

tomorrow

EXPERIENCING TECHNOLOGY WITH SCHAEFFLER



»» The development of innovative products, which offer the customer added value, is only possible if you know the customer's needs and have an in-depth understanding of the market.

Klaus Rosenfeld, Schaeffler

DEAR READERS,

The world economy is growing and this is good for the many people, whose living conditions are being significantly improved by education and high-quality work. However, we cannot simply carry on "business as usual" because natural resources are limited. This applies for both raw materials and the tolerance of our climate system.

We must develop new technologies, which satisfy both economical and ecological requirements, to enable all people to strive for an adequate standard of living and to ensure the protection of natural resources. At the same time, it is important to optimize conventional technologies with regard to material and energy efficiency in order to reduce the environmental impact as much as possible.

The Schaeffler Group is already making a contribution to advancing technology with many of its products and services. Our strategy concept "Mobility for tomorrow" with its focal areas eco-friendly drives, urban and interurban mobility as well as the energy chain is at the core of our activities. Schaeffler's strength lies in its cross-divisional expertise, which in addition to the automotive sector also includes all other forms of mobility, such as two-wheeled vehicles, railways, and aviation. Schaeffler is also a development partner in both conventional and renewable energy generation and, with its low-friction products, contributes towards making efficient use of the energy available.

In addition, the Schaeffler Group develops solutions for plant manufacturers and operators in a large number of different sectors. This development is based on an in-depth understanding of the systems and processes in customer applications and the specific requirements of the market. As central machine and drive elements, rolling bearings and rolling-bearing-based systems play a decisive role in increasing the cost-effectiveness, performance and efficiency of industrial applications. The expansion of rolling bearings to include sensors, actuators, control and software components, means that rolling bearings are becoming particularly



important for the linking of components machines and production systems as part of "Industrie 4.0." This has a range of objectives, from continuous condition monitoring through to independent solution-finding when errors are detected, and even selective process control based on logistics data.

The development of innovative products, which offer the customer added value, is only possible if you know the customer's needs and have an in-depth understanding of the market. India – partner country of the 2015 Hannover Messe – is a good example in this respect. The Schaeffler Group has been active in the country for many years, operating its own manufacturing plants and sales offices. So we can provide valuable technological support with the investments that are set to be made in the country's mobility, infrastructure and industry.

In this issue of our new customer magazine "tomorrow", we want to inform you about our widely varying range of tasks and objectives – and the people behind our ideas.

We hope you enjoy reading this exciting magazine and look forward to receiving your comments and suggestions.

Klaus Rosenfeld
CEO

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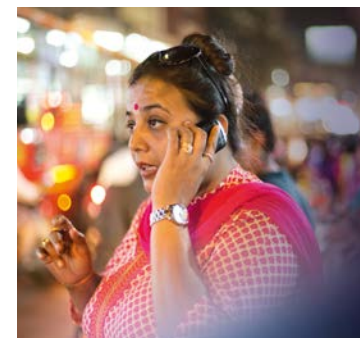
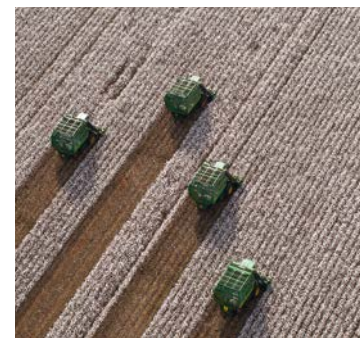
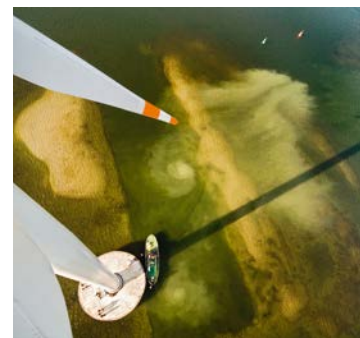
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LOOKING BEYOND ROLLING BEARINGS

The world is facing major changes – in mobility, power generation, and production. Technologies that provide greater efficiency therefore have a bright future according to Robert Schullan, a member of Schaeffler's Executive Board and CEO of the company's Industrial division.

— by Johannes Winterhagen

It's nice to see you getting on your bike for us, Mr. Schullan.

You're not the only reason I'm doing it. Cycling is a passion of mine.

But it's safe to assume that you choose a conventional racing bike, rather than a pedelec?

Actually, I have just recently purchased a new pedelec for my own use. It can be ridden like a racing bike, but it also allows you to take it easy and still set a respectable pace – while wearing a suit, for instance.

What role do you see the pedelec playing in the future?

I am convinced that it will be an important component of urban mobility in the future. Even today, it is easy to see how the volume of cycle traffic in cities is increasing, and this means the pedelec's role is becoming more and more important, since it allows individuals to get very comfortably from A to B in their daily lives.

All the same, people still won't be traveling everywhere by bicycle.

And that is precisely why many metropolitan areas are currently expanding their metro systems. These are the only solution that makes mobility possible for large numbers of people in big cities – something that can't be done with cars. As a side note, it also doesn't matter whether you are getting around town by pedelec, metro, or car – Schaeffler is almost always on board. The same also applies to interurban traffic, including high-speed trains and aircraft.

But your business is by no means restricted to just mobility. Your catalog products alone number more than 40,000 and you offer countless customer-specific solutions in addition to those – so what is the common denominator for Schaeffler Industrial?

The wide variety of our range is not an end in itself. What it does is reflect our customer orientation. The starting

ROBERT SCHULLAN

Robert Schullan (born 1958) is a Member of the Executive Board at Schaeffler AG and CEO of Schaeffler Industrial. The graduate engineer began his career at INA where, in 1998, he became a Member of the Executive Board with worldwide responsibility for Industrial, Sales, and Application Engineering. He has been CEO of Schaeffler Industrial since 2006, and has represented the company's Industrial division on the Schaeffler Executive Board since 2012.

Mr. Schullan is also part of the VDMA's Restricted Board, its Power Transmission Engineering Association, and its regional association for Bavaria. He is a member of the supervisory board of HAWE Hydraulik SE.

Robert Schullan is married and has three children.



point for everything is the rolling bearing, which is employed wherever things have to move. Another way to put it would be to say that rolling bearings are to industry what rice is to food – an essential basic element. We are therefore present in around 60 sectors, and our objective in each of these is to always supply the individual customer with the optimum solution for the application.

But of course you can't reinvent the wheel – or the bearing – in every application.

Correct, and that is precisely why we are stepping up our work in the development of modular solutions that now include far more than just rolling bearings. Our aim is not to expand our product range but to deliver the best possible solution. Modular systems also allow us to deliver this type of solution while taking cost-benefit factors into consideration. One example of this is our linear drives sector, where we offer a variety of carriage designs based on linear roller or ball bearing and guide-way assemblies, including additional elements such as drives, brakes, and seals. And as widely varied as the solutions for production facilities and medical equipment are, they are always based on a standardized modular system, which also has a high level of potential in other sectors.

How widely do the requirements of your customers vary in the individual regions of the world?

They vary in a lot of ways, which is why our global orientation is so vital to our success. Just as our customers in Europe all have a local point of contact, so too do customers in Chile and in Thailand. The work we do in each country is for the country itself – in the region, for the region – and this gives us an advantage not only in terms of speed but in terms of understanding the customer's requirements at a local level as well. However, there are common elements that tie the different regions together: It is a proven fact that we have to contribute towards the customer's success – that is the only thing that will be rewarded. What is more, our aim is to live by our core values: transparency, trust, and teamwork.

How great are the synergies that the Industrial division can achieve from cooperation with Schaeffler Automotive?

Our customers have always profited from the internal cooperation, which of course is particularly true in the case of rolling bearings. Needle roller bearings are one example: We can use the same production lines as our colleagues from Automotive use to produce large numbers of bearings for use in vehicle transmissions. In the same way, the Automotive division has profited from the fact that our high-precision needle roller bearings –



» “Industrie 4.0” digitally connects entire value added chains together

including those for printing and textile machinery – have enabled us to open up new performance ranges that subsequently became interesting in the light of increasing demands in vehicle applications. We are currently stepping this cooperation up to a new level, since we are now looking beyond rolling bearings.

And that means?

We are increasingly developing mechatronic modules, such as our automatic bicycle gearshift system. Modules of this kind often include drive and control components that are already being used in the automotive sector, albeit in different designs. The exceptional systems expertise of our Automotive division is also helpful to us here. These are joined by components and modules such as clutches and valve train components that we are developing further for use in motorcycles and driven machines. The other requirements in terms of load profile and rating life have to be taken into consideration at the same time – and of course the fact that quantities are usually lower.

Is energy efficiency now as much of an issue for your customers as it is in the automotive industry?

The automotive industry has long been subject to legal regulations governing CO₂ emissions and fleet consumption. Things are still different in the industrial sector, although efficiency guidelines are already in place for some individual applications such as domestic appliances. Despite this, however, the idea of saving resources is of course firmly engrained in our customers’ way of thinking, in addition to the fact that all customers now take the “total cost of ownership” into consideration. For this reason, every company works to ensure that its factories are operated efficiently. This understanding is still not very developed when scaled down to the level of individual machines, however – and our aim is to make our customers more aware of the potential that is still available here.

Is this practice of striving to achieve energy efficiency a purely western European phenomenon?

In the industrial sector, energy efficiency is an issue all over the world. Take China, for example: There has long been an awareness in China of the fact that pollution of the air and of the environment go hand-in-hand with energy consumption – that is why more and more laws are being passed there to counteract the problem.

Efficiency also means utilizing the capacity of existing machines and equipment to the greatest possible extent. What contribution can Schaeffler make here?

That is exactly the point that we have to understand. For machine operators, the objective is of course maximum capacity utilization. As a rolling bearing manufacturer, we only supply part of the machine and are therefore only a part of the overall maintenance cycle. The rhythm is not specified by us but by the process in question – our job is initially to design a product in such a way that it fits into the cycle. If we then also manage to design a bearing in such a way that it can go through twice as many maintenance cycles as a conventional bearing – through the use of a special coating, for example – then we have done the customer (and naturally the environment) a great service. But this is only one aspect. The other aspect is achieving preventive maintenance – in other words, adjusting the maintenance cycles to match the actual wear that occurs. Thanks to our condition monitoring and intelligent data evaluation systems, we are able to deliver the information required in order to achieve this. In addition, we are now already offering mounting, logistics, and reconditioning services for specific applications.

Condition monitoring sounds like a step towards “Industrie 4.0”.

There are certainly different definitions of “Industrie 4.0”. For me, the term first and foremost represents the digitalization of value added chains. However, digitalization can only work when the corresponding data basis is available. Rolling bearings play a decisive role here, because bearings – or linear guidance systems – are installed right where the required data are created: torques and speeds, temperatures, vibrations, and much more. We can use sensor technology to record these data. The integration of this sensor technology into the actuator, as we do with bicycles, is entirely in keeping with “Industrie 4.0”. The same is true of our FAG Smart-Check, which is used to transfer data to machine control systems and in doing so allow them to respond to rising temperatures in a machining operation, for example. Nevertheless, I still have to point out that these are just the initial steps: “Industrie 4.0” is much more than that.



For Robert Schullan, the e-bike is an important factor for the mobility of tomorrow in growing cities. The bicycle was a pioneer for mass mobilization and the core of rolling bearing technology in the 19th century.

Such as?

It is ultimately a matter of digitally connecting entire value added chains together, from logistics through to the end customer. There are many possibilities here just waiting to be opened up.

Schaeffler Industrial is heavily involved in the wind power sector – which has also had a difficult time over the last few years.

Those were just ordinary teething troubles in my opinion: A lack of grid capacity and connections at one time, discussions about further subsidization at another. I am convinced that we are now set to experience years of continuous growth – and worldwide growth at that. Many regions are just getting started, such as South America and Southeast Asia. Ultimately, there is a political desire to increase the proportion of renewable energies virtually everywhere. Wind power has an important

part to play in this context because, on land at least, it is currently the cheapest renewable energy source for generating electricity. This in turn means that efficiency, in other words the greatest possible utilization of the wind’s energy, has now become very important for operators. This is good news for Schaeffler, as our bearings allow us to contribute to increasing the efficiency and reliability of wind turbines.

Energy prices are relatively low at the moment – do you think that maybe this is slowing down the shift towards renewable energies?

All fossil fuels are finite. I therefore see no alternative to this shift in the long term – it ultimately comes down to the question of which generation will make it.

Many thanks for giving us this tour, Mr. Schullan! —

productivity

Regardless of the sector: Continuous improvements in productivity pay off

COMPLEX TASKS BEARINGS BECOME INTELLIGENT

— All of Schaeffler Industrial's customers want to work efficiently. The company has been making an often decisive contribution to this over many years through its comprehensive range of bearings. Digitalization has taken manufacturing to a whole new level. It is important for "Industrie 4.0" to be able to obtain data on the condition of machinery and equipment both reliably and quickly. Schaeffler is already contributing to this through solutions which provide on-line monitoring of rolling bearings and facilitate predictive maintenance.



CHECKED?

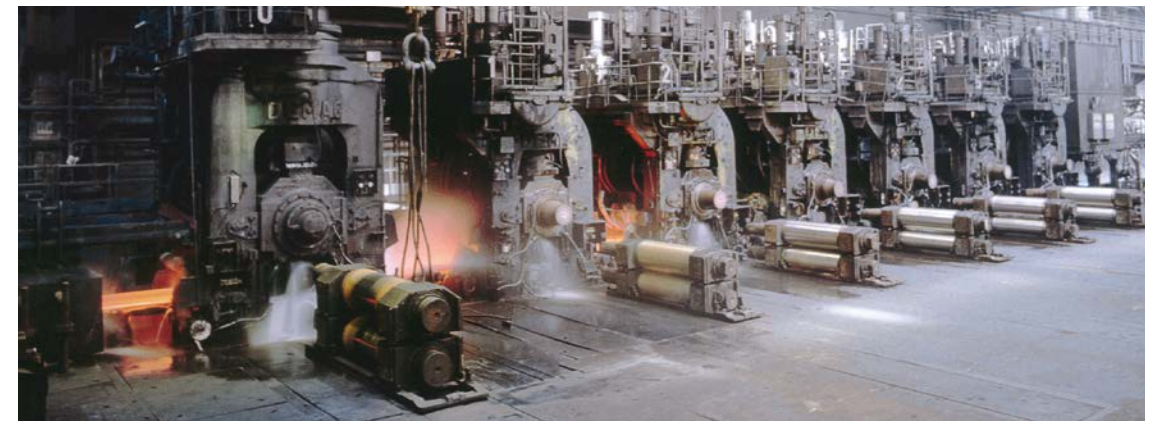
Important operating conditions in machines and equipment can be assessed by using intelligent sensors and bearings and made available to control systems. This system of “conditioning monitoring” has a central role to play in “Industrie 4.0.”

— by Stefan Schlott

Dentists have known it for a long time. Prevention is not only better than cure: It is more cost-effective and less painful. But this is true not only for the dental treatment that most of us do not enjoy but also in many other areas. Including in industry. For decades, maintaining machinery and manufacturing equipment had been a fire-fighting exercise. Only when something broke down or was no longer working would maintenance be called in. So they more or less resembled a repair crew.

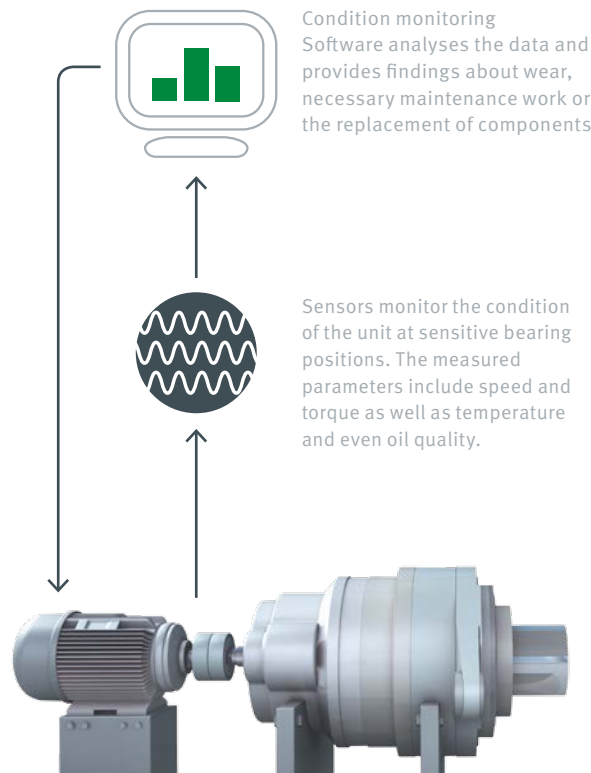
There has been a revolution in the way people think over the last 30 years, as increasingly closely interwoven supplier networks and just-in-time manufacturing have emerged. The rate of change in firstly preventative, then predictive and finally condition-based maintenance procedures is high. Extremely high. On the eve of future manufacturing models as part of “Industrie 4.0”, largely failure-free production due to good maintenance is playing an even more important role than previously.

The vision is that production will run itself, products will know where they are in the production cycle at any particular point in time and machinery will be able to control itself automatically. In fact, machines that operate perfectly. In order to guarantee this, industry is relying increasingly on condition monitoring in its manufacturing facilities. Diagnosis of vibrations was one of the processes where this was initially used in order to recognize the early onset of damage to machinery. Imbalances and alignment errors can thus be detected, as can damage to rolling bearings defects in gears. Subsequent development stages (depending on the task) included other factors, such as the lubrication condition or the number of abraded particles in the lubricating oil, temperature, vibrations and their frequencies. Schaeffler offers a range of off-line and on-line data collection procedures to suit customer requirements. For optimum connection to machine control or monitoring centers, all on-line systems have a comprehensive range of communication options as standard.



Tremendous forces and high temperatures act on the rolling mills and the incorporated rolling bearings during steel production. Predictive maintenance can significantly increase a plant's availability.

CONDITION MONITORING: THE PRINCIPLE



APPLICATIONS

Condition monitoring is generally possible in every machine with rotating components. Typical mounting locations are:



Gearboxes



Pumps



Motors



**Ventilators,
Fans**



**Decanters,
Separators**

For Oliver Massa, Schaeffler's Senior Vice President Product Management Industrial Aftermarket, there is one simple reason behind Schaeffler's commitment to offer intelligent bearings solutions: "Everything that influences the manufacturing process can be seen in bearing arrangements and guidance systems." As the bearings undertake the guidance and positioning tasks and transmit forces and movements, it is possible to detect variations in both the manufacturing process and the products in the bearings themselves.

As unplanned downtime and defective parts can quickly lead to chaos in an automated, interconnected production process, being able to plan for 100% availability of production machinery becomes an imperative for networked, intelligent production. Massa: "Monitoring the status of both machinery and various production processes is now one of the most significant challenges for mechanical engineering within 'Industrie 4.0.'" But Schaeffler is thinking beyond this as well. Which is why one of the technological showpieces at this year's Hannover Messe is a condition monitoring system which also monitors the lubricant status. If the system detects parameters which are approaching a critical level, it sends a signal to the lubricating system which triggers relubrication. The FAG Concept 8 lubricant dispenser, which was presented at the Hannover Messe in 2013, is now in volume production. A new model, FAG Concept 2, has two separately controllable outlets and can therefore dispense different quantities of lubricant.

However, the industry has been aware of monitoring and lubrication for a long time. New for "Industrie 4.0" is an automated message sent back to the system after lubrication stating whether the critical condition has been resolved. If not, an automated procedure can be initiated depending on the programmed strategy. This can range from reducing the rotational speed to analyzing the lubricant. For example, if excessive water content is detected, according to Massa, it is possible that the system could place an automated order for the appropriate seals or, perhaps, in a few years' time, send a production order to a 3-D printer.

Condition monitoring saves hard cash

Massa also highlights innovative business models as an important new feature in the preparation for "Industrie 4.0" as close networking urgently requires an exchange of information between producers, machine



Data from more than 4,000 measurement points are already being collected at Schaeffler's site in Herzogenrath. They are continuously analyzed by qualified diagnosticians.

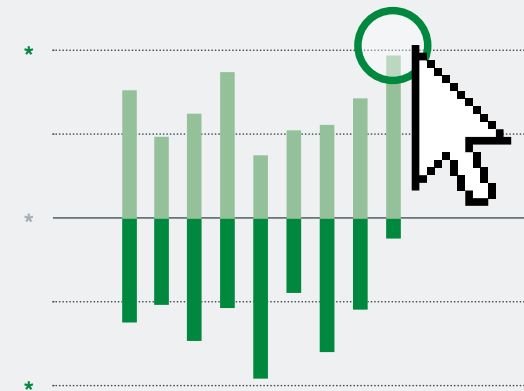
manufacturers, sellers and maintenance providers. Such an exchange of information could lead to rolling bearing manufacturers being able to offer machinery operators not only bearing solutions but monitoring, diagnostic and service packages as well.

This type of co-operative working is a reality. Schaeffler is already operating so-called Online-Monitoring Centers (OMC) in Herzogenrath near Aachen (Germany), Adelaide in Australia and Danbury (USA). At these sites, Schaeffler employees review condition monitoring data from machinery and equipment under service contracts and take appropriate measures when deviations from nominal values occur. Customers include not only companies from the manufacturing sector but also operators of wind turbines, oil rigs, refineries and even shipping lines. The latter uses the data from monitoring ships' drive technology, as supplied by the Schaeffler OMC, to

plan routes and stopovers for maintenance in dry dock. Away from "Industrie 4.0", Massa also highlights an example where targeted condition monitoring is increasing availability and saving money in the steel industry. An on-line system using FAG components has been used for some time now at ThyssenKrupp Stahl's cold rolling mill in Dortmund to monitor the pinion gear transmission and recognize surface defects. Measured data are sent to a master control center by remote access and these data are then assessed worldwide. Material damage such as scratches and the associated depreciation in coil value have reduced considerably since this system was introduced. And repair costs when replacing a roll on a planned basis are 10,000 euros less than for an unplanned failure so the total investment of 63,000 euros for the condition monitoring system paid for itself within the first three months by detecting three defects.



ABOVE AVERAGE



Each individual vibration can be assessed by the SmartCheck software.

The physical structure of the FAG SmartCheck is based on a piezoelectric sensor. It is a ceramic which creates a very small change in electrical voltage when it compresses or expands. This provides precise information on the magnitude of the distance covered or, for SmartCheck, how true a shaft is really running in a bearing. If deviations from the ideal rotational movement occur, this can be linked directly to the current machine loading. Experts call this “selective vibration analysis” as it is possible to recognize more than just deviations from a mean value which is the case in conventional vibration monitoring.

PRETTY SMART

Industrial equipment is becoming increasingly more complex. Conditioning monitoring of bearings and machines was often considered to be an expensive option. The fact that assumptions such as these are less frequent now is due in no small part to the FAG SmartCheck on-line monitoring system, a compact, modular on-line measuring system for continuous, local monitoring of machines and process parameters.

Installation and setup require little or no knowledge of vibration analysis

despite the multiple analysis options available in its delivered condition. The FAG SmartCheck can run from its default settings and the measuring system can also satisfy a range of more complex demands.

Three stages are available which provide the users with security for their investment and make technological changes a thing of the past. Individual components are monitored locally in the first stage. If the user selects the second stage, the device is intelligently integrated into the machine control system. The third stage facilitates integration into more complex applications. Support services are available for all three stages. Service options include remote access via an internet connection as well as technical support.

According to Diethelm Schüller, Conditioning Monitoring Product Manager at Schaeffler’s Industrial Aftermarket Division, “The FAG SmartCheck has become one of the few solutions on the market which can operate as a one-off monitoring system for smaller, redundant components as well as an integrated, all-encompassing monitoring solution.” Since the introduction of the FAG

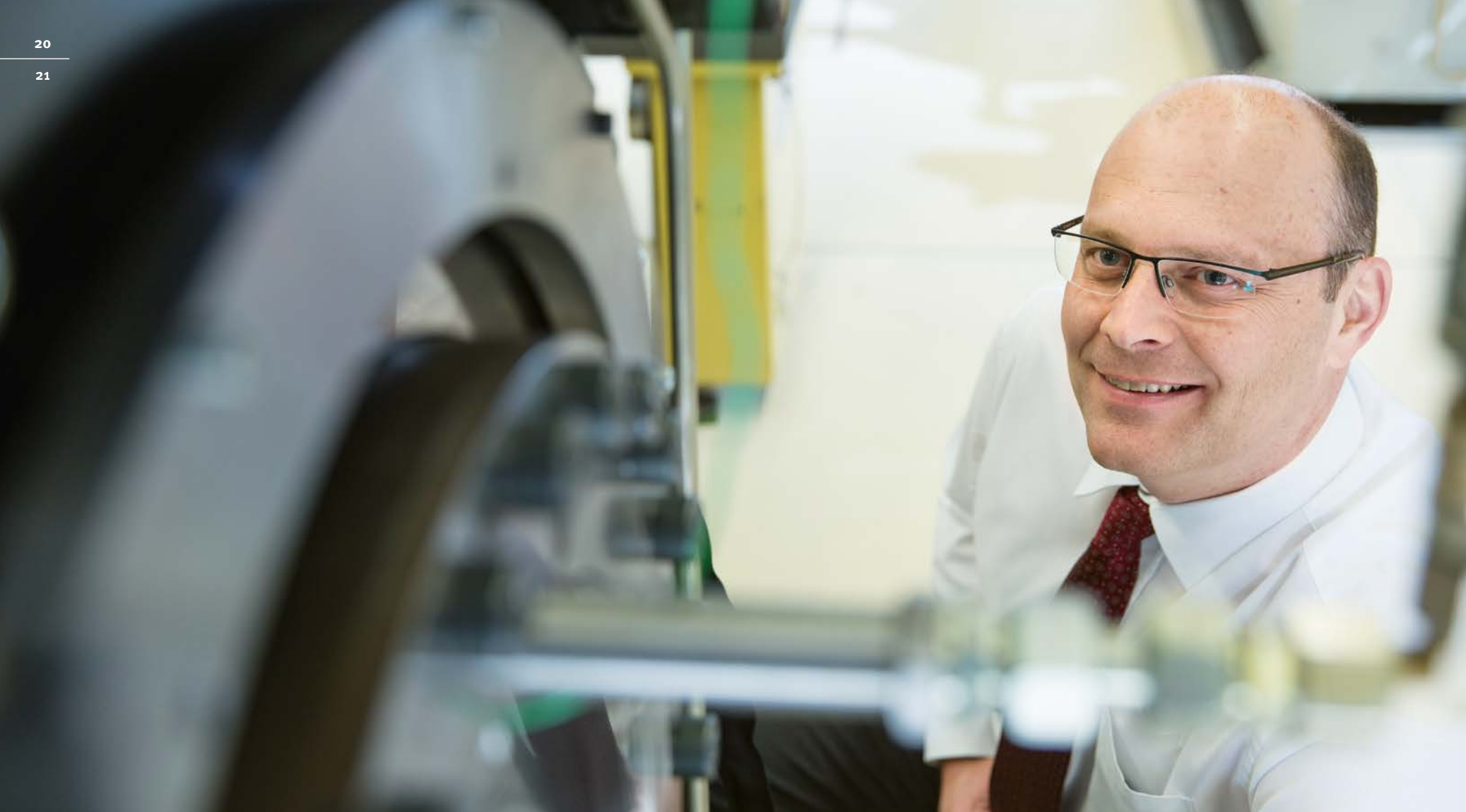
SmartCheck in 2011, these options are now being used in a growing number of applications across all industrial sectors. Special applications such as monitoring cable cars, loading cranes at container ports and rescue cruisers are amongst Schaeffler’s current reference sites as well as on-line vibration monitoring of vacuum

pumps from Oerlikon Leybold Vacuum GmbH. In order to make measured data accessible from a central point, the FAG SmartCheck has been connected directly to the Oerlikon Leybold network. Data can then be easily downloaded from the network and sent to Schaeffler for analysis.

PARTNERSHIP FOR INTELLIGENT AUTOMATION

The FAG SmartCheck is an important part on the road to “Industrie 4.0” for Schaeffler, particularly as regards the company’s involvement in Mitsubishi Electric Europe’s e-F@ctory Alliance which is creating an opportunity for Schaeffler’s engineers to apply their solutions to automation and process control systems. The joint e-F@ctory partnership projects allow the Mitsubishi electronic control system to be combined with the FAG SmartCheck to provide a complete, ready-made solution for customers. Automated connection generates a total solution for assessing the condition of machines and equipment.





» ***The fact that our employees think outside the box and are allowed to take a broader view is an important part of Schaeffler's corporate DNA. Structured processes with maturity criteria for each milestone subsequently ensure that ideas are turned into marketable products.***

Peter Schuster,
Vice President Advance Development
at Schaeffler Industrial

THINKING OUTSIDE THE BOX

Schaeffler's innovative force is based on the creativity of its employees and a corporate culture that promotes and encourages new ideas. This is how basic technologies such as the torque sensor bearing are created that makes e-bikes more comfortable and improves productivity in the agricultural industry.

— by Stefan Schlott

“People who deal with innovation know that Thomas A. Edison was right,” sighs Peter Schuster, thinking of the quote in which Edison says genius is one percent inspiration, 99 percent perspiration. These 99 percent involve time, strength and sometimes good nerves. And Schuster should know. With three coworkers, he formed the core of the Advance Development department at Schaeffler's Industrial division ten years ago. This is precisely the department that develops specific technologies based on new ideas until these technologies are mature enough to be passed on to product development.

Advance development has now developed into a team of 35 specialists under the management of Schuster. The creative ideas for new technologies arise in various ways, though mostly away from people's desks. The process often begins at conferences, trade shows or by simply talking to coworkers and customers. And – this

is particularly important to Schuster – “with our company philosophy of thinking outside the box”. Schuster says it's important to give employees enough space to work on an issue: “That's how a ‘baby’ is created – and that's where the perspiration begins.”

However, before the process starts one wonders how all the ideas from 35 such creative minds in Advance Development at Schaeffler can be channeled in such a way so that subsequent development results are suitable for the portfolio and ideally facilitate synergies. Dirk Spindler, Senior Vice President of Research and Development at Schaeffler Industrial describes this as a top down process. The initial basis for this process is the definition with which innovation is equated with commercial success by means of actively sought improvements. To ensure this happens, first of all Schaeffler derives relevant sector-specific trends from global social and technological megatrends. These then form the

basis for fields of action that are examined from all angles during creativity workshops. Specific planned innovations usually then come about by themselves. A Technology Board at the Industrial division, of which the directors of the business units and Spindler are members, supports these innovations from the initial idea up to production readiness.

Smart and networked products for "Industrie 4.0"

Putting Schaeffler's "Mobility for tomorrow" strategy concept into practice using forward looking mobility solutions is at the heart of development activities, according to Spindler. Among others, the "Industrie 4.0" initiative is an important technological driver in products and solutions. "Additional functions and intelligence in rolling bearings are the basis for networked and intelligent processes on the path towards 'Industrie 4.0'," says Dirk Spindler.

What form such an innovation project can take in practice is demonstrated by Schaeffler's innovative torque sensor. As an alternative to previously available technology for measuring the torque on shafts, Schuster and his coworkers derived a mechatronic solution that records the torque in exactly the place where it is applied. The process, called "inverse magnetostriction", involves measuring the outer magnetic field of the shaft and converting it into a torque signal. The engineers at Advance Development soon worked on equipping bottom brackets, one of FAG's oldest products, with the innovative torque sensors. The focus here wasn't really on bicycles, but rather on ergometers in medical and rehabilitation applications. Since sensor bottom brackets detect the total torque from the sum of pedal force on the left and right pedal, this would allow the load carrying capacity of each leg to be determined individually after knee operations, so the idea.

It's thanks to chance that these bottom brackets with added functions didn't just end up in the niche market of medical ergometers. At the same time as the bottom

bracket was being developed, the rapidly-growing market for e-bikes opened up at the beginning of the millennium and with it the requirement for a sensor system that detects the rider's need for motor assistance and converts this into a relevant control signal. The adaptations required were carried out quickly and the torque sensor bottom bracket has become so popular since 2010 that a second revised and improved generation is about to be launched on the market.

The innovation process ends for Spindler when Advance Development has produced a functional piece of technology. It is then passed on to volume-production development who is responsible for producing a design suitable for manufacturing and finding suitable suppliers and processes. The final stage of the development process involves application engineering who provides market information as well as ideas for possible applications. During this process, requirements stipulate that new applications must be possible without major changes to the basic technology.

From bottom bracket bearings in pedelecs to sensor modules for agricultural machines

It's thanks to application engineers that the story of torque sensors in bearings didn't end in bicycle bottom brackets. It has now developed into a torque measuring module with sensors that can be adapted to a very wide range of geometries. One of the first applications for this sensor technology is in agricultural engineering in manure and fertilizer spreaders where it ensures the fertilizer is distributed evenly using torque control, thus ensuring precise and safe fertilizing.

Turning products into ideas and watching things come into being is what makes advance development so exciting for Peter Schuster. In moments such as these, the 99 percent perspiration from Edison's quote also takes a back seat. So it's understandable that Schuster and his team are already looking forward to Schaeffler's next "Forum of Inspiration". During this event, which is similar to an in-house trade show, Schaeffler inventors present their newest ideas to each other and thus motivate each other. Schuster calls this an "institutionalization of inspiration".

Dirk Spindler is also looking forward to seeing what's going to be on display. In order to be innovative, according to Spindler, people need to keep their natural curiosity and be able to look up to ten years ahead.

INNOVATION IN FIGURES



5%

... of sales is invested by Schaeffler every year in research and development. Ten to twelve percent of this is made available for future topics in the form of projects from Advance Development.



16

... is the number of development centers Schaeffler has worldwide in all important markets, thus ensuring that innovations take regional requirements into consideration.



6,000

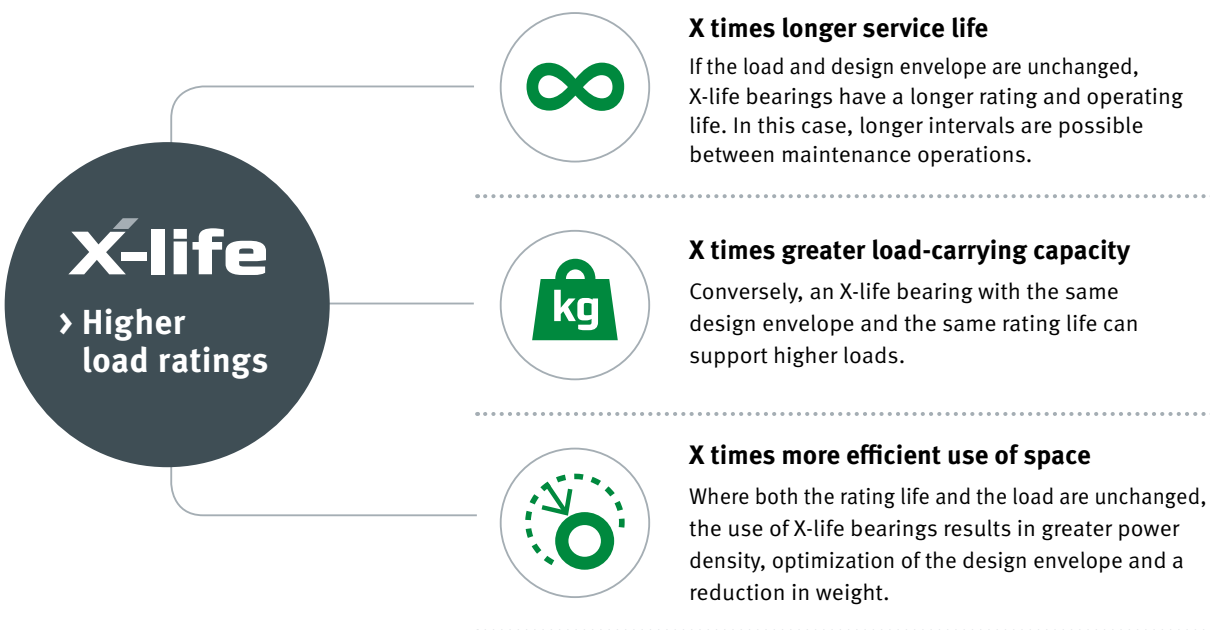
... Schaeffler employees work in development and are already making sure that the company will be offering the right products and solutions in the future. The obligation to think outside the box during this process doesn't just exist on paper – it forms a part of personal target agreements.



LONGER LIFE

Moving parts in industrial plants and machines often have to fulfill extreme demands in terms of load carrying capacity and durability. Rolling and plain bearings play a central role here, since bearing damage causes the total failure of technical systems in most cases. This is why Schaeffler has developed high-quality rolling bearings with the X-life seal of quality, which contribute to achieving a high level of cost-effectiveness and productive use of resources.

What does X-life stand for?



What does the load rating describe?

The load rating is the measurement of the force or load that a machine element can support. If this is exceeded under permanent load, the element (e.g. a rolling bearing) may prematurely suffer permanent damage. While the static load rating is based on a static machine element, the dynamic load rating describes the load limit of a machine element in motion, e.g. a rotating bearing.



Toroidal roller bearings

Toroidal roller bearings (TORB) are rolling bearings in X-life quality that feature an angular adjustment facility. They are capable of compensating for large changes in axial length between the raceways and the rolling elements, and the load is always symmetrically distributed over the roller rows in the bearing system. This produces a very high radial load carrying capacity.



Tapered roller bearings

Tapered roller bearings in X-life quality have a load carrying capacity that is up to 20 percent higher and thus a rating life that is up to 70 percent longer. The improved surfaces and the optimized geometry mean that a lubricant film that reduces wear and friction is formed more quickly.



Linear guidance systems

The KUVE-B-HS linear recirculating ball bearing and guideway assembly in X-life quality is suitable for use in the linear guidance of high-speed machine elements. The recirculation geometry is designed in such a way that the rolling elements are in even contact with the external contour. This increases the operating life by 30 percent compared to competitors' products.

The consistent further development of rolling and plain bearings offers significant potential in terms of the functionality, cost-effectiveness, and reliability of industrial applications. After all, the total operating life of a plant is dependent to a large extent on the reliability of the bearings. Schaeffler's FAG and INA brands offer bearings with the X-life seal of quality that deliver outstanding performance. Because these products have a higher dynamic load rating than the previous standard, their rating and operating life is significantly longer. This feature can alternatively be utilized as a way of increasing the load carrying capacity or reducing the size of the design envelope.

Exceptionally even surfaces and optimized internal geometry

The high performance of X-life bearings is down to the manufacturing technology used. The surfaces that serve as the contact surface between the rolling elements and the raceway are manufactured to be especially even, and the internal geometry ensures that the contact surfaces

are optimally positioned in relation to one another and the loads inside the bearing are distributed evenly. As a result, there is a reduction in the stress conditions present on the rolling elements and mating track under identical load. This produces a higher dynamic load rating and thus a longer rating life, less friction, lower bearing temperatures, and a reduction in the strain placed on the lubricant.

The higher load rating can be translated into a range of product characteristics, depending on the application. The rolling and plain bearings can also be designed in such a way that they can support significantly higher loads while maintaining the same rating life. Alternatively, the increased power density can be used to create a smaller component with the same characteristics – when a construction machine only has a small amount of space available for the installation of a spherical roller bearing, for example. The INA and FAG brands are continuously expanding their portfolio through the addition of new X-life bearings with optimized performance characteristics in order to fulfill customers' requirements and increase the cost-effectiveness of machines and equipment.



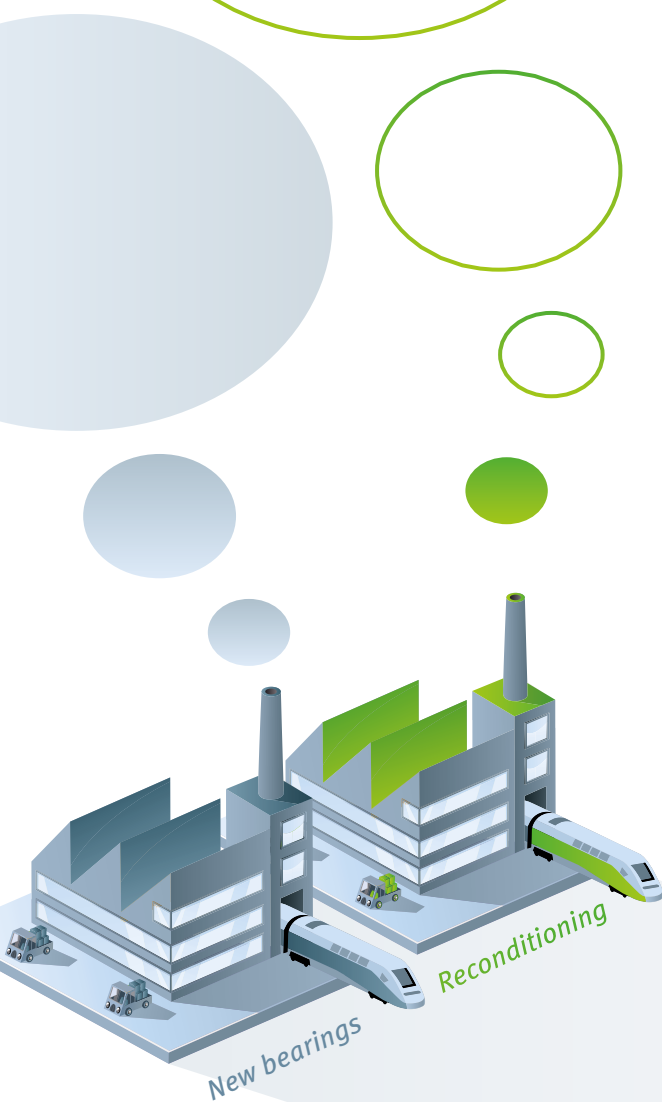
LASTING VALUES

Used rolling bearings don't necessarily have to end up on the scrap heap. In the hands of skilled experts, professional reconditioning methods enable components to be produced that are no way inferior to new parts in terms of function and operational strength.

— by Johannes Winterhagen

Axlebox bearings for rail vehicles: Reconditioning vs. fabrication of new bearings

97%
lower CO₂
emissions



Source: LCA according to ISO 14044

Frank Stern carefully strokes the surface of the steel. He's wearing gloves and magnifying spectacles similar to the ones dentists wear for root canal treatments. Stern is also working on a restoration, although his "patient" is a large rolling bearing and his "practice" is Schaeffler's manufacturing plant in Wuppertal that specializes in large-size bearings. The plant not only manufactures new bearings for gigantic mining vehicles, wind turbines and other types of large technical equipment, it also carries out industrial reconditioning of such bearings.

"Industrial reconditioning involves maintenance and repair using the same processes and the same level of professionalism as with manufacturing a new component," explains Reinhold Daft, who is responsible for the reconditioning of large-size bearings at Schaeffler. Reconditioning begins by disassembling and cleaning the bearing. The subsequent visual inspection of the raceways by experienced experts is an important step in the process. This is because it is only possible to put the bearings back into operation if the wear that has occurred is within defined limits. Ultrasound testing can also be performed on request to provide information about the internal material structure of the bearing. The results of the analysis are recorded in detail in a database. "This enables us to learn a great deal for new products," says Daft.

The raceways are either polished or ground, depending on the condition. If the latter is necessary, new rolling elements have to be manufactured, since the inside diameter of the bearing increases slightly during grinding. The rolling elements are manufactured on the same machines used during "normal" manufacturing. After assembly, reconditioned bearings are cleaned again, greased and professionally packed for transport. They not only look like new components but, like new parts, also receive a warranty.

Schaeffler also reconditions smaller industrial bearings at its location in Schweinfurt. Axlebox bearings for rail vehicles are particularly good business for Schaeffler, because they are dismantled and sent for reconditioning by many railway operators at fixed maintenance intervals, for example after one million kilometers. Assessing and reworking these components that are extremely critical to safety also requires high levels of expertise. However, in this case, reconditioning is performed on a partially-automated production line due to the large volume of parts involved. "Reconditioning is performed with a similar industrial approach as the one used for manufacturing new components," says Kurt Baumgärtner,

who is responsible for reconditioning industrial bearings with a diameter of up to 50 centimeters. The raceways of smaller bearings are not ground and damaged parts that cannot be saved by polishing are rejected.

Reconditioning axlebox bearings not only serves to increase the already high standards of safety in railway vehicles, it also contributes towards protecting the environment. In 2014, Schaeffler commissioned a lifecycle assessment in accordance with international standard ISO 14044. The result: In terms of CO₂ equivalents, reconditioning improves the carbon footprint by around 97 percent compared with that of new components. In absolute terms, this means the CO₂ emissions are cut by 221 kilos, which is equivalent to those of a flight from Hamburg to London, for each single axlebox bearing. At the same time, the amount of water needed per axlebox bearing is reduced by around 2000 liters. This simple rule applies in most cases – the larger the bearing, the more likely it is that reconditioning will be worthwhile. This is due to the great amount of material required by large bearings. The biggest bearing received for rework in Wuppertal weighed an impressive 28 tons and had a diameter of five and a half meters.

The bearings delivered to Wuppertal or Schweinfurt don't always sport the logo of Schaeffler brands INA and FAG. Schaeffler's service is generally available independent of manufacturer for all industrial bearings installed globally and it doesn't end when parts leave the plant in Schweinfurt or Wuppertal. "Our global presence and the

flexibility of our experts is a decisive competitive advantage for us," says Daft. Schaeffler can even offer mobile reconditioning services, as was the case for the roller grinding mill in a gold mine in Kazakhstan.

The flexibility of the employees is especially important when a job needs to get done quickly if no spare parts are available for an industrial plant. Daft remembers a case where a bearing for a fan in a power station cooling tower had to be reconditioned – literally overnight. Without the cooling system, the entire power station unit could not be operated. "It began at 5.30 pm with a call from the customer who said he heard strange noises coming from the cooling tower." The defective bearing was delivered by truck at 9.30 pm and Schaeffler was able to send the reconditioned bearing back as early as the next day.

Baumgärtner and Daft ensure that Schaeffler provides industrial bearing reconditioning in increasing numbers of regions across the globe. Specially-trained experts are already at work in manufacturing plants in Russia, China, Australia, Great Britain and the USA. "China is still a classic example of a market for new parts at the moment," says Baumgärtner. "However, we are noticing a change of opinion here, due to efforts being made to improve the safeguarding of resources." Discussions are currently taking place about industrial reconditioning in several other regions. The experts required often receive training in Schaeffler's main plants. This means it's likely that Frank Stern is not only checking raceways at the moment, but also the expertise of a colleague from China. —



AS GOOD AS NEW

The cost effectiveness of reconditioning for customers depends on the bearing type and its size. In some cases, reconditioning cuts the total cost of ownership by up to 85 percent. It is also worthwhile even if the reduction is considerably lower. Cost effective and better for the environment: Compared with new parts, reconditioning axlebox bearings for rail vehicles cuts CO₂ emissions by up to 97 percent.

mobility

People need mobility but also an unpolluted environment

FAST AND EFFICIENT MOBILITY FOR TOMORROW

— Whether an express train through Japan or an e-bike through the city: Modern mobility has many different faces. There is not one single solution as customer requirements vary considerably depending on the market. Whatever the mode of transport, Schaeffler is almost always involved and not only takes care of safety but also provides sustainable mobility. Making the best possible use of energy therefore demands drive systems with a high degree of mechanical efficiency. —

CYCLING MADE EASY

Bicycles are used in many different ways these days. Some people ride their bike to get from A to B, others as a leisure activity, a health exercise or as their choice of sport. But not everyone rides their bike in an optimal fashion – cyclists who don't like to shift gears pedal too much, get tired faster and use up too much battery power. With its FAG Velomatic, Schaeffler has developed an automatic bicycle gearshift system that changes gears at the right time, making it easier to ride your bike.

— by Dr. Laurin Paschek



When Karl Drais, a forest officer, presented his “running machine” in 1817, he had created the first individualized means of transportation since animals had been used for riding on. The reason for his invention was simple: Following several bad harvests, the price of oats had skyrocketed, and Drais was looking for an alternative to horses. Philipp Moritz Fischer, father of FAG founder Friedrich Fischer, further developed Drais’ machine into a bicycle with a foot pedal in 1853 that became highly successful. Today, bicycles are used in many different ways: Some people continue to use it for transportation, particularly in urban areas and more and more frequently in combination with an electric drive. Others see their bicycles as sports equipment that they use for fun or exercise. And there are people who are concerned about their health and ride their bike to stay fit.

A powerful combination: Automatic gearshifts in pedelecs

Since cyclists’ demands vary so much, Schaeffler has developed an automatic bicycle gearshift system called “FAG Velomatic”. One of the special features of this automatic system is that it can be configured as needed: It was developed based on open standards, making it work with any bicycle type and nearly any drive system. Due to its compact design, it can be installed in the seat post or frame of both a conventional bicycle with a derailleur or internal gear hub and a pedelec.

The automatic gearshift system demonstrates its strength particularly in the pedelec. Here, the electric motor drives a spindle via the clutch and transmission that is supported by a radial deep groove ball bearing. The spindle nut supports the gear cable; its position corresponds to the gearshift points of the bicycle’s internal gear hub. A communication module establishes the connection between the pedelec controls and the Velomatic electronic control unit. This electronic control unit contains the intelligence of the system: To provide cyclists with the best possible support, a sensor initially records the acceleration and the incline of the road. Based on the speed reported by the pedelec controls or recorded by a separate sensor, the electronic control unit uses special shifting algorithms to calculate the right gear and the optimum time for shifting gears.

During the actual shifting operation, a major problem has been that the electric motor was continually running at full power. This leads to uncomfortable jerky

shifting as well as to increased wear on the bicycle gearshift system. To avoid such disadvantages, the electronic control unit of the Velomatic informs the pedelec controls before a planned shifting operation, so that motor power is reduced. This makes the shifting operation smooth and quiet; cyclists' pedaling is no longer interrupted and there is less wear on bicycle gearshift system. Manual shifting is replaced completely; however, if cyclists with athletic ambitions would like to shift gears manually, they can use a separate, electric gearshift module in the form of a hold-to-run switch to change from automatic mode to manual mode.

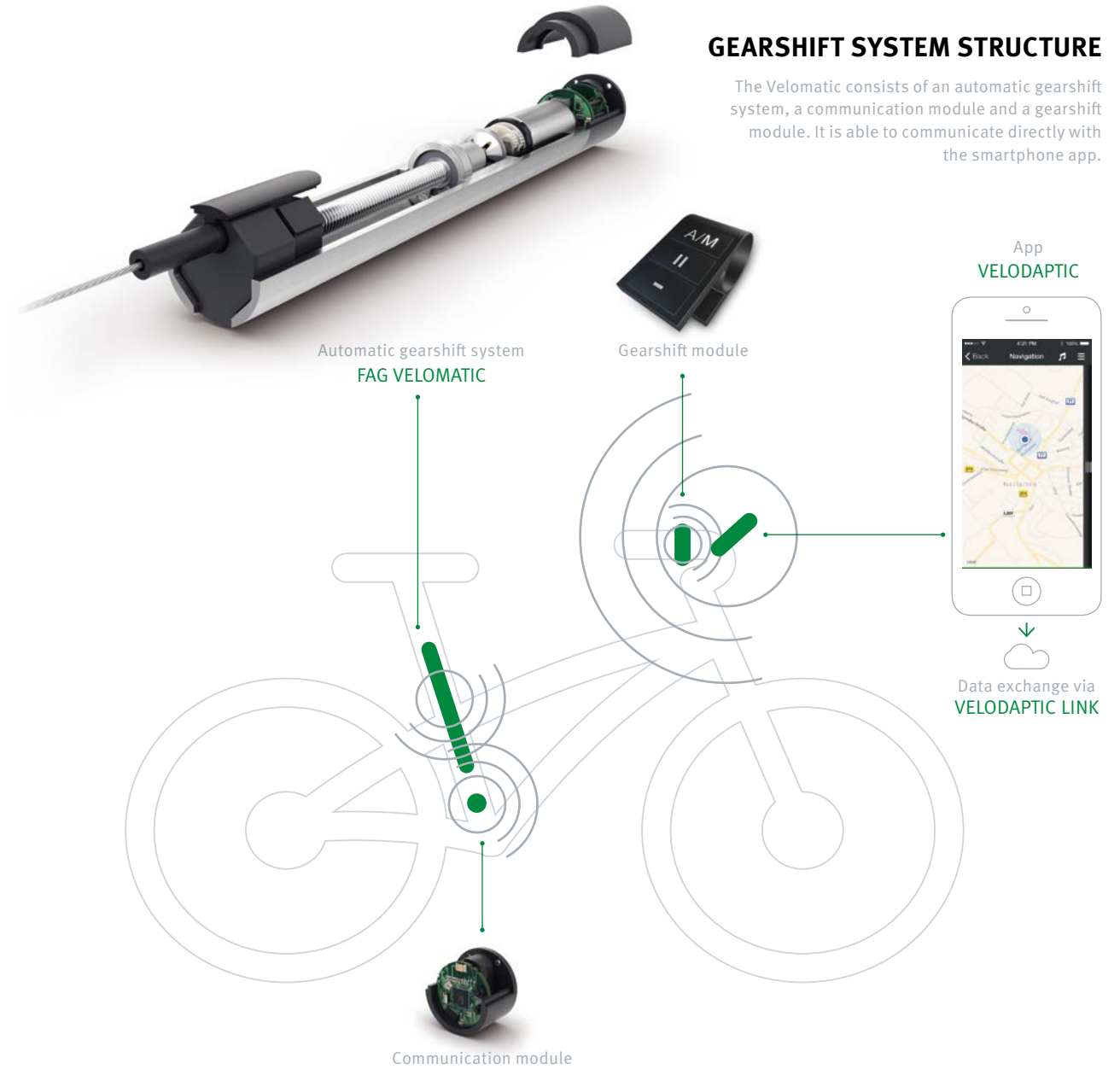
Via the communication module, the system is not only connected to the drive and the gearshift module, but also to a special app. This app is called "Velodaptic" and starts by analyzing all motion data, such as the speed, cadence and torque, as well as data relating to distance, position and topography. Cyclists can

use these data to analyze the route, differences in elevation, speed and personal calorie consumption. Based on these analyses, cyclists can use the app to generate customized shifting programs for their personal needs and activity values. The communication module is designed so that it will be able to exchange information with other Schaeffler components in future, such as with sensor bearings in the pedals that directly measure the force applied by the cyclist.

In this way, FAG Velomatic not only makes it more fun to ride a bicycle, it also offers a triple gain in efficiency. Its personalized coordination is easy on the battery and ensures a greater reach because the drive always operates at the optimum working point. In addition, it prevents early wear of the bicycle chain and gearshift system. And last but not least, it also makes it easier to ride a bike over longer distances because cyclists have to use less strength.

GEARSHIFT SYSTEM STRUCTURE

The Velomatic consists of an automatic gearshift system, a communication module and a gearshift module. It is able to communicate directly with the smartphone app.



AN AUTOMATIC GEARSHIFT SYSTEM FOR TOMORROW'S CYCLING:

Intelligent	Precise	Efficient	Flexible
Sensors record cadence, force, speed and topography	Fast and accurate gear shifting	Personalized coordination is easy on the battery	Suitable for conventional bicycles and for pedelecs
Special algorithms calculate the right gears and optimal shifting operation	Shifting without noticeable transitions	Intelligent control system reduces wear	Can be used with derailleurs and internal gear hubs
	Avoiding shifting errors	More endurance over longer distances	Compact design

Automatic gearshift system FAG VELOMATIC

The basic system consists of the actual automatic gearshift system and a communication module. Due to its compact design, the gearshift system can fit into the seat post or the frame of the bicycle.

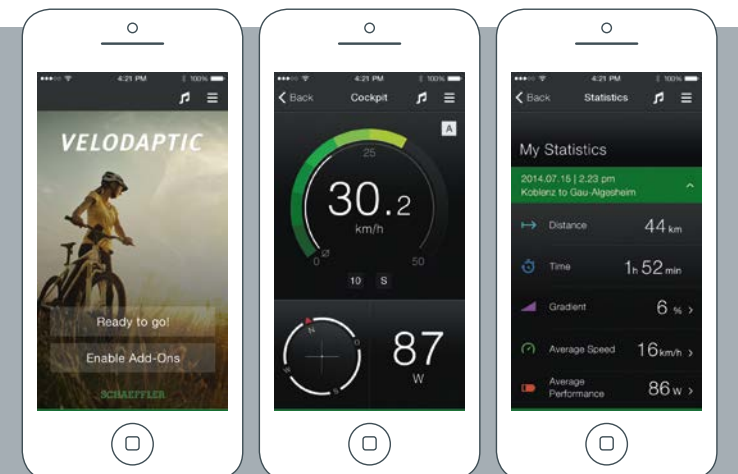
The communication module connects the electronic control system of the Velomatic with the pedelec control system.

Gearshift module

The separate electric gearshift module is the ideal complement for all athletic cyclists. It is also integrated through the communication module. Cyclists can use a hold-to-run switch to change from automatic mode to manual mode, which allows them to do the shifting themselves for more athletic cycling.

App VELODAPTIC

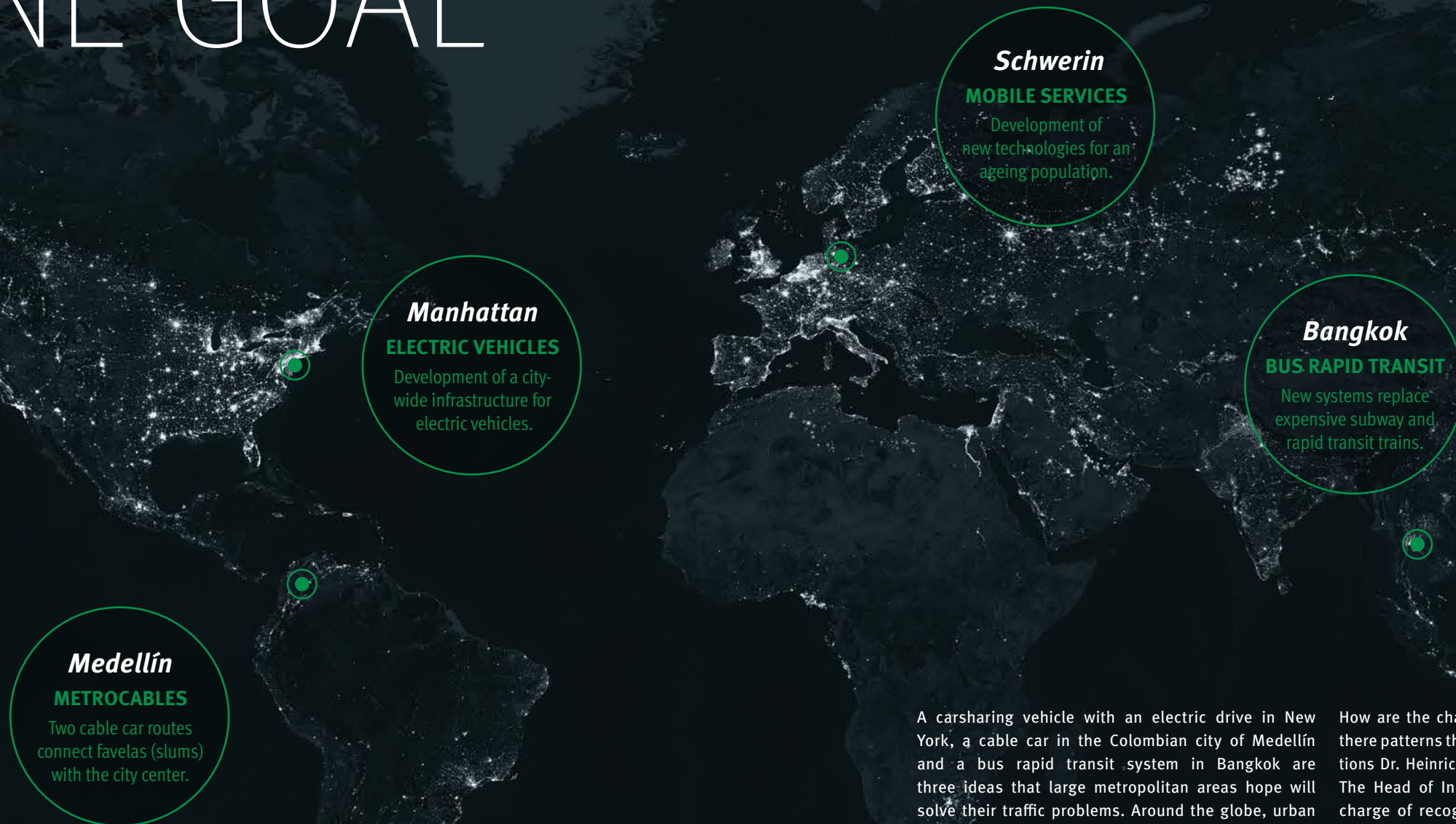
The Velomatic does not require a special display. It can communicate directly with any smartphone. This lets cyclists analyze their personal data, such as the distance traveled, differences in elevation, speed and calories burned. This can then be used to generate customized shifting programs.



MANY WAYS, ONE GOAL

The Schaeffler mobility study shows that while the forms of transportation continue to increase, energy efficiency and environmental sustainability are becoming dominant development goals everywhere.

— by Johannes Winterhagen



Schwerin

MOBILE SERVICES

Development of new technologies for an ageing population.

Manhattan

ELECTRIC VEHICLES

Development of a city-wide infrastructure for electric vehicles.

Medellín

METROCABLES

Two cable car routes connect favelas (slums) with the city center.

Bangkok

BUS RAPID TRANSIT

New systems replace expensive subway and rapid transit trains.

A carsharing vehicle with an electric drive in New York, a cable car in the Colombian city of Medellín and a bus rapid transit system in Bangkok are three ideas that large metropolitan areas hope will solve their traffic problems. Around the globe, urban centers are struggling to cope with ever increasing traffic. After all, demand for mobility and the availability of mobility correlate with economic development.

But the old adage that the more affluent the city, the more congested the roads does not apply here. While drivers in Singapore reach an average speed of 17 mph (27 km/h) even in rush hour traffic, it is only 7 mph (11 km/h) in the equally wealthy city of Tokyo.

How are the challenges in each region different? Are there patterns that apply to each? Those were the questions Dr. Heinrich Schäperkötter set out to investigate. The Head of Innovation Strategy at Schaeffler is in charge of recognizing basic trends, analyzing their significance for the company and initiating appropriate innovation projects.

He worked with internal and external experts for two years on a study dealing with mobility of the future. "We initially looked at how and where people live and work," Schäperkötter says. "When you do that, you find a wide variety of mobility patterns all over the world."

The authors of the study performed an in-depth analysis of a dozen regions worldwide that ranged from the sparsely populated German state of Mecklenburg-Vorpommern (180 people per square mile or 69 people per square kilometer) to Manhattan (70,239 people per square mile or 27,000 people per square kilometer). “From the start it was obvious to us that there must be regional differences in mobility patterns,” Schäperkötter said. The study revealed that these patterns can be categorized according to three criteria: 1) the level of urbanization, 2) the economic development status of a region and 3) consumers’ buying power.

Typical patterns in spite of diversity

When applying these criteria to the edges of a dice, this results in a three-dimensional matrix in which each region can be located. Yet Schäperkötter advises caution: “Two regions in the same quadrant can still have considerable differences.” This is because other aspects such as topography must also be considered. The cable car lines that connect downtown Medellín with two unofficial settlements (called favelas) are a good idea only because of the city’s location in a deep valley. “Depending on where people live, an optimum solution probably looks different than what one would expect,” says the Schaeffler expert.

As colorful and varied the mobility trends in each region may be, the analysis does reveal some general trends. The Schaeffler study identifies four “spotlights” that affect mobility on a global scale – as well as the development of new technologies by the company. It is becoming more and more important to consider the emissions balance of the entire energy chain (primary energy, energy transport, energy conversion). The reason for this lies in increased climate protection efforts, which are no longer a purely European phenomenon. “For the political decision makers,” Schäperkötter explains, “the complete production and consumption chain is increasingly becoming their focus.” This includes questions such as how electricity for alternative vehicle drives is generated.

For mobile people, however, CO₂ balances are less important than time and costs, which is particularly true for urban traffic. “People are going to develop very pragmatic ideas of mobility, especially in cities outside of the industrialized countries,” Schäperkötter predicts. He believes that intermodal traffic, which refers



75%

Percentage by which aircraft should reduce their CO₂ emissions by 2050, as demanded by the EU Commission.



7,000,000

charging stations for electric vehicles

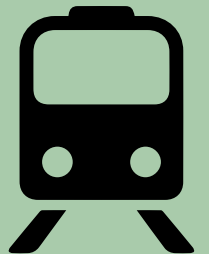
are to be installed in Europe by 2030.



20,000

kilometers

Length the Chinese railway network is expected to have in 2020. This will help to reduce the strong growth in air traffic.



2.5 BILLION

Number of cars worldwide in 2050, as forecast by Shell – there are currently around 900 million.



to alternating between different modes of transport, will be the normal procedure of the future. For Schaeffler, this trend also represents an opportunity because no matter what means of urban transport people choose and how many times they change transport, Schaeffler will be on board in cars, electric bikes and of course subways. The company supplies axlebox bearings for the driverless cars used in the Nuremberg subway.

In inter-urban traffic, time efficiency is becoming increasingly important. "Mobility between large metropolitan regions is characterized primarily by economic elites," Schäperkötter explains. Depending on the distance to be traveled, either high-speed trains or airplanes are the transport of choice. Both means of transportation use Schaeffler engineering in places that are not readily visible, such as in the modern wide-body aircraft Airbus A380, which only uses 3.3 liters of kerosene per person and per 100 kilometers. The precision engine components developed by Schaeffler's Aerospace division also play their part here.

Energy-efficient drives become a factor for success

Regardless whether it is on land, on water or in the air: Energy efficiency is becoming an important factor in the success of drives for all modes of transport. A priority of all Schaeffler engineers is to design all components and systems so as to minimize loss – such as by using low-friction rolling bearings. But we are also developing completely new drive systems," says Schäperkötter, referring to the wheel hub drive for electric vehicles. Here, electric motors and their controls are installed in the wheels of the car, which allows extremely agile urban vehicles with large interior space and small outside dimensions. Such cars can do entirely without an engine compartment. In cities with a large population and traffic density, small space requirements and low emissions are the most important requirements for well-functioning mobility.

"We are not going to have a solution that covers all mobility needs either tomorrow or the day after tomorrow," says Schäperkötter. Nonetheless the Schaeffler study has shown that the great variety offers great opportunities – for mobility, for the environment and for the company. —

TRENDS

INTERURBAN MOBILITY

Mobility is becoming increasingly regulated. At the same time, passengers have increased requirements with regard to comfort and journey times.



NEW MOBILITY CONCEPTS FOR THE CITY

Densely developed urban centers require close links between individual modes of transport (intermodal transport).



ANALYSIS OF THE ENTIRE ENERGY CHAIN

An analysis of the entire energy chain is increasingly carried out when introducing and monitoring climate protection targets. This promotes the use of renewable energies.



ECO-FRIENDLY DRIVES

Eco-friendly drives, which make particularly economical use of the available energy, are becoming established in all modes of transport.



SOLUTIONS



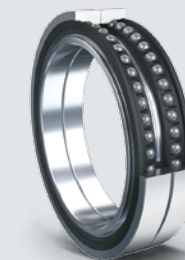
Aircraft engine bearings

Low-friction steel-ceramic bearings ensure low fuel consumption and a high level of safety in aircraft engines.



Axlebox bearings

Autonomous subway and metro trains require axlebox bearings with a particularly high level of safety.



Water-lubricated bearings

Ocean current and tidal power plants with water-lubricated bearings from Schaeffler are helping to ensure a sustainable power supply.



Wheel hub drive

The motors are located in the wheels of the wheel hub drive. The first Schaeffler prototypes for the electric car of the future already exist.

efficiency

The efficient use of resources benefits the economy and ecology

UPTURN WEALTH THROUGH EFFICIENCY

— *Humankind is growing – and, fortunately, so is the standard of living in many countries. In order to protect limited natural resources, a move to renewable energy is in full swing. Wind energy has a leading role to play here throughout the world and Schaeffler already has a long history of involvement in this area. However, other areas, such as medical technology, are also planning to achieve more whilst using fewer resources in the future.* —



SIGNIFICANT EXPANSION OF WIND POWER

An increasing number of wind turbines are being installed worldwide. The success of wind power means that the productivity of wind turbines is gaining in importance. Schaeffler is making its contribution by providing reliable components and a comprehensive range of services.

— by Johannes Winterhagen

The wind year 2015 began with a new record. The wind turbines installed in Germany produced 9,776 gigawatt hours of power during January, the largest amount ever produced in a single month. This amount of power is equal to the production of twelve nuclear power plants operated at full power round the clock. The new record is due to the consistent expansion of wind power, which also reached a new record mark in the previous year. According to information from the Germany Engineering Federation VDMA, new wind turbines with a total output of 4.8 gigawatt were installed on shore alone in 2014. This is in addition to the number of new wind turbines installed off shore, which was significantly less than on land. All the offshore wind turbines had a combined output of more than one gigawatt for the first time at the end of 2014.

Germany is proceeding with its energy revolution but it is not the only country in the world in which wind power is being significantly expanded as an economical method of generating green electricity. New wind turbines with a total output of approximately 20 gigawatts were installed in China in 2014 alone. And despite the

natural gas boom in the USA, the expansion of wind power there is equal to the increase in Germany.

The Schaeffler engineer Andreas Mangold laughs when he hears such figures. Not only because he is convinced that renewable energies are the way forward, but also because every new wind turbine is a business opportunity for Schaeffler. This mechanical engineering company has been involved in the wind power sector since the 1980s, when the first large wind turbines were tested in Germany. As Mangold joined Schaeffler ten years ago, the wind power business was already professionalized – and very different from today. “The capacities were smaller and the delivery times were up to 15 months in the boom years.” Today, Schaeffler is a global player, which supplies rolling bearings for rotors as well as the planetary gears and shafts in wind turbine gearboxes. The company not only has manufacturing capacity in China. It also has a team in Anting near Shanghai, which develops wind power components specially for local customers. In the USA and India, large-size bearings are also manufactured for the relevant markets.

The development in the markets has not been uniform: The two-megawatt class dominates internationally with correspondingly high quantities. In contrast, there is a trend towards higher outputs in Europe. For example, the average output of the wind turbines installed in Germany in 2014 was 2.7 megawatts. This means that rotor diameters are increasing: The average is currently 99 meters. In comparison, the Airbus A380 has a wingspan of only 80 meters. However, this is not the end of the line. At the beginning of 2014, the first prototype of an offshore wind turbine from MHI Vestas was put into operation in Denmark. The peak output of eight megawatts is achieved with a rotor diameter of 164 meters.

A decisive difference to the pioneering days is that the power from today's wind turbines must satisfy economic criteria. "The current production costs for generating wind power on land are almost as low as the costs in a modern gas-fired power plant," explains Mangold. There is a trend toward falling electricity prices on the markets worldwide and reduced subsidies in individual markets. This perspective shows that Schaeffler's customers, i.e. wind turbine and gearbox manufacturers, are facing strong, global competition. Therefore, the operating life costs of wind turbines are becoming increasingly important. These are mainly dependent on three factors: the investment costs, overall efficiency and reliability throughout the entire operating life, which must be a minimum of 20 years.

In view of the large quantities of steel that are installed in a wind turbine, it is essential to save material or increase the power density in order to reduce investment costs. For Schaeffler, this primarily means offering solutions which enable downsizing. For example, there is a trend towards direct bearing supports in gearboxes. Schaeffler has developed a high-capacity cylindrical roller bearing for this application. When designing these bearings it is important that the load carrying capacity is ensured under all conditions without "overspecifying" – i.e. installing levels of safety that are unnecessary. In addition to its extensive experience in the wind power business, Schaeffler also uses relevant development tools in the design process. A complete wind turbine including the detailed drive train can therefore be tested using multi-body simulation before the first prototype is built. Schaeffler specialists can subsequently check if their calculations were correct on the large-size bearing test rig "Astraios" in Schweinfurt. "This is a closed development cycle," explains Mangold. The results from the test rig runs and measurement data from the field are used to refine the simulation.

A decisive factor for the economic balance of a wind turbine is the number of achievable operating hours. Downtimes must be prevented. Furthermore, repairs are very expensive, particularly on offshore wind turbines. If a gearbox fails due to bearing damage at sea, the operator will be faced with repair costs of at least one million euros. "Today, reliability is a decisive differentiation criterion for wind turbine manufacturers," says Mangold, "regardless of whether on land or in the sea."

Schaeffler presents modular system of solutions to prevent bearing damage

Wind turbine manufacturers and operators have been concerned for some time by a phenomenon, which is described as white etching cracks (WEC) by engineers. This refers to damage in the bearing raceways, which is not initially visible from the outside and develops under the surface in the form of particularly hard zones. Due to overrolling of the rolling elements, cracks occur between the hard zones and the adjacent material, which spread up to the surface and ultimately destroy it. Schaeffler is the first bearing manufacturer to successfully reproduce WEC damage in extensive test stand runs.

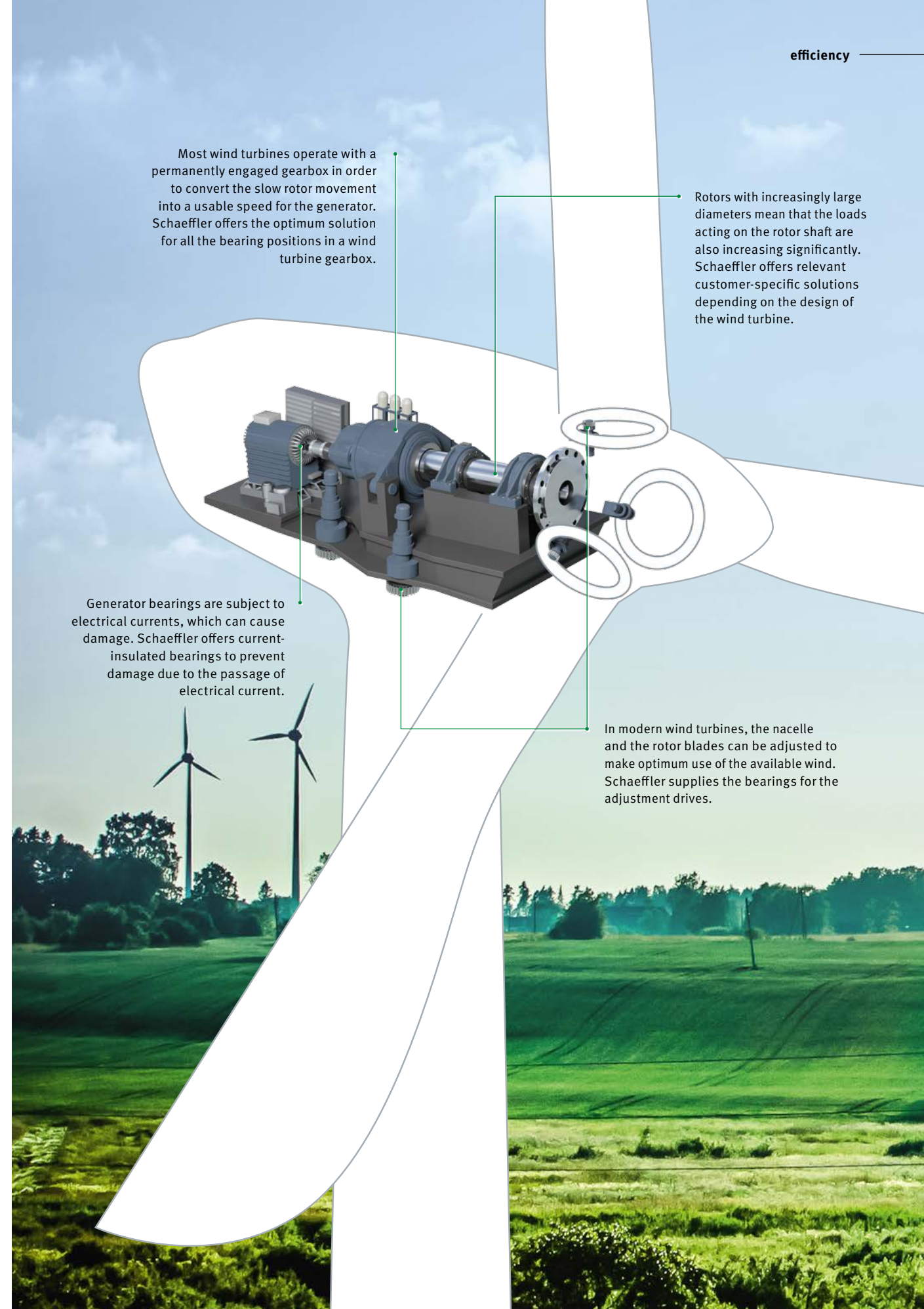
Help is now at hand because Schaeffler will be presenting a modular system of solutions for WEC at the Hannover Messe 2015, which provides three alternatives. The first alternative comprises rolling bearings made of through hardened standard steel coated with "Durotect B", a further development of conventional black oxide finishing. Alternatively, "Mancrodur" carbonitrided case hardening steel can be used. During carbonitriding, the surface of the bearing is enriched with nitrogen and carbon and subsequently hardened. Carbonitrided Mancrodur provides a 25 percent increase in the load rating compared with a standard bearing. These bearings must also be coated with Durotect B in order to make them robust against WEC. The third solution provides the highest level of safety against WEC. Here, Schaeffler uses "Cronidur 30" special steel, which has a high chromium content and is used in the aviation sector. "These bearings are more expensive to manufacture," says Bernhard Köhler, WEC expert at Schaeffler. "But there has not been a single case of WEC either in the bearings that were tested on our test stands or those that we have used in the field during the last four years." In addition, the use of special steel significantly increases the load carrying capacity and anti-corrosion protection.

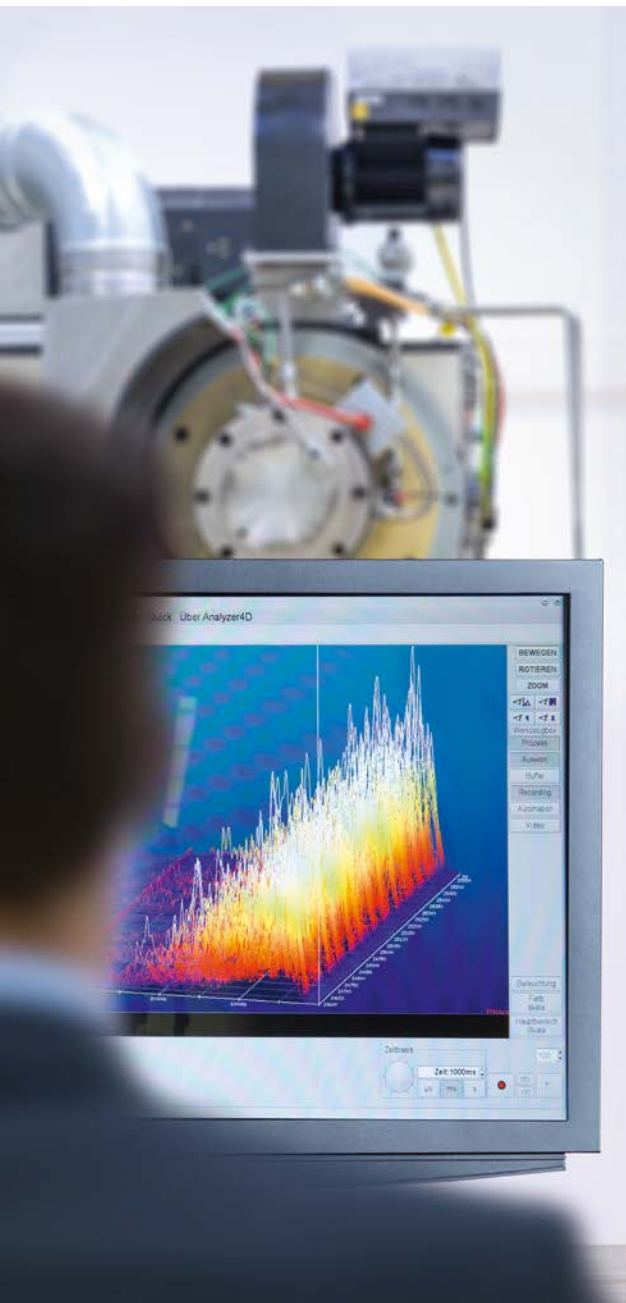
Most wind turbines operate with a permanently engaged gearbox in order to convert the slow rotor movement into a usable speed for the generator. Schaeffler offers the optimum solution for all the bearing positions in a wind turbine gearbox.

Rotors with increasingly large diameters mean that the loads acting on the rotor shaft are also increasing significantly. Schaeffler offers relevant customer-specific solutions depending on the design of the wind turbine.

Generator bearings are subject to electrical currents, which can cause damage. Schaeffler offers current-insulated bearings to prevent damage due to the passage of electrical current.

In modern wind turbines, the nacelle and the rotor blades can be adjusted to make optimum use of the available wind. Schaeffler supplies the bearings for the adjustment drives.





FOR THE SAKE OF OPERATIONAL RELIABILITY

Schaeffler is the first bearing manufacturer to have simulated the feared WEC damage on a FE8 test stand on a reproducible basis.

In order to increase the reliability of wind turbines, it is important to know the condition of the machine elements and plan essential maintenance work in advance. A solution for monitoring the condition of bearing grease is provided by the FAG GreaseCheck, which is based on an infrared sensor only five centimeters long. This sensor allows online measurement of the water content, cloudiness, wear and temperature of the bearing grease and an evaluation of the data, which enables conclusions to be drawn about the condition of the rolling bearings. In the past, it was necessary to take a sample of the lubricant and analyze it offline – a complex method, which was only possible if the machine was shutdown.

“This system is an important part of our condition monitoring range,” explains Torsten Sobek, manager for customer processes at Schaeffler. “But we do a lot more than just monitoring the condition of rolling bearings supplied by Schaeffler. As a partner to operators, we want to make a contribution to reducing life cycle costs as much as possible.” The company therefore operates an online monitoring center in Germany, in which the condition data of wind turbines is monitored. Permanent monitoring indicates damage at an early stage and enables predictive maintenance to be carried out.

Schaeffler also offers a retrofit solution for machines, which are not equipped with systems for electronic condition monitoring ex-works. Local inspections with portable analysis equipment are also part of the range of services. The Schaeffler experts with the special cases are particularly in demand at the end of the five-year warranty period. “We have a fundamental understanding of systems for all bearing-based mechanical components from the rotor and gearbox through to the generator,” explains Sobek the competitive advantage of the supplier.

The service and original equipment sectors enrich each other mutually. The data from existing plants enables the next bearing generation to be designed even more precisely for actual loads. The increased productivity leads to even lower power production costs – and will certainly result in the next reports about record numbers of new wind turbine installations.



GIGANTIC TEST RIG

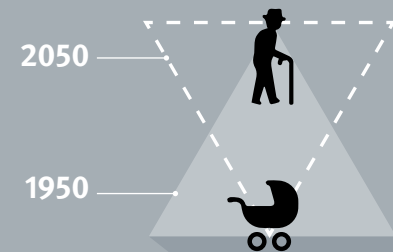
In Greek mythology, the Titan Astraios is the father of the wind gods who blow from the four points of the compass. In contrast, the large-size bearing test rig “Astraios”, which Schaeffler put into operation in Schweinfurt in 2011, has much more down-to-earth objectives. This test rig is used to test bearings with a mass of up to 15 tons and a diameter of 3.5 meters – including the very large rotor bearings for wind turbines with a peak output of up to six megawatts. Huge hydraulic cylinders produce the axial and radial forces, which act on the rotor and its bearings due to the wind under real conditions. 300 electronic sensors are used to evaluate and monitor the tests.

BETTER TREATMENT

All over the world, the number of patients requiring treatment is growing all the time – both in the aging societies of industrial nations and the growing populations of emerging nations. Schaeffler's innovative solutions in the field of medical technology are helping to improve the quality and the efficiency of medical treatment.

DEMOGRAPHIC CHANGE

Within just a century, the age pyramid has been almost completely inverted – a process that will soon be complete. Without immigration, the number of people in employment in Germany could decline by half by the year 2050, according to a study by the German Federal Employment Agency. At the same time, average life expectancy will be as high as 98 years by the middle of the 21st century. A large number of industrial nations also share Germany's fate.



Source: German Federal Statistical Office

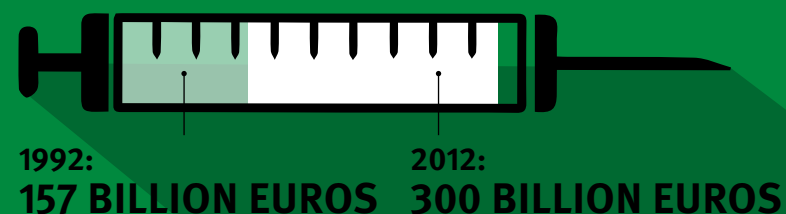
WORLDWIDE AVAILABILITY OF CARE



The quality of medical care available around the world is greatly varied. While some regions of Africa have only one doctor to every 50,000 people, doctors in developed countries have only a few hundred patients to deal with. To meet the targets set by the United Nations, functioning healthcare systems must first be established in many countries.

Source: World Health Report of the WHO

EFFICIENT HEALTHCARE SYSTEMS



Healthcare system expenditure is increasing all the time. In 2012, expenditure in Germany reached the 300 billion euros mark for the first time. Because only 10 billion euros were spent on buildings and technology, many hospitals began talking about an investment lag. Modern medical technology must therefore be particularly efficient without compromising the quality of the care being provided.

Source: IAQ

The mobile computer tomography system

Schaeffler supplied a rail-mounted computer tomography system to the Frankfurt am Main University Hospital. The advantage of this solution is that the equipment can be used in two treatment rooms at the same time. While one room is used for running planned tests, accident victims can be examined in the other without the need for a second expensive machine. This "sliding gantry" system comprises the drive, support rail guidance system, and electronic control system and was supplied as a complete solution by Schaeffler. The greatest challenge for the engineers was designing the system in such a way that the device can pass over the patient in a completely smooth and even motion at a speed of 120 mm per second in order to achieve sufficiently high image quality.



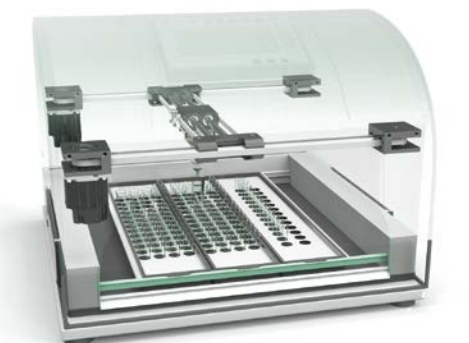
High image quality, low noise



Outstanding performance that should remain imperceptible to the patient during the examination if possible. An important objective during the development of new computer tomography machines, to which Schaeffler makes a significant contribution: The mechanical engineering experts supplied the drive unit for a new generation of extra-quiet computer tomography machines. This ensures that the X-ray imaging unit, weighing almost a ton, can revolve around the patient in a completely smooth, even motion at speeds as high as 300 revolutions per minute. The maximum level of noise generated is 65 decibels – the equivalent of the background noise level in a company canteen. The drive unit includes a bearing that is approximately one meter in diameter. The need for quality here is extremely high, as the bearing must be a perfect circle accurate to within ten millionths of a meter.

The automated laboratory

Fast analysis of blood, tissue, and urine samples increases the accuracy of diagnoses and therapy, and today is usually done in large laboratories that are organized in the same way as the state-of-the-art production lines found in factories. The analysis equipment itself can handle a dozen samples at once, sometimes significantly more. A handling system feeds the samples completely automatically into the analysis unit itself. Two and three-dimensional handling systems like this are the kind of customer-specific solution that Schaeffler Medical Technology develops and produces for a wide range of suppliers.




partnership

Solutions are developed in partnership with customers and users

HARVESTING FIELDS OF EXPERTISE

— Not simply working as we always used to, but developing new solutions to meet new demands: that is the task for applications engineers at Schaeffler. Rolling bearings with integral sensors help to increase productivity in the agricultural sector by precisely adjusting operations to suit the ground conditions. And Schaeffler's technology is also providing spectacular results on the world's largest working boats.

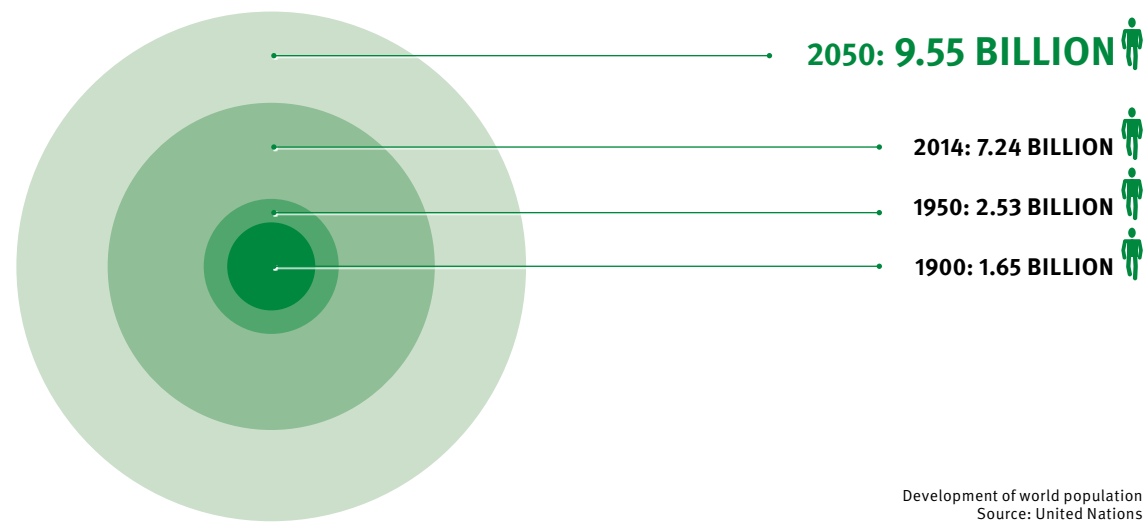
An aerial photograph of a vast agricultural landscape. The foreground and middle ground are dominated by a large, dark brown field with distinct, parallel furrows, indicating recent plowing or tilling. A small tractor is visible in the middle ground, working in the field. To the left, a bright green field is separated from the brown one by a light-colored dirt road or path. The background shows more of the brown field, curving away into the distance. The overall scene is one of active agriculture in a rural setting.

A BROAD FIELD

In the future, tractors will not only pull machinery – they will also be controlled by intelligent accessory equipment. This so-called “tractor implement management” technology is currently being tested with help from Schaeffler and is aimed at significantly increasing the yields produced in the agricultural sector. It could also be part of the answer to the issue of food supplies that arises in the light of the world’s growing population.

— by Dr. Laurin Paschek

One of the central challenges for the global agricultural industry is to sustainably supply the world's growing population with food. In 2014, the world's population stood at 7.24 billion, according to the United Nations' estimate. The statisticians behind the World Population Monitoring Report expect the number of people to keep increasing and reach the 100-billion mark by 2050, depending on the scenario.



This is not the only reason for the increasing demand for land that can be cultivated, however: Changes in eating habits such as the increased consumption of meat also mean that more space is needed, and the production of bioenergy, packaging materials, and raw materials for textiles also require cultivable space. However, because the world only has a limited amount of usable agricultural land, the agricultural industry faces the challenge of obtaining larger harvests from that land. This is why Schaeffler is developing intelligent agricultural engineering solutions that allow arable land to be cultivated in a targeted manner. This "precision farming" increases the yield and helps to protect the environment at the same time.

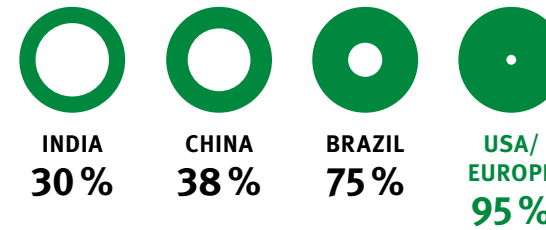
For a start, the process of fertilizing the fields can be significantly improved. Applying excessive quantities of fertilizer is damaging to the plants. What is more, the excess fertilizer is not absorbed by the plants and is

therefore washed into the groundwater by rain and irrigation, which means it also has a negative effect on the environment. On the other hand, inadequate quantities of fertilizer reduce the crop yield. "The aim of every type of spreader is to achieve an ideal spreading pattern to the greatest extent possible and to distribute the fertilizer evenly," reports Bernd Wittmann, a mechatronic solutions engineer in Schaeffler's Off-Highway unit. "We have developed a torque sensor that is integrated into the drive hub and precisely measures the current fertilizer flow in direct proximity to the process. This makes it possible to put out exactly the quantity of fertilizer that is required at that moment."

The new torque sensor measures the material stresses in the shaft that drives the fertilizer spreader disk by means of a non-contact measurement of the changes in the magnetic field, which are then converted into a torque signal. The fertilizer output quantity is propor-

MECHANIZATION LEVEL IN AGRICULTURE

(selected regions)



Source: VDMA

tional to the shaft's torque in this case. If the sensor detects that the quantity of fertilizer being fed to the spreader disk is too high or too low, a controller adjusts the quantity accordingly. "This means that the farmer's desired quantity of spreading material and push-off distance can both be precisely adhered to," reports Wittmann. "A particular advantage of this is that the system immediately detects any blockages or obstructions that might form on the metering slides. The material being spread is usually a granulate, which of course can clump together – as soon as that happens, the system warns the farmer, who can then clear the blockage."

In order to make the installation process as simple as possible for agricultural machinery manufacturers, the

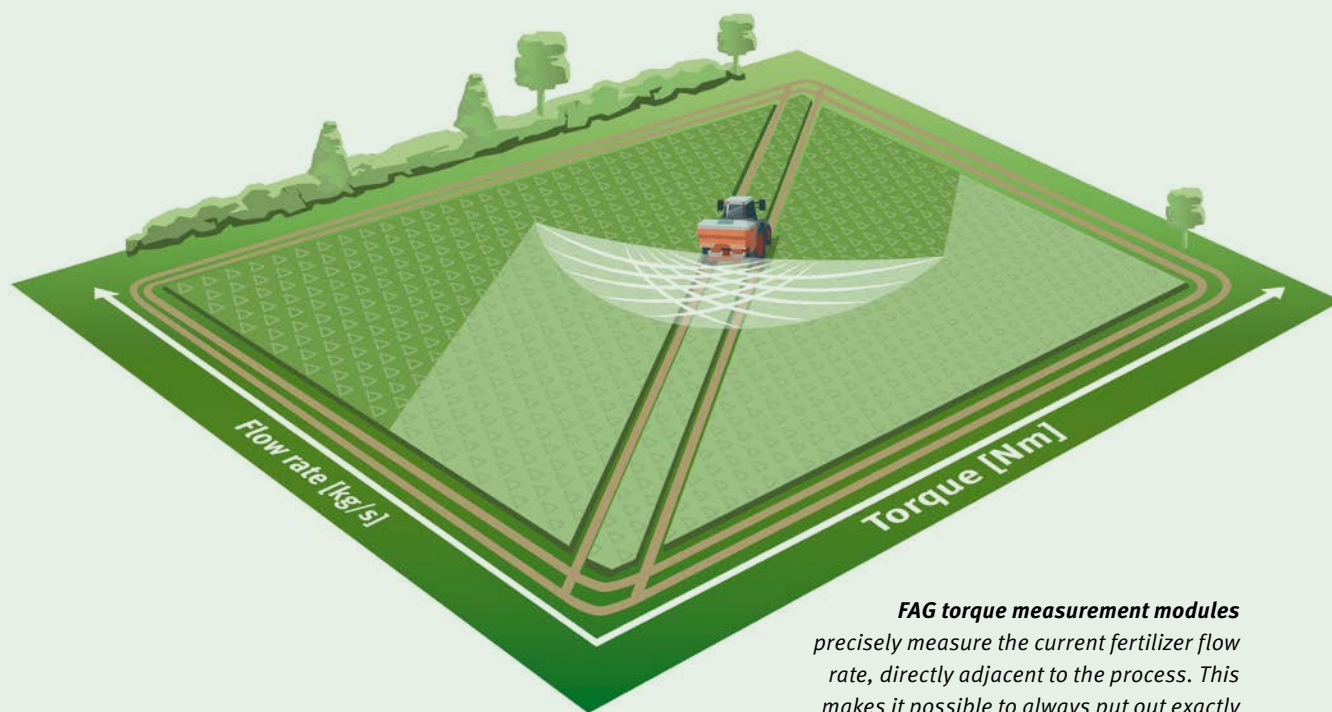
torque sensor is embedded in a ready-to-fit module that consists of a shaft with two bearing supports. The housing that contains the sensor is located between the two rolling bearings. This sensor carries out a non-contact magneto-elastic measurement of the mechanical stresses around the shaft. The sensor is also equipped with electrical interfaces that use standardized protocols like CAN and ISOBUS to communicate with the agricultural machine's electronic control system. From the tractor, the farmer can then use mapping and GPS to precisely meter the quantity of fertilizer according to the condition of the soil.

The agricultural engineering specialist Rauch was the first manufacturer to put fertilizer spreaders equipped with torque measurement systems into volume production. The system replaces the previous measuring method, which relied on oil pressure sensors in the hydraulic motors, and thanks to the new technology delivers faster and even more precise results. Even when it comes to spreading organic fertilizers, the new torque measurement system can help to increase the yield. This type of fertilizer is not a granulate but rather a solid material that widely varies in mass. Fliegl Agrartechnik currently also equips its new fertilizer spreaders with these sensors in order to control the fertilizer push-off according to the drive torque of the spreading rollers and thus to distribute the fertilizer as evenly as possible over the surface of the field.

Schaeffler and John Deere are jointly testing new technologies in an innovation tractor.



EXACTLY THE RIGHT QUANTITY OF FERTILIZER



FAG torque measurement modules precisely measure the current fertilizer flow rate, directly adjacent to the process. This makes it possible to always put out exactly the quantity of fertilizer that is required.

Equipping agricultural machines with sensors and actuators is a milestone on the road towards mechanically controlled, efficient ways of working. This

Torque measurement can be used in almost all sectors of agriculture

development also makes a long-standing agricultural practice obsolete: The accessory equipment is no longer simply drawn by the tractor – instead, the accessory equipment features an intelligent control system and steers the tractor. This always makes sense when the accessory equipment is more directly involved in the actual process than the tractor. This is therefore an

application area for torque measurement that goes far beyond the spreading of seed and fertilizer. The technology can theoretically be applied in almost all areas of farming and contribute towards increasing yields and improving efficiency. “We have already equipped machines in other areas of application within the agricultural sector, which at present are also operating reliably in the test phase,” reports Armin Gerner, development engineer in Schaeffler’s Mechatronics Off-Highway unit.

The torque sensor measures the quantity of produce to be harvested – in other words how much biomass the agricultural machine is currently gathering. If there is too much hay in the field, the sensor notifies the tractor’s electronic control system via the ISOBUS, and a message is then displayed telling the driver to reduce

the speed. However, the reduction in speed can also be carried out completely automatically, depending on the design. If the quantity of harvestable material on the field then becomes less, the sensor then detects the drop in resistance and allows the tractor to accelerate. “In this way, farmers can either harvest entire fields at the highest possible speed or, alternatively, minimize their fuel consumption and therefore their CO₂ emissions,” explains Gerner. The harvesting machinery is additionally protected from overloading, which means that machine blockages can be prevented, thus saving the operator time and effort.

All this means that intelligent agricultural solutions can make an essential contribution towards ensuring a sustainable supply of food for the world’s population. In Europe and North America, where agriculture is already mechanized to a large extent, the advantages of these smart technologies are already paying off. The two most populous countries in the world, China and India,

have a mechanization level of only 38 and 30 percent, respectively, and therefore have even greater potential. In these countries in particular, environmentally friendly food production can be significantly increased while maintaining the same amount of cultivable land if intelligent and efficient agricultural machinery is used right from the beginning.

Intelligent agricultural solutions can make an essential contribution towards ensuring a sustainable supply of food for the world’s population – especially in countries such as China and India.

APPLICATION AREAS FOR TORQUE MEASUREMENT



Fertilizer spreader

Spreaders of all kinds are designed to spread the material as optimally and evenly as possible. The torque of the spreader disks is measured for this purpose. The exact quantity of fertilizer required is spread according to this measurement.



Push-off fertilizer spreader

The consistency of solid manure can vary significantly. By measuring the torque of the spreading rollers, it is possible to precisely control both the quantity of the dung being spread and the push-off speed.

OIL RIGS ON PIGGYBACK

Schaeffler supplied key components for the world's largest working ship which help to lift loads of up to 48,000 tons.

The "Pioneering Spirit" is the ultimate ship. It is not only the world's largest vessel but, with a width of around 124 meters (406 feet) and a gross tonnage of 403,342, it is the largest ship ever built. Its designer and operator is Allseas, a Swiss offshore service company that has built the 370 meter long Pioneering Spirit to move very big structures such as offshore platforms and to lay pipelines. The vessel runs on ten diesel-electric engines with a total power of 94,460 kW. A total of 66,000 kW

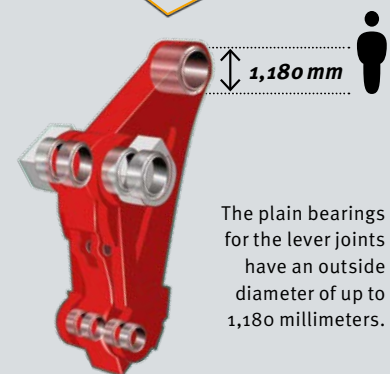
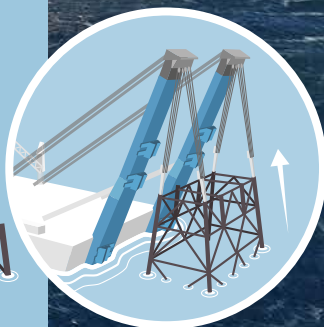
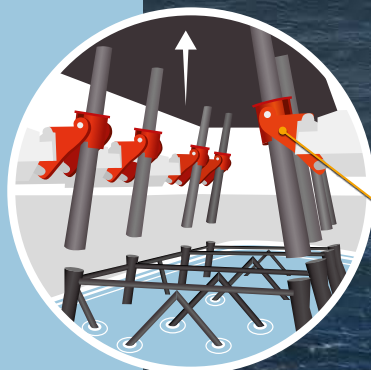
are provided for driving twelve thrusters; in addition, the generators supply a hydraulic system that can lift up to 48,000 metric tons. This so called "topside lift system" allows the vessel to carry even the heaviest top sides of oil platforms in one piece. Another device, the "jacket lift system", is able to lift the substructure of a platform up to a weight of 25,000 metric tons. There are 600 oil rigs in the North Sea alone that must be uninstalled by 2040.

The ship catches the drilling platform between its bows ...

... and lifts the separated platform on deck.

Tilting beams connected and lift jacket from seabed.

The jacket is tilted towards the deck.



The plain bearings for the lever joints have an outside diameter of up to 1,180 millimeters.

To remove the topside of a platform, 16 enormous lift beams are fitted under the structure. They clamp around the legs of the platform. Since the vessel moves with the waves during the manoeuvre, the plain bearings must compensate the forces that occur here. Schaeffler found the right answer to this problem in large spherical plain bearings with an Elgoglide sliding layer. They can withstand the high loads and are maintenance free. The Pioneering Spirit uses a total of 272 of these bearings in its levers and in the hydraulic cylinders of its lift system.

on location

Only through proximity to the customer's location, is it possible to know him

INDIA ON THE RISE ECONOMIC TURNAROUND

— India, partner country at the 2015 Hannover Messe, is not only a fascinating and multi-faceted country with an ancient history, but also an increasingly important industrial location. Schaeffler has been active on the sub-continent since 1962 and is now benefiting from the economic upswing the country is currently experiencing. The editorial team of “tomorrow” has been to have a look around – in the factories and on the streets – and found positive signs everywhere.

CREDIBLE INDIA

India's new government in Delhi is taking major steps to modernize the country, which include investing billions in its infrastructure and the "Make in India" economic aid program. This means major opportunities for Schaeffler, which has been active on the Indian subcontinent since 1962. We visited the partner country of the 2015 Hannover Messe.

— von Johannes Winterhagen





An endless, absolutely straight line stretches off towards the horizon. The brightly painted lorries in the left-hand lane are the only indication that this four-lane highway is in India. The sight of this smooth asphalt would spark a fit of jealousy in many an official from the German highway authorities, and were it not for the strict 100 km/h speed limit, it would be possible to drive much faster.

Industry's share in the gross domestic product is to rise significantly

The state of Gujarat, western India, is home to the economic centers of Ahmedabad and Vadodara, which are connected by the NE1 national expressway. Since its completion in 2003, the roughly 100-kilometer highway has shortened the traveling time between the two by more than half. More important than that, however, is its symbolic value. This is because Gujarat is the home of India's new prime minister, Narendra Modi, who was elected in May 2014. He previously also served as the state's Chief Minister for more than a decade, during which the state experienced significant growth even as India regressed to single-digit growth rates following the world economic crisis. India's economy grew by around five percent in the 2013/2014 fiscal year – too little for a country in which 30 percent of the population have to get by on less than one dollar a day.

Since Modi took up office, a new spirit of optimism has been running through India's economy. Government officials have once again confirmed their goal to strengthen the country's industrial sector. The aim is to increase the proportion of the gross national product made up by industrial production from 15 percent to 25 percent – the same value as Germany and a realistic target in the opinion of many managers and entrepreneurs. "I am optimistic that this country's industry will experience a double-digit rate of growth over the coming years," says Rajendra Anandpara, President Industrial Schaeffler India.



By the end of 2017, the amount of energy generated from renewable resources should have more than doubled to

55 GIGAWATTS

The Indian car market is expected to grow rapidly. According to "Make in India", the number of vehicles sold in 2020 will amount to more than

6,000,000

5 BILLION

passengers are transported by Indian Railways every year, which makes the company the world's largest public sector railway operator.



India is a democratic federal republic in South Asia, which comprises 29 states and seven union territories. With a population of more than 1.2 billion people, India is the world's most populous state after China. The country is a multi-ethnic state, in which more than 100 languages are spoken. If the gross national product is divided by the population, India is ranked 132 in the country rankings with a per capita income of 4,000 dollars.

Schaeffler India

YEAR OF FOUNDATION 1962

PLANTS Pune, Vadodara (2), Hosur (2)

SALES OFFICES 6

SALES PARTNERS 300



QUALITY FROM **SAVLI**

Thus far the mechanical engineering company from Germany has enjoyed successful growth on the Indian subcontinent, with sales increasing by an average of 17 percent per year for the last five years. Maintaining a strong local presence for more than sixty years has no doubt played a part. Schaeffler has five manufacturing locations today, the newest of which was opened in mid-2012 and is located in Savli, an industrial park outside Vadodara. The location comprises two factory halls of 6,000 square meters each that are bordered by a vast expanse of undeveloped land. "We have space for further expansion here," explains Chinmay Mishra, plant manager at Savli, who estimates that the existing buildings will be used to full capacity by the end of 2015. Two product groups are currently being manufactured: The first is ball bearings (with the current

figure standing at 36 million) that are machined and assembled in highly-automated facilities. The second is large-size industrial bearings, e.g. for wind turbines, which are manually assembled by specially trained workers.

"We have the same quality standards as those of Schaeffler's plants in western Europe," says Mishra while proudly leading the way through the laboratories where ball bearings that were randomly selected from the production line are inspected. The equipment is modern and even includes a 3D coordinate machine with which large-size bearings measuring more than a meter in diameter can be inspected for deviations from perfectly circular form – accurate to just a few thousandths of a millimeter.

A tour of the manufacturing facility also confirms how successfully Schaeffler's worldwide standards have been applied, not only in terms of quality but also with regard to material flow, which has been consistently organized according to lean production principles. The stock of material in the production line is kept as low as possible, and not a single box can be found where it isn't needed.





CONCEPTS FOR THE INDIAN MARKET

Road traffic in major Indian cities is the slowest in the world. The average speed of a car driver in Delhi during the rush hour is only 9 km/h – and the rush hour can last until midnight. In order to meet these requirements, the concept vehicle that Schaeffler has specially developed for the Indian market not only has a start-stop system, but is also equipped with an automatic clutch. This vehicle consumes 15 percent less fuel than current volume-production cars.



family – often with three or even four people sharing the seat. What is more, the average price for a machine – just 700 euros – is significantly lower than on other markets. “We have to adapt to this cost structure if we want to be successful,” says Arora.

The national company manager himself comes from the automotive industry, having already carved a successful career path for himself at General Motors before moving to Schaeffler. One thing he is sure of is that, in the next ten years, more motorcycles than cars will be produced and sold in India. “However, we can also see a clear trend towards the establishment of India as a production center for small cars.” For example, the market-leading manufacturer with almost 50 percent of all new vehicle registrations, is relocating more and more capacity from Japan to its development center in India. The main products currently manufactured by Schaeffler in India are clutches and engine components for the local market. “With our India concept car, we have shown that we have the expertise needed to reduce fuel consumption by up to ten percent.” The technologies used here are selected to suit the specific features of Indian traffic: An automated clutch, for instance, is combined with a start-stop system to ensure comfortable driving in the continuous stop-and-go traffic of the country’s major cities.

LOCAL DEVELOPMENT

»» *The possibilities are virtually endless*

Dharmesh Arora,
President and CEO Schaeffler India

Four out of every five ball bearings produced will be installed in a motorcycle or motor scooter after being delivered. The demand is enormous, with more than 18 million new registrations every year making India the world’s second-biggest market for two-wheel motor vehicles. Dharmesh Arora, President and CEO of Schaeffler India, estimates that there could be as many as 25 million by the year 2020. This is one reason why, since 2014, India has held worldwide responsibility within the company for all components used in motorcycles with an engine capacity of up to 150 cubic centimeters. India is not merely a local leading market, however, it is also becoming a global development and production center for the motorcycle industry, from which numerous other markets are supplied. “Our engineering hub means that we are close to our customers and their needs”, explains Arora. And these needs are very different from those of Europe’s leisure-time motorcycle users. The motorcycle is the vehicle of choice for India’s upcoming middle classes, for whom it provides an opportunity to bypass the chaotic traffic in the country’s metropolitan areas on their way to the office or to visit

About 60 percent of the overall population is currently employed in agriculture

While the most important developments in the automotive sector currently still come from Germany, responsibility for the worldwide development of agricultural machinery in the drive power range up to 50 HP rests with India, the world’s biggest market for tractors. The market leader Mahindra alone puts out more than 200,000 units a year. But the country has a lot of catching up to do, as India’s agricultural industry still only has a mechanization level of around 30 percent, with the remaining fields being worked by hand. Approximately 60 percent of the overall population is currently employed in agriculture, for the most part in tiny fields that serve as a reminder that partible inheritance is still in practice. Indian tractors are thus still correspondingly small when compared to the 500-horsepower giants controlled by GPS that till vast expanses of land in the USA. “However, the demand for high-quality components is constantly on the rise,” says Arora. “Our hope is that, through this new organization, we will also gain significant shares of the tractor market.”

THE WORLD'S FUTURE NO. 1 IN STEEL

» **Double-digit
growth over the next
few years**

Rajendra Anandpara,
CEO Schaeffler Industrial India

Mobile machinery is not the only area where Schaeffler is growing. The base materials industry is at the front end of the chain and is also set to grow drastically over the next few years. India is already the world's second-largest steel producer with an output of around 100 million tons, and there are plans to double this capacity by 2020, even triple it by 2025. Most of the country's rolling mills are supplied by German plant manufacturers and already frequently employ Schaeffler bearings. Local service business now also promises major potential, as manager Seshan Iyer explains. "We have successfully concluded initial service con-

tracts to ensure that the bearings function correctly at all times." 100 percent availability that is ensured by regular inspections and the preemptive replacement of worn components should increase the cost-effectiveness of existing plants – and this is a model that will also be of increasing interest for other processing industries such as paper and cement manufacture.

**900 billion euros to be spent on
infrastructure development**

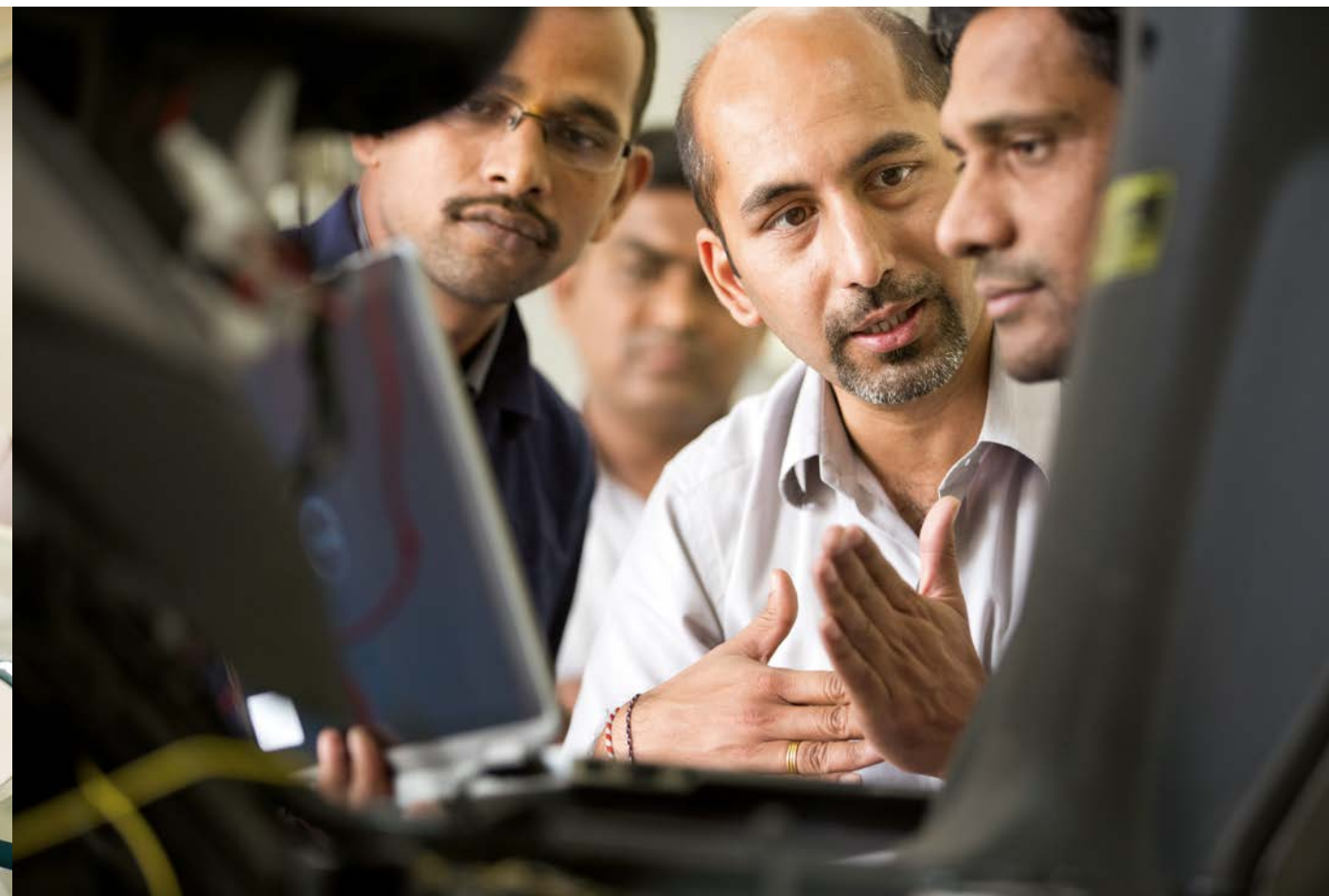
The fulfillment of India's vision of becoming a rich industrial nation is dependent on the establishment of a functioning infrastructure. The government plans to invest a total of 900 billion euros before the end of the decade, chiefly in roads, energy supply, and education. "Ambitious plans have been a frequent occurrence in India," says Anandpara. "This time, however, we believe that there is also a chance to make them a reality." This means working to overcome the existing obstacles to investments, such as the high level of bureaucracy that comes with employing personnel and

purchasing real estate. If this is done successfully, the necessary investments can then go ahead for things like a continuous nation-wide supply of power to be implemented.

A stable power grid is an important prerequisite for the expansion of alternative energy usage, which the government is also planning. Top priority is being given to wind power here, with turbines boasting a peak output of 21 gigawatts already installed on the Indian subcontinent and the addition of a further 15 gigawatts planned by the end of 2017 – all from domestic production. Schaeffler has installed a black oxide coating facility for the gearbox bearings at its Savli plant. This surface treatment method increases the bearings' load carrying capacity while reducing friction and wear.

Wherever investments are being made in infrastructure, it is almost certain that Schaeffler is making an important contribution: Schaeffler wheelsets are part of Delhi's new metro system, which brings newly-arrived airline passengers into the center of town in just 20 minutes – a journey that used to take an hour

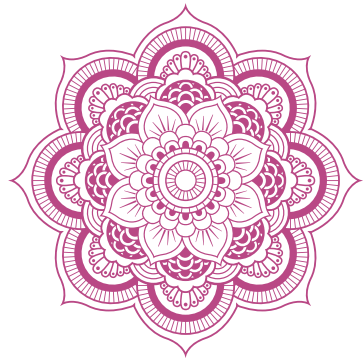
Finding the best solution to a problem requires close coordination. This is true for India and for all other Schaeffler plants worldwide.



and a half by taxi. Major cities such as Pune (home of Schaeffler's headquarters in India) now have fully-asphalted roads, and the machines that made this possible also rely on Schaeffler bearings. And that is not all: Long and difficult transportation routes mean that, at 13 percent, logistics costs in India are very high on the international scale, so a functioning network of roads is key to reducing these costs. The roads are ultimately the prerequisite for people to purchase more cars and motorcycles – equipped of course with Schaeffler bearings.

**India and Germany:
Partners in developing India's industry**

"In terms of absolute size, we are still a small market for the company," explains Arora. "But the possibilities are virtually endless." The organizers of the Hannover Messe must have been thinking along the same lines when they selected India to be their partner country for 2015. Prime minister Narendra Modi will be in attendance at the opening of the event. During his last visit to Germany in September 2014, he remarked that "Germany and India are made for each other". This was more than just a guest's conventional politeness, however: The "Make in India" industrialization program that Modi has initiated echoes "Made in Germany" in more than name.



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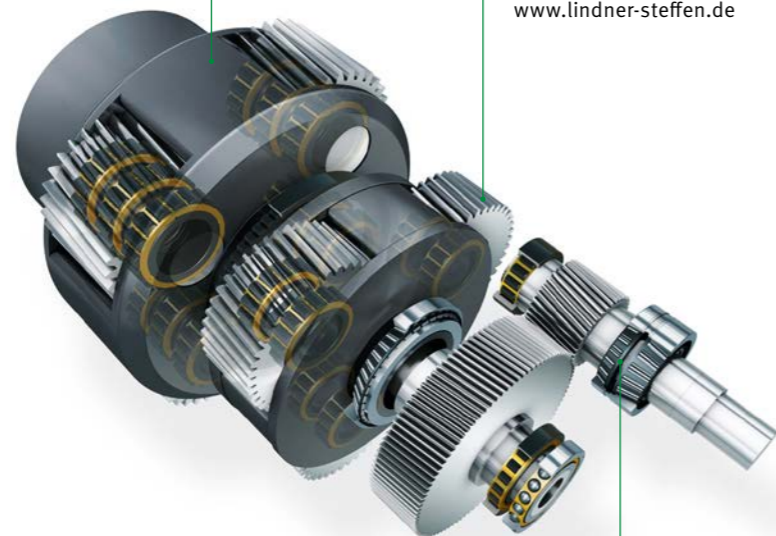
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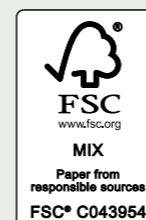


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