire range of other functions that could be optimally integrated into a 48-volt system architecture. These include electric clutches, high-performance rapid-reaction actuators for the chassis, a wide range of electromechanical adjusting elements for clutch and steering systems, self-leveling suspension for improved aerodynamics, and comfort-enhancing systems such as the movable load floor in the trunk.

The overrunning alternator pulley supports belt-driven starter generators, which with 48 volts are powerful enough to provide kinetic energy recovery and drive the wheels for short periods in addition to the starting and alternator functions.

ADVANTAGES IN EFFICIENCY

The electrically-operated camshaft phasing unit with 48 volts, for example, allows cylinder-selective adjustment even during transient operation. The system makes a convincing case in start-stop operation due to its extremely fast acceleration capability and thus its fast and barely noticeable adjustment action – even when the engine is stationary. The adjustment system is independent of the oil pressure and thus offers a significantly wider operating range than conventional systems, even in low ambient temperatures.

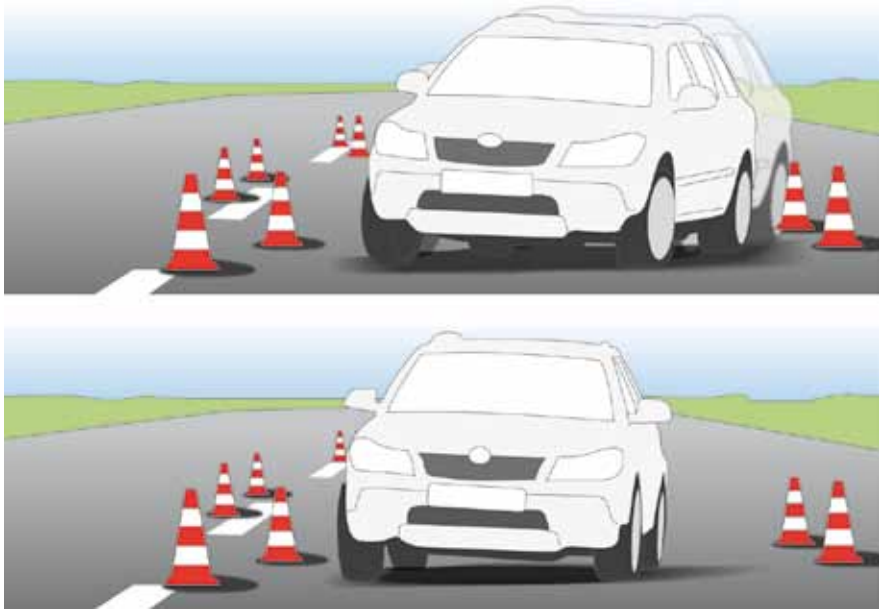
Another example is the so-called overrunning alternator pulley. This function is embedded in the belt pulley of the generator and decouples it from the high irregularities and speed changes of the crankshaft of the internal combustion engine. The overrunning alternator pulley thus supports belt-driven starter generators, for example, which with 48 volts are powerful enough to provide kinetic energy recovery and drive the wheels for short periods in addition to the starting and alternator functions. The belt pulley can be decoupled from the crankshaft using an additional magnetic clutch, which allows the starter generator to be used to operate the air conditioning compressor even while the engine is stationary. A tensioning element on the overrunning alternator pulley always sets the belt drive to the optimum tension and thus reduces the belt drive's preload forces and frictional power.

Electrified internal combustion engines not only deliver advantages in terms of efficiency, however – they also make operating conditions more difficult. Frequent start-stop operation and frequent "sailing" phases, for example, prevent the fast heating-up of the engine's cooling circuit. Schaeffler has solved this problem with its thermal management module. A sophisticated rotary slide valve with step control mixes hot and cold water according to requirements, and regulates the cooling currents in such a way that cooling circuits that are as small as possible and heat up quickly are formed in the engine during a cold start, for example. If heat then has to be discharged from the assembly, the radiator/fan module is integrated into the circuits. "The thermal management module is being used in a volume-production application in Audi engines, where it reduces fuel consumption by around five percent", explains Michael Weiss, Vice President Product Group Thermal Management Module at Schaeffler.

Dr. Tomas Smetana: "This entry-level form of hybridization with 48 volts offers the essential advantages of a fully-hybrid vehicle and, at the same time, is an economically attractive, low-cost option".

Finally, at the systems level, Schaeffler offers complete hybrid modules. The simple variant is a 12 kW electric motor that is operated with 48-volt current and includes a clutch; this acts as a starter generator for the crankshaft and replaces the conventional starter and generator. Thanks to its high torque, it also provides electrical assistance when the vehicle moves off, and could even be used as the vehicle's sole source of drive power. Because of its compact design, this hybrid module can be integrated between the engine and the transmission without major adaptations.

The electric drive module, which can be placed either on the front or rear axle, is significantly more refined. This is an electric drive with an output of up to twelve kilowatts and two ratio stages that includes the clutch and planetary transmission. This space-saving module generates significantly lower costs than complex high-voltage solutions and paves the way for hybrid-



The electric axle also allows torque vectoring, the variable distribution of torque. The flow of force is selectively distributed (lower image), drive torques can be superimposed, and driving safety is thus increased.

ization without major outlays. Major advances can be made in terms of drive efficiency, however. The 48-volt electric system makes operating strategies possible that were previously the exclusive domain of vehicles with high-voltage hybrid components: These include so-called "crawling" in traffic jams and parking using electric power, in addition to boosting when moving off, "sailing", and fuel consumption-reducing energy recovery.

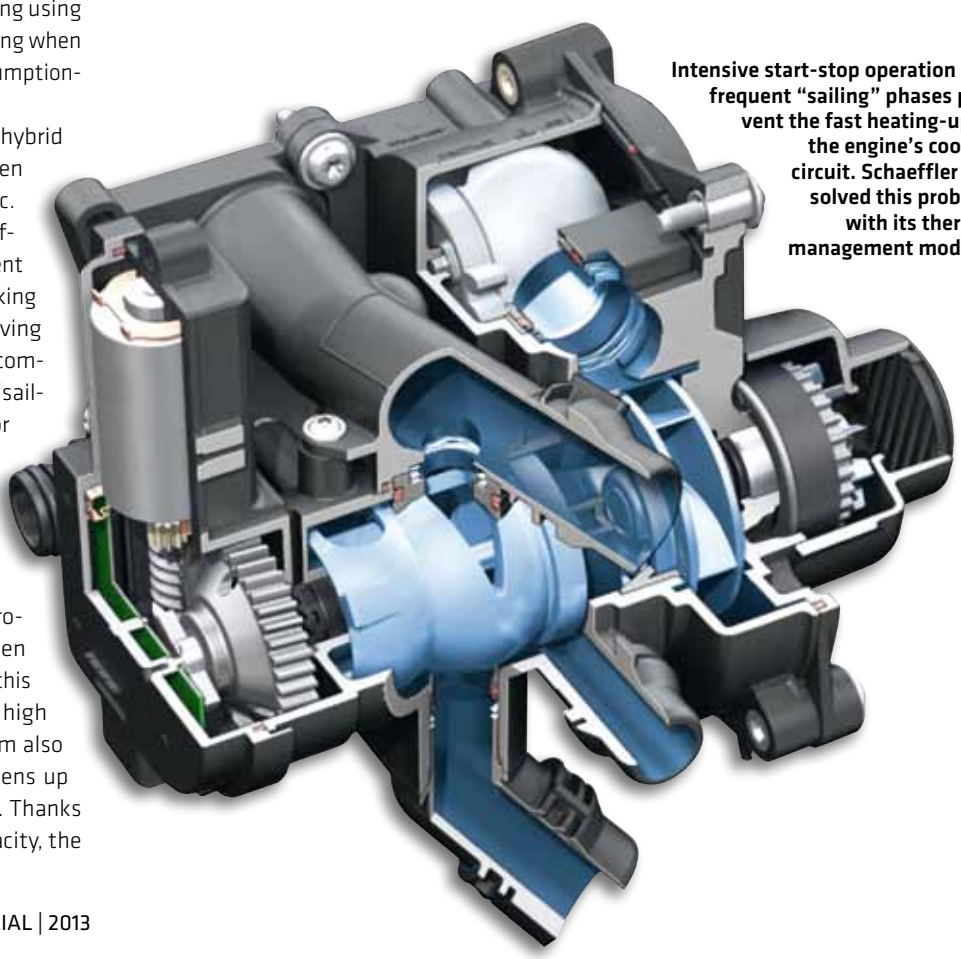
The electric motor acts as the hybrid vehicle's sole source of power when "crawling", i.e. in stop-and-go traffic. The electric propulsion of Schaeffler's 48-volt module is also sufficient for driving in residential areas, parking garages, and other low-speed driving situations. This is also true of the comfortable driving mode known as "sailing", in which the electric motor ensures virtually constant speed across a wide operating range while the internal combustion engine is switched off.

The electric drive assists the internal combustion engine by providing additional torque, e.g. when moving off from the traffic lights; this is referred to as "boosting". The high performance of the 48-volt system also means that the drive element opens up new potential for energy recovery. Thanks to the higher energy recovery capacity, the kinetic energy released during deceleration is efficiently fed back into the on-board electric system in the form of electrical energy.

"This entry-level form of hybridization already offers the essential advantages of a fully-hybrid vehicle and, at the same time, is an economically attractive, low-cost option that allows CO2 emissions to be reduced by up to 15 percent", explains Dr. Tomas Smetana, Vice President Product Group Electric Axle Systems at Schaeffler.

The fact that the drive unit is connected directly to the propshaft in vehicles with rear-wheel drive means that drag losses by the internal combustion engine are prevented. It is thus possible to achieve maximum efficiency and driving situations that were previously only offered by hybrid vehicles with significantly more complex designs. The selected combination of an electric motor and transmission also allows the flow of force to be distributed selectively, drive torques can be superimposed, and even torque vectoring – the variable distribution of torque that serves to increase driving safety – is possible.

In its current configuration, the cylindrical component is 235 mm long with a diameter of 165 mm. Its compact design means that it can easily be integrated into the drive train, so it can be integrated into the architecture of the vehicle without any space having to be sacrificed by the trunk or the fuel tank



Intensive start-stop operation and frequent "sailing" phases prevent the fast heating-up of the engine's cooling circuit. Schaeffler has solved this problem with its thermal management module.

START-STOP SYSTEMS – MUCH MORE THAN JUST A STARTER

Start-stop systems are the point of entry into drive train electrification. They perform more functions than just starting the engine in some current vehicles. Schaeffler considers itself as a partner for different start-stop concepts with its broad technology portfolio.

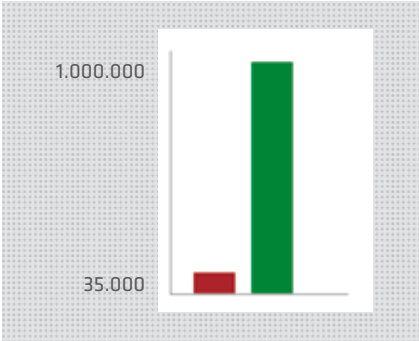
Schaeffler offers a large number of components for modern start-stop systems such as sensors, belt tensioners, starters and latching valves.

Start-stop systems are not present day developments: The first vehicles with this technology were presented by Volkswagen and Toyota in the 1970s. However, these systems were not widely accepted: Comfort was considerably impaired when the engine was started and switched off and there were also problems with the durability of components. In addition, the necessity of saving fuel was not so great as it is today. Meanwhile, every driver wants to switch off the engine as frequently as possible when it is not required for cost and environmental reasons but without restricting the comfort and safety of passengers. The most efficient possible use of the electric power available from the start-stop system installed in the vehicle is one of the engineers' development goals. An increase in the internal combustion engine's load point, requirement-based operation of the accessory units, regenerative braking, boosting and sailing are all indispensable when it comes to fulfilling future emission regulations.

"Over the past few years, Schaeffler has developed a series of innovative products that contribute to the optimization of start-stop systems. Starting with general optimization of the components in order to accommodate the significant increase in the number of start procedures – from approximately 35,000 in the case of conventional vehi-

IMAGES: SCHAFFLER

cles without start-stop systems to more than one million in the case of vehicles with a sailing function or hybrid operating modes", emphasizes Schaeffler CTO Prof. Peter Gutzmer. The crankshaft bearings, for example, now run much more frequently with mixed friction before a stable hydrodynamic lubricant film is formed. This phenomenon also affects the camshafts and tapping elements of the valve train. The situation is also similar for many components in the drive train, such as the dual mass flywheel, which is subjected significantly more often to the resonance that occurs when the engine is started.



The number of starting operations during the life of vehicles with start-stop systems increases to approximately 1,000,000.

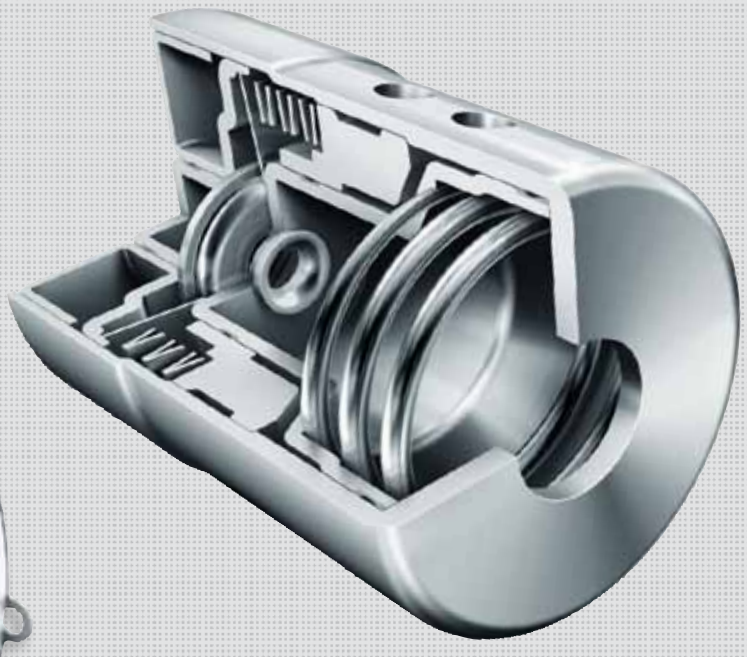
A RANGE OF CONCEPTS

Schaeffler has developed a range of concepts for permanently engaged starters for the optimization of starting operations, which are often a source of inconvenience with conventional systems – in which the driver decides that he/she wants to accelerate again while switching off the engine. In the first concept, the starter motor is placed above the torque convertor housing of a conventional automatic transmission. The starter pinion is permanently engaged with the starter ring, which is supported by back-up rollers and can be rotated in one direction in relation to the torque converter housing. A wrap spring mechanism connects the starter ring to the torque converter housing as soon as the starter motor begins to turn.

When the engine "overtakes" the starter as it starts up, the wrap spring disengages from the torque converter housing and the return spring ensures that a defined disconnection takes place. When the engine is running, the starter is decoupled from the torque converter, thus minimizing wear and friction. The complete mechanism operates without actuators or a control system and even a reduction in the complexity of the conventional starter motor by eliminating the engagement unit is possible. This system allows fast and quiet restarting and rapid re-acceleration of the crankshaft while the engine is being switched off (dead time from when the driver decides that he/she wants to accelerate while switching off the engine until the engine reaches idling speed is less than 600 milliseconds).

A second concept, based on a locking roller one-way clutch installed in the oil circuit of the internal combustion engine, works with a conventional starter ring and also offers rapid restarts and cold starts – even while the internal combustion engine is being switched off and irrespective of the transmission type. The one-way clutch also

Schaeffler has developed a range of concepts for permanently engaged starters in order to optimize engine start-up.



The latching valve stores a small quantity of pressurized oil for the subsequent start-up operation for the switching element of automatic transmissions with torque converters.

completely disconnects the starter ring when the engine reaches the required speed and thus does not cause any drag torques during normal engine operation.

"A problem that occurs when a belt-driven starter generator is additionally used for boosting and energy recuperation is that rapid switching between boosting and energy recuperation can cause vibrations in the belt drive. This is prevented by a special tensioner on the belt drive, which assists the load reversal", explains Dr. Eckhard Kirchner, Director of the Extending Systems Product Group at Schaeffler. The tensioner uses an oscillating movement to decouple the starter generator from the vibrations caused by the internal combustion engine and thus prevents peak stressing in the belt drive. The tensioning element also ensures a constant optimum tension in the belt and compensates for the lengthening that it undergoes due to aging. The decoupling tensioner is mounted on the starter generator in a space-saving way and replaces the two tensioning elements that would otherwise be required in the belt drive.

Dr. Eckhard Kirchner: „Vibrations can be generated in the belt drive when a belt-driven starter generator is additionally used for boosting and energy recuperation. This is prevented by a special tensioner on the belt drive, which assists the load reversal."

ALTERNATIVE SOLUTIONS

Another new aspect of start-stop operation is the positioning of the movable components for optimum restarting. Most gasoline engines today have hydraulic phasing units that are moved to the most convenient starting position when the engine is switched off – which is generally a locked position – so that no noise is generated when the engine is started. Schaeffler uses the existing rotational angle sensors, which identify the position of the phasing units with a high degree of precision, for this purpose. Controllable pins ensure that they are locked during the phase in which no oil pressure is present.

The effects of the engine start-stop system extend all the way into the drive train, however. Many vehicles feature automatic transmissions with torque converters, which have to be specially prepared for restarting. Many drivers have been irritated until now by the delay that occurs between when the start requirement is sent to the engine and when the engine starts and accelerates to the point where there is a sufficient pressure build-up of transmission oil at the switching elements transmitting the power.

The solutions currently being used to shorten these delays include additional electric oil pumps and hydrostatic pressure accumulators. These supply the transmission with high-pressure oil for the start-up procedure while the internal combustion engine is at a standstill and therefore the main pump is inactive. However, with regard to costs, benefits and design envelope, electric pumps and accumulators are not ideal.

"In choosing to use latching valves, Schaeffler is intentionally choosing to go another way. This is a valve that was developed by us and is activated by a hydraulic pressure pulse before the engine stops", explains Dr. Eckhard Kirchner. This causes a small quantity of pressurized oil to be stored for the subsequent start-up operation for one of the transmission's switching elements and the element is held at the contact point, thus allowing more rapid closure and helping to ensure rapid initial acceleration of the vehicle. No additional electric elements are required to control the latching valve. This means the outlay for integrating the valve is low, also with regard to additional space requirements.

An integrated solution in the design envelope of a clutch or brake piston is also feasible as an alternative design to a latching valve in the hydraulic control circuit. Both designs are based on the same functions and comprise two functional units: A non-return valve and a switch unit to activate and deactivate the non-return function. The functional principle is based on the fact that the active non-return valve prevents the return flow of oil from the switching elements and holds these in the required position. This means the engine start and start-up operation are carried out as quickly as possible – even while the transmission's hydraulic system starts operating.

DESIGN MEASURES

The switch unit comprises a bistable diaphragm spring, which activates the non-return valve before the engine stops, or deactivates the non-return valve after the engine starts. To activate the non-return function, the hydraulic system generates a short pressure peak (slightly higher than the operating pressure), which switches the diaphragm spring and activates the non-return valve. The diaphragm spring switches back during the next normal actuation of the clutch in the transmission and deactivates the non-return valve.

If the automatic transmission is supported with a stop valve during start-stop operation, the time period between pressing the gas pedal and acceleration of the vehicle is reduced by around 400 milliseconds – compared to a vehicle with a conventional automatic transmission without an oil supply when the internal combustion engine is at a standstill.

For vehicles with manual transmissions, other safety strategies and thus other design measures are required for restarting the internal combustion engine. For the engine to be stopped, the transmission must be placed in a neutral position and the clutch pedal must be free of any load. A sensor that is integrated into the pedal mechanism recognizes the actuation of the clutch pedal during the stopping phase as a signal to switch on the internal combustion engine. A further sensor in the transmission's actuation mechanism monitors the neutral position of the transmission in order to eliminate the risk of an incorrect actuation during the restarting procedure. Both sensors are integrated into known components – without any sacrifices being made in terms of ease of operation thanks to the non-contact measurement technology

„48-VOLT HYBRID FOR SMALL VEHICLES“

→ Personal information

Prof. Dr.-Ing. Peter Gutzmer (59) studied mechanical engineering in Stuttgart with a focus on internal combustion engines and transport and completed his doctorate there. He moved to Porsche's development department in Weissach in 1984. In 2001, he joined the Schaeffler Group as a development manager for product strategy. Prof. Gutzmer has held various various positions within the company and is currently responsible for product development at Schaeffler AG. He also has lectureships at Karlsruher Institute of Technology and Tongji University in Shanghai.

Volatile world markets, alternative drives, new product segments, continuously increasing competitive pressure and much more: Schaeffler Automotive is facing great challenges. Prof. Peter Gutzmer, Member of the Executive Board and CTO at Schaeffler AG explains how the company will overcome these challenges with the right corporate strategy and technology.

THIS INTERVIEW WAS CONDUCTED BY JÜRGEN GORONCY.

What are the trends in the various regional markets?

Hybridization and electrification are often driven by legislation in the triad markets (EU, USA, Japan). In contrast, the electric mobility of two-wheeled vehicles is part of day-to-day life in China and the legislator is now also pushing for the electrification of passenger cars. However, the introduction of electric vehicles has been slow up to now. This is why hybrid drives are now receiving significantly more attention than in the

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past. We are expecting significantly staggered development in India because India does not invest nearly as much in its automotive future, has a strong diesel market and buyers are considerably more cost-conscious than in China. India addresses all automotive issues very carefully, while China is aims to rapidly gain market leadership with regard to specific industrial issues. East Asia will be the hotspot for the automotive future with its large number of trend-setting megacities. But electrification is also gathering momentum in Europe and North America will follow.

Are these also your markets with the current highest growth rates?

Yes. Asia is still the leader with the absolute highest growth rates. Our sales in the North American market also exceed our expectations.

What are the reasons for this positive business development in North America?

The vehicle fleet in North America is firstly very old and there is a large requirement for purchasing replacement parts. The legislator is also pushing very hard to reduce fuel consumption. Our efficient technologies such as rolling bearings, valve train components and transmission technologies are very much in demand.

Is the collaboration between Chrysler and your good customer Fiat already bearing fruit?

North America is generally a conservative market, which adapts slowly to new technologies such as double clutch transmissions or hybrid drives. The Chrysler technology portfolio is certainly heavily influenced by the collaboration with Fiat. For example, fully-variable drive trains and double clutch solutions are also planned in Chrysler vehicles.

What product groups are currently experiencing the strongest growth at Schaeffler?

Firstly, the products for variable valve trains, such as components for cylinder deactivation, cam profile switching or timing adjustment. The second growth motor are our components for clutch and transmission technology, for example, for double clutch and modern automatic transmissions and vibration damping applications. We are also very satisfied with sales of our bearing solutions and components for auxiliary drive systems.

The increasing change from plain bearings to rolling bearings is driving our business in the bearings sector, for example, for balancer shafts in four-cylinder engines. This type of engine will largely replace six-cylinder engines as a result of downsizing, although it can only come close to achieving the smooth running of a six-cylinder engine when it is equipped with balancer shafts. It is actually very logical because rolling friction is more advantageous than sliding friction, particularly under mixed friction conditions such as in start-stop systems.

And what product group will have the best future growth according to Schaeffler's forecast?

The products mentioned have very good opportunities for growth in the medium and long term because the internal combustion engine will continue to provide good service in cars for some decades. This is in addition to systems such as start stop systems, or electrified systems for all types of hybrid drives. "It can generally be said that the requirement to increase the efficiency of internal combustion engine and its increasing hybridization plays into the hands of a drive specialist like us. For example, variability in the valve train will continue to increase and variable compression ratios could also become an issue again. And in addition to the range of different hybrid components and systems, we have also got electric drives in our portfolio.

In what markets does Schaeffler need to catch up?

We are very well positioned overall. We expect the greatest growth in Asia, particularly in China where we have a very good network. More than one third of the vehicle platforms, which will appear on the market during the next ten years, will be developed in Japan. We must intensify our efforts in this area. Automobile manufacturing will also increase in Southeast Asia, for example, in Indonesia and Thailand, which will effectively be an „extended workbench" of Japan. In Europe, we consider Russia in particular to be a growth market.

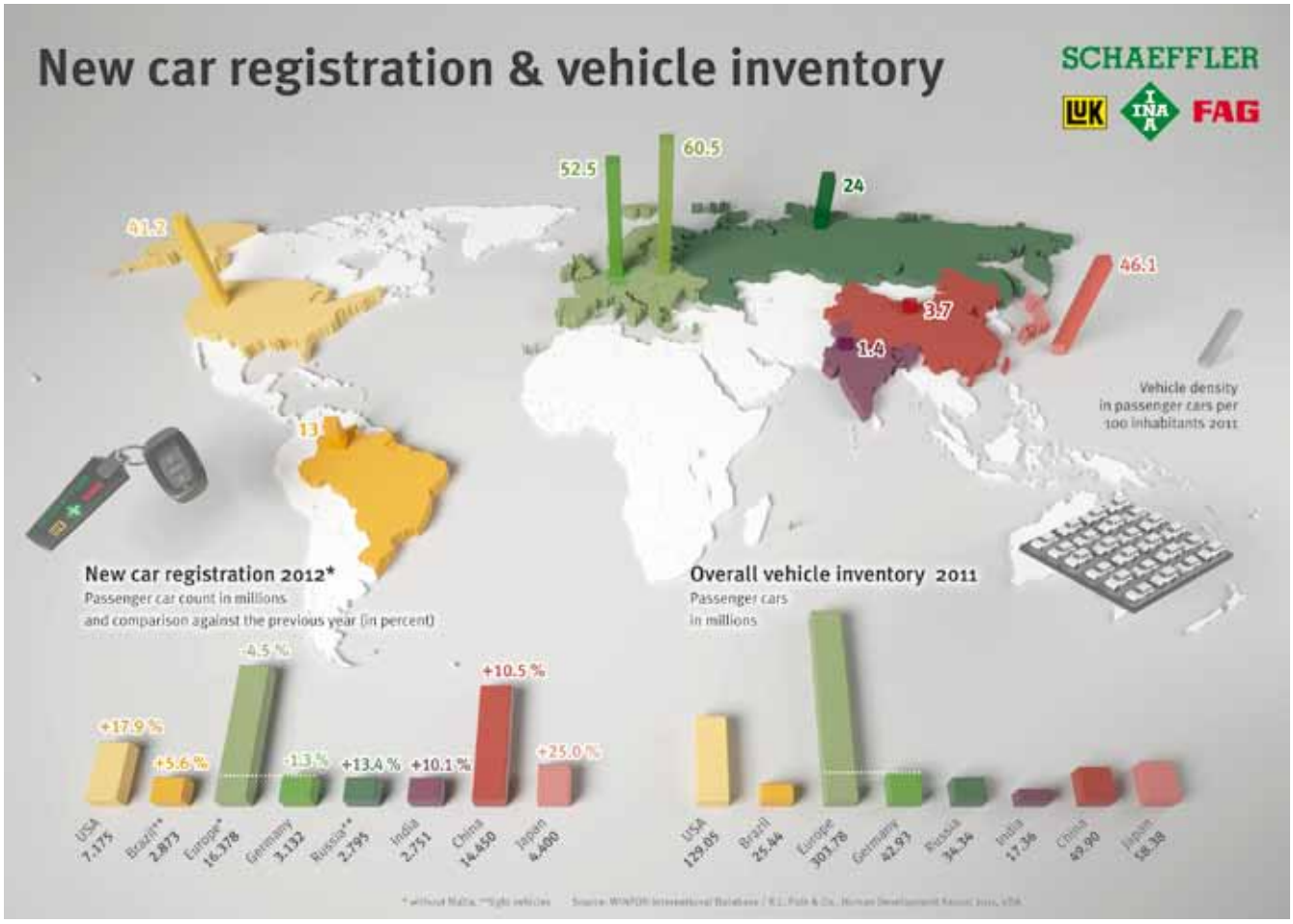
> "We expect the greatest growth in Asia, particularly in China."
>
> Peter Gutzmer

How will Schaeffler take on the challenges of increasing globalization with regard to its manufacturing processes? By means of more Internationalization?

We will develop our manufacturing expertise for valve train technology as well as torque converter and clutch technology in China. We also want to manufacture these products in India. The countries in South East Asia such as Thailand, where an impressive market with a large number of trade policies must be served on a just-in-time basis. And also the conditions in the USA justify increased local production. In general, Schaeffler always ensures there are

Fuel reduction in % / Technology:	City	Highway
Belt Drive Friction Optimization	1.0	1.0
Valvetrain Friction Optimization	0.5	0.5
Balance Shaft Bearings	0.6	1.0
Thermal Management Module	1.0	1.0
Adaptive Grill Shutters	0.2	0.8
Engine-Start-Stop	6.0	2.0
AWD Disconnect	2.0	6.0
Wheel Bearings Optimization	0.5	1.0
TC with Centrifugal Pendulum-type Absorber	3.0	1.0
Total:	**15**	**14**

Schaeffler also enables large potential savings to be achieved with different systems in conventional drive trains, as shown in this example of the concept vehicle Efficient Future Mobility North America.



Changes in vehicle production and the vehicle fleet in the most important markets.

sufficient local development and manufacturing capacities.

Where do you see gaps in the market, which Schaeffler could fill with new products?

We are already well positioned with our actuators and increasingly electrified products with minimized friction. I still see potential in the growing turbocharger segment. The entire system could be improved with actuators and electrified components, thereby replacing expensive twin turbocharger concepts. Good growth can also be expected from electrified components and modules, which replace hydraulic and mechanical units and only operate if required in order to save energy. There are opportunities here mainly in the field of chassis systems.

Are products already available?

We already have a number of actuator systems in volume production, such as the intelligent cooling module for an Audi engine. We want to improve such systems by adding further functions and optimize the design for volume production. In the case of the cooling module, the warm-up phase can be further optimized or heat retention in the system can be improved during start-stop operation.

It is worth considering whether improved control of the various thermal circuits can be achieved with robust mechanical products. This question is inevitable if there are a number of thermal circuits in the future (for example, engine, air conditioning system, battery) with very varied requirements.

Variable valve trains combined with a turbocharger can – as with the electrification of the turbocharging system – improve the responsiveness of the turbocharger. In ancillary drives, the focus is placed on belt-driven starter generators and 48-volt systems, which allow start-stop functions and mild hybridization. We offer enablers such as tensioning elements and clutches for this combination. And last but not least the chassis systems mentioned such as electromechanical roll stabilizers.

And what about the combination of the engine and transmission?

That is another interesting option. Transmissions with an increasing spread of transmission ratios and number of gears will make improved use of the most favorable operating points of the engine. The double clutch transmission is an improvement, the CVT has increasingly improved driving

"We are very well positioned overall."
Peter Gutzmer

dynamics thanks to electronic control systems and conventional automatic planetary transmissions are becoming increasingly efficient and more comfortable. Schaeffler supplies clutch systems, CVT chains and complete bearing systems and torque converters.

What type of transmission will gain in the medium term?

Double clutch transmissions will gain market share in Europe and probably in Asia. The CVT will be successful in Asia and America – and will tend to have greater success than the double clutch transmission in its markets. Automatic transmissions with torque converters have an increasingly wide spread of transmission ratios and more gears, new torque converter concepts with optimized friction behavior are being developed with high priority. We are following all these trends by providing innovative products such as the „intelligent" torque converter for start-stop systems, which is currently being tested in North America.

How does Schaeffler see the development of the ideal electric drive? Is there such a thing and how does it look in terms of the regions?

It would be preferable to have worldwide standards for electrification for reasons of scale. An electric motor between the internal combustion engine and the transmission (hybrid module „hybrid disk") seems to be gaining acceptance in hybrids because it is relatively cost-effective and can be produced without making major changes to the drive train layout. In addition, the electric axle without a fixed connection to the axle driven by the internal combustion engine should also be taken into consideration. This concept allows adaptive all-wheel drive or short distance driving using only electric power without the internal combustion engine if required. Such a concept is currently generating a great deal of interest, particularly in Asia where hybridization is being pushed very vigorously.

Can Schaeffler already report any success on the market at this level?

Absolutely. We have development projects for the hybrid disk that are close to volume production and hopefully we will start volume production in two to three years. We are already holding very promising discussions with regard to the electric axle.

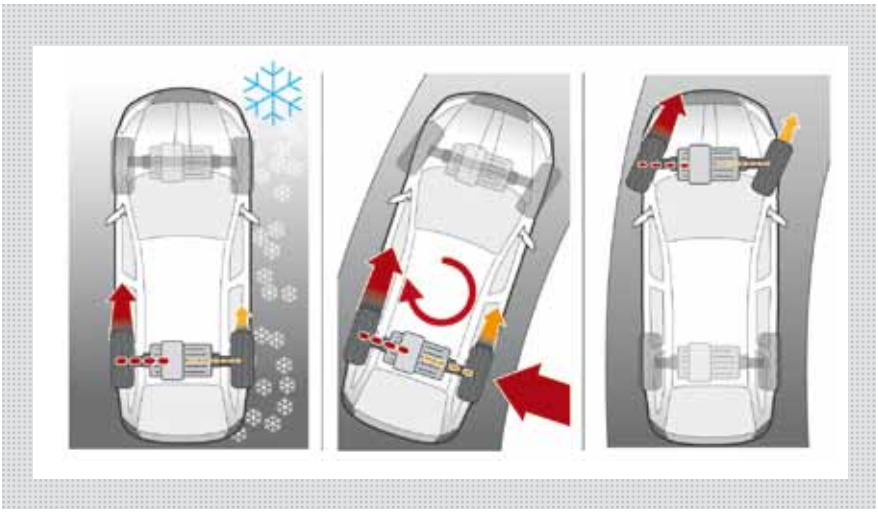
Do the electric motors also originate from Schaeffler?

We want to offer our own electric motors as part of a modular system for the electric axle – but also third-party products.

What type of technology?

Permanently excited synchronous motors are of course the best choice with regard to the design envelope, power density and functionality. The risks associated with the unreliable supply of rare earths and magnet prices are arguments against this motor technology. Asynchronous motors would be another option but have disadvantages with regard to efficiency and package size. A decision about the best solution must be made on a project-to-project basis.

What vehicles will be hybridized?



The electric axle as the eDifferential improves traction (left), vehicle dynamics (center) and supports the steering function (right).

"One must keep calm and set priorities."

Peter Gutzmer

If one takes the 95 gram CO2 per kilometer in Europe as the emissions standard, this can only be achieved in the mid and upper class vehicles with hybrid drives. And this means plug-in hybrids, which have a certain range of electric operation and enable fuel savings of 25 percent. Mild hybrid systems with an operating voltage of 48 volt could be a feasible solution tailored to the mid class vehicle market and below because they are more expensive than conventional 12 volt-systems – from a systematic perspective – but are still with an acceptable price range and significantly cheaper – up to 70 percent – than full hybrid high-voltage systems in the medium term. 12 kilowatts would be sufficient output for stop-and-go traffic, moving off using only electric power, parking and correct recuperation and would allow fuel savings of up to 15 percent. Further development of the battery technology is also very important here.

How do you position yourself as a supplier when every month another hybrid concept, another electric drive is proclaimed to be the only really viable system of the future?

One must keep calm and set priorities. We know precisely where we can use our product range and expertise for suitable products for electric mobility. We are placing our focus on the internal combustion engine and transmission, as well as the hybrid disk, electric axle and on the wheel hub drive in the long term. We consider the 48-volt hybrid to be suitable for small vehicles. It can be designed as a hybrid disk and as an electric axle. 48 volts are not suitable for the drive but will allow optimization of chassis systems such as electric steering systems, self-leveling suspension or roll stabilization. In general, we think energy-intensive actuators will be used in combination with 48-volt on-board electric systems for reasons of efficiency. The advantages of a combined 12/48-volt on-board electric system are sufficiently well known. An OEM must now start volume production of this system.

Many thanks for your time

THE HYBRID OF THE FUTURE

What is a hybrid drive? There are many correct and quite a few incorrect answers to this question. The following text describes how drive specialist Schaeffler envisages the hybrid drive of the future.

Whether its a mild, full or plug-in hybrid: Schaeffler offers the right components and systems for every variant of hybrid technology.

There is a consensus in the sector that a hybrid drive is a combination of an electric motor and an internal combustion engine. There are also a number of different technical and functional variants of the hybrid drive, which have varied strengths and are suitable for different applications and vehicle segments. „It is currently not foreseeable which of these variants will become established on the market", says Rainer Gut, Sales Director for the eMobility Systems Division at Schaeffler Automotive. „We already offer a number of products with a high cost-benefit factor for start-stop systems, the entry-level hybrid technology. We are also concentrating on two forward-looking system solutions: The hybrid module and the electric axle."

In a first step, Schaeffler is already supplying a disconnect clutch for two models produced in Germany and for a Japanese vehicle . This is a clutch positioned between the electric motor and the internal combustion engine, which disconnects the internal combustion engine if required and therefore eliminates drag torque. The electric motor then performs the work to drive the vehicle and enables, for example, sailing, recuperation or all-electric driving. The electric motors originate from another supplier.

IMAGES: SCHAEFFLER

The disconnect clutch used in volume production also has a damper and actuators. This damping element in the form of a damped clutch disk „smoothes" the rotational irregularities of the internal combustion engine. A dual mass flywheel could also be used as an alternative damping element. A plug-in hybrid will be equipped with this type of hybrid module soon but it will feature an electric motor with significantly higher performance (80 klilowatts) than in the other applications. Schaeffler could supply modern electric motors at any time via its subsidiary IDAM if required. The decision regarding the selection of an electric motor manufacturer will be made after conducting a market and project-specific make-or-buy analysis.

Rainer Gut: „We think hybrid technology has a lot of potential in the future."

FURTHER DEVELOPMENT OF HYBRID MODULE

Schaeffler has further developed the hybrid module due to the high level of interest shown by customers. Engineers at Schaeffler have successfully integrated the mechanical components („dry" disconnect clutch with up to 250 newton meter capacity, with an additional one-way clutch of up to 800 newton meter capacity, actuators, rotor bearing support) into the electric rotor (a so-called internal rotor). The electromechanical actuator in particular offers advantages. It is controlled by a single cable instead of a complex hydraulic line and only requires energy during actuation – and not in its idle state. The axial length of the module was reduced from 150 to 100 millimeters (the length of the electric motor). A dual mass flywheel performs vibration damping in this new development because it is better equipped to meet the current NVH requirements of modern downsized engines. This means the hybrid module can be combined with all conventional transmission types and not just with automatic transmissions with torque converters.

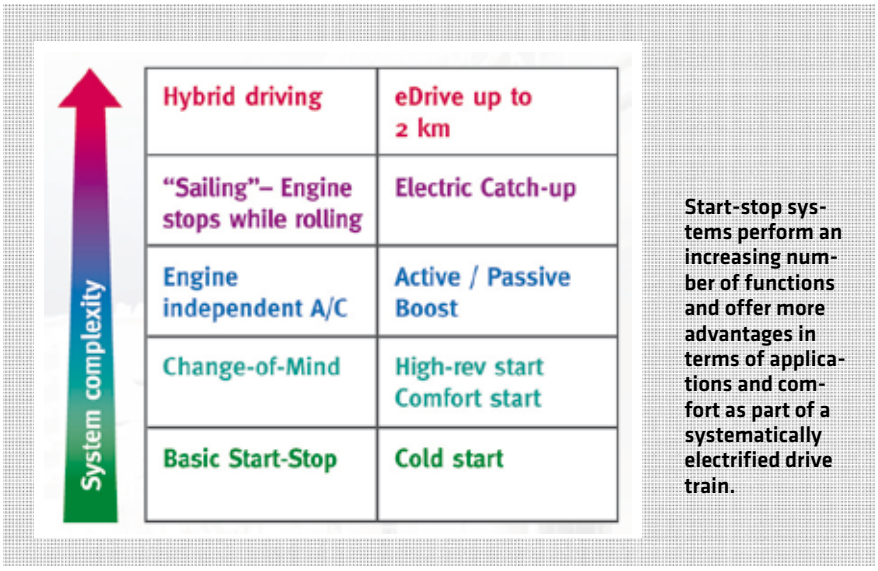
The electric axle also allows an all-electric drive, which is not the case with the hybrid module. It can be located on both the front and rear axle because essential system components are mounted coaxially to save as much space as possible. Torque vectoring is also possible allowing more driving enjoyment and benefits with regard to driving safety. The drive power of 40 to 100 kilowatts currently produced by the hybrid module is comparable with the electric axle.

Most of Schaeffler's hybrid and electric components are suitable for both high-voltage and 48-volt applications. With available outputs of up to approximately 12 kilowatts, a 48-volt hybrid system can also achieve astonishing potential fuel savings – with lower costs and less safety measures than with high-voltage technology. The changes required are not significant and the package size and components are practically the same for both voltage variants. The 48-volt electric axle offers the functions of an electric drive in stop-and-go traffic, parking and moving off as well as torque vectoring, even if all the functions are not available at the same time. It is a designed with two gears like the high-voltage module in order to achieve a good recuperation capability at high speeds. Schaeffler has already started advanced development projects for the 48-volt system and successfully tested prototypes for both the hybrid module and the electric axle.

CURRENTLY NO SIGNIFICANT TRENDS

Whether – irrespective of the operating voltage – a hybrid module or an electric axle is selected for a vehicle depends on the preferences of the OEM and the structural conditions of the vehicle. There are currently no significant trends. Schaeffler has even received inquiries for a combination of both technologies. The hybrid module could, for example, generate current to drive the electric axle using an internal combustion engine in this high-tech solution for premium vehicles.

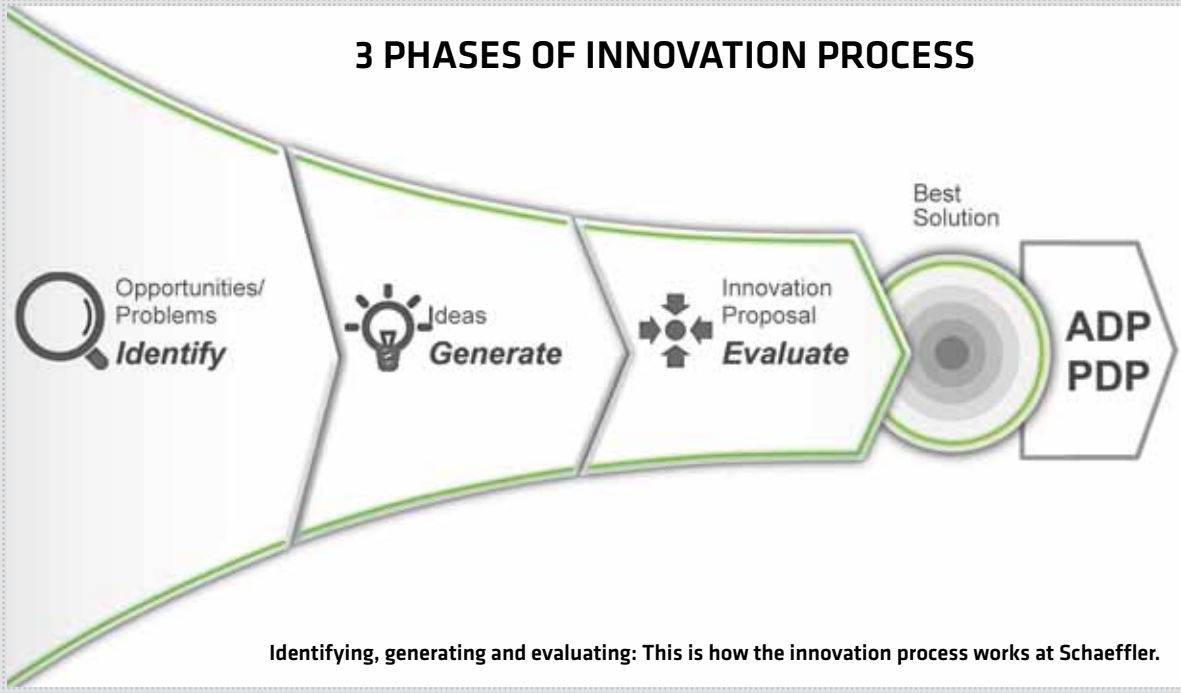
The Schaeffler hybrid module has received a great deal of interest particularly in China from OEMs, but also in Europe and after an initial delay in North America, too. A total of more than 230 employees are currently working on further development of the hybrid portfolio at the three locations Herzogenaurach, Bühl in Germany and Anting in China. „During the next few years, we are expecting a lot of potential from the hybrid technology in Schaeffler's diversification strategy, which ranges from the optimization of the conventional gasoline engine to the all-electric drive system", says Rainer Gut looking optimistically into the future. ‹



Start-stop systems perform an increasing number of functions and offer more advantages in terms of applications and comfort as part of a systematically electrified drive train.

USING KNOWLEDGE TO MAKE PRODUCTS

If Schaeffler only sometimes knew, what Schaeffler knows.... The „Corporate Innovation and Knowledge Management“ department optimizes the exchange of information at Schaeffler, identifies trends and converts them into new product ideas. But these are only part of the department‘s responsibilities



Identifying, generating and evaluating: This is how the innovation process works at Schaeffler.

The department‘s 15 employee‘s are part of Prof. Gutzmer‘s Research and Development organization and take on three important interdisciplinary tasks. Firstly, they organize and promote the internal exchange of information and transfer of knowledge at Schaeffler using the Intranet, Wiki platforms or document storage. Another task is giving technical presentations outside the company – at universities – in order to position Schaeffler as an attractive employer and technology innovator.

The third and most important task is supporting departments with the development of new product ideas. „We are a classic corporate service department for the entire Schaeffler Group. We „view the situation as outsiders“ and help our internal customers to consider and assess things in a comprehensive manner“, explains Heinrich Schäperkötter, director of the department. „It‘s about sharing knowledge, a modern name for it is internal open innovation. The barriers between groups, departments, areas or divisions must always be overcome.“

Schaeffler has already transformed itself into an integrated mobility supplier. In addition to the established automotive portfolio, additional business fields include railway engineering, the two-wheeled vehicle sector and other modes of transport such as airplanes and ships.

It is becoming more and more important for a company to be able to see further into the future than ever before. Schäperkötter: „What trends will influence our everyday life and economic system during the next years and decades? What solutions can Schaeffler

FOTOS: SCHAEFFLER

Heinrich Schäperkötter places great importance on diversity in his team.

→ Personal information

Dr.-Ing. Heinrich Schäperkötter (56) studied mechanical engineering in Braunschweig and earned a doctorate about internal combustion engines. He then went to Elring Klinger as head of basic development. He also worked as head of R&D at Sachs Dolmar (a manufacturer of small engines, chain saws and garden tools), was managing director of Hilti Entwicklungsgesellschaft for power tools and managing director of an automotive manufacturer for armor-plated limousines and special vehicles. Schäperkötter has been Director of Corporate Innovation and Knowledge Management at Schaeffler since 2003.

offer at the right time?" Innovation and Knowledge Management deals systematically with these and other questions – always working together with representatives from relevant departments or selected external partners. In an optimum case, this results in the development of a well-founded business plan.

INNOVATIONS ARE NO LONGER ONE-OFF INVENTIONS

As in the example of the „bicycle project". This project initially started as an internal workshop about the future importance of individual modes of transport. It became evident that the importance of bicycle traffic will increase enormously in the future worldwide. In subsequent workshops, the sensor bearing in the Schaeffler portfolio was identified as being marketable. This is because the popular pedelecs, in which electric assistance depends on the torque applied to the pedals by the rider, require an exact and simple method of torque measurement. Schaeffler subsequently developed its sensor bearing and tailored it for the needs of the manufacturers of pedelec drive units, who now use the sensor bottom bracket in growing volumes.

„The main task of our innovation managers is to carry out moderation of these innovation processes. This not only necessitates moderation skills but also a large amount of expertise in methods and above all a knowledge of human nature", says Schäperkötter. „A healthy curiosity, perseverance and an empathy for the working world and living environment of other people are also an advantage." The professional background of the 15 employees is intentionally very varied. Engineers, sociologists, natural scientists, graduates of business management, IT experts and a terminologist are on board. The age structure is very mixed and there are a number of women in the team.

An ideal innovation process comprises three phases and usually starts with an inquiry from Schaeffler's business units. A small team of innovation managers determines the white areas and opportunities of the relevant range of tasks in comprehensive discussions.

If the precise tasks and problems have been defined, consideration is given as to how an appropriate solution can be developed using Schaeffler's expertise. In this creative, „chaotic" phase, the innovation managers create new ideas and fills these with technical input in collaboration with the business units.

In a third step, an assessment is made about whether these products and business ideas could be marketable and profitable. A very important question is whether a new product can be optimally placed on the market. If disruptions occur in this third phase, the subsequent transfer to the normal (advance) development process and production as well as sales will not function at Schaeffler. In this case, an excellent idea may be put on ice or shelved for good in certain circumstances.

Basic rsearch is carried out before the moderation of innovation processes at Schaeffler. Innovation managers mainly identify future trends from work and studies by professional trend researchers. They derive scenarios with various weightings about how a technical or social issue could develop from these trends. Schäperkötter is certain that „innovations are no longer one-off inventions of ingenious minds but are the result of teamwork". „We must increase our efforts to bring different people and specialist disciplines together and achieve our collective goals." ‹

FOTO: VDA

VDA president Matthias Wissmann.

CO_2 regulation has been at the top of the VDA's agenda for the last few months. The issue is not only about climate protection but also involves fundamental decisions about industrial policy and Europe's competitiveness. German automotive manufacturers are currently making the largest contribution to reducing CO_2. The premium manufacturers in Germany must reduce the CO_2 emissions of their vehicle fleets by approximately 25 percent by 2015. They will achieve this target – with optimized conventional drive systems, smaller engine capacities, high-performance turbocharging, direct injection and consistent use of lightweight design.

However, the next step is considerably more difficult. The German automotive industry has always been committed to achieving the ambitious target of reducing the CO_2 emissions of the EU's fleet of newly registered cars by an average of 95 grams by 2020. However, the renowned RWTH Aachen University has also confirmed in a report that this target cannot be achieved solely by optimizing conventional drive systems. A significant proportion of cars with alternative drive technologies will also be required.

This involves providing the stimulus for the innovations required. On the one hand, these are technologically challenging targets. On the other hand, no one can say with any certainty today what the market demand for electric cars will be in the future. The differences in cost and price between cars with conventional internal combustion engines and vehicles with alternative drives will remain significant in the coming years. The question is whether the startup phase for alternative drives in Europe will continue to gather momentum.

The expertise of suppliers is indispensable during the development of these innovations. They provide 75 percent of the added value of an automobile and many are world market leaders in their fields of technology. Especially medium-sized suppliers underscore the excellent reputation of Germany as an automotive manufacturing location with their technical innovations.

Germany still has a very successful industrial base. Employees and employers have gained from the structural reforms and the intelligent collective bargaining policy of the last few years. But the difficult economic situation in Western Europe, increasing protectionism in many emerging markets and the threat of increases in taxes and contributions present companies with special challenges. Increasing energy costs act as a „negative location factor" – it is essential that they eased again.

Placing an additional load on companies by increasing taxes and contributions, as demanded in some election manifestos, would be a risk to Germany as an industrial location. Plans for a wealth tax are a source of anxiety for many family-owned suppliers. The success of German industry up to now – which was also possible on the basis of suitable boundary conditions – must not be put at risk by any new financial burdens!

Today, medium-sized companies are required to be present worldwide. It is important to make the correct investment decisions at an early stage in order to maintain the competitiveness of companies in the long term. Many suppliers face the challenging task of reacting to global developments.

Schaeffler AG is based in the town of Herzogenaurach in Bavaria and is a leading supplier. The company's consistent globalization strategy – more than every second employee is employed at one of the 180 international locations – and its speed of innovation are examples for the forward-looking focus of this German supplier. They make Germany the automotive location that it is: A powerhouse and manufacturing location for the world's best vehicles.

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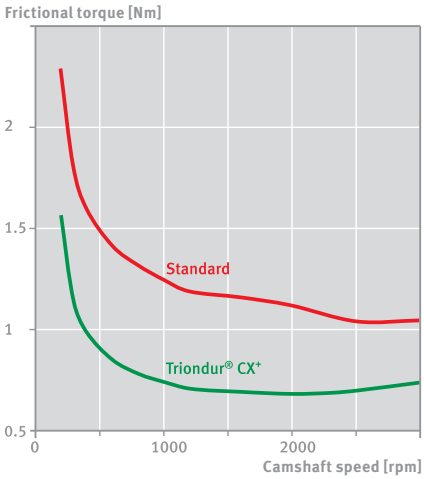

Friction in the engine wastes valuable drive power. That is why we only supply components that are subjected to particularly high stresses with special coatings. After all, surface coatings are an effective weapon for combating friction and wear.

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