

**SCHAEFFLER**

01—17

# INDUSTRIAL AUTOMATION

## **INTERVIEW WITH RALF MOSEBERG**

SMART COMPONENTS AND INNOVATIONS  
FROM SCHAEFFLER AT EMO

## **NO MORE SURPRISES!**

MONITORING SPINDLE BEARING LOADS AND  
AUTOMATED RELUBRICATION OF FEED AXES

4-7



## INTERVIEW WITH RALF MOSEBERG

The Senior Vice President Industrial Automation on trends in the machine tool sector and new products from Schaeffler.



12

## NEW POTENTIAL FOR OPTIMIZATION

With the new M-series High-Speed spindle bearings, the load carrying capacity of motor spindles can be increased even further. As a result, machine tools become more efficient.

## INDIVIDUAL LINEAR SYSTEMS ARE JUST A MOUSE CLICK AWAY

The optimum route to customized and ready-to-fit single- and multi-axis linear guidance systems and why Schaeffler is the perfect partner here.



18-19

22

## LOOKING TO THE FUTURE

The new multi-channel Condition Monitoring System (CMS) allows the condition of multiple key components to be monitored and forecast as well as flexible integration of sensors from any manufacturer.



# CONTENTS

## 04 INTERVIEW

## 08 WELCOME TO EMO

From components, via systems and digital services to Machine Tools 4.0

## 10 A NEW PERFORMANCE CLASS

Further development of the KUSE six-row linear recirculating ball bearing and guideway assembly in X-life quality

## 11 ENABLER FOR MORE SPINDLE PERFORMANCE

Benchmark – the X-life version of the high accuracy cylindrical roller bearings

## 12 NEW POTENTIAL FOR OPTIMIZATION

New X-life high-speed spindle bearings, series M, increase machine tool productivity

## 13 VACRODUR – NEW HIGH-PERFORMANCE MATERIAL

Stable up to temperatures of over 400°C

## 14 COMPLETE REDESIGN

Revisions to the rotary table bearing series YRTC provide machine tool operators with access to more cutting capacity and greater precision

## 15 LINEAR ACTUATOR WITH EXTREMELY HIGH POWER DENSITY

Small but powerful! The PWG planetary screw drive offers extremely high power density with an attractive price/performance ratio.

## 16 INNOVATIVE MODULAR SYSTEMS

High speed, high performance or high precision – it doesn't matter! Schaeffler offers exactly the right components for rotary tables and rotary axes.

## 17 BEST IN CLASS BEARINGS GET EVEN BETTER!

A large range of series to choose from for rotary table bearings

## 18 INDIVIDUAL LINEAR SYSTEMS ARE JUST A MOUSE CLICK AWAY

Condition monitoring throughout machine tools

## 20 NO MORE SURPRISES!

Requirement-oriented and automated relubrication of linear guidance systems significantly reduces unplanned downtime

## 22 LOOKING TO THE FUTURE

## 23 SCHAEFFLER SMART ECOSYSTEM:

Added value from digitalized machine components

24 Partnership Paves the Way for Industry 4.0 Tackling high cost and innovation pressure with an Industrie 4.0-compatible machining center

## 26 SCHAEFFLER APPS:

Information at your fingertips

Whenever, wherever – an overview is always available with Schaeffler apps



# EDITORIAL

## DESIGNING PROGRESS TOGETHER

Dear readers,

I have been the new President Industrial Europe for the Schaeffler Group since April 2017. After positions with Honeywell, Leybold Vakuuum, Eaton (Cooper Industries) and Bartec, I am now ready to work with our customers in Europe, the Middle East, Africa and India. I would like to take this opportunity to personally introduce the highlights of Schaeffler's presence at EMO 2017 in this, the first edition of Industrial Automation. In Hanover, we are presenting four completely new series of bearings for machine tools in X-life quality. They are the new international benchmark. The rolling bearing steel Vacrodur produced using powder metallurgy, is a completely new rolling bearing steel which has been developed specifically for high-speed spindle bearings; this produces significant increases in the performance of spindle bearings and therefore the whole spindle. We are also presenting new torque motors for ultra-high precision machines and rotary table bearings with extremely high tilting rigidity, amongst other things. We have recognized that it is still possible to achieve significant progress through purely mechanical developments. However, that should not detract from the fact that more and more of our products now include sensors, or should I say digital technology. We are therefore proud to present

automated and condition-oriented relubrication for guidance systems in feed axes and an innovative sensor system for monitoring the load in spindle bearings. These mechatronically and digitally supported solutions make it possible both to optimize the actual machining process with new control loops and to extract the last reserves of performance from the rolling bearing support. This means that our system solutions ensure the performance limits of machine tools are being exploited to the full while the operating life is simultaneously being extended. This is clearly demonstrated at the Schaeffler booth throughout the 'glass' Machine Tool 4.0.

Dear customers, we invite you to sit down with our engineers at EMO in Hanover and discuss not only our mechatronic products but also the control loops they can achieve in your machine tools, as well as the benefits they bring.

Industrial Automation is an excellent source of information on our latest products for the machine tool sector before the doors to the trade fair open.

With best wishes for a very informative read!

A handwritten signature in black ink, appearing to read 'M. Eisenhuth', written in a cursive style.

Marcus Eisenhuth  
President Industrial Europe

A professional portrait of Ralf Moseberg, a middle-aged man with a receding hairline, wearing a dark suit, white shirt, and a striped tie. He is looking directly at the camera with a slight smile. The background is a blurred office setting with windows.

# RALF MOSEBERG

A green icon consisting of two right-pointing chevrons, one slightly larger than the other, positioned to the right of the text box.

Ralf Moseberg, Senior Vice President Industrial Automation at Schaeffler, in conversation with the Industrial Automation editorial team on trends in the machine tool sector, smart components and the new products from Schaeffler at EMO 2017 in Hanover. He makes a promise, right at the start: “Our products will provide significant increases in the availability, productivity and machining quality of machine tools.”

**MR MOSEBERG: YOU ARE HIGHLIGHTING EMO 2017 AS A HIGHLY SIGNIFICANT MILESTONE AS FAR THE PRODUCTS BEING PRESENTED BY SCHAEFFLER IN HANOVER ARE CONCERNED. WHY AT EMO AND WHY NOW?**

**Ralf Moseberg >>** Very rarely have we launched so many new and innovative products at a trade fair. At Hanover, we are presenting, amongst other things, a new rolling bearing steel specially designed for spindle bearings which is produced using powder metallurgy, as well as integrated sensor technology for measuring displacement and monitoring loads in main spindles, a multi-channel condition monitoring system for machine tools, a torque drive without disruptive magnetic forces for high-precision machining etc. The main themes for us are always the same: Using our products to provide the customer with greater machine availability, more productivity and improved machining quality. We are using new technologies more and more frequently in order to achieve this. Or, put more succinctly, at Schaeffler, research into volume production is producing new technologies at an increasingly rapid rate.

**WE HAVE SEEN THIS IN THE PAST IN MOTOR RACING. WHERE DOES THIS "ACCELERATED" DEVELOPMENT COME FROM AND HOW ARE YOU PUTTING IT INTO PRACTICE?**

**Ralf Moseberg >>** Yes, motor racing is a particularly good example. This acceleration can also be found in the machine tool industry. In order to keep pace here, a business has

to satisfy two conditions. Firstly, it must be able to develop sufficient new technologies and, secondly, it must be able to industrialize them quickly. Achieving this has been a lengthy process requiring appropriate resources and a motivated, dynamic and flexible team. We are well equipped for the future, not least due to the well equipped Engineering Center which was set up at the end of 2016 at our Homburg site. Schaeffler is bringing together the Schweinfurt rotary products team and the Homburg linear technology team to pool its activities in the new Industrial Automation Division, which is my responsibility. Just like the large "automation specialists", which have developed out of control technology, we see ourselves as an automation specialist coming from the mechanical and mechatronic side. Our core expertise is the automation of movement, starting with the bearing and guidance system, via the mechanical drive, to the motor.

**INDUSTRIAL AUTOMATION IS ALSO THE TITLE OF THE CUSTOMER JOURNAL FOR THE INDUSTRIAL DIVISION OF SCHAEFFLER. WHAT WERE THE REASONS FOR CHANGING THE TITLE?**

**Ralf Moseberg >>** Our magazine had been called 'added competence' for many years and to some extent this was also the motto of the machine tool division. In the last two years in particular, we have introduced many new products, services and innovations to the market and there is no doubt our customers are now well aware of the 'added competence' message. It could be said that our innovative products have outgrown this slogan. So, it was time for a new title. "Industrial Automation" sends out a new signal that, in developing optimum solutions – and not just since Industrie 4.0 – we are focusing on complete automation of movement and of the customer's process. The recently established Industrial Automation Division and the associated restructuring was also a significant contributory factor. In the future, our customers will already be fully aware of the 'added competence' in our products.

**CAN YOU GIVE ME AN ACTUAL EXAMPLE?**

**Ralf Moseberg >>** We will be presenting the second generation of the linear recirculating roller bearing and guideway assembly RUE 4.0 at EMO 2017 as part of the condition-orientated relubrication of linear axes. Apart from the fact that it is now possible to relubricate six carriages with one system, the new linear recirculating roller bearing and guideway assembly includes sensor technology which we have developed ourselves. In my opinion, it is a clear indication of added competence that we, as a "bearing supplier" are able to develop sensors for our mechatronic products ourselves. Obviously, we only do this if the sensor market is unable to provide an adequate solution. The point is that we can do it – within specific time and cost constraints. However, these internal developments will always be the exception as we have no intention of becoming a sensor supplier. Our focus is, as always, the customer benefits we can achieve by using rolling bearings as integral system components.

**>>> EMO 2017 is a highly significant milestone for Schaeffler. <<<**

#### WHAT YOU MEAN BY THE BEARING AS AN INTEGRAL SYSTEM COMPONENT?

**Ralf Moseberg >>** I mean that there are interactions between the bearing support and the machine and that we include these interactions in the development as far as we can. In the past, we have concentrated on purely mechanical interactions, for example, at the simplest level, the fact that in a transmission, the bearing deflection influences the bearing forces as well as the shaft deflection at the gear teeth. For us, the system consisted of bearings, shafts, gears and housings. The term 'system bearing' has taken on significant new meaning through the digitalization of our products. To take a second example, today, we use the displacement of the main spindle bearing caused by the machining forces as a "control value" which allows operators to adjust machining parameters in such a way that the main spindle is overloaded as infrequently as possible and there is almost no damage. The traditional term 'bearing system' is no longer adequate; we now need to talk about the bearing as an integral system component and, here, 'system' means the whole machine or a large subsystem. That is very exciting.

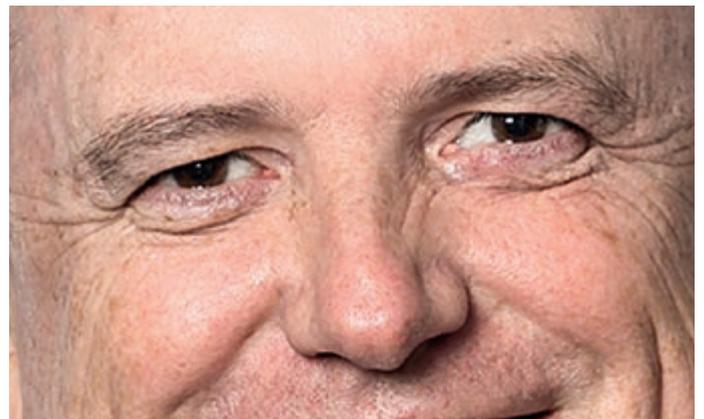
#### WHAT NEW PRODUCTS IS SCHAEFFLER EXHIBITING AT EMO? WHAT HIGHLIGHTS CAN WE EXPECT FROM SCHAEFFLER?

**Ralf Moseberg >>** Two things. On the one hand, a few new products now include sensor technology. I have already mentioned automated relubrication of linear recirculating roller bearing and guideway assemblies and monitoring spindle load. However, we are also making significant progress in the load carrying capacity, limiting speeds and operating life of rolling bearings with our new manufacturing and production methods. In total, we are launching four

new bearing types in X-life quality. The new FAG spindle bearing angular contact ball bearings, series M, an FAG high-precision cylindrical roller bearing series, the six-row INA linear recirculating ball bearing and guideway assembly, series KUSE, and the YRTC series for rotary tables. For the first time, we are also offering a kit for driven rotary axes and rotary tables. The main components of the kit are the bearing support, the drive and the angle measuring system as well as other components such as flanges. The possible designs range from pre-assembled components packaged together to pre-assembled sub-assemblies. These sorts of kits make procurement easier for rotary table manufacturers, saving them time and money during assembly. The portfolio of three series of INA rotary table bearings, three series of IDAM torque motors, and several measuring systems, all of which are matched to each other and can be combined with each other, allows system suppliers in the machine tool sector to offer rotary tables and rotary axes which are precisely matched to the target price segment and the application requirements. We regard this as a major USP for us as well as for our customers. A further highlight is the new SRV torque motor series from IDAM for machining accuracies in the sub-micron range.

#### AT EMO 2015, SCHAEFFLER PRESENTED INITIAL STUDIES AND PRODUCTS UNDER THE TITLE "ADDED VALUE THROUGH DIGITALIZATION" WHICH INCLUDED THE MACHINE TOOL 4.0 AS AN INNOVATION PROJECT. WHAT FURTHER DEVELOPMENTS HAVE THERE BEEN IN THIS AREA?

**Ralf Moseberg >>** Allow me to recap so that you have a better understanding of what we are currently offering. Since 2014, Schaeffler has produced quite a number of innovations as part of its digitalization strategy. We have developed "basic technologies", such as the magnetostrictive torque sensor presented in 2015, or accurate, contactless measurement in microns of rolling bearing displacement, as presented at Hanover in 2017. These basic technologies are used in mechatronic components such as the FAG torque sensor and the FAG VarioSense – a combination of standard ball bearings and sensor clusters. We also call these products smart components.



**>> In the next generation of machines, advances in productivity will be driven by smart components. <<**



We have also adapted the functional principle of measuring the displacement on spindle bearings specifically for the machine tool market. We can now capture the displacement of the front spindle bearing extremely accurately in five axes. At EMO, we are presenting these innovations in a single size.

To date, we have been using the Machine Tool 4.0 in Höchststadt for practical testing of this and other systems. It allows us to carry out practical testing and further development of the basic technologies already mentioned, the smart components and, if necessary, the new control loops. In the meantime, we have also fitted approximately 1500 of our own machine tools with sensors and the appropriate algorithms in order to make use of the benefits of digitalized components in our own business.

Since the last EMO, we have also developed software to volume production levels such as automated diagnosis of machine components based on structure-borne vibration. Schaeffler has had a market presence in the area of structure-borne noise analysis for decades with the FAG Condition Monitoring Systems (CMS). These systems have grown in significance for Schaeffler as additional customer benefits can be established based on their data due to extended networking within manufacturing systems. Developing these further has allowed a rapid implementation of new digital services such as the automated diagnostics mentioned above – incidentally, this is also a result of developing the Machine Tool 4.0.

At EMO 2017, Schaeffler will be presenting the prototype of a multi-channel CMS, which was specially configured for monitoring key components and subsystems in machine tools.

A completely new development is the option of interpreting vibration signals from ball screw drives. The beta version of the software module, which is currently in the testing phase, will be available to customers after EMO 2017.

#### **IS IT ESSENTIAL TO NETWORK THE SMART COMPONENTS TO THE CLOUD?**

**Ralf Moseberg >>** No, in principle, Schaeffler designs mechatronic components such that they can run locally in the machine or plant. However, they always have an interface to cloud structures, whether the Schaeffler cloud or a private cloud. Measured data can be extracted here for new digital services to increase customer benefits even more. A local solution is always available from us in order to reduce the number of hurdles for our customers in a product launch but also to be able to collate the first experiences from the field from machine tool operators. Greater benefits can obviously be achieved using digital services from the cloud.

#### **WHAT DO YOU THINK THE LIKELY DEVELOPMENTS WILL BE IN THE NEXT FEW YEARS IN THE FIELD OF MACHINE TOOLS AND AT INA-LINEARTECHNIK?**

**Ralf Moseberg >>** If sufficient operating data is available from the field in a few years time, i.e. real load data, there is a significant chance that these data, once they have been suitably processed in statistical terms, can be used to design the next generation of machines. Current designs are based on load collectives which are, in turn, generally based on past experience and estimates. In a few years' time, we will have access to much better design data in qualitative terms. It will then be possible to reduce the safety margins which are currently included in the calculation in a targeted manner.

Depending on the development goal, this will allow further downsizing or cost reductions. But it is also possible to envisage optimized machine series for specific customer groups.

The systems for condition monitoring and forecasting of key components in machine tools are a further point of developmental focus. On the product side, we will be extending our standard linear technology portfolio even further which will allow us to cover even more application areas. The further development of our monorail guidance systems is particularly important because our linear modules and linear systems are built on these products. I can see a great deal of development potential for INA Lineartechnik in the field of electro-mechanical linear actuators. The planetary screw drive which we are offering is one of the first linear actuators with very high performance density and an attractive price/performance ratio. The cylindrical design is something new for us and is providing us with the opportunity to develop completely new sectors and applications.

#### **WHAT ARE YOUR RECOMMENDATIONS FOR VISITORS TO EMO IN HANOVER?**

**Ralf Moseberg >>** Take some time to visit the Schaeffler booth and to have the new products explained to you by one of our applications engineers. Much of the progress cannot simply be explained in numbers. The concepts and effects on machine performance behind them are just as interesting. ◀





# WELCOME TO EMO

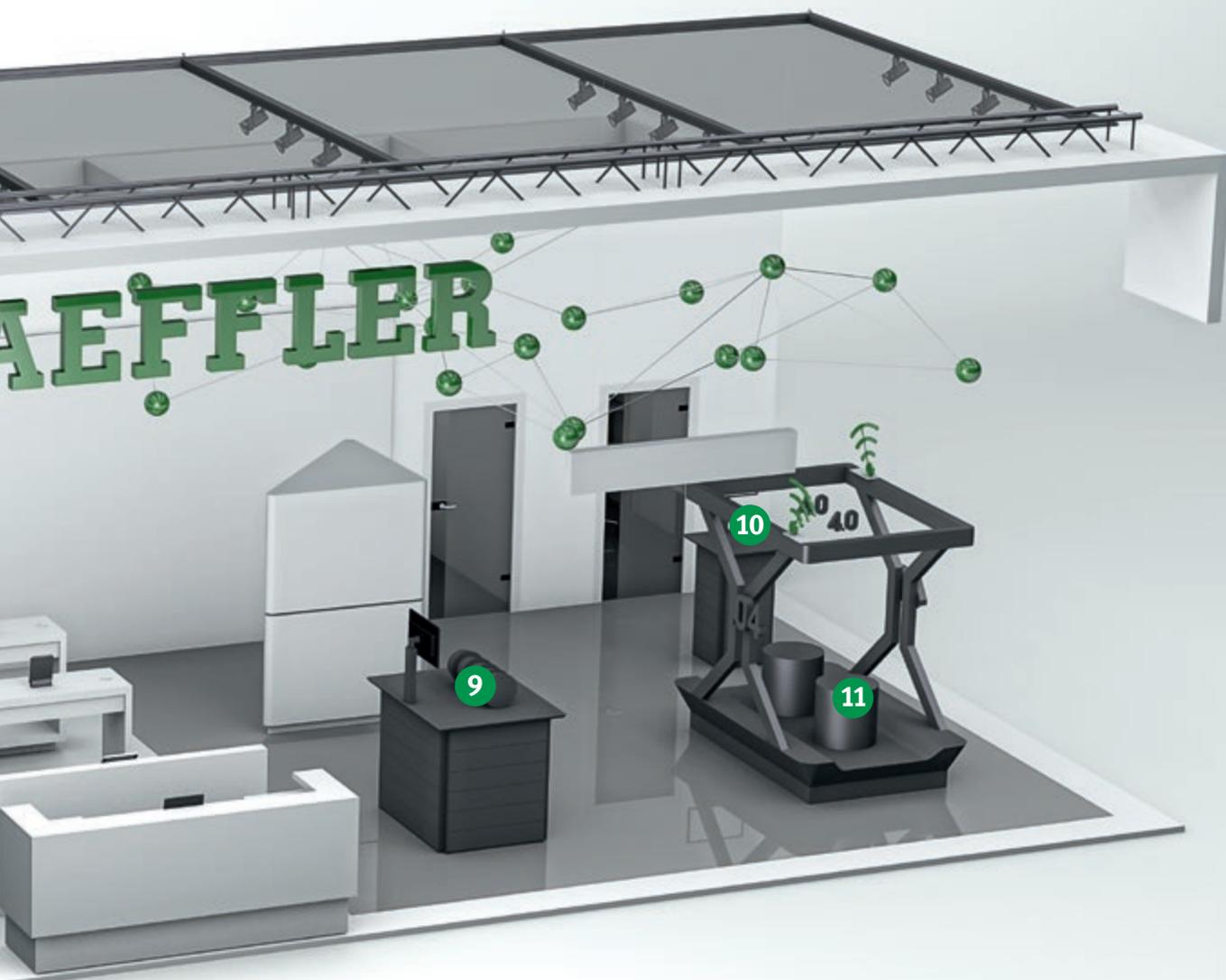
**EMO**  
Hannover  
18-23·9·2017  
Hall 7 – Booth C42

## Build your own: Rotary tables with USPs

On the touchscreen, you can create your own individual rotary table (⑥). You have three series of torque motors and three series of rotary table bearings to choose from to find a solution to even the most specialized machining job.

- New for EMO, Schaeffler is presenting its so-called Rotary Table KITS (⑦): In the future, you will be able to incorporate rotary table bearings and torque drives into your design as a complete, pre-assembled unit – with an option for an integral angle measuring system in the bearing.

- The complete redesign of the series YRTC rotary table bearing (⑤) will be on display at the Schaeffler booth in Hannover for the first time. The exhibit provides more detail on the design changes as well as the significant progress made with respect to limiting speeds and tilting rigidity.
- Are you looking for a development partner for an integrated bearing solution? Then have a closer look at the tool changer (③) and let one of our Engineering Service engineers tell you more about it. For more information on high-end components for rotary tables, see pages 14 to 19.



### Best in class: X-life linear and rotary components

Highly productive machine tools can only be achieved by using the most powerful components. We have just these high-end components on display:

- Our revised six-row linear ball bearing and guideway assembly (2) – the benchmark for rigidity and quiet running;
- Our planetary screw drive (4) – a screw drive with one of the highest load carrying capacities up to 25 mm on the market and our new spindle bearing series: The series N10 and NN30 cylindrical roller bearings (5) and the series M angular contact ball bearings (6). These are available in a choice of three performance classes, the highest performance coming from the HCM variant with Vacrodur rolling bearing steel made using powder metallurgy and ceramic rolling elements. More information on our X-life products can be found on pages 10 to 15.

### Smart components for the Machine Tool 4.0

Everything you need to know about networking components and subsystems is visible in our 'glass machine tool' (11): logical measuring points and measured quantities; this is what we understand as smart components

as well as the control loops which allow the last reserves to be extracted from the components. We two exceptional highlights on display: Firstly, the new generation of our automatic, condition-oriented relubrication system for monorail guidance systems (9) for feed axes. Secondly, the first public viewing of our innovative sensor system for spindle bearings (10). This system assesses and monitors the mechanical load at the front spindle bearing. More information on the enormous progress and increases in productivity which can be achieved by monitoring the spindle bearing load and with automatic relubrication of linear axes can be found on pages 20 and 21.

In addition to this, we are also exhibiting a new multi-channel Condition Monitoring System specifically designed for machine tools. Using an IEPE interface, sensors from any manufacturer and subsystems can be incorporated into the CMS.

Our digital services can also be sampled on another screen, including the new PrecisionDesk app (12) which can be used to call up the measurement logs for high-precision bearings. More details are available on pages 22 to 27. ◀



# AN NEW PERFORMANCE CLASS

New developments in the six-row KUSE linear recirculating ball bearing and guideway assemblies in X-life quality put it among the monorail guidance systems based on balls with the highest rigidity levels and load carrying capacities that are currently on the market. Not only the concept behind the design but also an optimized internal construction ensure extremely high load carrying capacity and extraordinarily quiet running.

In the KUSE X-life linear guidance system, the loads are supported by six instead of the usual four rows of balls. Four rows of balls transmit loads in a compressive direction with a contact angle of 45°. The tensile forces are transmitted by two additional rows of balls. To increase their load carrying capacity, these two rows of balls have a greater contact angle of 60°. Lateral forces are supported by three rows of balls in each case. This special arrangement of the rows of balls, in a combination of X- and O-arrangements, means that the KUSE X-life series is ideal for combined load directions in particular. Compared to four-row linear recirculating ball bearing and guideway assemblies, the combined rigidity can be increased by 15% on average.

## Load ratings increased by up to 44% and rating life extended approximately threefold

The infeed zones in linear recirculating rolling bearing and guideway assemblies, i.e. the area in which the rolling elements are guided into the load carrying element until the load is fully applied, are critical areas in terms of performance limitation. They generally limit the guidance system's operating life and load carrying capacity. The infeed zones should ensure that the load is applied to the rolling elements gradually rather than abruptly. Due to a new optimized design of these infeed zones in the carriages and significant further developments in manufacturing options,

INA-Lineartechnik has been able to increase the basic load ratings of the six-row linear recirculating ball bearing and guideway assemblies by up to 44% depending on the size and type. As a result, the rating life is approximately three times longer than that of previous designs. Thanks to the significant increase in performance, the redesigned KUSE series has been awarded the well-known X-life quality mark.

## Pulse amplitudes reduced by more than 86%

The recirculating rolling elements also prevent a constant number of fully-loaded rolling elements being present in the load zone of the carriages. Depending on the effective number of rolling elements supporting the load in the load zone, the carriage balances deflections along the stroke to varying degrees. This causes a slight, pulsing equalizing movement in the load direction of the carriage. This kind of movement is called stroke pulsation. Pulse amplitudes of up to 0.75 µm (peak to peak in the 35 size) for a single ball are not uncommon. In the new generation of KUSE X-life guidance systems, it has been possible to optimize the contour of the infeed zone in such a way that the stroke pulsation is now less than 0.1 µm, particularly at higher loads. This represents a reduction of more than 86%. The new KUSE X-life series is therefore characterized by extremely quiet running as well as extremely high precision and load carrying capacity. They are an excellent solution for all high-accuracy applications such as in electronics production, die manufacturing, microscopy and optical systems. They can even be used in measuring machines. ◀

# ENABLER FOR MORE SPINDLE PERFORMANCE

Test results from test rigs in Schweinfurt provide impressive results: In benchmark testing, the X-life version of the high-accuracy cylindrical roller bearings N10 and NN30 has the lowest level of heat generation, the lowest running temperatures and the highest limiting speeds on the market.

# S

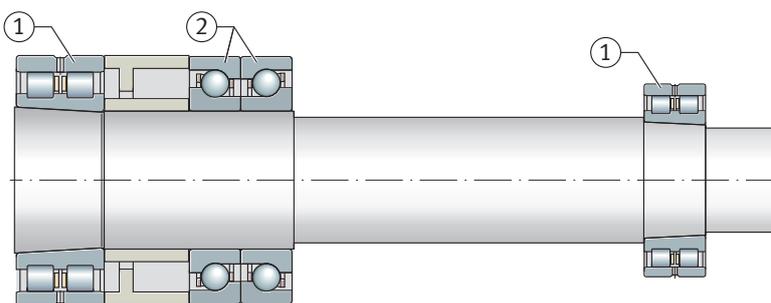
chaeffler has made significant improvements in its proven single-row N10 and double-row NN30 high-accuracy cylindrical roller bearings in the 30 to 120 mm bore diameter range.

A completely new design, optimized manufacturing methods and a new window cage made from high-performance plastic PPA (polyphthalamide) reduce the friction and heat generation in the bearing considerably. Tests completed on test rigs in Schweinfurt have produced running temperatures up to 12 degrees lower when compared to the brass cages currently in use and up to 5 degrees lower when compared to competitors' plastic cage variants.

## 35% improvement in limiting speeds and 19% greater basic dynamic load ratings

Limiting speeds can be increased by up to 35% in grease and oil lubricated bearings when compared to previous designs due to the lower friction. The lubricant is less stressed and there is a significant increase in the grease operating life. Speed parameters of almost one million mm/min are possible with minimum quantity oil lubrication. At the same time, it was possible to increase the basic dynamic load ratings by up to 19% compared to previous designs. With these parameters, Schaeffler is now setting the benchmark in the field of precision cylindrical roller bearings. End users find that when spindles

It's the combination that does it: FAG X-life N10 and NN30 cylindrical roller bearings and FAG BAX axial bearings now have matched limiting speeds.



The combination of these bearings in a head spindle increases spindle performance:  
1. FAG X-life high-accuracy cylindrical roller bearing 2. FAG BAX axial bearing

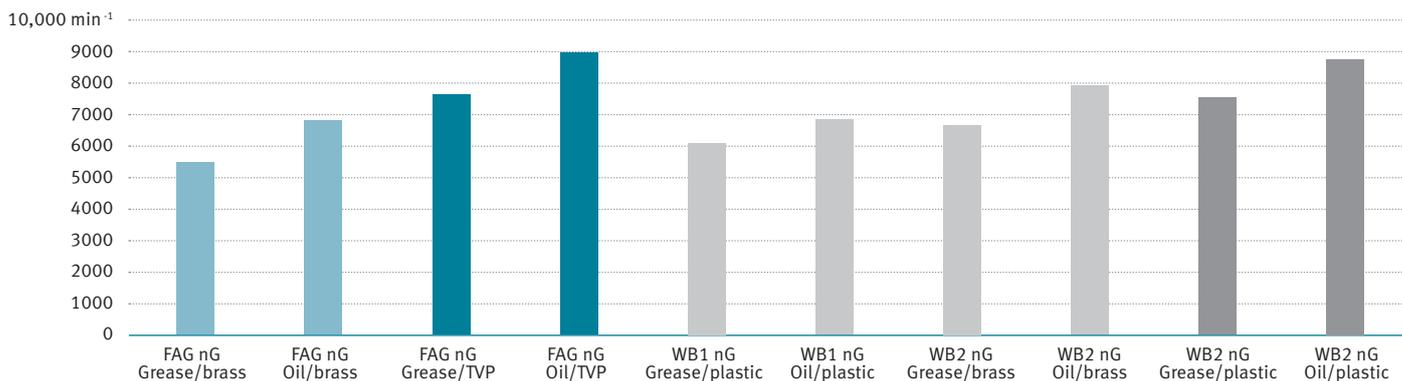
rotating at high speeds are supported by N10 and NN30 bearings, the running noise is particularly quiet and much more favorable.

The higher limiting speeds of the X-life high-accuracy cylindrical roller bearings produce designs with significantly greater performance. This is particularly true when combined with series BAX high speed axial bearings. The BAX axial angular contact ball bearings have the same diameter as series 70 bearings and are therefore matched to the diameter of the N10 and NN30 cylindrical roller bearings. FAG BAX bearings and N10 and NN30 bearings are frequently used as a locating/non-locating bearing combination in high-speed spindles. Until now, N10 and NN30

bearings have had lower limiting speeds than BAX bearings which meant their speed capacity could not be utilized to the full. With the new X-life high-accuracy cylindrical roller bearings, the limiting speed of the whole bearing support has now been increased by almost 20% to that of the FAG BAX bearings. When combined with the greater load carrying capacity, this represents greater cutting capacity, longer operating life and reduced lubricant requirements.

It's the combination that does it: FAG X-life N10 and NN30 cylindrical roller bearings and FAG BAX axial bearings now have matched limiting speeds. Increased spindle performance and greater cutting capacity are now a reality. ◀

## THE HIGHEST SPEEDS ON THE MARKET WITH FAG X-LIFE CYLINDRICAL ROLLER BEARINGS.



Comparison between FAG X-life cylindrical roller bearing NN3018 and the competition.



# NEW POTENTIAL FOR OPTIMIZATION

A new series of high-speed spindle bearings offers significant potential to increase the load carrying capacity of motor spindles even further in terms of maximum speeds, high machining forces and high temperatures. This increases machine tool productivity even further.



Three fundamental spindle bearing designs have established themselves on the market, and these can be categorized according to the size of the rolling elements: Large-ball series, small-ball series, and designs with medium-size balls. With the new X-life High-Speed spindle bearing series M, HCM, and VCM, Schaeffler has optimally combined the kinematic suitability for high speeds of existing small-ball high-speed series with the robustness and load carrying capacity of large-ball bearings by matching the ball size, osculation, and radial internal clearance together in a targeted manner. Important development objectives for the X-life High-Speed series also included an internal construction with particularly optimized friction behavior and a high tolerance towards rapidly changing thermal operating conditions such as those that frequently occur in motor spindles. This optimized construction greatly reduces the increase in bearing preload caused by influencing factors such as interference between the bore and the bearing, high speeds, and large temperature gradients between the shaft and housing. Background: The increase in preload is only desirable within certain limits, because parameters such as friction and heat generation in the rolling contact also dramatically increase at the same time, which limits the maximum permissible speed.

## M version – cost-effective and robust

The balls and rings of M series X-life High-Speed spindle bearings are manufactured from the proven 100Cr6 rolling bearing steel. This version provides a high-performance, cost-effective bearing solution for motor spindles.

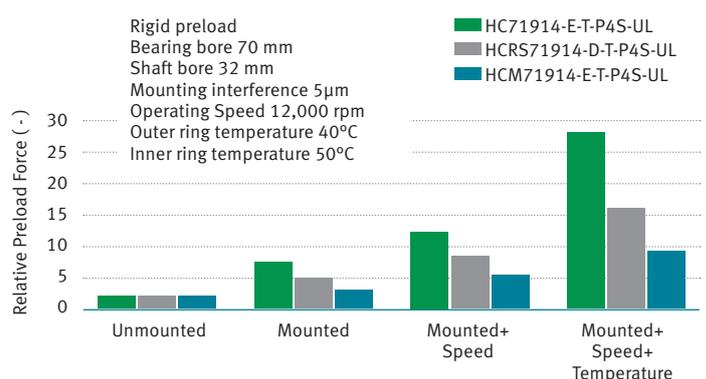
## HCM version – higher speeds and greater load capacity

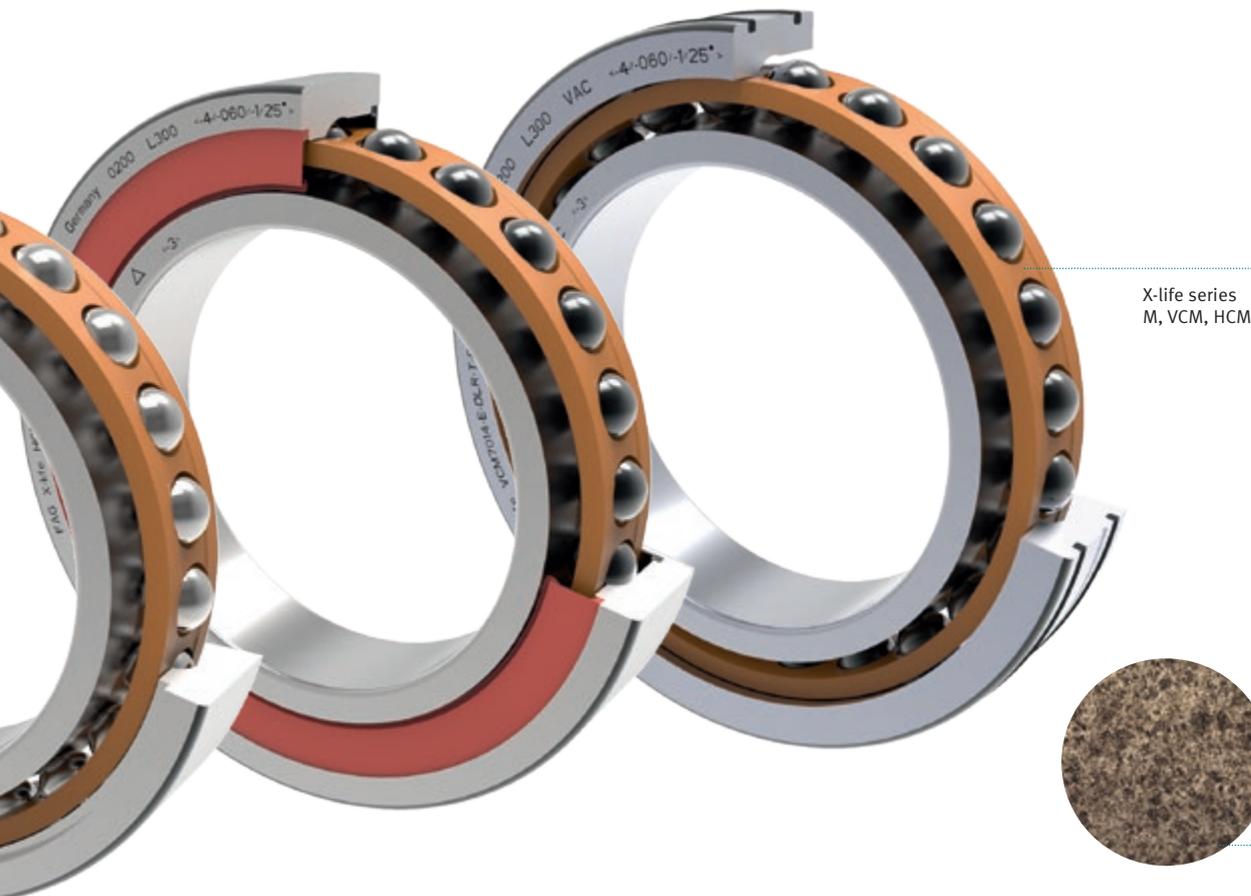
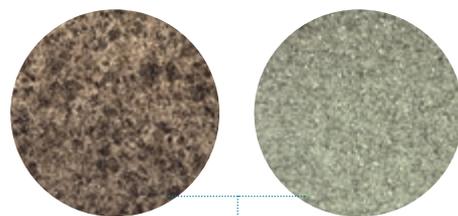
HCM type X-life High-Speed spindle bearings are equipped with ceramic balls and rings made from 100Cr6 rolling bearing steel. Thanks to their high performance capability and suitability for very high speeds, HCM spindle bearings allow the performance of motor spindles to be increased further.

## VCM version – new degrees of freedom in motor spindle design

X-life High-Speed spindle bearings VCM also feature balls made from ceramic material, but with bearing rings made from the newly-developed Vacrodur high-performance material. The VCM version offers new degrees of freedom in the design of motor spindles when compared to standard spindle bearings, such as replacing paired bearing supports used in sets with a single bearing. The spindle can therefore be shortened by one or two bearing widths; the significantly lower mounting outlay reduces costs, and the amount of heat transferred from the bearing support to the spindle is also reduced. The VCM bearings are characterized by an extremely high load carrying capacity, wear resistance and very high stability at high temperatures - even in the event of impaired lubrication conditions such as occur during inadequate lubrication or contamination. ◀

CHANGE IN THE RELATIVE PRELOAD FORCE DUE TO THE INFLUENCE OF THE FIT, KINEMATICS AND TEMPERATURE



X-life series  
M, VCM, HCMMicrograph of standard rolling bearing steel  
100Cr6 (left) and Vacrodur

# VACRODUR – NEW HIGH-PERFORMANCE MATERIAL

The extraordinarily high mechanical and thermal load capacity of Vacrodur, a rolling bearing steel produced using powder metallurgy, is providing the machine tool industry with access to significantly greater levels of performance and spindle reliability.



Unlike conventional rolling bearing steels such as 100Cr6, Vacrodur's hardness is not reduced at temperatures above 120 °C but remains stable even above 400 °C. There is no structural transformation in Vacrodur up to this high temperature. Spindle bearings made from Vacrodur thus retain a very high load carrying capacity and remain dimensionally and geometrically stable for an

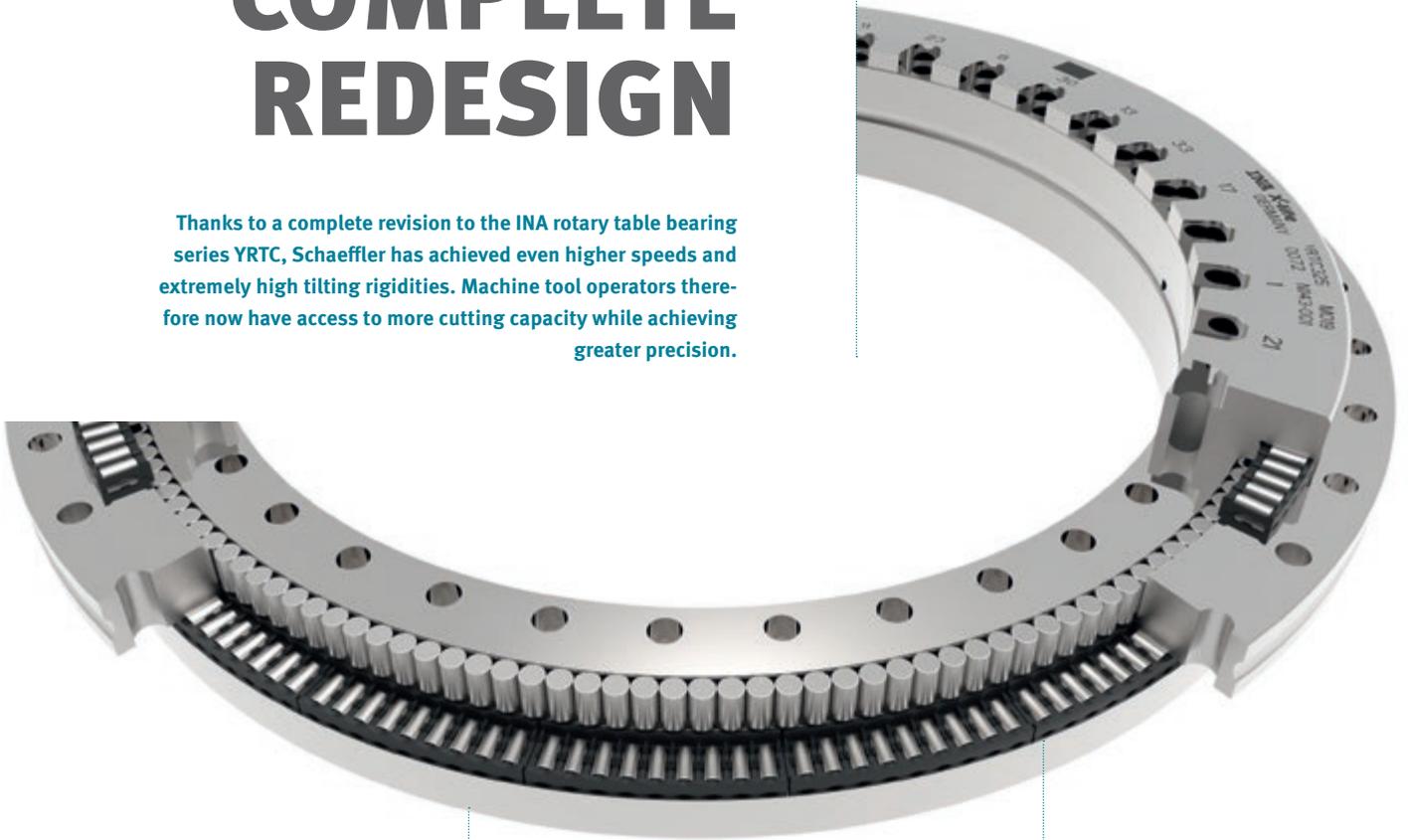
extremely long time, even under very high thermal loads, such as exhaust heat in motor spindles, and as a result of inadequate lubrication. Vacrodur has a very homogeneous structure with a high percentage of very finely distributed carbides. The carbides are responsible for Vacrodur's extraordinary resistance to abrasive wear. What is more, the specially alloyed material goes through a multi-stage heat treatment process that produces very high hardness values of up to 66 HRC and a tough (basic) structure. In tests under controlled contamination conditions, the operating life up to bearing failure was increased almost 20-fold compared to the existing benchmark. The high rolling resistance and resistance to fatigue from over-rolling under good lubrication conditions leads to bearings made from Vacrodur having a significantly longer operating life. Certified tests produced a 2.4-fold increase in the dynamic load carrying capacity compared to standard rolling bearing steel 100Cr6. This represents a 13-fold increase in the bearing's nominal rating life. Due to the high hardness and the subsequent lower tendency to plasticize, Vacrodur bearings have a 40 % higher basic static load rating than those made with 100Cr6. ◀

## SIMPLIFIED OVERVIEW OF THE PERFORMANCE AND SUITABLE SPEEDS FOR THE THREE X-LIFE HIGH SPEED SPINDLE BEARING VARIANTS M, HCM AND VCM



# COMPLETE REDESIGN

Thanks to a complete revision to the INA rotary table bearing series YRTC, Schaeffler has achieved even higher speeds and extremely high tilting rigidities. Machine tool operators therefore now have access to more cutting capacity while achieving greater precision.



Rotary table bearing  
series YRTC325

**YRTC 325**  
IN X-LIFE QUALITY

**S**chaeffler is presenting the YRTC INA rotary table bearing unit in X-life quality at EMO. This includes the YRTC bearing dimensions already available on the market of 580 to 1030 mm as well as the new YRTC sizes of 100 to 460 mm which will be introduced in stages after EMO 2017.

As part of a complete redesign of the YRTC bearing series in the size range 100 to 460 mm, Schaeffler was once again able to significantly outperform current performance levels as far as rigidity and speed were concerned. The frictional torque of the new YRTC bearing design is extremely uniform and is reduced by up to 50 %. This allows the limiting speeds to be increased by up to 80 % in places. It was also possible to increase the tilting rigidities by up to 20 %. These performance features mean

the series has now been awarded the X-life quality mark. Technical features of the new YRTC bearings are plastic cage segments with a special grease reservoir, a more substantial bearing ring and an optimized rolling element geometry. In addition to this, the bearings also have excellent axial and radial runout accuracies. The YRTC series is also available with an optional measuring system integrated into the bearing. The X-life YRTC bearings are particularly suitable for use in plane milling machines as well as in highly loaded positioning and pivot axes and for extremely high precision machining.

#### Series YRTC compared to series YRTS and ZKLDF

The three series of INA bearings available from Schaeffler, YRTC, YRTS and ZKLDF, provide an outstandingly large choice of rotary table bearings for preferred machining processes, types of axes,

sizes, and load and speed ranges. In addition to the YRTC series, Schaeffler offers the YRTS rotary table bearing (S = speed) for applications with very high speeds and increased requirements in terms of tilting rigidity. They are typically used in extremely high precision milling, grinding and gear cutting machines as well as in rotary tables with very high speeds. The double row axial angular contact ball bearings of series ZKLDF are available for applications with extremely high demands in terms of speed. The applications of choice for these bearings include bearing supports that have a long operating duration in rotary tables with a main spindle function. All series can be fitted with an integral angle measuring system. In addition to this, Schaeffler is also offering ready-to-fit combinations consisting of rotary table bearings from the above series and IDAM torque motors. ◀

# LINEAR ACTUATOR WITH EXTREMELY HIGH POWER DENSITY

The PWG planetary screw drive from INA Lineartechnik is a small spindle drive with extremely high power density and an attractive price/performance ratio.



Screw drive for compact electromechanical linear actuators

»» We have targeted a gap in the market in the small diameter range with our PWG planetary screw drives. Successful projects in the last two years have clearly shown that electromechanical drives consisting of a motor, a PWG unit and an axial bearing support require very little space and offer significant benefits to the customer. It is also usually possible to make significant weight reductions when compared to the current established solutions on the market. <<

Dipl. Wirtschaftsingenieur (FH)  
Wolfram Hau,  
Product Manager PWG

**E**xtrremely small pitches from 0.72 mm and therefore very high ratios can be achieved due to the internal design of the planetary screw drive. Due to the lack of transmission and the relatively small torques, it is therefore possible to produce high axial forces. The forces are transmitted via the flanks of the spindle, rollers and nut. Due to the large number of contact points, this produces a very high axial load carrying capacity and rigidity. The PWG planetary screw drives from INA Lineartechnik can therefore be used to develop not only electronic linear actuators with very high performance density but also economical motors. Integrating the PWG planetary screw drive into customer applications is a very simple process using a feather key connection on the outside diameter of the spindle nut; the motor is then connected to the end of the spindle.

#### Economical modular design with non-cutting technology

The spindles and planets in the PWG are manufactured without the use of cutting technology. This forming process ensures the material has a high density and optimum flow of fibers. In addition to being an economical manufacturing process, it also produces extremely high strengths and a basic load rating which is 15 % higher than that produced using cutting technologies. The PWG planetary screw drives are available in a modular range with diameters from 5 to 25 mm

and pitches from 0.7 to 3 mm. The dynamic load carrying capacities range from 8 kN for a 5 mm spindle diameter to typically 40 kN for a 25 mm spindle diameter.

#### Suitable bearing kits for the PWG

INA also supplies non-locating and locating bearing kits matched to the relevant bearing seating and the load carrying capacity of the planetary screw drive. Two angular contact ball bearings in a tandem arrangement are used for the locating bearing and radial ball bearings for the non-locating bearing. Bushes are used to adapt the bearing kits to the spindle ends. Bearing supports can also be made to specific customer requirements. By selecting a suitable spacer between the two halves of the spindle nut, it is possible to supply either clearance-free or preloaded units. The design of the PWG also allows either the spindle nut or the spindle to be driven.

#### Applications in an extremely diverse range of sectors and machines

Application areas for PWG units are opening up in, for example, radial press tools, in servo table presses and riveting machines, in welding technology, in cutting technology in modern machine tools, in building and process automation and in controlling maritime propulsion units. An initial pilot project is in place in the medical sector. Our system solution specialists have also produced a plug-and-play ready linear actuator for a customer consisting of a PWG, a motor and an axial bearing support. Full details on the design of linear actuators using PWG planetary screw drives are available in the Schaeffler publication TPI 254. ◀

# INNOVATIVE MODULAR SYSTEMS

Schaeffler offers a highly-specialized, finely-tuned modular system that allows customers to select exactly the right components for their rotary tables and rotary axes – that includes high-speed, high-performance, and high-precision designs.



Rotary table bearing ZKLDF – the market leader for rotary tables with extremely high speeds



Virtually no other type of electric drive exists in which the motor and bearing support have so much influence on each other as in driven high-precision rotary tables and rotary axes: The three sources of heat, the rotor, the stator and the bearing, are all very close to each other due to the very compact design. The design measures taken for heat transfer and heat dissipation must therefore be tailored to each application in order to ensure optimum functionality. The rigidity of the bearing support and the machining forces also directly influence the air gap between the stator and the rotor. Because of these close functional dependencies between the motor and the bearing, the components of rotary tables and rotary axes always have to be developed as a system.

#### Large selection of torque motors and rotary axis bearings

In order to keep the development outlay for customer-specific designs at a manageable level, Schaeffler has three series of standard torque motors from INA – Drives & Mechatronics AG

& Co. KG (IDAM) and three series of INA rotary table bearings and rotary axis bearings readily available. The torque motors and bearings can be combined as desired, enabling the user to apply exactly the right solution for any machining process – whether it's combined soft turning and milling, plane milling, gear grinding, grinding and hard turning, spindle applications, positioning tables, or pivot axes for ultra-precise machining. This optimum combination of components is adjusted by Schaeffler's engineers to match each individual customer's cutting process and deliver exactly the required precision and dynamics.

#### Series RIB torque motors – more productivity and precision

When compared to the previous series RI and depending on how they are used, the thermally optimized direct drives RIB can be operated with a 20 % increase in maximum torque (design strategy "torque-optimized motor") or at up to 30 % less heat loss (design strategy "loss-optimized motor") due to

The new SRV torque motor series stand out thanks to their extremely smooth running characteristics

lower utilization at the same working point. The RIB motors are suitable for extremely dynamic movements and precise positioning. Ideal applications for these motors include rotary tables, axes for rotary vibration tables, and milling heads for highly-dynamic and powerful milling, positioning, clocking, and swiveling.

#### Series RKI torque motors – extremely high torques and speeds with low heat losses

The innovative rotor design of the RKI motors is the main differentiating factor from the standard RI series.

On the one hand, this rotor produces up to 30 % more force in the air gap and therefore a correspondingly higher torque. On the other hand, the iron and magnetic losses in the RKI rotor have been reduced to such an extent that considerably higher speeds can be achieved which are up to four times greater than the standard torque motors. The magnetic circuits in the RKI motors have also been optimized using FEM calculations so that the detent torque (cogging) is largely eliminated when there is no current present. RKI



motors offer a very favorable combination of a high power yield, very good uniform running characteristics, and low power loss. Ideal applications here include rotary tables with optional turning operation and rotary tables for combined milling, turning, hard turning, or grinding.

#### New SRV torque motor series – machining accuracy in the sub-micron range

Due to the development of an internal compensation mechanism for disruptive magnetic forces, the machine structure is not subjected to any measurable pulsating axial or radial forces from the new SRV torque motors. Very low running noise, optimum surfaces without visual errors and extremely high geometrical and dimensional accuracy are now achievable. SRV motors are therefore ideal for use in ultra-precise milling, grinding, and gear cutting machines, particularly as drives for rotary tables and rotary axes with very high speeds and tool or workpiece spindles (up to 14,000 rpm). ◀

## BEST IN CLASS BEARINGS GET EVEN BETTER!

With its two series of axial-radial cylindrical roller bearings and a series of double row axial angular contact ball bearing, Schaeffler has an extraordinarily large selection of rotary table bearings. Each series has its own particular strengths.

As part of a complete redesign, Schaeffler was once again able to increase the performance spectrum of its new X-life YRTC rotary axis bearings in terms of tilting rigidity and speed. The new YRTC bearings offer very low and uniform frictional torques and therefore even high limiting speeds. In addition to this, they also have excellent axial and radial runout accuracies. This combination of characteristics means that the X-life YRTC bearings are particularly suitable for use in plane milling machines as well as in highly loaded positioning and pivot axes and for extremely high precision machining. Overall, the X-life YRTC rotary table bearings can guarantee the machine tool industry's international competitiveness in many areas, including combined milling and turning with extended operating duration, higher speeds and extremely high cutting capacity.

#### Extremely low friction with YRTS bearings

The patented raceway geometry of the YRTS axial-radial bearings allows them to achieve levels of bearing friction which are lower than those previously achieved in preloaded roller bearings. When combined with the high rigidity, this

means the YRTS bearings are exceptionally well suited for use at high speeds. A further major advantage is the integrated measuring system, which is also available as an option for all rotary table bearings.

#### Extremely high speeds with ZKLDF...B bearings

ZKLDF axial angular contact ball bearings are particularly low friction bearing units for use at high speeds, for high axial and radial loads, and high tilting rigidity requirements. When combined with RKI torque motors, ZKLDF...B bearings provide a significant increase in rotary table limiting speeds. Applications of choice for these bearings are bearing supports that have a long operating duration in rotary tables with a main spindle function (e.g. for combined milling and turning operations), bearing supports in milling, grinding, and honing heads, and in measuring and testing equipment. The range of bearing supports, drives and angle measuring systems available from Schaeffler means the company can

supply all the main components for rotary axes and driven rotary tables. The fine-tuned portfolio of products which can be combined in many different ways allows manufacturers to offer rotary tables and rotary axes with their own USPs at a very low development cost. ◀

Schaeffler offers an option of an angle measuring system integrated into the bearing for all rotary table bearings



# INDIVIDUAL LINEAR SYSTEMS ARE JUST A MOUSE CLICK AWAY

Today, the route to customized, ready-for-use single and multiple axis linear systems has never been easier: A wide range of linear axes and configuration tools are available on the market. This article explains why mechanical engineering should always have linear systems from INA-Lineartechnik on its shortlist.

Today, there are four main factors to consider when selecting a linear system: A realistic design, a configured linear axis which is optimally matched to the application, a good price/performance ratio and a short delivery time. In order to address all these factors in the best possible way, INA-Lineartechnik, based in Homburg, offers

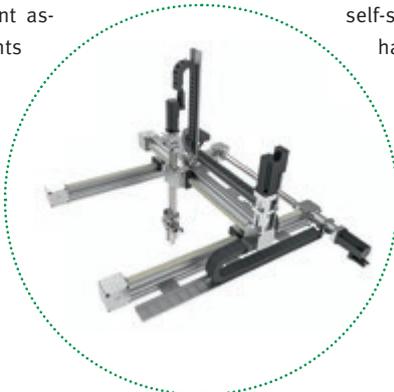
- Freely available calculation and configuration tools,
- A substantial range of standardized single axes supplemented by axes with special functions and
- A large network of drive technology suppliers for customer-specific, pre-assembled solutions including a range of manufacturers of electric motors, planetary transmissions, controls and sensors to choose from.

## Linear actuators with realistic design

With Bearinx® Online Easy Linear Systems, Schaeffler is offering its customers, whether special machine builders or OEMs, a free calculation tool which can determine the actual demands on the linear guidance systems and linear actuators right down to individual rolling contact points. Despite this, Bearinx® Online is simple and intuitive to use without a great deal of previous experience. The Bearinx® calculation algorithms consider many aspects including

- Connecting all the linear modules to create a closed calculation for the linear system and all accelerated table and machine bed masses,
- The non-linear elastic deflection behavior of the rolling elements,
- The elasticity of supporting components and profile guideways in recirculating rolling element assemblies, contact angle displacements due to loads in linear ball bearings and
- The actual contact pressure taking tilting and profiling of the rolling elements into consideration.

Typical multi-axis system from the Schaeffler system solutions portfolio.



## An almost infinite choice: Linear actuators

The whole range of INA linear actuators is available in Bearinx® Online Easy Linear Systems, with cross sections from 40x45 mm to 415x200 mm. The linear actuator portfolio ranges from high accuracy compact actuators with minimal cross section, through actuators with additional functionality, to tandem actuators with high load carrying capacity.

Linear actuators from the four-row KUBE-B or the new six-row KUSE linear recirculating ball bearing and guideway assembly ranges can be fitted in applications where noise and vibration are particular issues, such as in medical technology or in metrology. Speeds of up to 10 m/s can be achieved with the four-row linear ball bearing and guideway assemblies KUBE-B-HS (HS = High Speed) in X-life quality which means the potential of actuators with belt drives or even direct linear drives can be used to the full. As far as the achievable speeds are concerned, the following limits apply: 8 m/s for linear actuators with track roller guidance systems and belt drive; 2.5 m/s in general for linear actuators with ball screw drive; 5 m/s as standard for linear actuators with monorail guidance systems and belt drive.

## INA tandem actuators: More precision and safety

The INA tandem actuator has a single carriage which is supported by two parallel linear recirculating ball bearing and guideway assemblies. Drive options are belt drive (MDKUBE..-3ZR design) and ball screw drive (MDKUBE..KGT design). With their large profile cross section and the resultant high rigidity, these linear actuators are particularly suitable for use as self-supporting transverse axes in assembly and handling technology, as rigid transverse axes in measuring machines, or for joining processes and processing machines. They can support particularly high torques in all three axes. The -3ZR design is always driven by three parallel belt drives. Due to the redundancy in the drive, these tandem actuators are also the preferred solution for vertical axes.



Innovative MTKUSE telescopic actuator combined with an MDKUYE-KGT tandem actuator

#### INA telescopic MTKUSE: More free space

Telescopic axes offer a significant benefit when compared to standard linear axes in that their travel distance extends beyond the envelope of the driven supporting profile. The work area can therefore be released for other machines and processes. For example, the telescopic function allows transfer into areas behind safety barriers or into other work areas. Schaeffler's INA-Lineartechnik engineers have developed the MTKUSE telescopic actuator specifically for this type of secondary axis, such as in pick-and-place or tool transfer applications. The telescopic actuator has three precision linear ball bearing and guideway assemblies arranged on top of each other making the possible travel distance more than twice that of the basic actuator.

#### MKKUYE clamping actuator: Fix, center, clamp

Another interesting solution from the standard INA portfolio is the clamping actuator. Two carriages are mechanically driven in opposite direction by integral belt drives. The clamping actuators provide a simple solution to fixing, alignment, centering and clamping functions in handling and assembly technology as well as in packaging technology such as palletization.

#### Linear tables: Precise and with particularly low section height

The second main product group is INA linear tables. They are available with shaft or monorail guidance systems as precision linear tables (LTE, LTS and LTP). Precision linear tables LTP are used where positioning tasks with high repeat accuracy are required. These units are always driven by a ball screw drive. In order to be able to assemble servomotors from a range of manufacturers in accordance with customer requirements, a coupling housing KGEH has been developed as an open interface. The KGEH coupling housing is compatible with the whole portfolio of linear actuators and linear tables.



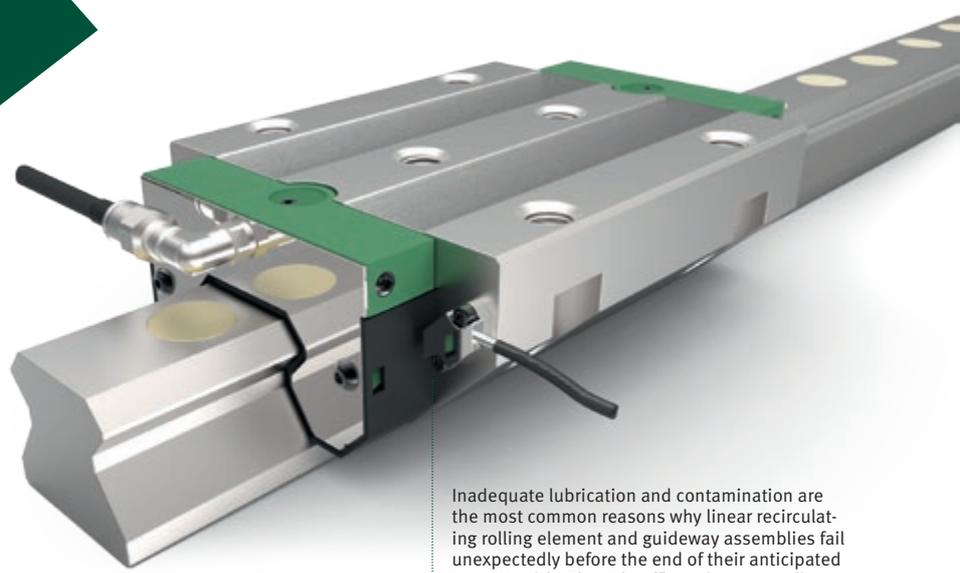
Just a small selection from the Driven linear units catalog AL1 (from left): Linear table with open shaft guidance, linear actuator with monorail guidance system and ball screw drive, and linear actuator with external track roller guidance system and belt drive.

#### Designing, configuring and ordering linear systems

Bearinx® Online Easy Linear Systems allows users to combine actuators with servomotors and planetary transmissions to form driven single or multi-axis systems and to lay this out as a system. The selection of an appropriate combination of motor and transmission for the relevant actuator is made significantly easier for the user with preferred series clearly shown. This ensures the load carrying capacity of the guidance system, belt drive or ball screw drive matches the motor/transmission combination. At the end of the calculation, there is an option of generating a request for a proposal together with an automatically generated bill of materials. ◀

	Linear actuators with monorail guidance system				
Drive element	Linear actuator	Tandem actuator	Clamping actuator	Compact actuator	Telescopic actuator
Belt drive	✓	✓	✓		
Ball screw	✓	✓	✓	✓	
Toothed rack					✓
Application/function	Handling, positioning, processing	As self-supporting transverse axis, rigid axis, measuring tasks, processing	Aligning, clamping, fixing, centering	Positioning, handling, processing	Handling, transfer, freeing up work areas

Large choice of INA linear actuators with monorail guidance system



Inadequate lubrication and contamination are the most common reasons why linear recirculating rolling element and guideway assemblies fail unexpectedly before the end of their anticipated operating life. The Schaeffler solution: Intelligent, i.e., on-demand and automated relubrication of linear recirculating rolling element and guideway assemblies.

# NO MORE SURPRISES!

**In the real world, every now and then, machine tools do not run perfectly: Optimum lubrication intervals were not selected resulting in inadequate lubrication. Or foreign bodies or coolants can find their way into the carriages on linear guidance systems. Peak loads due to collisions and longer-term overloading during roughing or during high speed cutting are not a rarity and often subject the front spindle bearing to load.**

These recognized factors of poor lubrication, contamination and overloading can cause initial damage on the raceways of rolling bearings and the rolling elements in linear guidance system which intensifies during continuous operation and eventually manifests as wear or vibrations.

The result: Apart from poorer surface qualities and more rapid tool wear, premature total failure of the axis or the spindle is now inevitable. Unplanned failures in machine tools are the aggravating and very expensive result of an extended, continuous and unnoticed development of damage. Schaeffler has developed an innovative counter-measure specifically for linear recirculating roller bearing and guideway assemblies and spindle bearings.

## **Monitoring the lubrication conditions in linear recirculating roller bearing and guideway assemblies**

As lubricant ages, the quantity of lubricant becomes less or the lubricant loses its damping effect in the rolling contact due to contamination by coolant; the innovative new system makes use of this relationship. The rolling elements then generate more vibrational energy in the supporting elements. This vibrational energy is measured by a measuring system on the carriage and assessed by an electronic evaluation system located in a small housing. The electronic evaluation system allows up to six carriages

to be monitored on each axis. If the threshold value generated based on the bearing's new condition, the so-called lubrication indicator, is exceeded, the system automatically triggers a relubricating impulse on a lubricator such as the FAG Concept8 system.

## **Benefits of requirement-oriented and automatic relubrication impulses**

If an axis is only subject to short travel distances and low machining forces, the system will trigger less frequent lubricating impulses, which become more frequent as load conditions increase. If foreign bodies get into the carriage as a result of contamination or the carriage becomes contaminated with cooling lubricant, this is immediately detected through the solid-borne sound emissions, evaluated, and a lubricating impulse triggered. As long as the solid-borne sound emissions are above the threshold value, the lubricating impulses are repeated. If the key values return to the normal level again after the lubricating impulses, the raceways and rolling elements have not been damaged by the contamination. Without this innovation, the linear guidance system would remain in operation with contamination in the rolling contact until the next planned lubrication interval – and would thus suffer corresponding initial damage. The inevitable consequence would be premature total failure of the linear axis. ◀



## **Benefit for machine manufacturers and operators**

The innovative system has the following competitive advantages for machine manufacturers and operators:

- Monitoring and maintaining optimum lubrication conditions in the linear guidance system significantly extends the operating life and consequently allows a constantly high level of manufacturing quality to be achieved.
- With less stress on the linear guidance system, lubricant demand can be reduced by up to 30 % compared to static relubrication intervals which are always predicated on the worst case scenario.
- When the inside of the carriage becomes contaminated, the “flushing” effect prevents damage to the linear guidance system from the start.
- The amount of machine downtime is thus reduced and the availability of the machine tool increased.

### Monitoring displacement in the spindle bearing

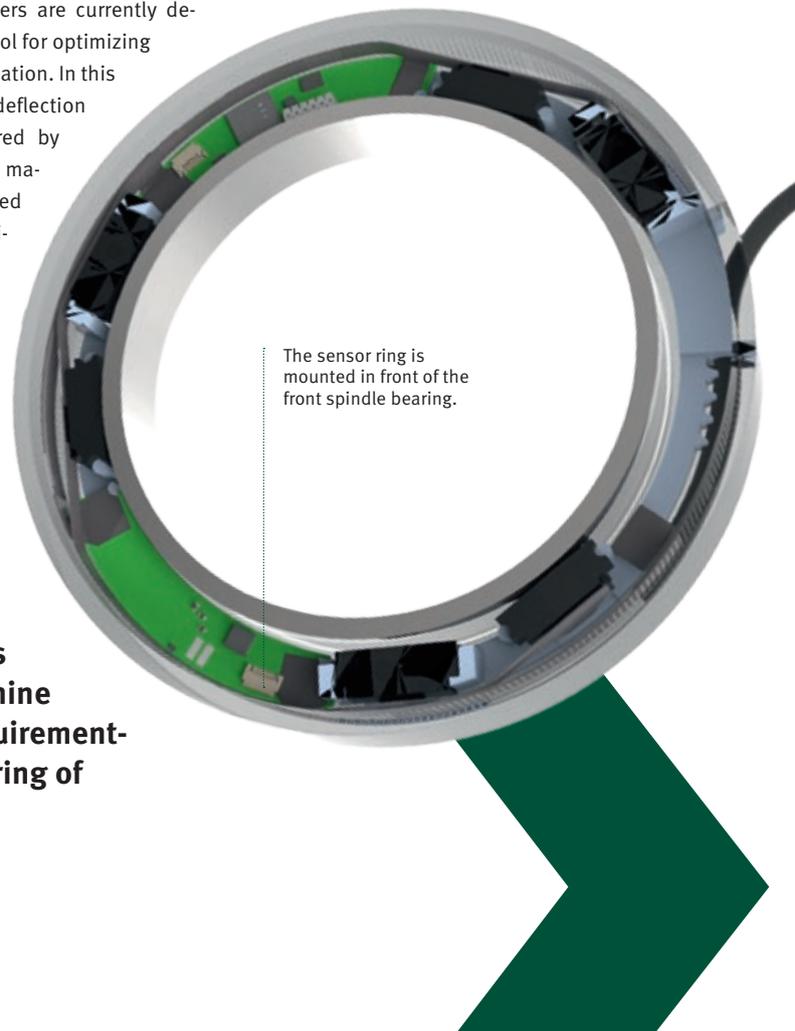
Continuous overloading and very high peak loads, such as can occur during collisions, mean that sooner or later the whole machine tools will stop. To prevent overloading, it is first necessary to be able to detect these occurrences with a degree of certainty. For spindle bearings, it is not so much the forces but the deformations and deflections in the rolling contact which are the decisive factor. The spatial deflections in the rolling contacts in the bearing result in displacement of the bearing inner ring. This displacement of the inner ring thus represents the stress condition in the spindle bearing material. This was the approach taken by Schaeffler's engineers in solving this problem and developing a new type of sensor ring specifically for this innovative concept of monitoring the spindle load. The sensor system measures the displacement at the front spindle bearing under load in a very high resolution and in five spatial directions – three translational and two rotatory. This, combined with the matching expertise in rolling bearings, allows the kinematic conditions in the bearing and the operation-related parameters such as pressure, spin/roll ratio, and cage pocket clearance to be clearly calculated. The sensor ring transmits an electrical warning signal to the machine's control system if the deflections measured on the rolling elements exceed a specific threshold. This threshold is set individually for each spindle and machine type. A particular feature in these times of cloud computing is that all of the software and the required algorithms are integrated into the sensor technology. The system is locally functional and transmits an individual warning signal to the machine's control system, which makes the following applications possible:

- Detecting a crash (collision): The sensor technology is capable of signaling an overload at a digital output within 2 milliseconds. This allows serious subsequent damage to be minimized or even prevented through fast deactivation of the drive.
- Long-term protection for machine tool spindles: If the system triggers a warning signal, the operator can adjust the machining program immediately after the first manufactured part or reduce the spindle load by using a new tool or by employing a more suitable tool type. He therefore achieves lower peak loads, reduces their frequency and benefits from a longer operating life for the spindle. Effectively, this means more manufacturing time for the operator and lower repair costs.

Measuring the displacement using a sensor ring and integral load monitoring has reached the preproduction stage. The first sizes are now available to customers for practical testing. What is more, Schaeffler's engineers are currently developing a new analysis tool for optimizing the degree of spindle utilization. In this extended system, the deflection collective that is measured by the sensor ring during the machining process is visualized over the time axis in addition to a threshold value being defined. For the



first time, machine operators will know to a very high degree of accuracy what percentage performance is being achieved at the spindle and in which machining processes. They can now take a targeted approach to optimizing the machining process on the machine in terms of utilization and operating life. This means that harmful overloads are prevented despite high spindle loads. Safe operation in the limit range allows the operators to increase not only their productivity but also to benefit from longer spindle operating life and less machine downtime. ◀



»» For the first time ever, machine tool operators have highly effective and easily manageable tools to protect the most important subsystems in machine tools and to extend their operating life through requirement-oriented relubrication of linear axes and monitoring of spindle loads. ◀◀

# LOOKING TO THE FUTURE

**With a new multi-channel condition monitoring system (CMS) specifically for machine tools, Schaeffler is pursuing two objectives: Firstly, condition monitoring and condition predictions for various key components in machine tools using a single CMS, and secondly, the flexible integration of sensors from different manufacturers into the CMS.**

Condition monitoring systems for machine tools must fulfill complex requirements with regard to the available space and the number of drive components to be monitored. In addition, manufacturers of subsystems and suppliers of ancillary equipment integrate their own measuring systems into machines. A CMS for machine tools must therefore be able to operate sensors from different manufacturers.

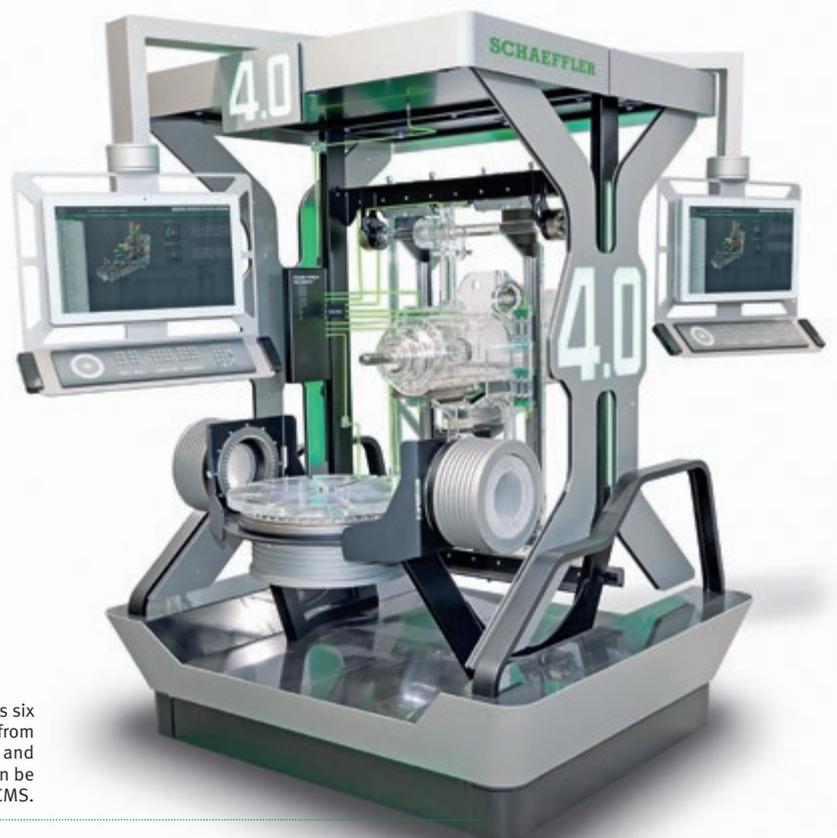
At EMO 2017 in Hanover, Schaeffler is presenting a functional prototype of a multi-channel CMS for machine tools. On the one hand, in-house systems and sensors such as piezoelectric vibration sensors can be connected to the CMS. On the other hand, piezoelectric vibration, force, and pressure sensors from other manufacturers can also be integrated into the CMS via an IEPE interface. This offers the major advantage that operators can use the sensors that are available and suitable for the individual measurement point and measurement task. The current prototype has six measurement channels. The system is designed so that, for example, the electronic monitoring of the lubrication conditions in linear recirculating roller bearing and guideway assemblies can also be integrated in the future.

## **Software intelligence and cloud connection ported from other developments**

The software of the presented prototype is very sophisticated, since most functions, algorithms, and the optional connection to the Schaeffler cloud from other projects could be ported with only minimal outlay. Thanks to the connection to the Schaeffler cloud, all digital services offered by Schaeffler for monitoring and detecting damage on rolling bearings are already available in the prototype stage of the CMS. As a local solution, the multi-channel CMS facilitates the monitoring of FAG rolling bearings based on the integrated bearing catalog as well as bearings from other manufacturers after entering the bearing-specific data.

A completely new development is the option of interpreting vibration signals from ball screw drives. The beta version of the software module, which is currently in the testing phase, will be available to customers after EMO 2017. Spindle load monitoring and a system for monitoring rotary table bearings is currently in the testing phase with the multi-channel CMS.

The presented prototype is intended primarily to provide pilot customers with the CMS functions in a development stage close to volume production status. The prototype is currently being tested in initial pilot projects with various machine tool types in in-house production and by selected partners. At the same time, the system is also being implemented in the Machine Tool 4.0 at Schaeffler's manufacturing site in Höchststadt. This machining center provides Schaeffler with a technology platform and development project for digitalized products in the machine tool sector. ◀



The condition monitoring system prototype has six measurement channels. Sensors and systems from Schaeffler as well as piezoelectric vibration, force, and pressure sensors from other manufacturers can be integrated into the CMS.

# SCHAEFFLER SMART ECOSYSTEM

What began two years ago with the Machine Tool 4.0 research project has since become a comprehensive infrastructure: The Schaeffler Smart EcoSystem. This allows added value to be generated from digitalized machine components ...

... and is subdivided into three levels of mechatronics, virtual twins and applications. The lowest level (Mechatronics) contains the so-called smart components – mechatronic products with additional sensor or actuator-based functions. These are the “enablers” that record machine and process data. Schaeffler’s mechatronic products today already include

- The FAG VarioSense, a standard ball bearing equipped with a sensor cluster for recording machine and process data (temperature, speed, angular position, direction of rotation, and bearing support deflection in the  $\mu\text{m}$  range)
- The FAG SmartCheck for vibration-based condition monitoring and damage detection for individual bearings right through to entire machines,
- The FAG Concept8 automatic lubricator for requirement-oriented relubricating impulses on linear guidance systems, and
- The electrically driven planetary screw drive.

New for EMO 2017 is the automated, condition-oriented relubrication of linear recirculating roller bearing and guideway assemblies and an innovative system for monitoring the load on main spindles.

## Creating virtual twins with domain expertise

These smart components are always designed so that they can be used as a stand-alone solution within a machine. Additional digital services and more competitive advantages are available via the interface to the next level of ‘Virtual Twins’. This includes, for example, optimization of the manufacturing process by making maximum possible use of the spindle capacity when monitoring the main spindle. For the linear guidance system, this means predicting the remaining useful life after the start of incipient changes to the surface that have been detected by the sensor technology.

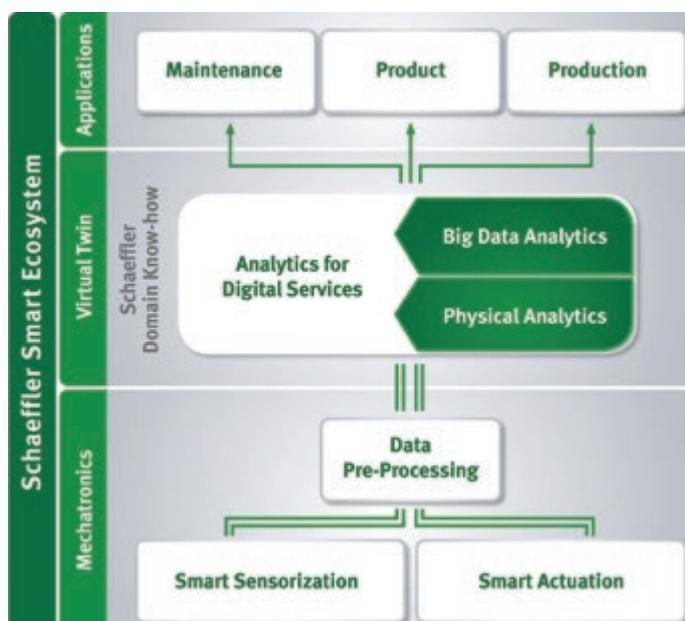
Schaeffler Smart EcoSystem: The achievable customer benefit is the starting point for the development of new products and services.

## Additional customer benefits in three areas of application

The additional customer benefits are derived from the top level of the Smart EcoSystem, ‘Applications’, and are divided into three fields of application: Maintenance, Product, and Production. The focus is on the following areas, with the degree of emphasis depending on the machine type:

- Increased machine availability and productivity
- Reduced operating and maintenance costs
- Improved process stability and quality
- Improved product quality

These focal areas remain the starting point and motivation for the development of new products and services. The digitalization of products to smart components is simply a means of generating added value for the customer. For example, market analyses regarding the causes of machine tool failures were decisive in initiating two new developments, “Lubrication condition monitoring” and “Monitoring main spindle load conditions by measuring displacement”. ◀



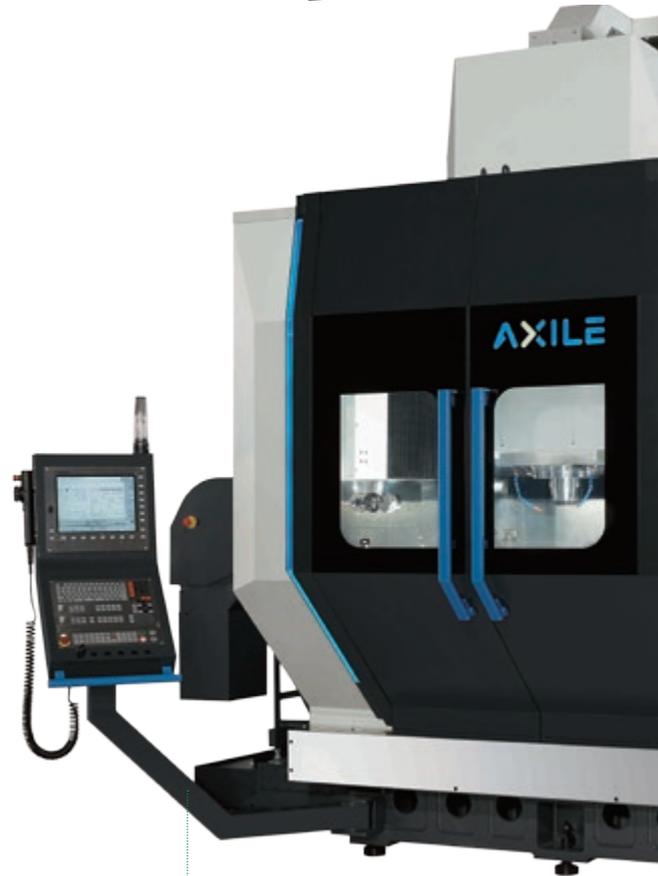
# PARTNERSHIP PAVES THE WAY FOR INDUSTRY 4.0

Hardly any other industry is facing such high cost and innovation pressure as the machine tool industry. It is not only the productivity of machine tools that is expected to increase continuously, but also their reliability, operating life, and machining quality. Buffalo, a machine tool manufacturer, presents a solution by introducing Taiwan's first Industry 4.0-compatible machining center.

So far, conventional condition monitoring systems (CMS) have been used to optimize the availability and operating life of machine tools; in machine parks, these are usually deployed as remote systems. A special focus in the development of these CMS was placed on extending the mean time between failure, which is the time between machine downtimes. These systems compare the condition of new machines with their current condition by using sensor technology. Changes and damage can therefore be detected early. This supplies the basic information for predictive maintenance programs. However, these are purely passive systems that have no impact on the machine's operating parameters. An increase in productivity, for example, by means of higher cutting capacities and information on how they influence the machine's operating life in the future, can hardly be achieved with systems designed solely for monitoring purposes.

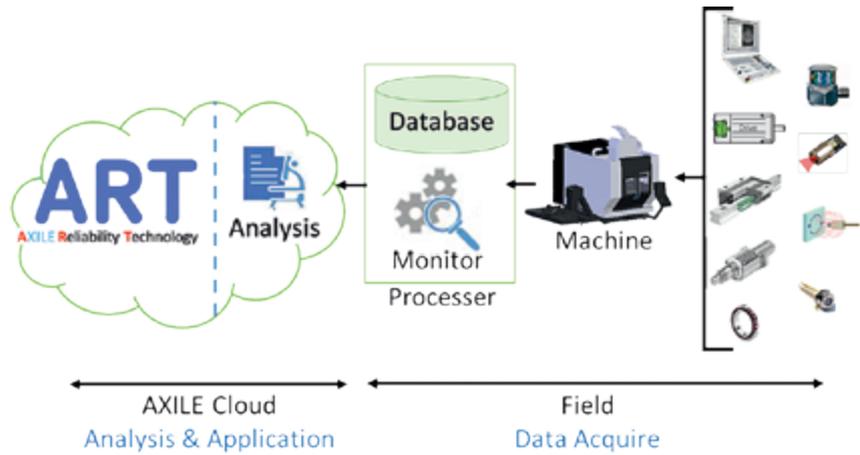
## Intelligent subsystems for machine tools

In order to meet the targets for increased cutting capacity, improved surface quality, higher precision, and increased availability, the next generation of machines will have integrated control loops. Not only will they make it possible to monitor the condition of machine components, but they will also allow the condition of machine components and the manufacturing process to be actively controlled throughout the entire operating life. With support from Schaeffler, Buffalo Machinery is putting this plan into practice in several high-tech machines. The Taiwanese company Buffalo Machinery Co. was founded in 1979 and comprises two product lines: MICRO CUT and AXILE. Today, the company combines monitoring systems with compensation strategies for innovative control loops under the SMT label (Smart Machining Technology). In 2016, Buffalo and Schaeffler entered into a cooperation agreement with the focal topic "Industry 4.0" aiming to develop enhanced condition monitoring of machine tools. To this end, Buffalo Machinery's AXILE G8, a 5-axis machining center, was equipped with all the necessary measuring systems and presented to the public for the first time at the TIMTOS 2017 trade show. Schaeffler is contributing technologies for condition monitoring and predictive maintenance of linear guidance systems to this development project. The linear axes of the Buffalo machining center have been equipped with RUE 4.0 INA linear recirculating roller bearing and guideway assemblies. The sensor system, which has been integrated into the carriage, continuously monitors the lubrication conditions and triggers a lubricating impulse that is sent to an automatic lubricator



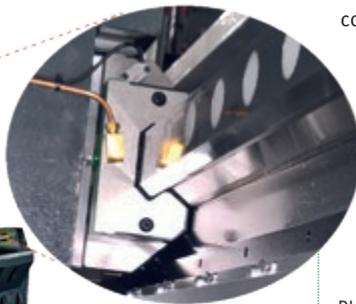
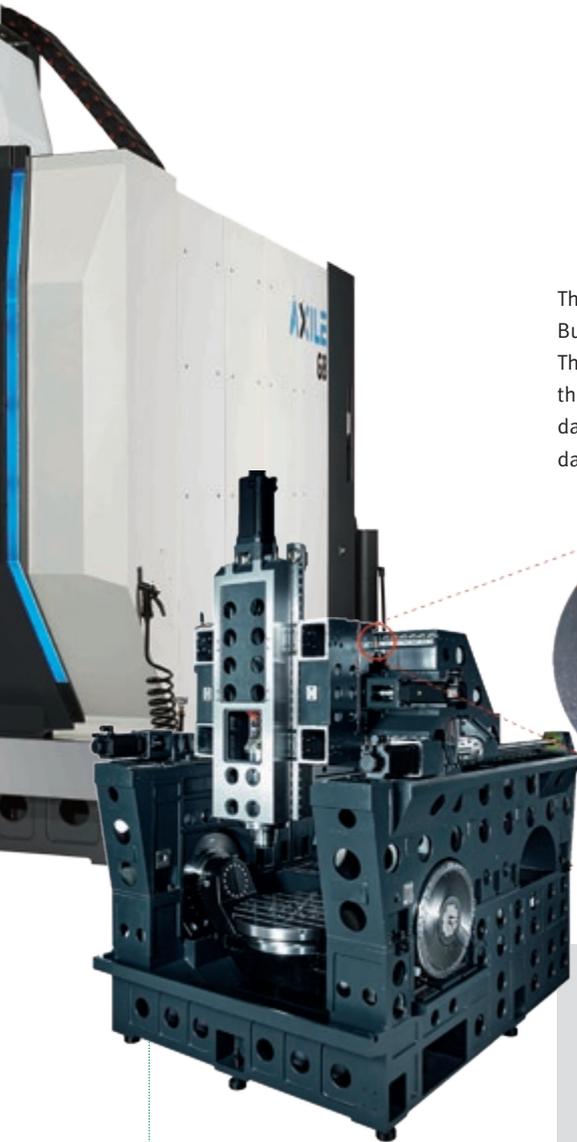
The AXILE G8 machining center from the Taiwanese manufacturer Buffalo is mainly used in tool and mold manufacturing, aerospace, the automobile industry, and medical technology.

when structure-borne vibrations above a predefined threshold value are emitted. The retrofit was extremely easy to complete: The only difference from the standard RUE guidance system is the carriages. The machine design can therefore remain unchanged. The control loop between the sensors on the carriage and the lubricator acting as an actuator make condition-oriented and automated relubrication possible. The system even automatically flushes foreign particles and cooling lubricants out of the linear guidance system. Information on the condition of the axis bearing and the lubrication consumption can be retrieved using the machine control display. This way, lubricant can be saved while, at the same time, downtimes caused by inadequate lubrication can be avoided. Inadequate or insufficient lubrication is one of the main causes of premature failure of linear guidance systems; the RUE 4.0 system increases availability and reliability of the entire machine.



**Combining technologies for Industry 4.0**

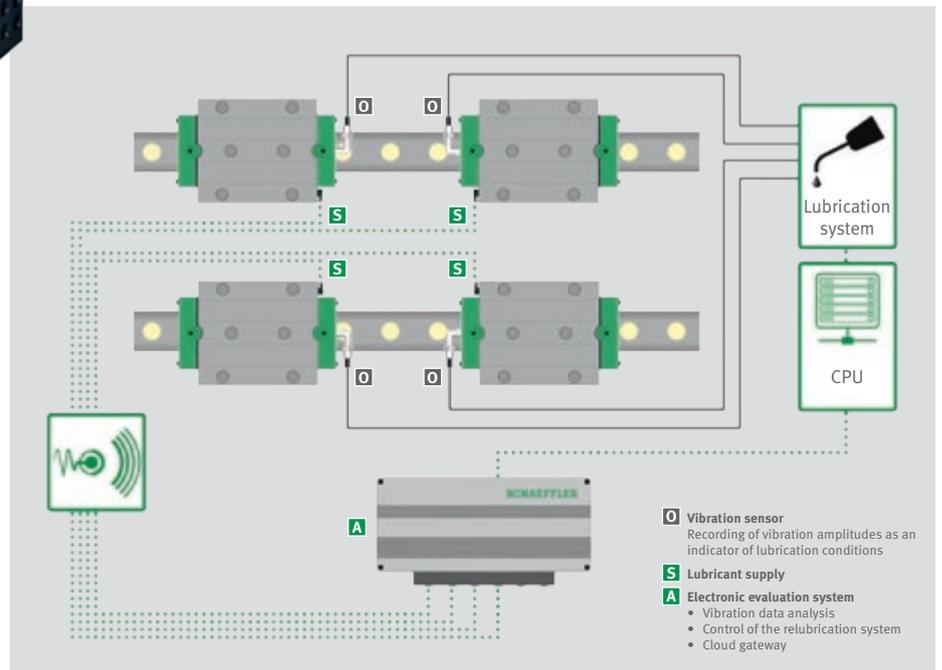
The intelligent combination of Schaeffler’s technologies for condition analysis and prediction using Buffalo’s smart machine technology allows machine tool manufacturers to develop new services. These are combined under the AXILE Reliability Technology (ART) label. ART uses both sensors on the key components and information from the machine control system to collect data. After real-time data have been preprocessed, they are uploaded to the AXILE cloud for analysis. The preprocessed data are used, on the one hand, to determine the condition of the machine components based on the operating data using Schaeffler algorithms. The data are also used to control and optimize the manufacturing process by means of Buffalo’s SMT. The AXILE G8 5-axis machining center represents the first machine tool in Taiwan to offer this combination of technologies that is ready for Industry 4.0. As part of the cooperation with Schaeffler, the machines are currently undergoing various tests. In addition, operating data will be collected over a longer period of time in order to drive software development. ◀



RUE 4.0 carriage on the portal axis of the AXILE G8 5-axis machining center.

Buffalo and Schaeffler bundle their domain expertise and technologies to make machine tools fit for Industry 4.0. The services developed from it go by the name AXILE Reliability Technology (ART).

Control loop for requirement-oriented and automated relubrication of recirculating roller bearing and guideway assemblies: Piezoelectric sensors on the carriage, controller with interface to the machine’s control system and the automatic lubricator. The current condition of the linear axis can be displayed on the machine console screen.



- O** Vibration sensor  
Recording of vibration amplitudes as an indicator of lubrication conditions
- S** Lubricant supply
- A** Electronic evaluation system
  - Vibration data analysis
  - Control of the relubrication system
  - Cloud gateway

# SCHAEFFLER APPS: INFORMATION AT YOUR FINGERTIPS

Whether measurement logs for high-accuracy bearings from FAG production, information on the correct quantities of grease and grease distribution curves, or assembly instructions - the PrecisionDesk app provides all this information on the go, whether in the workshop, during assembly or quality inspection, or for resource planning systems.

Schaeffler is now offering its customers and sales partners ten apps for communication on the go. This includes the OriginCheck app which uses data matrix codes (DMC) to check manufacturer provenance in order to protect against counterfeit products, the Technical Pocketbook app as a portable reference work, the InfoPoint app for catalogs and brochures, and the SmartCheck app, which shows the current status of all vibrations analyses on a local WLAN network using FAG SmartCheck. Last but not least, the Schaeffler app PrecisionDesk is now available free of charge via the Apple App Store, Windows Store and the Android Play Store. This free app contains a range of information on FAG rotary and linear bearings in high-accuracy designs and has been designed specifically for customers, engineers, sales partners and fitters.

## Measurement logs and connection to resource planning systems

The PrecisionDesk app reads the data matrix codes (DMC) on bearings or bearing packaging. The DMC allows Schaeffler customers to retrieve the specific measurement log for high-accuracy bearings directly via the app; this can then be saved or sent directly as a pdf for documentation purposes. The measurement log for spindle bearings contains data on the bearing ID, the bearing designation, the date of manufacture, parameters for actual values, as well as the width deviation, the contact angle and the overhang - data which is particularly relevant for assembly, professional advice or efficient inventory

management. In addition to this, it is also possible to generate bearing-specific electronic data records (.csv) and, for example, to utilize these in logistics systems. The app therefore offers Schaeffler customers the opportunity to monitor their own bearing inventory securely and to increase quality levels in the mounting process through efficient pairing of bearings, shafts and housings.

Just two clicks take the user directly to the current product information in Schaeffler Mediatek: this provides, for example, the necessary assembly instructions, details on recommended grease quantities or grease distribution curves, and permissible heating temperatures.

## Security in seconds

The PrecisionDesk app, like the OriginCheck app, also offers increased protection against product piracy by using the data matrix code to check provenance; this is already being used to an extensive degree in the trade. The app is available in German and English. In the future, it will be even easier to integrate the app's functionalities into customer intranets: At EMO, Schaeffler is presenting a web browser based solution which uses a hand-held scanner to allow all the functionality of the Schaeffler app to be used by a PC located, for example, in a workshop or assembly hall. ◀



In an instant: Retrieve, save and send measurement logs by scanning the data matrix code

## IMPRINT

### Published by:

Schaeffler Technologies AG & Co. KG  
Geschäftsbereich Industrial Automation /  
Lineartechnik

### Executive in charge of production:

Jürgen Klein

### Address:

Schaeffler Technologies AG & Co. KG  
Berliner Straße 134  
D-66424 Homburg/Saar  
Email: info.linear@schaeffler.com

### Editorial team:

Ralf Moseberg  
Dr. Martin Voll  
Dietmar Rudy  
Dr. Michael Pausch  
Sebastian Mergler  
Marco Pfeiffer  
Jochen Krismeyer

### Produced by:

trio-group, Mannheim

### Picture credits:

Schaeffler  
Buffalo



PrecisionDesk app for high-accuracy bearings in machine spindles, feed axes, rotary tables and linear products

Contributing to security against counterfeiting: Check the data matrix code on the packaging or the bearing itself



Improved product documentation:  
Bearing-specific measurement logs  
for spindle bearings and rotary table  
bearings.



## PASSION 4.0 MACHINE TOOLS

Passion is the driving force behind everything we do. You will see the result in every detail of our bearing solutions for machine tools: The highest level of quality and expertise. We develop innovative product and bearing solutions, which will significantly increase the performance of the next generation of machine tools – with increased availability, higher productivity and improved machining quality. Why not see for yourself? We look forward to seeing you.

[www.schaeffler.de/en](http://www.schaeffler.de/en)

**SCHAEFFLER**