

2020

MARCH  
ISSUE 15

# Bearing NEWS

BEARING INDUSTRY MAGAZINE

# BEARING Testing Methods & STRATEGIES



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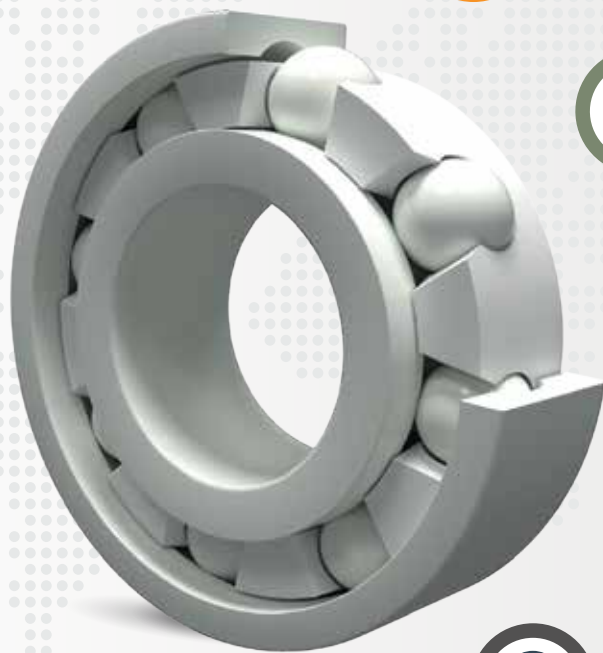


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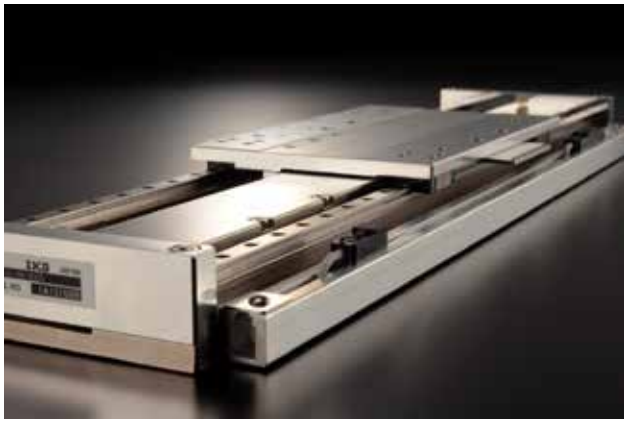


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Currently, we are supporting the development of technology with the first-of-its-kind C-Lube Maintenance Free Series and a rich array of other creative products that respond to diversifying customer needs.

IKO Nippon Thompson Europe's Headquarters has relocated, not far from our previous location in Rotterdam, to accommodate our growing operations.

**Our New address is; Keersopstraat 35, 3044 EX, Rotterdam, The Netherlands.**

Our communication details will remain the same: +31 (0)10 462 68 68 and e-mail: [nte@ikonet.co.jp](mailto:nte@ikonet.co.jp)

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## The Industrial Transformation continues amid turbulent times

The global industrial sector is in the middle of a period of major change, driven primarily by the megatrends of digitization, individualization and climate protection. At the same time, it is grappling with some very challenging economic and political fundamentals. The current period of change is one which we haven't seen for a long time.

Today's industrial-sector companies are facing more and more different requirements and challenges than only a few years ago. This results in a very different demand-side situation. The challenge is to take control and actively shape this transformation process, and that means investment in areas like Industry 4.0, Logistics 4.0, artificial intelligence, 5G, CO2-neutral production, lightweight design and electric drive technology.

There are 2 events on our radar for 2020 were the latest developments for the current industrial transformation and the latest technological developments for the bearing technology will be presented – Bearing World 2020 and Hannover Messe 2020. The third edition of the Expert Forum for Bearings - Bearing World 2020 will be held on 31 March - 01 April in Hannover. This event is the place where industrial research and latest developments on bearing technology meets with science and where all topics relating to bearings in theory are linked with practice. The second event on the radar is Hannover Messe 2020 – which will be held from 20 till 24 April. Hannover Messe is the world's leading trade show for industrial technology. Under the lead theme of "Industrial Transformation", the 2020 show will spotlight all the latest trends and topics, such as Industry 4.0, artificial intelligence, 5G and smart logistics. The display categories to be featured are "Future Hub", "Automation, Motion & Drives", "Digital Ecosystems", "Energy Solutions", "Logistics", and "Engineered Parts & Solutions". The program will be rounded off by more than 80 conferences and forums.

Further in this issue, we have as always 'a BearingNEWS classic': exclusive interviews with key persons from leading production, service and distribution organizations in the motion and drives industry. The main interviews in this March issue of BearingNEWS is with Dr. Oliver Koch, Vice President Bearing Analysis Tools at Schaeffler and with Ruediger Sontheimer, Director Sales Industrial Seals & Strategic Account Management

at SKF. Schaeffler and SKF are the main sponsors of The Bearing World 2020 event. We tried to reveal more details about their support and participation during an interview.

As we start a new decade, we asked the founder of Romax Technology Dr. Peter Poon, about what advice he would give to new businesses and individuals looking to advance in the engineering industry.

Another interview is with Mr. Mikael Östman - Key Account Manager Bearing at Ovako Sweden AB. The importance of clean bearing steel is increasing together with the demand for high precision, excellent quality bearings for more and more demanding applications on the market. OVAKO's BQ steel is considered as one of the most clean and suitable within the bearing industry. We tried to understand the importance of BQ-Steel specifications for producing high quality bearings during an interview.

### What's Rolling..

What's rolling in the bearing industry? A brief summary of what happened during the last six months in the bearing industry; more details about key trends in the Global bearing industry; new technologies for improving applications with ultrasound detection; automatic lubrication systems for bearing; bearing testing methods and strategies; Top 100 bearing tips vol.06... and many more motion and bearing industry related articles, case studies, insights and developments can be discovered in this March issue of the BearingNEWS magazine.

144 pages full of BearingNEWS. hope that you will enjoy it!

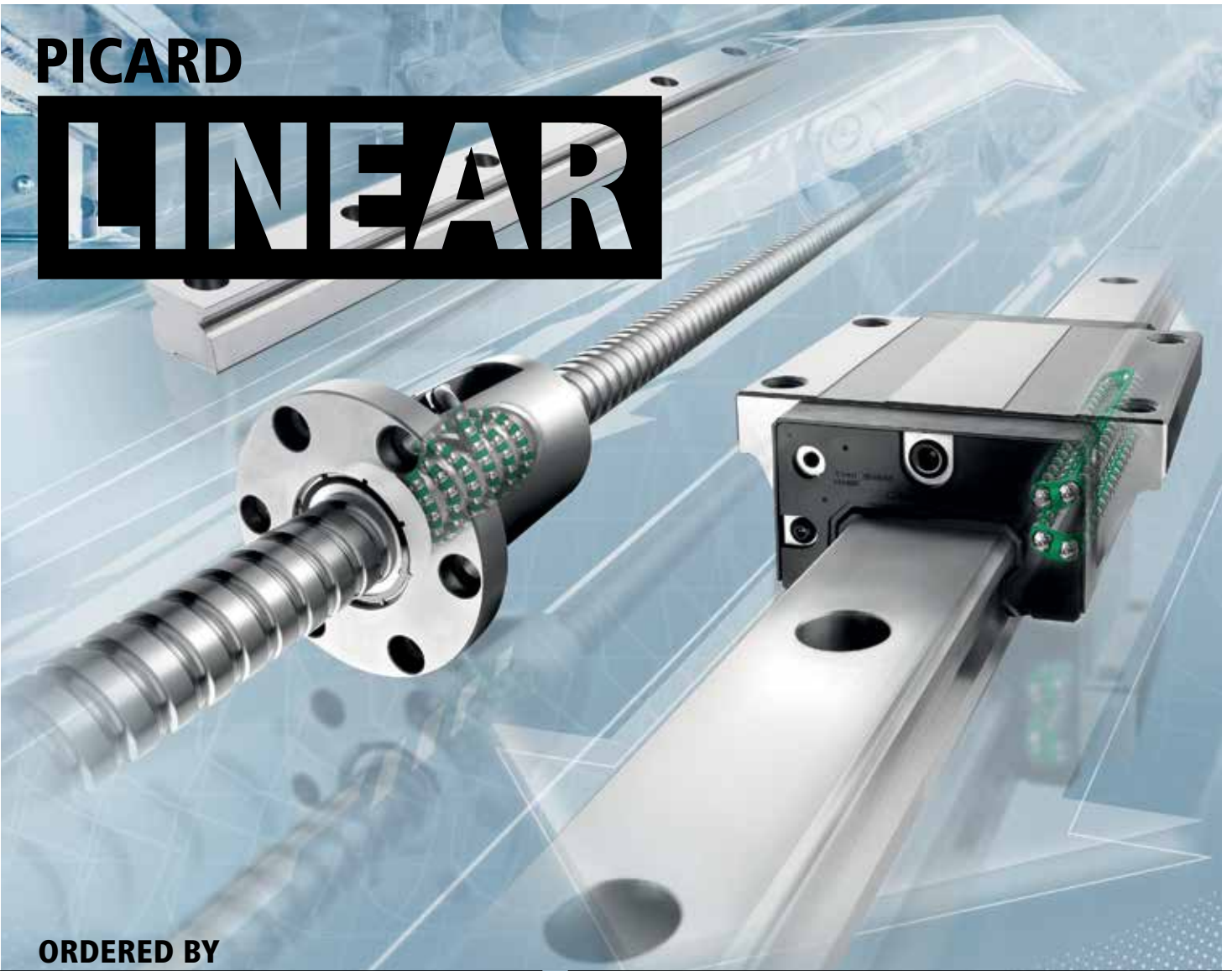
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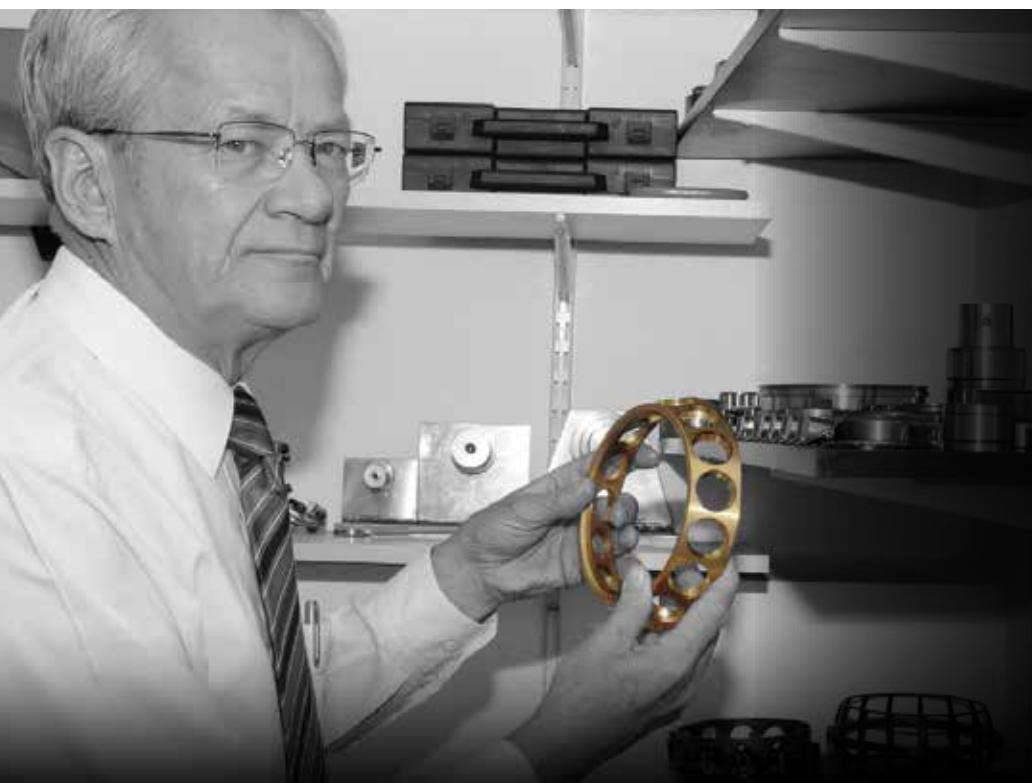
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DUROLUB © SOLUTIONS FOR: FOOD AND  
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vol.06

# TOP100 TIPS *for* BEARING REABILITY

by Per Arnold Elgqvist

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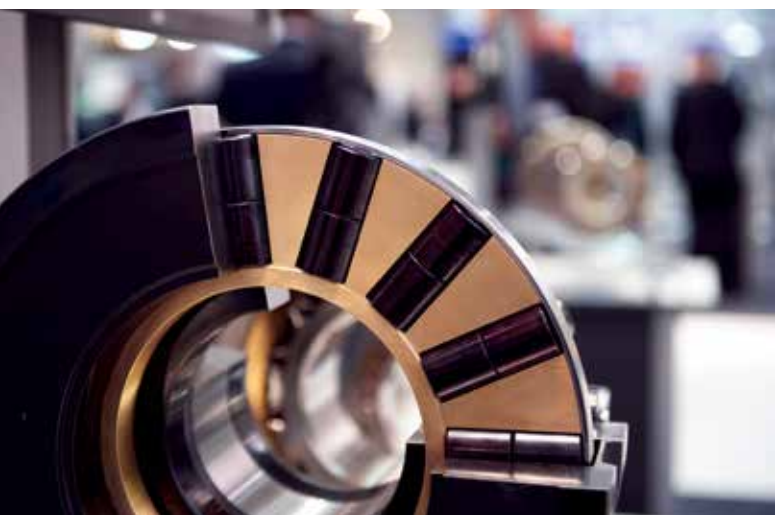


20 - 24 April 2020

# “Industrial Transformation”

lead theme shows the way forward amid turbulent times

HANNOVER MESSE 2020 will coincide with a period of rapid technological change and political and economic uncertainty. Sporting its 2020-season lead theme of Industrial Transformation and featuring some 6,000 exhibitors, the world's top trade show for industrial technology will shine a light on the opportunities arising from new technologies, changing buyer behavior and a growing awareness of climate protection.







The global industrial sector is in the midst of a period of major change, driven primarily by the megatrends of digitization, individualization and climate protection. At the same time, it is grappling with some very challenging economic and political fundamentals. “The world is embarking on a period of change, the likes of which we haven’t seen for a long time,” said Deutsche Messe Managing Board Chairman Dr. Jochen Köckler. “And that makes HANNOVER MESSE more important than ever – because it is the only trade show to accord the industrial transformation process the holistic and ongoing focus that it warrants. Thanks to the diversity and expertise of its multi-industry exhibitor base and its lead-theme focus on Industrial Transformation, HANNOVER MESSE is a trend barometer and innovations driver for a globally and digitally integrated industrial sector.”

Today’s industrial-sector customers are facing very different requirements and challenges than only a few years ago. The result is a very different demand-side situation, and the R&D sector and providers of production, logistics and energy supply technology need to adapt to it. The challenge is to take control and actively shape this transformation process, and that means investment in areas like Industry 4.0, Logistics 4.0, artificial intelligence, 5G, CO2-neutral production, lightweight design and electric drive technology.

HANNOVER MESSE’s comprehensive coverage of these technologies

and its holistic focus on Industrial Transformation make it the perfect platform for exhibitors from the mechanical engineering industry. “Companies from the mechanical and plant engineering industry want a platform where they can connect with an international industry audience and showcase their strengths as providers of solutions in a digitally integrated production landscape. That’s solutions across entire value chains, from materials procurement to production and logistics, to energy supply, right through to new platform-based sales channels. At the same time, these companies seek inspiration and fresh ideas for the ongoing changes they need to make in their own operations. HANNOVER MESSE meets both of these requirements. As such, it is a unique meeting hub that shows the way forward into the future,” said Thilo Brodtmann, CEO of the German Engineering Federation (VDMA).

Whatever they are looking for, whether it’s individual components, complete systems or entire digital ecosystems, HANNOVER MESSE is the place where industry CEOs, design and development engineers, production, logistics and IT directors and supply chain and energy managers can find all the technologies they need in order to keep their companies competitive and futureproof their business models.

Approximately 6,000 companies will be exhibiting at HANNOVER MESSE 2020. Among them are names like ABB, Amazon Web Services, Arburg, Beckhoff, Bosch Rexroth, Cisco, Dematic, Endress+Hauser,

Festo, Fraunhofer, Harting, IBG, IBM, ifm, igus, Kawasaki, Knapp, Lapp, Lenze, Microsoft, Mitsubishi, Phoenix Contact, Pepperl+Fuchs, Rittal, SAP, Schaeffler, Schneider Electric, Schunk, SEW-EURODRIVE, SICK, Siemens, Software AG, Still, Toyota Materials Handling, Wago, Weidmüller and Yaskawa.

Köckler: “The entire industrial sector is represented at HANNOVER MESSE, so visitors can experience end-to-end production and supply processes, from product development to production, plus everything they need for new, data-driven business models. This integrated focus is important, because the transition to smart factories will not be possible without close integration of production and logistics.”

## HANNOVER MESSE

HANNOVER MESSE is the world’s leading trade show for industrial technology. Under the lead theme of “Industrial Transformation”, the 2020 show will spotlight all the latest trends and topics, such as Industry 4.0, artificial intelligence, 5G and smart logistics. The display categories to be featured are “Future Hub”, “Automation, Motion & Drives”, “Digital Ecosystems”, “Energy Solutions”, “Logistics”, and “Engineered Parts & Solutions”. The program will be rounded off by more than 80 conferences and forums. The next HANNOVER MESSE will be staged from 20 to 24 April 2020 in Hannover, Germany, with Indonesia as its official Partner Country.



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## CASE STUDY

# How to improve paper mill rotating equipment by using **Ultrasound Technology**

*Experience feedback on the implementation of an ultrasound-based preventive maintenance program.*

### Introduction

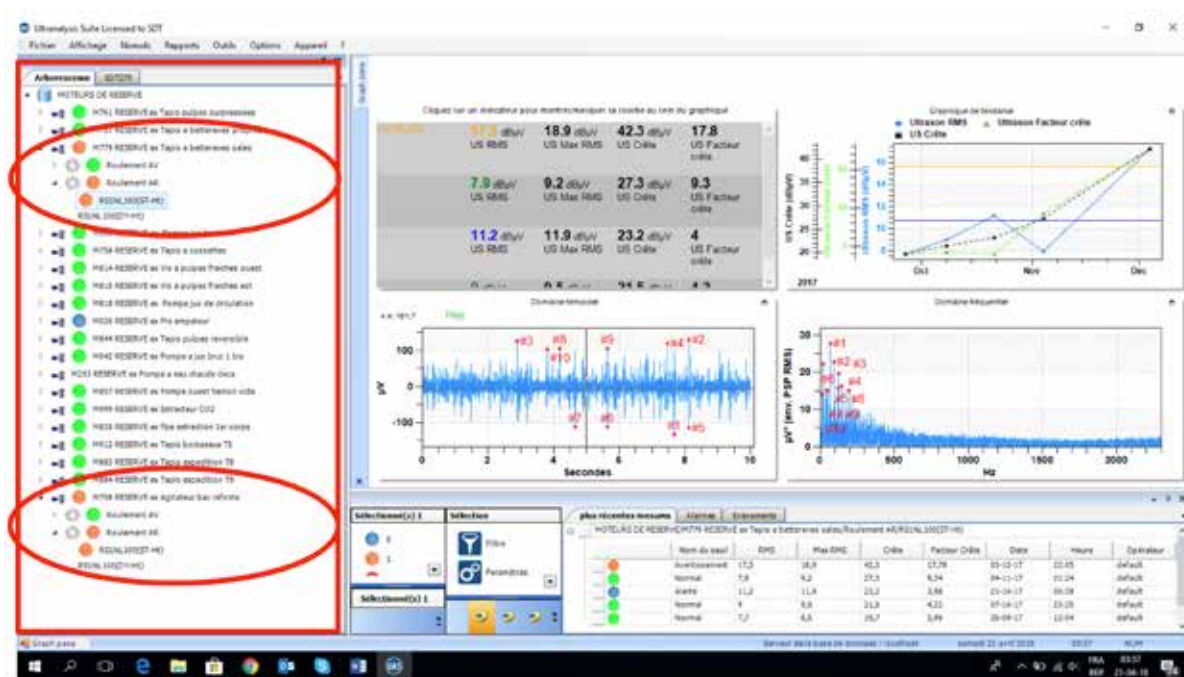
Today, we would like to share an experience feedback from a paper mill that has implemented a preventive maintenance program to monitor rotating machines using ultrasound technology. SDT International helped implement this monitoring program by training and coaching the teams in charge of mechanical maintenance reliability. The purpose of this program is to monitor a fleet of about 70 rotating machines during the year after its implementation and to extend it to 100 machines over the second year.

### Issue

This paper mill has relied on preventive maintenance for many years, using known and proven technologies for the monitoring of rotating machines. In 2018, they decided to extend this monitoring to equipment with rotation speeds up to 30 RPM, as well as to their speed-reducing gears. They purchased an SDT270 type ultrasound detector, in DU version, along with its UltrAnalysis (UAS) software, and SDT International and the Reliability department of the paper mill developed a training program suited to the rotating machinery monitoring program. The first step consisted in creating the database

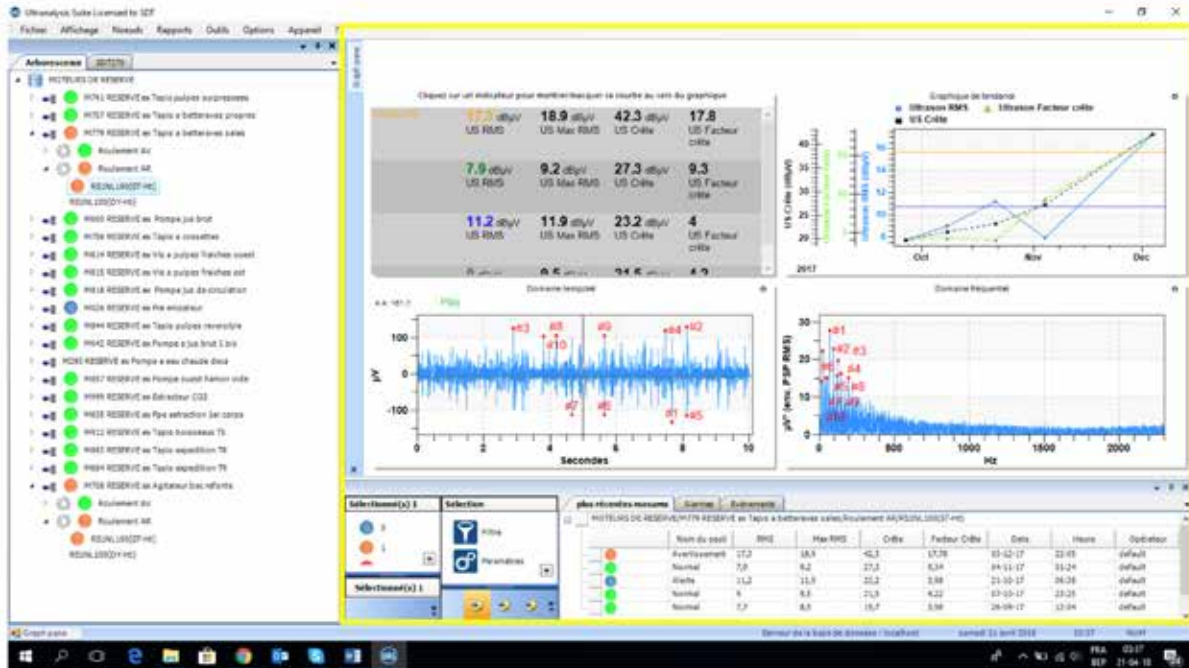
including these 70 machines, and then in recording an initial measurement of the mechanical status of each bearing and each gear. After a simple onsite analysis (ultrasonic listening) and a more detailed analysis (overall or static measurements and spectral or dynamic measurements) using UAS, pre-alarm, alarm and danger thresholds were assigned to each measurement point. This background work, which is required, allows technicians of the reliability department in charge of the measurements routes to get a quick overview of the asset hierarchy and immediately see the machines that have an alarm status.

### Display of the database in the UAS software



— Display of the asset hierarchy including all rotating machines under monitoring and alarm statuses for each piece of equipment. In the present case, 19 rotating machines are monitored, 2 of which have exceeded the danger threshold for the bearings of the rear motor.





– Display of the software graphic tools (matrix, trend curves, time signal, FFT spectrum, measurement time history).

**Issue**

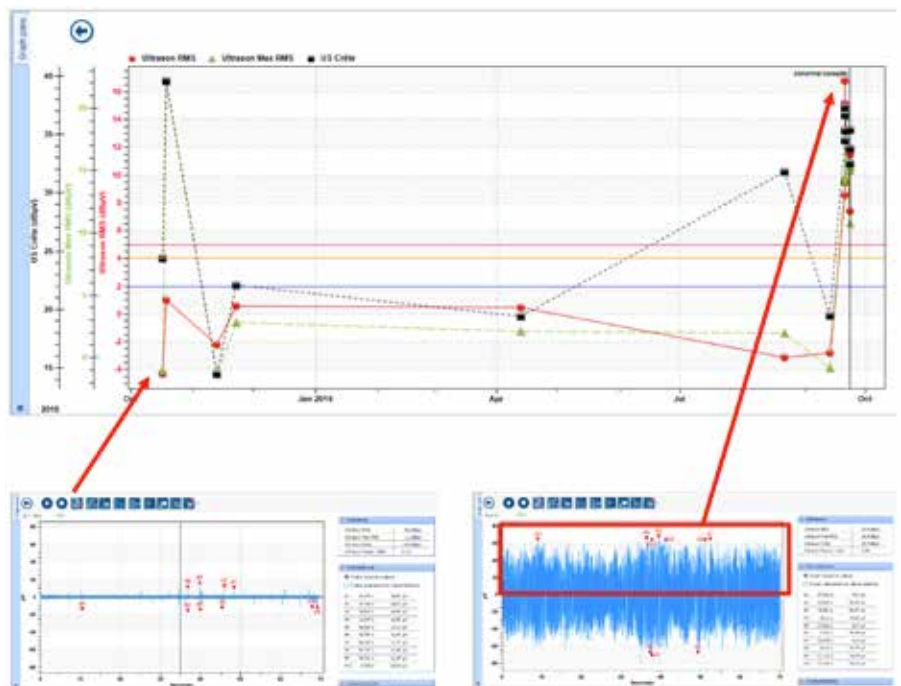
This preventive maintenance program has 3 objectives:

- Highlight the efficiency of ultrasound measurements on rotating machines.
- Issue a relevant diagnosis.
- Offer preventive maintenance with reliable indicators.

**Experience feedback after onsite measurement sessions from October 2018 to November 2019**

Monitoring of a parallel reduction gear

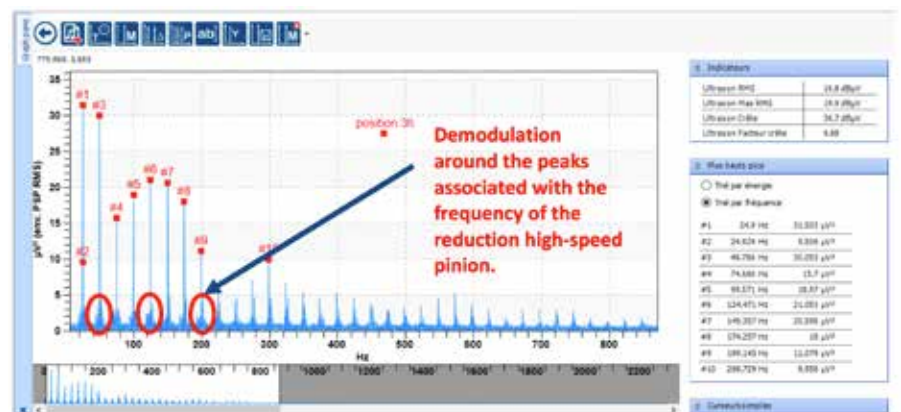
- Machine: Decanter – High-speed input bearing of the reduction gear

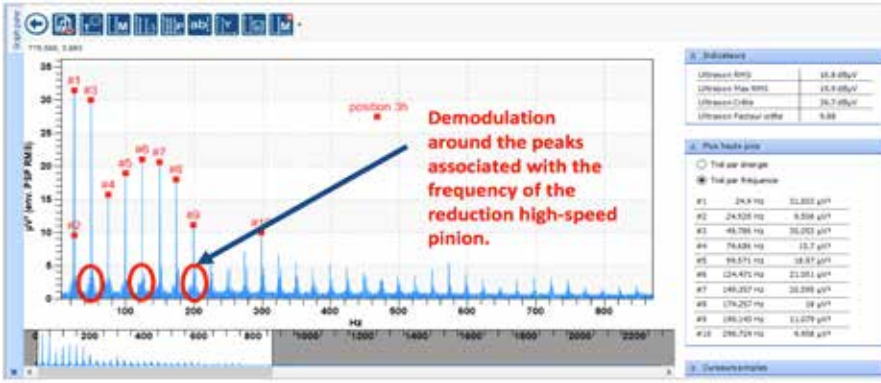


Measurement carried out on 16/10/2018

Measurement carried out on 20/09/2019

On the time spectra (same scale), we can observe the occurrence of shocks compared to the first measurement carried out in 2018. The trend curves show the evolution of the RMS static value: from -4.3 dBµV in 2018 to +16.8 dBµV in 2019. Based on SDT criteria, this increase corresponds to the early failure of a mechanical part of the reduction gear (bearings and/or gears).





the high-speed input drive pinion of the reduction gear (24.93 Hz and its harmonics) with demodulation at each peak. Broken tooth and teeth clearance. Replacement of the reduction gear during a scheduled production shutdown, which avoided an untimely breakdown which could have generated significant expenses due to production losses.

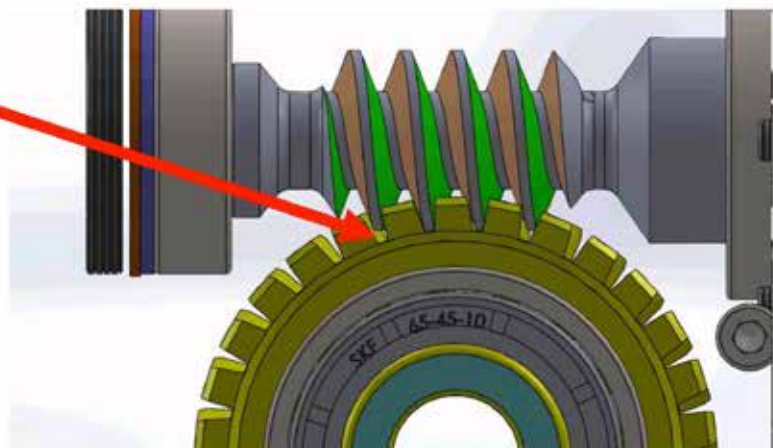
Wear detected on the tooth of the worm screw of a reduction gear, wheel and screw:

Listening to the bearing and analysing the frequency spectra (see chart below) has allowed confirming this diagnosis by observing the emergence of significant

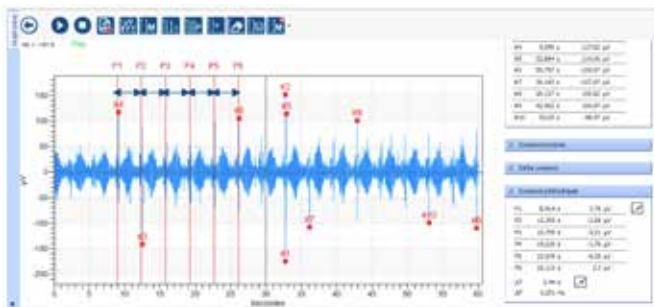
peaks associated with this gear damage.

We can observe repeated shocks associated with the frequency of

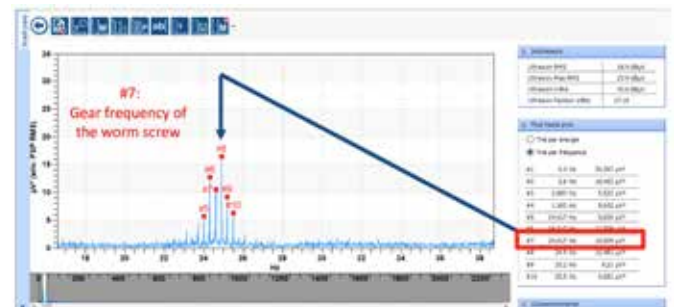
- Machine: Lime mud filter agitator – High-speed input bearing of the reduction gear



We can observe that between each revolution of the worm screw, there is a phenomenon occurring, which can be heard through the ultrasound detector as a sliding of the gear (worm screw/bronze wheel).

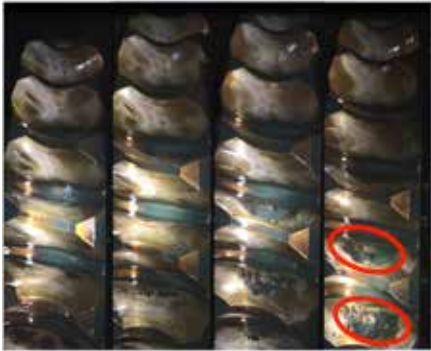


Measurement carried out on 11/12/2016

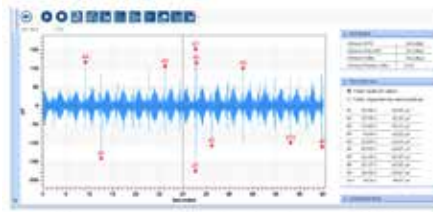


Zooming in on the FFT frequency spectrum allows highlighting dissymmetry of the modulation around the meshing frequency, which is characteristic of a damaged gear mesh.



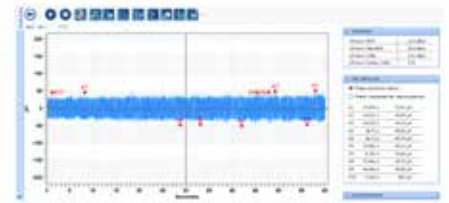


The endoscopic video inspection of the worm screw of the reduction gear confirmed the ultrasound diagnosis.

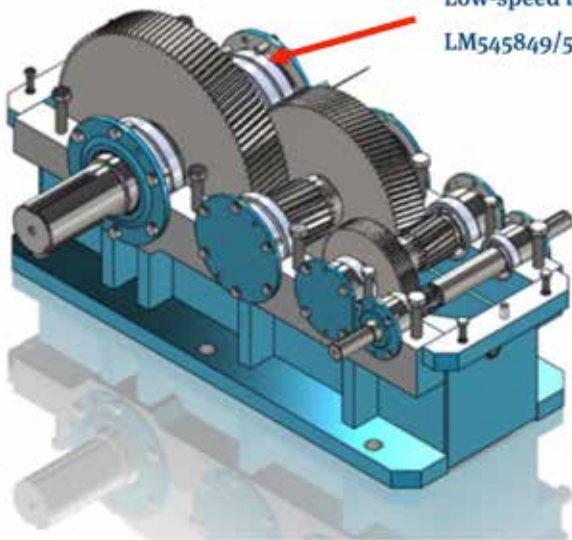


Measurement carried out on 10/07/2018

The customer took the reduction gear down during a production shutdown.



Measurement carried out on 29/10/2019 After replacement of the reduction gear

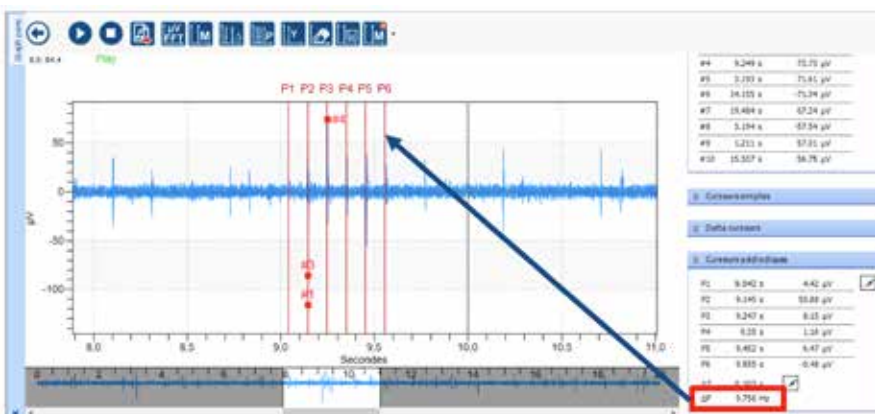
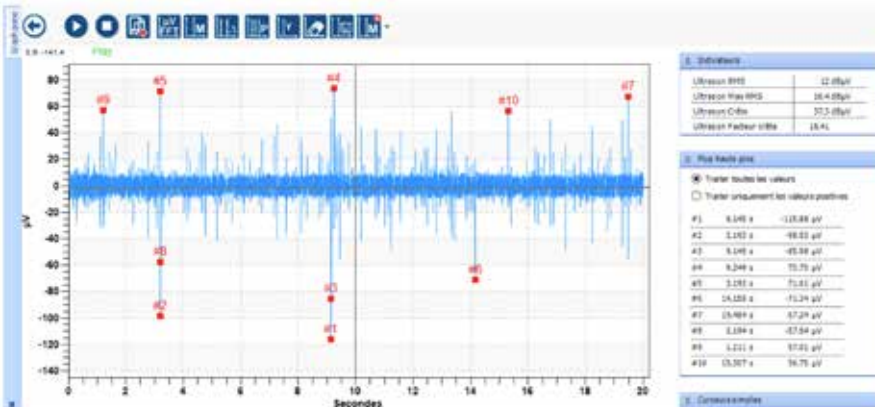


Low-speed bearing of reduction gear LM545849/545810

Monitoring of the degradation of the bearing of a low-speed reduction gear (opposite transmission):

- Machine: **Vertex separator reduction gear – 4-train parallel reduction gear**

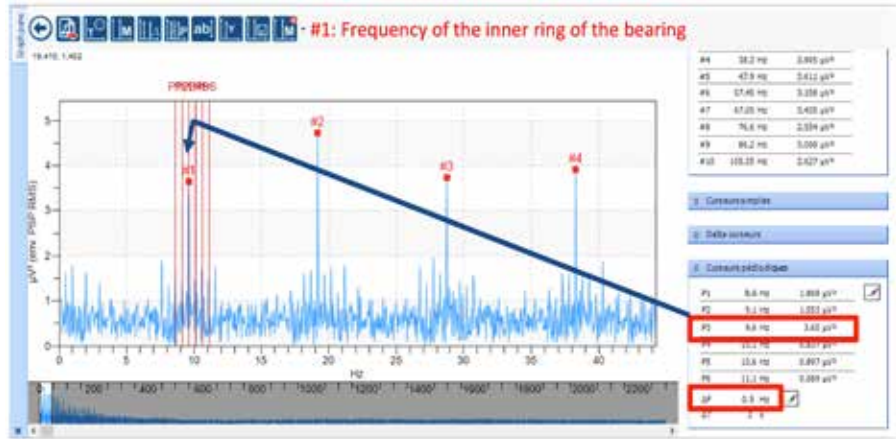
From the beginning of the monitoring of this reduction gear (August 2018) using ultrasound technology, the occurrence of shocks can be observed on the time spectrum.



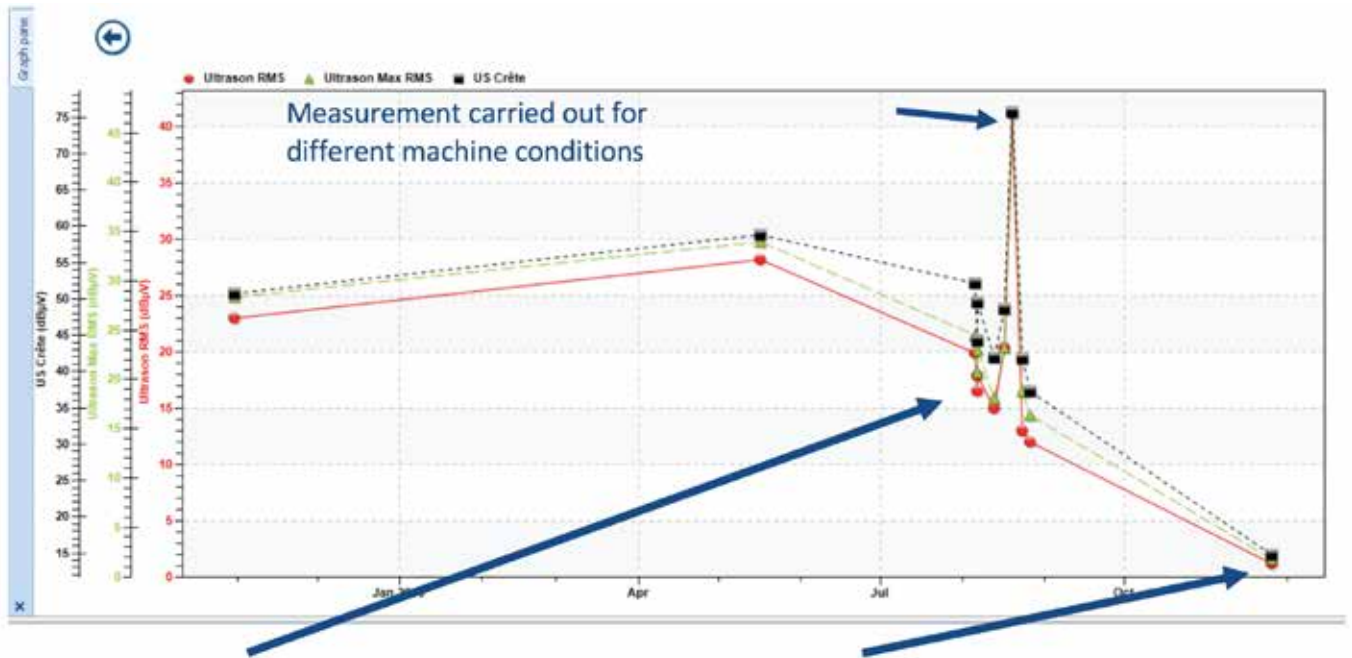
By zooming in on the time spectra, one can observe repeated shocks at **9.756 Hz** (see the table of characteristic frequencies below) related to the frequency of the inner ring of the bearing of the low-speed reduction gear (opposite side of transmission). Diagnosis confirmed on the frequency spectrum (see below).



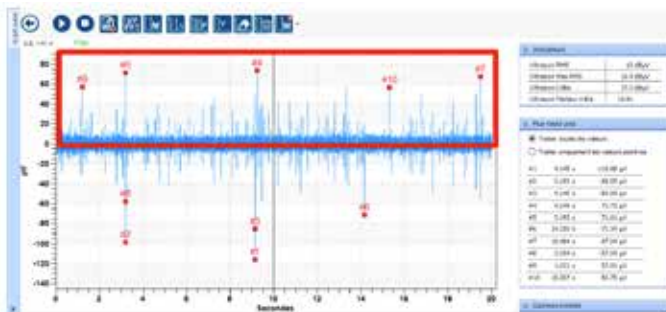
The amplitude of the scaling-type defect is modulated by the rotation speed. On the spectrum, this is evidenced by a peak at the frequency of the defect of the inner ring of the output bearing of the reduction gear and by sidebands at the rotation frequency of the shaft, i.e., 0.5 Hz – 30 RPM (low-speed reduction gear).



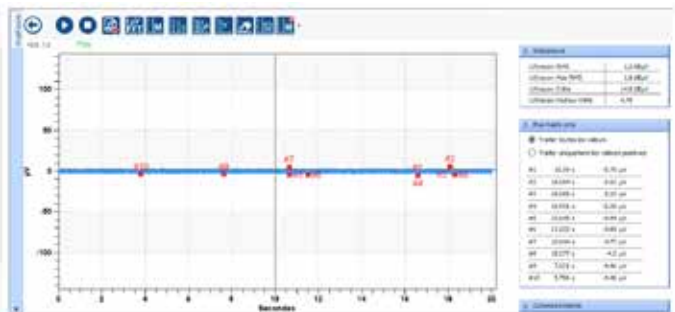
CHARACTERISTIC FREQUENCIES						
BEARING	FBE	FBI	FER	FCAGE	F ROTATION	
LM545849/545810	8.31	9.59	3.39	0.23	0.50	LOW-SPEED RED.



Trend curves show the decrease of the RMS value after servicing, from +12 dBµV in 08/2019 to +1.2 dBµV in 11/2019.

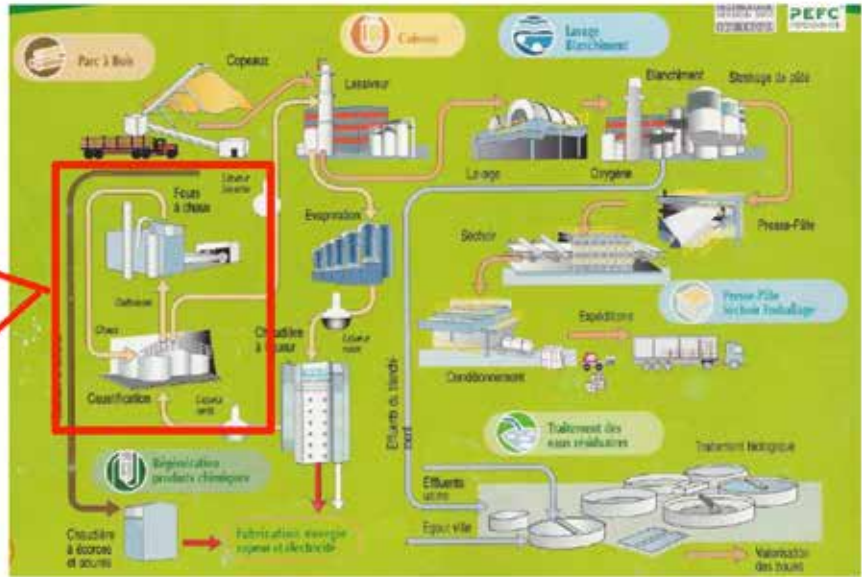


Measurement carried out on 26/08/2019



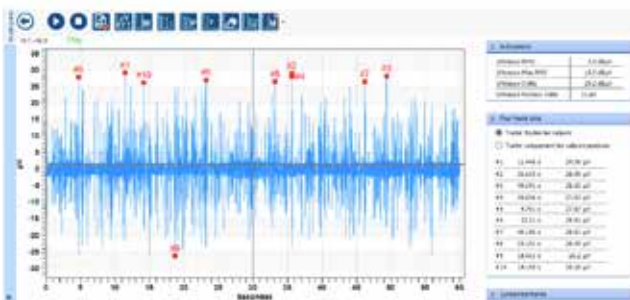
Measurement carried out on 25/11/2019 After replacement of the reduction gear

Replacement of the reduction gear during a scheduled production shutdown, which avoided an untimely breakdown which could have generated significant expenses due to production losses.

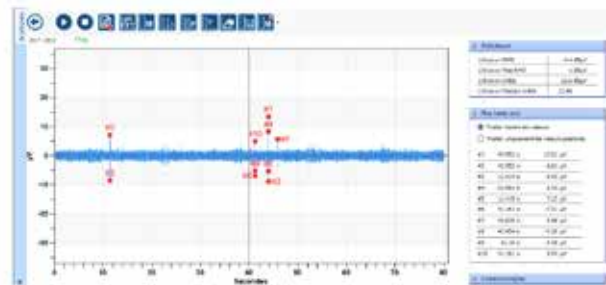


Monitoring of the degradation of the bearing of a low-speed reduction gear (opposite transmission):

- Machine: Lime mud filter – Bearing opposite transmission 23140 CCK – 14.28 RPM

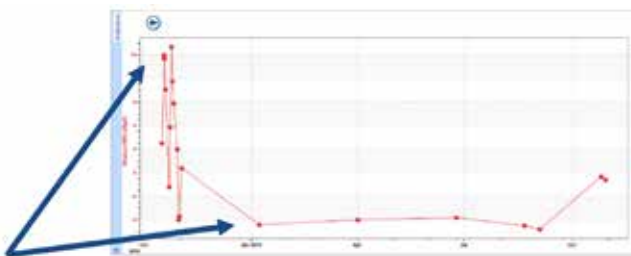


Measurement carried out on 16/10/2018



Measurement carried out on 07/01/2019

On time spectra (same scales), one can observe the occurrence of shocks right from the beginning of the monitoring of this bearing. After replacement of the bearing, all shocks disappeared. The rolling elements were no longer held in their housings.



Trend curves show the decrease of the RMS value after servicing (from +10.7 dBµV in 10/2018 to -4.4 dBµV in 01/2019).

**Conclusion**

The challenge was taken up by the Reliability team of this paper mill. The implementation of a preventive maintenance program for 70 rotating machines has had

a beneficial and decisive outcome. It will be extended to 100 other machines over the course of 2020.

SDT International offered a simple solution and suitable measurement tools, along with a LEVEL1 ASNT

certified training program. Users have acquired a comprehensive mastery of this technology, which was new to them.

1. Using ultrasound technology to monitor low-speed rotating machines, this paper mill was able to avoid a number of





unscheduled shutdowns (see examples below) and highlight the complementarity of ultrasound and vibration technologies.

2. Based on this experience, the Reliability department has decided to initiate ultrasound-aided greasing campaigns. Using suitable equipment (software and hardware), this acoustic lubrication program will ensure perfect greasing by indicating:

- the right grease,
- the right greasing location,

- the right greasing interval,
- the right quantity of grease to add,
- the right indicators for the lubrication condition.

Thus, full traceability of the lubrication program will be ensured.

3. The versatility of ultrasound detector SDT270DU also allowed for the implementation of:

- An energy-saving policy

(detection of compressed air leaks, control of steam traps).

- Control of tubeblowers (detection of leaks on steam valves).
- Preventive maintenance of high voltage electric systems (corona, tracking, arcing).

*Author: Patrice DANNEPOND  
– Area Sales Manager, SDT Ultrasound Solutions Brussels, 07/02/2020.  
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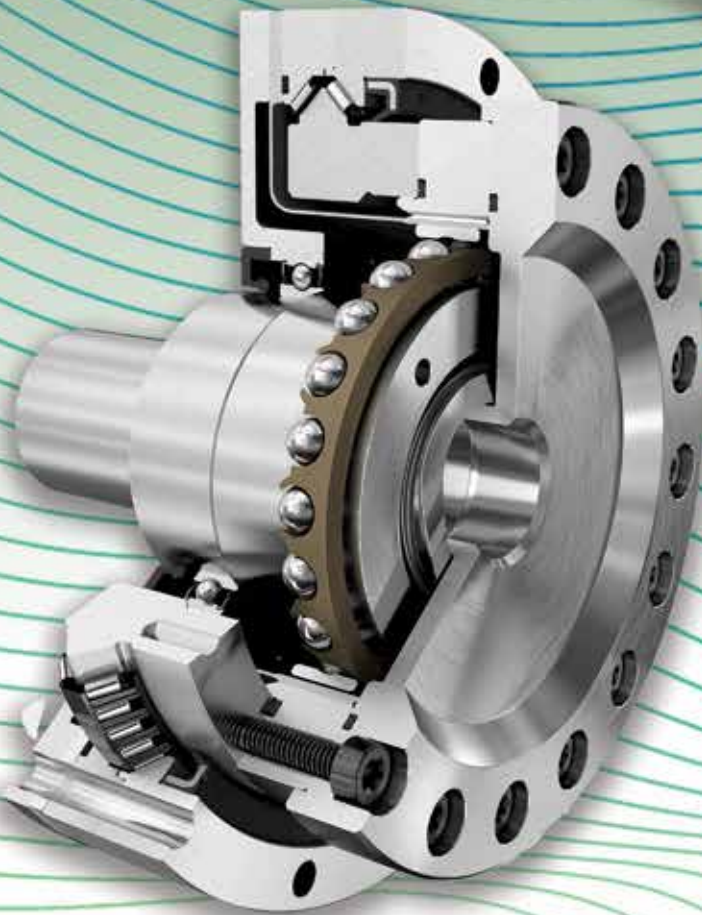
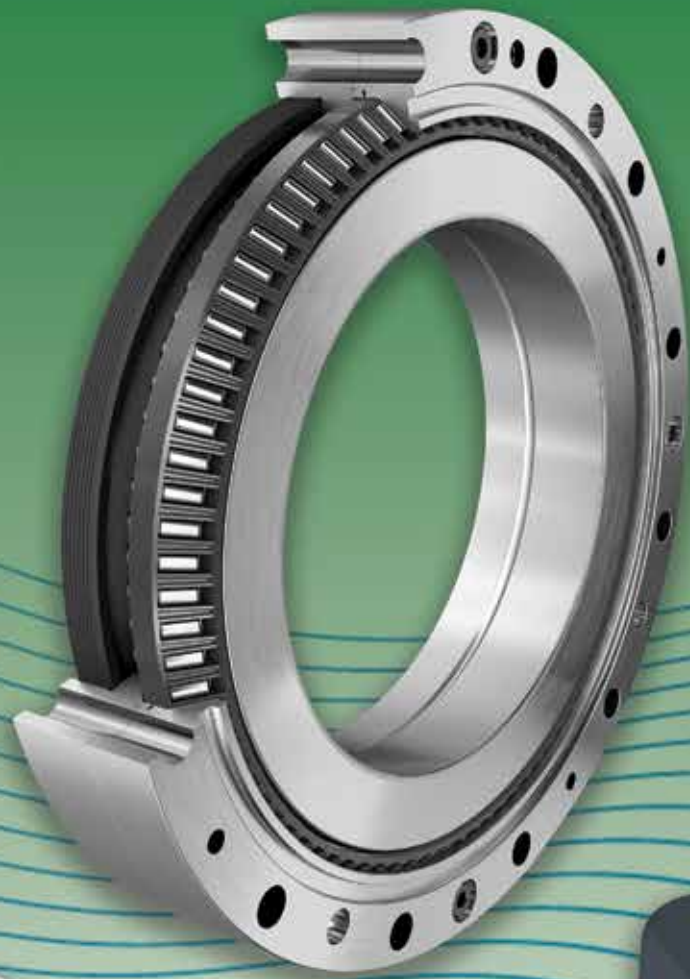
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**Koyo** — Bearings

**TOYODA** — Machine Tools / Mechatronics







**Schaeffler**  
*expands  
its services*



*products for*  
**Condition  
Monitoring  
and Robotics**



# Schaeffler is continuously expanding its range of service solutions

Total maintenance transparency avoids costly shutdowns

- Three condition monitoring systems for different customer requirements and plant sizes
- Schaeffler OPTIME: New addition brings CMS to the multitude of assets typically monitored only periodically or not at all
- Leveraging Schaeffler's rolling bearing expertise for maintenance personnel and plant operators



— With OPTIME, SmartCheck, and ProLink, Schaeffler can provide vibration-based condition monitoring solutions for any requirement scenario. A key benefit of all three systems is that users do not need any expertise in vibration-based condition monitoring. The output data are analyzed by special Schaeffler algorithms.

Vibration-based condition monitoring systems (CMS) are a proven and highly effective means of avoiding unplanned machine shutdowns and the associated production losses. At the HANNOVER MESSE 2020, Schaeffler will be showcasing OPTIME, a new vibration-based CMS for low-cost applications. OPTIME is a new addition to the Schaeffler CMS portfolio that makes condition monitoring automated and cost-effective for the multitude of indirectly process-critical machines and assemblies typically found in today's production facilities. The other CMS solutions in the portfolio are SmartCheck, a single-channel system that has been on the market for several years, and the more recently introduced multi-channel system ProLink. A key benefit of all three systems is that maintenance personnel do not need any expertise in vibration-based condition monitoring in order to install them. The same simplicity also applies to analyzing the output data, since the analysis is done by Schaeffler algorithms. These three systems mean Schaeffler can provide vibration-based condition monitoring

solutions for any requirement scenario.

## **OPTIME: For the condition monitoring of entire facilities**

OPTIME comprises multiple wireless, battery-powered vibration sensors that transmit KPI data and raw vibration and temperature data for all machines in the production facility to the Schaeffler IoT Hub via a dedicated mesh network. The data are automatically analyzed by special Schaeffler algorithms, and the results are sent to the associated app, where they are displayed in a clear and readily transparent manner in a range of user group-specific views. The system is readily scalable because installing and integrating a new measuring point takes only a few minutes. OPTIME offers cost savings of some 50 percent compared with offline measurements and significantly outperforms other wireless CMS systems in terms of quality. With OPTIME, in-house maintenance crews and external service contractors receive several weeks' advance warning of impending problems as well as specific

recommendations on remedial measures, so they can easily plan their maintenance work, manpower requirements, and spare parts procurement in a timely and cost-efficient manner.

## **SmartCheck: For stand-alone, process-critical machines**

Designed for permanent machine and process monitoring, the Schaeffler SmartCheck is a wired, online monitoring system, complete with integrated web server and learning mode. Its ability to handle variable rotation speeds and process information and, more especially, its differentiated signal recording make it ideal for monitoring process-critical machines in small-scale plants. KPIs and alarm states can be visualized using any standard browser or transmitted directly to the control system via Ethernet using the module's integrated communication protocol. For customers wishing to use Schaeffler's online digital services, the SmartCheck module can send its data via OPC UA interface to the Schaeffler IoT Hub.

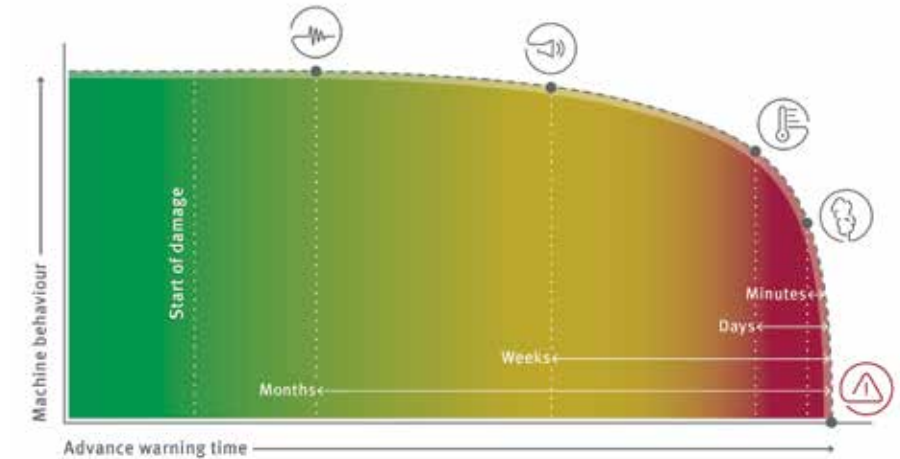


**ProLink: For process-critical larger-scale machines and facilities**

ProLink is the SmartCheck module’s “big brother” for process-critical machines with between four and 16 measuring points. It is a wired, modular multi-channel condition monitoring system that can record and analyze data on vibrations and several other variables. As with the SmartCheck module, the ProLink’s firmware features both Schaeffler-defined parameters and a learning mode for machine-specific adaptation. The ProLink module can be mounted in a switch cabinet and is integrated into the customer’s infrastructure via a Fieldbus module. The system supports OPC UA, and other protocols such as Profinet and CC-Link IE are in the pipeline.

**ConditionAnalyzer: Digital service for automated analyses**

Schaeffler’s ConditionAnalyzer is a digital service for all Schaeffler systems and other commonly available condition monitoring systems. All vibration-based condition monitoring systems can



— Vibration-based condition monitoring systems (CMS) are a proven and highly effective means of avoiding unplanned machine shutdowns and the associated production losses.

capture and visualize vibration data, but figuring out what those data mean in terms of damage progress and severity and, more especially, bearing condition requires in-depth domain knowledge of the various components involved. The Schaeffler ConditionAnalyzer software provides this level of condition information automatically, enabling users to quickly determine whether the bearing in question needs to be

replaced and when, thereby largely avoiding unplanned shutdowns. With ConditionAnalyzer, maintenance crews no longer have to spend precious time manually analyzing and interpreting all of the vibration data generated by their CMS systems. ConditionAnalyzer can easily be integrated into remote maintenance systems and existing IoT platforms via a REST API.

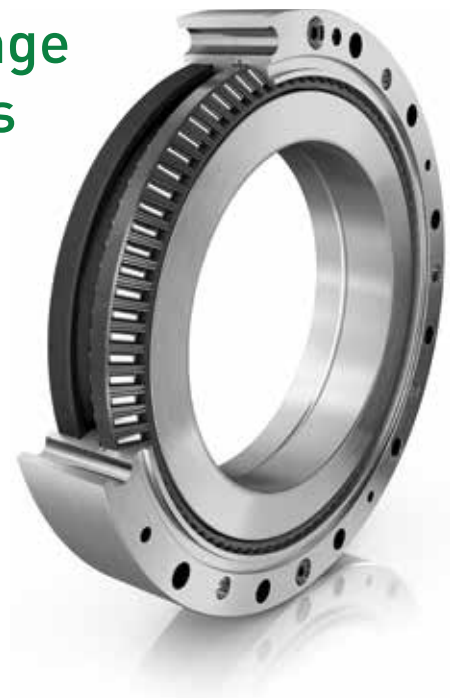
**Schaeffler gives cobots greater range with plug-and-play linear actuators**  
**Greater working radius**

Innovative components for robots and cobots

- Schaeffler develops new market with major growth potential
- New XZU conical thrust cage needle roller bearing for robot and cobot joints: 20 percent less friction and 30 percent greater rigidity
- New RTWH precision gearbox for compact design envelope

Today’s advanced automation and production facilities need lightweight robots (LWRs) and collaborative robots (cobots) that are highly dynamic and accurate. Drawing on its many years of experience in industrial automation,

Schaeffler has developed two new and highly innovative components for LWRs and cobots, with which it is opening up new opportunities in a fast-growing market segment. The new XZU conical thrust



— The new XZU conical thrust cage needle roller bearing by Schaeffler is used in lightweight and collaborative robots both as an articulated arm bearing and as a main bearing support for Schaeffler’s new RTWH precision gearbox.

needle roller bearing is used both as an articulated arm bearing in LWRs and cobots and as the main bearing support for the company's new RTWH precision gearbox. This combination of RTWH gearbox and XZU bearing ensures the most compact design envelope and the greatest rigidity possible in application.

**XZU conical thrust cage needle roller bearing for articulated-arm bearing supports**

Schaeffler's double-row conical thrust cage needle roller bearing is the culmination of 70 years of experience in the design and manufacture of needle roller bearings. The main benefit of the bearing for customers is that it has more load-bearing rolling elements than the crossed roller bearings currently used for articulated-arm bearing supports while maintaining the same design envelope. Customers thus have the option of using smaller-sized bearings, thereby saving on space and weight – major benefits when it comes to downsizing. This opens up new opportunities and possibilities in the development of LWRs and cobots. The bearing technology spells a constantly growing array of new applications for users.

Apart from more load-bearing rolling elements, the XZU unit's X arrangement of needle rollers in two raceways offers support distances that, depending on installed size, increases rigidity by at least 30 percent compared with crossed roller bearings. What is more, by housing the rolling elements in cage guides and having them configured in two raceways instead of just one, the XZU delivers a 20 percent reduction in friction.

For customers, this all translates into more precise movement and less overshoot on reaching the end position. Overall, applications using these bearings require fewer control processes and can operate at higher speeds, thereby making the production cycle in question much more efficient.

**RTWH precision gearbox – silk hat-type speed reducer**

Schaeffler offers ready-to-install silk



– The new RTWH gearbox by Schaeffler comes fully finished and ready to install. The main bearing consists exclusively of a XZU conical thrust cage needle roller bearing from Schaeffler. The precision gearbox developed by Schaeffler is characterized by clearance-free operation, high positioning accuracy, compactness, and a long operating life.

hat-type speed-reduction gears – or “speed reducers”, as they are also known – for use in robot articulated joints. By harnessing the functional principles of strain wave gearing, the RTWH combines high gear ratios – and correspondingly high torques – with relatively lightweight construction. The RTWH precision gearbox developed by Schaeffler is characterized by clearance-free operation, high positioning accuracy, and compactness. It is also very durable and therefore has a long operating life.

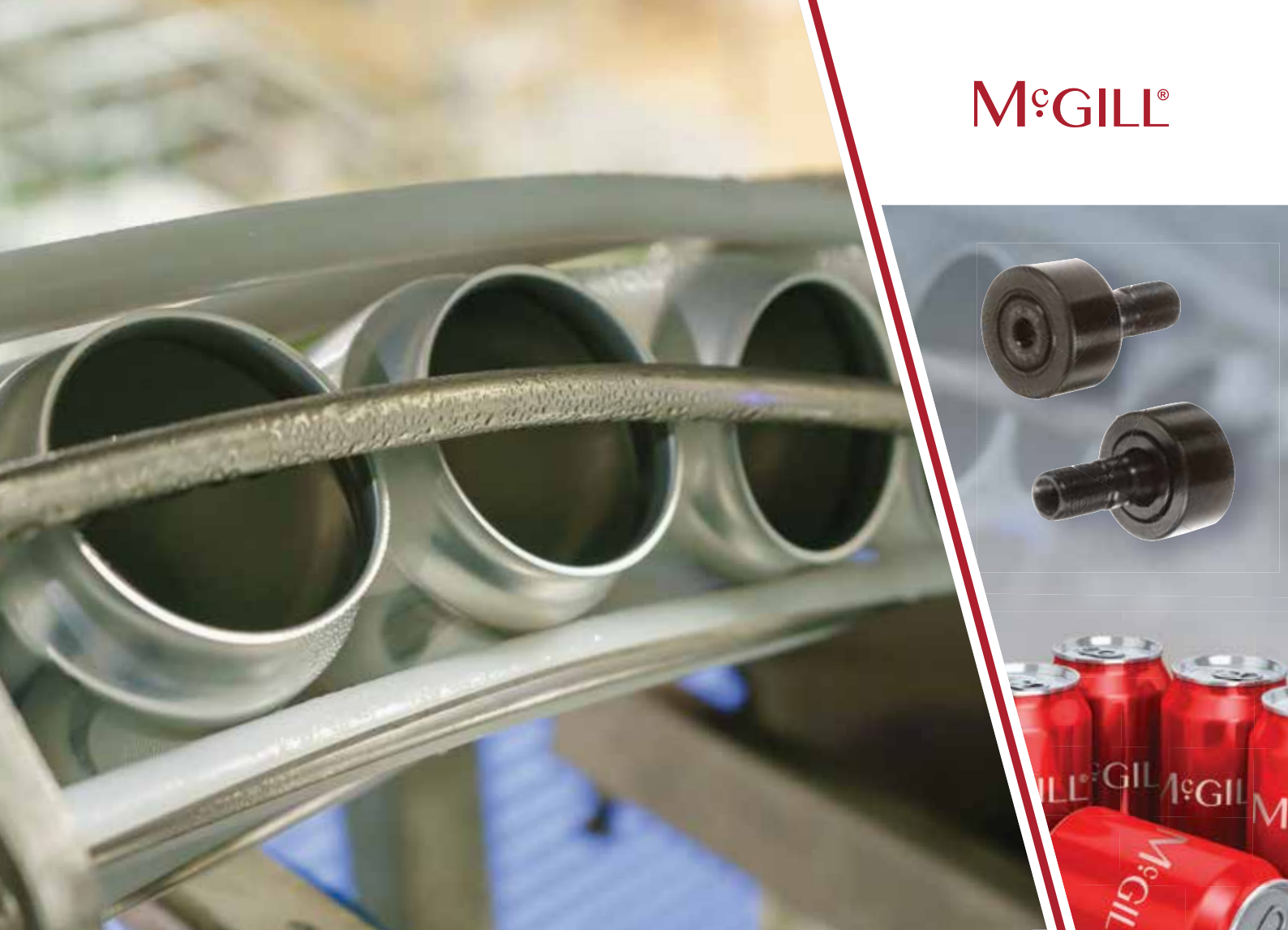
A long operating life is a key factor in robots, which need to operate with a maximum of reliability and a minimum of downtime. Depending on their size, Schaeffler's RTWH gearboxes can deliver reduction ratios of 50:1 to 150:1. The torques resulting from these reductions are transmitted reliably

and accurately thanks to the gearbox's robust construction and the integration of the highly rigid XZU conical thrust cage needle roller bearing. As a result, robots fitted with RTWH gearboxes are highly efficient and able to move through to their end positions dynamically, accurately, and without excessive overshoot. This means they are able to complete sorting, handling, and assembly tasks quickly and efficiently.

Another stand-out feature of the new precision gearbox from Schaeffler is its compact and maintenance-free design. It is available in all standard sizes. The drive flange is a hollow shaft and can be factory-tailored to the customer's requirements.



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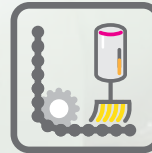
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# Bearing

## testing methods and strategies

### Abstract

As machine elements designed for multiple applications, rolling contact bearings can be exposed to very different and also challenging operation conditions. Additionally, since bearings are standard parts, suppliers are interchangeable and it is necessary to constantly monitor both quality and technical performance. Testing on test rigs is the most reliable method for product verification. This publication gives an overview of different testing methods, the required equipment and testing strategies. The main testing methods are for frictional torque or temperature and for endurance. Both have their justification depending on what is most critical in the associated application. Concerning testing equipment, two standard options provided by Elgeti Engineering GmbH will be discussed and compared with other common test rig concepts present in the market. A particular point of reference is the FE8 test rig which is described in DIN 51819 [2] and is very common for research on bearings in major technical universities. Finally, testing strategies for various cases are developed and explained.

### Motivation

The main reasons for bearing testing are:

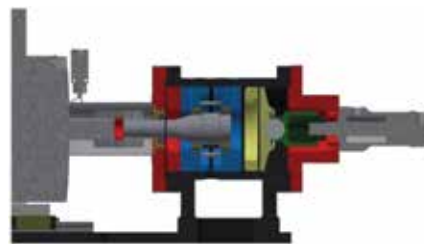
- Technical validation / supplier approval
- Comparative assessment (applies to different suppliers or to different production methods)
- Continuous quality control for incoming or outgoing inspections

Due to the complexity associated with testing, suitable approaches and strategies are essential for balancing time, expense and benefits.

### Testing methods

Among testing methods, one firstly has to distinguish between testing for frictional

torque or temperature and testing for endurance. Friction and temperature testing can help understand the effect of various operating conditions on the frictional torque and the equilibrium temperature. Such tests can help to evaluate power losses due to friction which contribute to the overall system efficiency. As an example, the losses in individual bearing elements in the drivetrain of an automobile and hence the total efficiency of the drivetrain can be evaluated. This testing method can also be used to provide a quick evaluation of the quality standards of regular deliveries (incoming inspections) [1] and to identify performance limits. Finally, steady state temperature can be a performance limiting

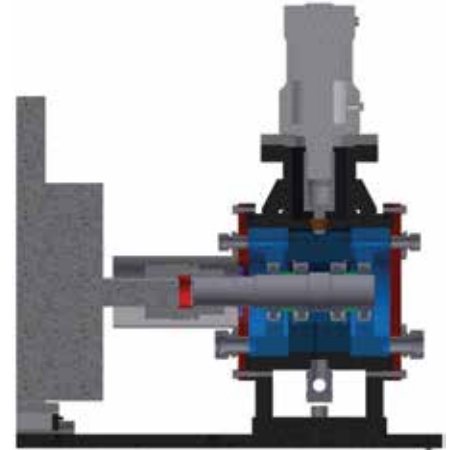


– Figure 1: Axial load application

criterion for grease lubricated bearings.

Endurance testing is used in order to evaluate the bearing lifetime under sustained use. Testing can be used to validate if the performance of the bearing and the lubricant comply with the technical specifications or expectations. When switching to or acquiring a new supplier one typically needs to ensure that the performance of the new product is better - or at the least not worse - than the current supplier. An accelerated endurance test can provide a quick comparative assessment of different suppliers and help one to make an informed decision. An endurance test which extends beyond theoretical life rating can also provide a quick test for incoming inspection [1].

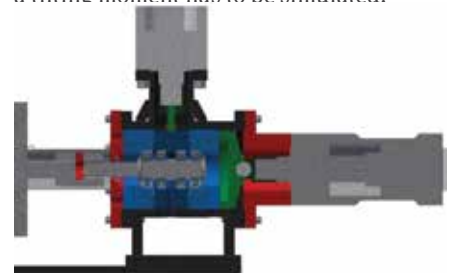
Test rig setups offered by Elgeti Engineering can be classified as



– Figure 2: Radial load application

pure axial or pure radial testing can be the preferred approach even if combined loads would have to be expected in the related application.

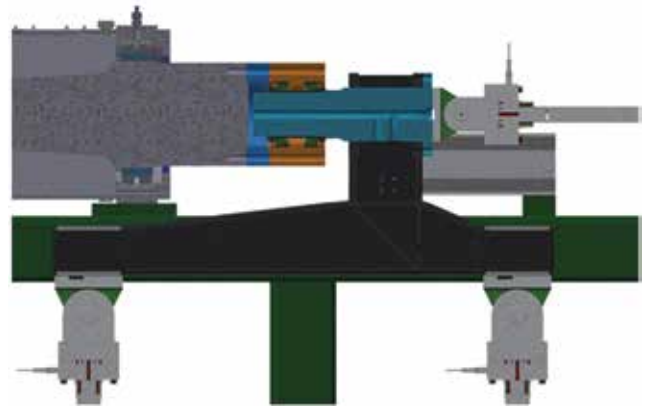
As compared with the standard test setups, customized setups by Elgeti Engineering permit a customized application of loads by which more realistic test conditions can be achieved. Figure 4 shows a multi-axial test rig which allows application of load with three degrees of freedom. This test rig is especially relevant for truck wheel hub bearings, pulley or planet bearings where apart from axial and radial loads, a tilting moment has to be simulated.



– Figure 3: Combined load application

### Testing Equipment

Standard test rigs all over the world use very similar main testing concepts. They are differentiated mainly based on the methods of temperature control and load application as well as the

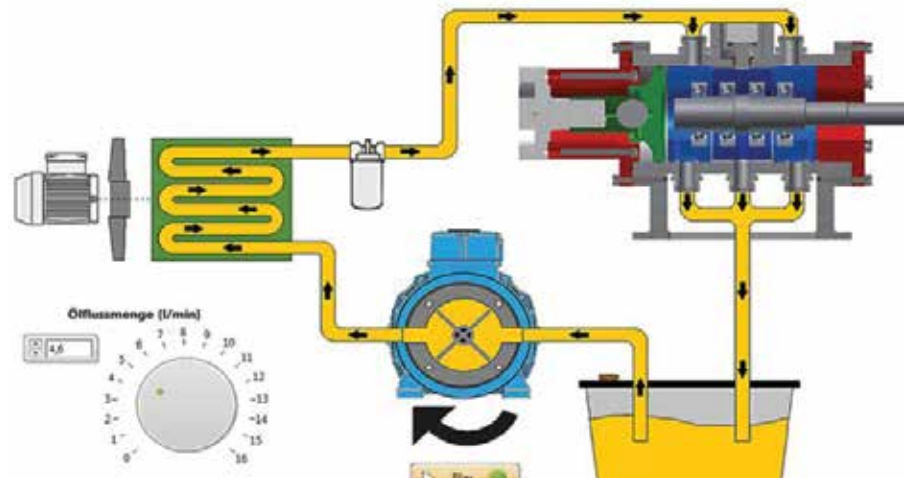


– Figure 4: Multi-axial load application

degree of automation. A compromise between cost and the required equipment precision as well as cost and the required statistical significance is necessary. More precise control and a higher degree of automation are accompanied by an increase in costs. Therefore, a test should be as simple as possible while being as complex as necessary. If high precision testing is too expensive, one is likely to do decline the service. In such cases, imprecise testing would still be the better option than no testing at all.

There are three major concepts for temperature control. No control at all results in the lowest cost. In this case, the ambient conditions are expected to be constant or at least repeatable. The second method of using a heated housing is common for low speed application such as testing of lubricants in bearings at extreme mixed friction with the FE8 test rig according to DIN 51819 [2].

The third method, which is implemented on Elgeti Engineering test rigs, as shown in figure 5, provides complete and precise control of the degree of cooling and the oil flow rate and hence of the oil temperature. A closed loop control scheme is implemented whereby the rotational speed of the heat exchanger cooling fan motor is controlled according to the measured oil temperature (an average of inlet and outlet oil temperature at the housing). If necessary, the rotational speed of the pump motor can also be controlled. An optional heating device can be introduced into the lubrication oil circuit if operation if higher temperature is required. There are four major methods for load application. A crude load application can



– Figure 5: Temperature control and lubrication system

be achieved by using preloaded plate springs with washers, as is the case in the FE8 standard test rig. Although it is a very low-cost solution, it offers very low precision. Another method consists of a hydraulic transmission of load by using weights. This offers moderate precision compared to plate springs at an increased cost. This method is used in the majority of bearing test rigs available today.

A third method, which is implemented in Elgeti Engineering test rigs, uses

hydraulic cylinders with a closed loop control of the hydraulic pressure. This method also offers moderate precision but at slightly increased cost over the previous approach. The major advantage over the previously mentioned methods is automation which allows the application of complex load cycles. Typical applications are smooth running in and automatic increasing of the load if there is no failure within a specified time. The fourth method achieves higher precision by measuring the loads

	Costs	Precision	Automation
Plate springs	Very low	poor	none
Hydraulic transmission	low	moderate	none
Pressure control	Moderate	moderate	Allows for complex load cycles
Load control	High	high	Allows for complex load cycles

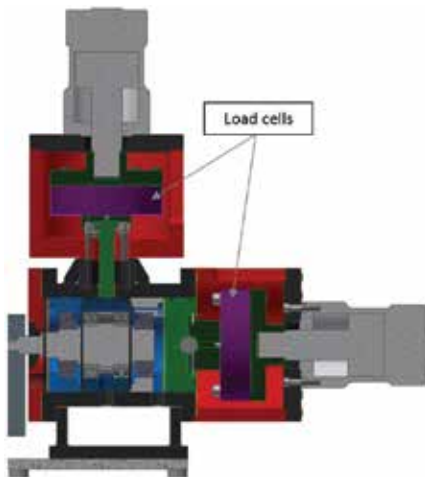
– Table 1: Comparison of load application concepts



directly with load cells instead of measuring the hydraulic pressure. Elgeti Engineering test rigs are also compatible with this approach as shown in figure 6. The characteristics of the different load application methods are summarized in table 1.

**Testing Strategies**

Before developing particular testing strategies on bearing testing, one should firstly reflect the general kinds of



— Figure 6: Load control using load cell

testing by which bearing performance shall be assessed. Depending on the level of abstraction, tests can be classified as field tests, component tests, part tests and model tests.

Field tests involve testing of complete systems in real applications, e.g. test driving a car on a public road. This test is used to verify product behavior. Component tests involve the testing of aggregates on a test bench at defined operating conditions in order to assess their performance, e.g. testing a gearbox on an embracement bench. Part tests include testing of complete parts at defined conditions in order to verify the part’s properties, e.g. testing bearings on a bearing test bench. Model tests involve testing simplified specimens under defined physical and chemical influences, e.g. ball on disc tribometer. This type of test is mainly used for basic research purposes and product development. The parameter trends of the various types of test are shown in the figure 7. The field test represents close to zero

abstraction since the test takes place in a real application. This test is also highly complex, time consuming and expensive. The part test offers good level of abstraction for a bearing endurance or friction and temperature testing at a reasonable cost and complexity. This test is also precise and has highly repeatable testing conditions.

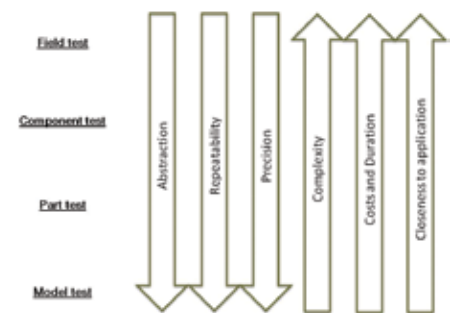
For endurance testing, statistical significance is an important topic as individual test results may vary greatly. Achieving a sufficient level of statistical significance is the main reason why bearing endurance has to be measured on a bearing test rig instead of a gearbox test rig despite the fact that the latter option is very common.

Figure 8 shows the result of ten lifetime test runs with the cumulative frequency of failure on the vertical axis and observed life in hours on the horizontal axis. The square boxes represent the results of individual test runs. In order to evaluate the lifetime of the population, a two parameter Weibull distribution is fitted to the plot (the solid line in figure 8). The parameter “a” is referred to as the scaling factor which represents the characteristic life and parameter “b” as the shape factor. These parameters are also liable to statistical variation depending on the samples.

When taken in to account, this variation results in additional plots, shown as dotted lines in the figure 8. It can be concluded that the experimental L10 life of the population, when 10% of the bearings show the first evidence of fatigue failure, lies within certain limits defined by these plots of parameters variation. This interval size can be reduced by increasing the number of test samples. It is obvious that in most cases, gearbox test runs will be far too expensive for providing a sufficient data base. In order to increase the statistical significance of testing, one has to consider a tradeoff between increasing the number of test runs and the precision of the test setup. The expense to increase the number of test runs is evident in terms of the increase in testing time whereas the expense to increase the precision of test setup is evident in terms of equipment costs. In some cases,

particularly in academic applications, the higher precision offered by advanced equipment may be indispensable. For a standard test, the cost advantage of choosing to increase the number of tests instead of using expensive equipment may compensate for the disadvantage of increased testing time.

The testing strategies differ depending on the motivation behind conducting the test. Tests can be conducted for supplier approval or technical

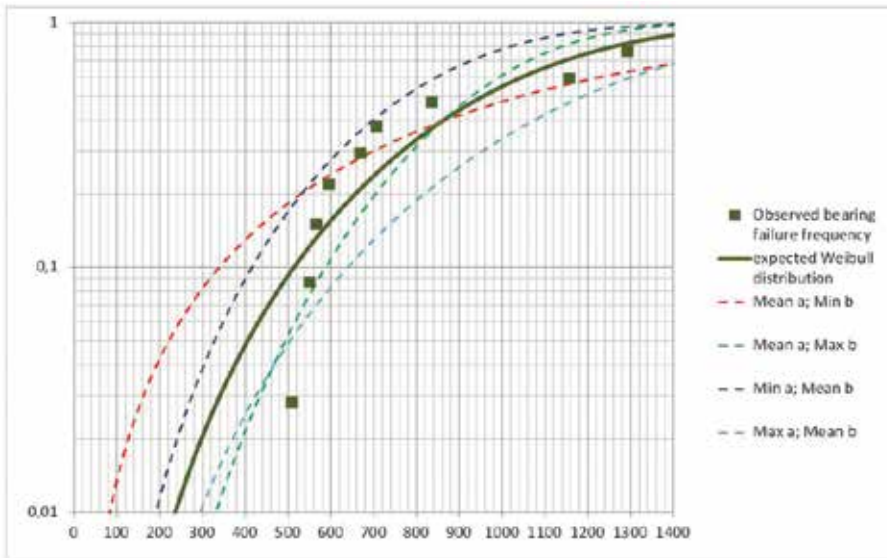


— Figure 7: Trends with respect to types of test

validation, comparative assessment of endurance, or regular quality control.

Supplier approval may be necessary in order to reduce costs, shorten delivery time, improve quality and reduce risks. Supplier approval or technical validation can be addressed by validating the frictional torque behavior and endurance performance. Frictional torque or temperature testing tests are observed to be highly repeatable. Each test lasts for about a day including working time for setting up the specimens. In the case of an endurance test for technical validation, frequently five test runs are conducted with the following approach. In order for the entire batch to be approved, no failure must be observed in these samples until a test time of at least twice  $L_{n,m}$  (the modified test life according to ISO 281). In case of one failure, further test runs are required in order to reach a conclusion. In the case of two failures, the batch is not approved.

For a comparative assessment of endurance, test runs must be conducted until failure. The standard option involves conducting the test at steady state conditions, for example at half the dynamic load rating, for a given time



— Figure 8: Cumulative Probability Distribution of bearing failure

and then subsequently increasing the load. Shaft bending should be avoided while increasing the load, as different bending would lead to different contact stress pattern and therefore to misleading results. A single test run typically lasts between two and four weeks. Accelerated performance tests provide the possibility to reduce the testing time to about one week while still being able to make a reasonable comparative assessment. In these tests, the load is continuously increased while avoiding shaft bending. This continuous increase of load can only be achieved on automated test rigs, as offered by Elgeti Engineering.

Apart from supplier approval, it is also important to ensure continuous quality control of deliveries. The incoming inspection is essential for the identification of non-qualified products prior to using them. For the supplier an outgoing inspection can prove to be beneficial for maintaining quality standards. In comparison to regular bearing inspection methods by visual appearance, geometry and material, inspection using test rigs can prove to be advantageous. In this test strategy, four randomly selected samples from each batch are tested at tough conditions until twice  $L_{n,m}$  (the modified test life according to ISO 281). This test could be completed within five days and at very limited costs. Although such a quick test is not sufficient for a precise evaluation of bearing performance, most common

production and transportation faults that may mature to failure can be easily detected. Some of the flaws that have a high probability of being detected include poor material, geometrical deviation (detected during mounting on the test rig), hardening cracks, grinding burns, one rolling element of wrong diameter and mixing with low quality fake bearings.

**Conclusion**

Standard test rigs are very similar to each other concerning their basic concepts; yet, there are major differences in their approaches to temperature control and load introduction. Since testing is always a compromise between cost and accuracy, one must find a proper balance for each individual case – high level academic research must be clearly distinguished from the verification of moderate bearing quality.

While temperature and frictional torque testing typically yields repeatable results, the test results of life tests may vary considerably. Therefore, there is a trade-off between number of test runs that can be afforded and precision of equipment. For temperature and frictional torque testing, typically three test runs per population is sufficient.

For endurance testing, the following applies to the most common cases:

- 5 test runs until two times theoretic life for product validation

- 5 test runs until failure per population for comparative testing (here, one can apply either steady state conditions or increasing loads for accelerated performance tests)
- 4 samples (one or two test runs) at very tough condition until twice theoretic life for continuous quality control.

The last option is extremely powerful as it is quick and affordable for small size bearings. Testing can be done within one week leading to approval or rejection of a particular batch while removing the need for any other form of incoming or outgoing inspection – every major flaw that could be detected by geometrical or material inspection would most probably lead to premature failure during such tests.

**References**

[1] *Bearing testing for incoming inspection, Elgeti Engineering Publication-2016-05-Bearing-testing-for-incoming-inspection.pdf*, retrieved from <https://www.elgeti-engineering.de/en/unternehmen/download/>  
 [2] *DIN 51819, 12/1999*

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**Authors:**

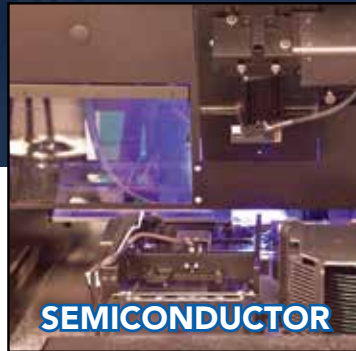
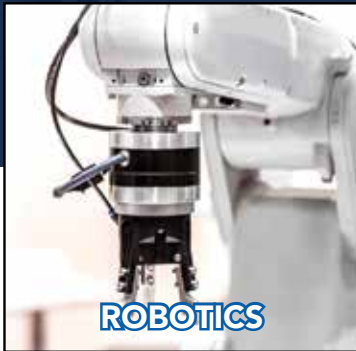


— Hagen Elgeti



— Sanket Yadav





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# Key Trends in Global Bearing Industry

Bearings are critical components of every machinery. They not just reduce friction but also support load, transmit power and maintain alignment and thus facilitating efficient operation of equipment. Global Bearing market is around \$ 40 Billion and is expected to reach \$ 53 Billion by 2026 with a CAGR of 3.6%.

Bearing sector may be considered as a traditional industry dominated by companies in the business, operating efficiently for multiple decades. Last few years have been more dynamic than before, few industry trends are prominent and may play a significant role in shaping the industry in this decade.



## Customization:

There is a growing trend in industry (particularly automotive & aerospace) for “Integrated Bearings” where the surrounding components of the bearings become integral part of bearing itself. Such types of bearings are developed

to minimize the number of bearing components in the final assembled product. As a result use of “Integrated Bearings” reduces the equipment cost, increases reliability, provides ease of installation and boosts service life.

Requirements for ‘application specific

solution’ are gaining worldwide momentum and driving customer interest. The bearing industry is shifting to developing new types of application specific bearings. Bearing suppliers are thus offering specialized bearings to suit specific requirements in applications like agricultural machinery,



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weaving looms in textile sector and turbocharger in automotive application.

### Life Prediction & Condition Monitoring:

Bearing designers are using sophisticated simulation software tools to better match bearing designs with actual operating conditions. The computer and analysis codes used for bearing design and analysis can now predict, with reasonable engineering certainty, bearing performance, life and reliability beyond what was achieved a decade ago without undertaking expensive time-consuming laboratory or field tests.

As greater demands are placed on existing assets in terms of higher output and increased efficiency, the need to understand when things are starting to go wrong is becoming more important. Unexpected equipment failures can be expensive and potentially catastrophic, resulting in unplanned production downtime, costly replacement of parts and safety & environmental concerns. Bearing Condition Monitoring is used to dynamically monitor various equipment parameters and helps in detecting the faults before a catastrophic failure occurs. Bearing OEMs are continuously working towards development of sensorized 'Smart Bearing'. The technology that enables bearings to communicate their operating conditions continuously

with internally powered sensors and data-acquisition electronics.

### Materials & Coatings:

Advancements in materials have extended the operating life of bearings, even under severe operating conditions. The bearing industry is now using hard coatings, ceramics and new specialty steels. These materials, not readily available few years back, boost performance and improve efficiencies. Specialized bearing materials in some cases enable heavy equipment to continue to operate under conditions where no lubricant is able to effectively operate. These materials along with specific heat treatments and specific geometry are able to handle extremes in temperature and cope with conditions like particle contamination and extreme loads.

Improvement in surface texturing and the incorporation of wear-resistant coatings in rolling elements & raceways have accelerated significantly in last few years. For example, development of Tungsten carbide coated balls that are both wear and corrosion resistant is a significant development. These bearings are well suited for high stress, high impact, low lubrication and high-temperature conditions.

As global bearing industry grapples with Regulatory requirements of emission, improved safety norms, lighter products

with lower friction & noise, improved reliability expectations and global steel price fluctuations, spending on R&D seems to be a strategic decision to lead the market. Also most organizations continue to focus on accurate demand forecasting and incorporating digitization in manufacturing to gain advantage globally.

### Author:

*Vikas Manral*

*The author is a bearing expert with significant experience in global bearing industry. Presently leading a growth start-up SolutionBuggy Connect Pvt Ltd working closely with manufacturing sector and helping entrepreneurs to grow and run businesses efficiently.*



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# The fall of friction in bearings

## New material innovations give bearings a new lease of life

Design engineers have long searched for material coating methods to reduce friction. But, could the restructuring of newly found materials reduce friction on macroscopic scales? Here, Chris Johnson, managing director of **EZO bearings supplier SMB Bearings**, explains how future surface treatments, including innovations in graphene and graphene related materials (GRM) could enable better, or limitless, bearing wear.

Frequently encountered in many industries and sectors, friction is a fact of life. Rolling, rotating or sliding contact interfaces in every man-made, natural or biological system generate friction. If not reduced or controlled effectively, a high amount of friction often leads to higher wear losses and ultimately, poor reliability and lifespan.

Friction's most basic definition is the force that prevents smooth and easy movement of two moving surfaces in contact with each other. With friction comes wear and tear, and thus, lubricants in a liquid or solid form are needed to prevent this. However, friction is somewhat of a sticky problem for engineers – bearing friction is not constant and is addressed using

certain tribological phenomena that occur in the lubricant film between the rolling elements, raceways and cages. A proper lubricant will reduce friction between the internal sliding surfaces of the bearing's components and reduce or prevent metal-to-metal contact of the rolling elements within their raceways. While this is a good way of reducing wear and preventing corrosion, there are new materials that, when used on bearings, dramatically reduce friction compared to the lubrication and surface treatment options that are currently on the market.

### Super lubricity

On the macroscale, friction is the result of microscopic imperfections in surfaces.

On the atomic scale, however, friction concerns the attractive forces between individual atoms. This opens up the phenomenon of super lubricity; where the atomic scale structural mismatch makes it impossible for multiple atoms in one surface to get close to atoms in the other, leading to extraordinarily low friction.

Since super lubricity was first proposed in 1990, several groups have observed the effect, but it has been difficult to scale because of the inconsistency between macroscopic surfaces. That is, until now.

Graphite was used in early investigations due to its layered lattice-like properties. Imagine egg cartons; when the cartons are aligned, they stick together inside one



another, but if they're out of alignment, they do not stick, and they can easily slide over one another. Graphite's lattice composition, somewhat comparable to these stacks of egg cartons, makes a great candidate to further these investigations into super lubricity.

### Graphene and GRM

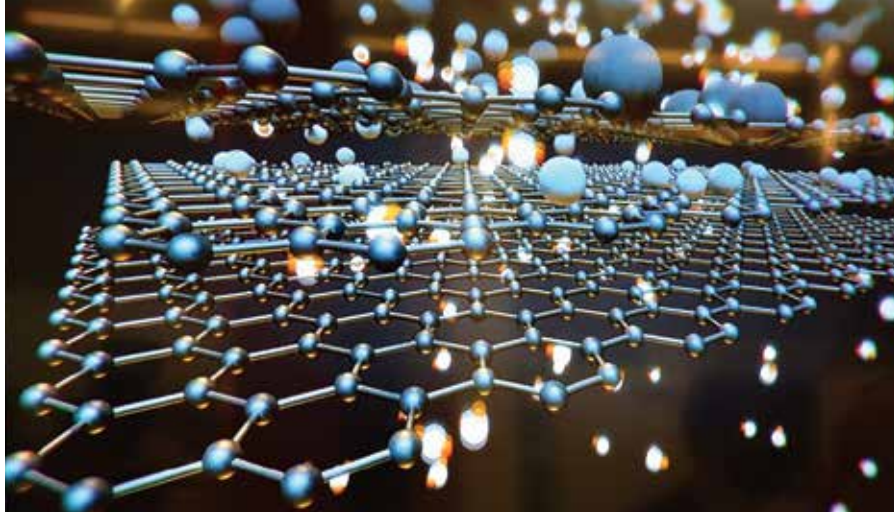
Graphene and its tribological potential as a lubricant remains relatively unexplored, with few investigations into its use as a self-lubricated solid or as an additive for lubricating oils. With graphene being a two-dimensional material, it offers unique friction and wear properties that are typically not seen conventionally. Besides its well-established thermal, electrical, optical and mechanical properties, graphene can serve as a liquid or colloidal lubricant for bearings and can even be applied as flakes to the surface.

Since graphene is ultrathin even with multiple layers, it can be applied to systems with oscillating, rotating and sliding contacts to reduce friction and wear, as well as protecting bearings from corrosion when exposed to water, a process commonly known as tribo-corrosion. This is due to graphene exhibiting a slippery texture, which could potentially make it an excellent lubricant.

As well as being low shear and highly protective, the application of graphene in bearings prevents oxidation of the steel surfaces due to its relative lack of permeability to liquids and gases. **Research shows** that the small number of layers in graphene not only reduces friction in steel seven times more, but also wear-and-tear 10,000 times more, reducing tribo-corrosion.

The process of adding a graphene coating to bearings is relatively simple compared to adding a traditional lubricant – graphene does not require any additional processing steps, other than just sprinkling a small amount of solution or spraying the solution on the surface, making this process simple, environmentally friendly and cost effective.

As well as not being harmful to the environment, graphene flakes that are



added to the surface of a bearing can last a considerable amount of time, due to the ability of the flakes to reorient themselves during the initial wear cycles, providing a very low coefficient of friction (COF).

In a study on the potential of **graphene as a new emerging lubricant**, researchers estimated that the reduced loss of energy to friction offered by new materials would yield potential energy savings

of 2.46 billion kilowatt-hours per year, equivalent to 1.5 million barrels of oil.

*It is obvious that innovations in graphene and newly discovered materials have real potential as both solid and liquid lubricants for bearings, and once fully developed, could have positive impacts on many mechanical applications that could lead to tremendous energy savings. For further information visit [www.smbbearings.com](http://www.smbbearings.com).*

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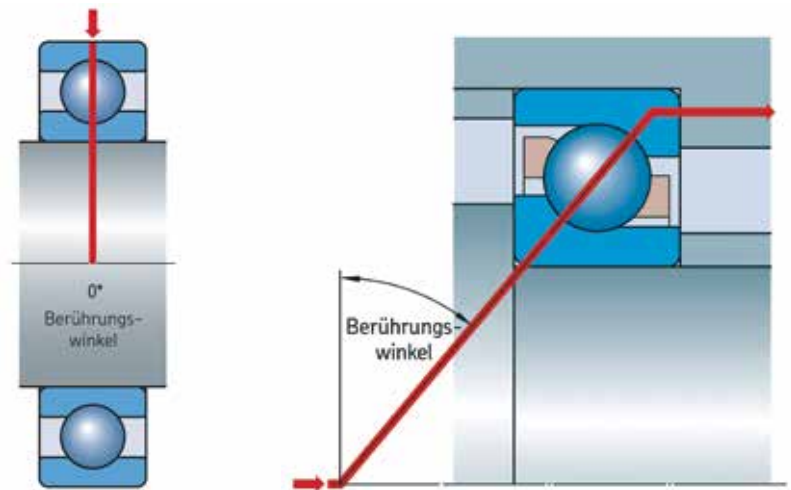
# Angular Contact Ball Bearings of SKF: The new 25° contact angle enables asymmetrical bearing sets as a robust solution at very low loads

Usually angular contact ball bearings have a contact angle of 40 degrees. Now SKF has increased its range of angular contact ball bearings with the new series of 250. In this way, it is for the first time possible to easily realise asymmetrical bearing sets that offer great service life advantages in axially loaded applications such as pumps or electric motors - by solving well-known minimum load problems in a highly effective manner.

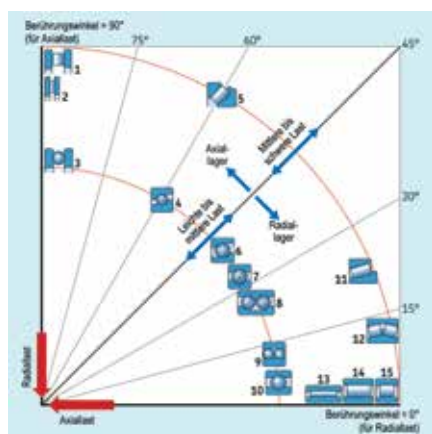
By Achim Schmidt

Each roller bearing has a contact angle, which transfers the forces within the bearing. The simplest matter is a deep groove ball bearing: There is the contact angle for pure radial loads 0°. Compared with this, an angular ball bearing has always a contact angle greater than 0°. (Fig. 1).

The axial load capacity of the rolling bearing increases with increasing contact angle. In extreme cases there is a contact angle of 90°; which is the case for a pure axial bearing. Thus, the angular ball bearings move between pure radial and pure axial bearings. Accordingly, they can best absorb combined radial and axial loads (Fig. 2).



– Fig. 1: Contact angle of a deep groove ball bearing (left) compared to an angular ball bearing (right).



– Fig. 2: Suitability of different bearings for radial or axial loads.

## More options with a smaller contact angle and better cage

SKF has recently launched an expanded

range of single-row angular ball bearings with a brass cage, which has a smaller contact angle than the usual 40°: Fig. 3 provides an overview of the range of the new 25° angular ball bearings (suffix AC).

Because of the smaller contact angle, the axial load-bearing capacity drops a little; but this results in other advantages: For example, under certain conditions, number of revolutions up to 20% higher

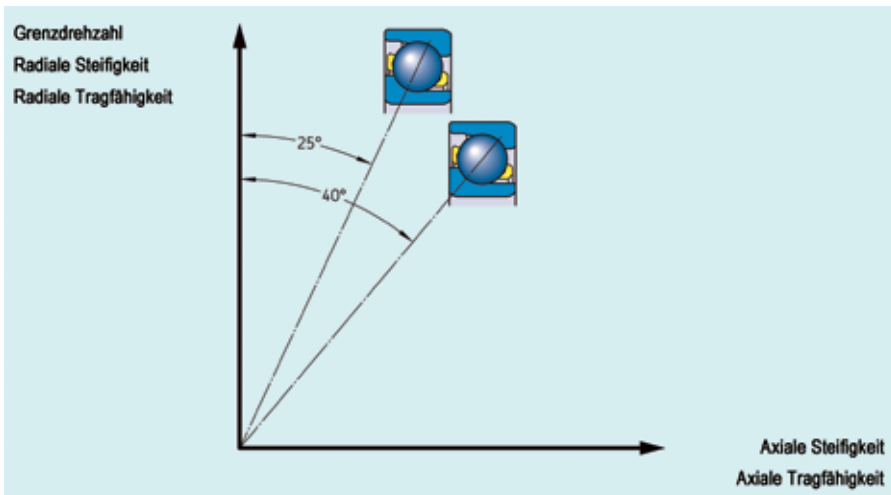
than those with a 40° contact angle can be achieved. This is because of among other things due to the more favourable kinematic conditions in the bearing, which minimize the amount of friction and therefore generate less heat. In addition, the smaller contact angle ensures greater radial rigidity, which is favourable in predominantly radial applications (Fig. 4).

Beyond that, SKF has optimized the

SKF Sortiment einreihiger Schrägkugellager		10	12	15	17	20	25	30	35	40	45	50	55	60	65	70	75	80
Bohrungsdurchmesser [mm]		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
72.. ACCBM	73.. ACCBM																	
72.. BE-2RZP	73.. BE-2RZP																	
■ SKF Explorer Lager																		
■ SKF Standardlager																		

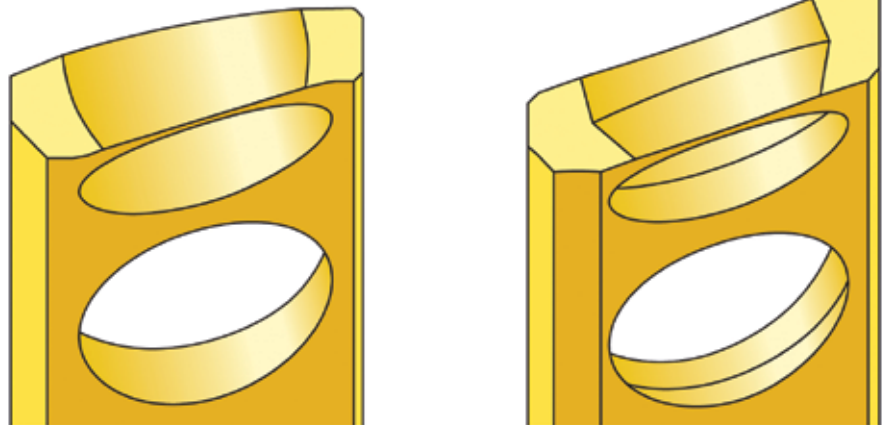
– Fig. 3: SKF product range of angular ball bearings with 25° contact angle (ACCBM) and sealed bearings with 40° contact angle (BE-2RZP).





– Fig. 4: Comparison of 25° against 40° contact angle with regard to number of revolution suitability, rigidity and load capacity

brass cage for both the 25° and the 40° variants: Due to its stronger material and its improved shape (Fig. 5), the cage is now even more robust and allows a higher number of revolutions than before. Despite these increases in performance, the cage needs less space than its predecessor, so that more volume is available for the lubricant – and that enables longer lubrication intervals. Additionally the vibration and noise levels are 15% lower with the new brass cage.



– Fig. 5: Solid brass cages of the SKF angular contact ball bearings - the optimized version on the left; her predecessor on the right.

### Applications and configurations

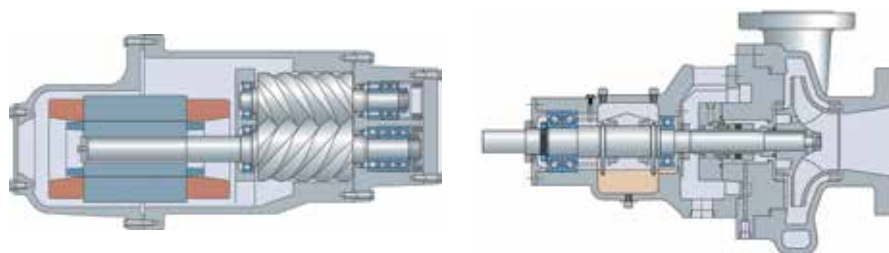
Frequent areas of application of angular ball bearings are pumps, compressors and electric motors (Fig. 6). Such units, equipped with the improved SKF angular ball bearings, can operate much more quietly and achieve longer service lives.

For such applications, single row angular ball bearings are usually (at least) installed in pairs. When an angular ball bearing is loaded purely axially or purely radial, its contact angle always creates

a corresponding radial or axial force. However, due to the design, axial forces can only be absorbed in one direction by a single bearing. If it is loaded in the opposite direction, it can be damaged.

Because in most applications the axial forces occur from both directions, the opposite forces must therefore be

called “universal bearings”). Universal bearings offer the advantage that they are already coordinated with one another in the factory so that a defined preload / air is set when mounting on a block. The initially existing block gap between the inner or outer rings of the bearings is closed by clamping the bearings (Fig. 8).

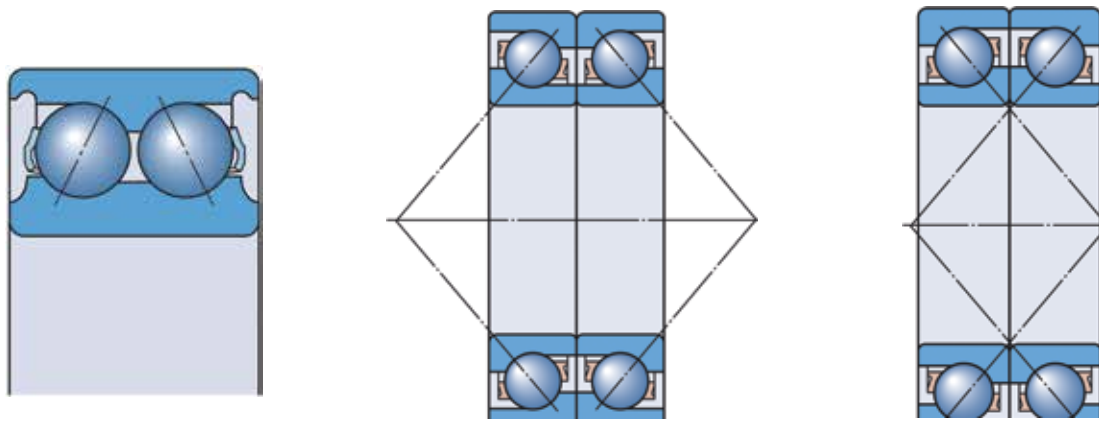


– Fig. 6: The compressors, pumps or electric motors equipped with improved SKF angular ball bearings can run much more quietly and achieve a longer service life.

absorbed by a counter bearing. The simplest form of a paired bearing is the double-row angular ball bearing with a fixed “O order” (based on the shape outlined by the contact angle lines). Individual universal angular contact ball bearings can also be combined in different ways - both in an O and an X order (Fig. 7).

### Paired angular ball bearings

If angular contact ball bearings are installed in pairs, there are various options for setting a defined preload or internal bearing clearance. The most common method is the use of so-called “universally pair able” bearings (simply



– Fig. 7: Double-row angular ball bearing / paired universal bearing in an O order/ paired universal bearing in an X order (from left).

In order to achieve the exact preload / internal clearance, a very limited tolerance of the residues and projection of just a few micrometers is required (Fig. 9). Therefore the universal considerably simplifies assembly. The other assembly methods are associated with a significantly higher cost. For example, in this way the preload of the bearings can also be adjusted by making special intermediate rings in the housing or on the shaft. However therefore the bearings must be measured in a complex manner and intermediate rings must be manufactured individually for each pair of bearings (Fig. 10).

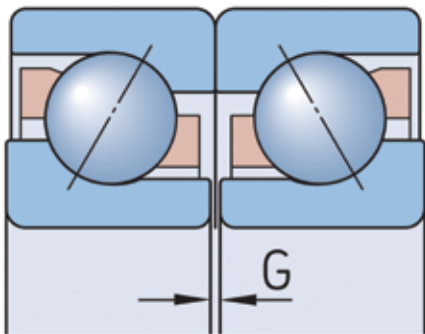
force often acts dominantly from one direction. That can i.e. be the case with fans or pumps that rotate mainly in one direction. In such applications, one angular ball bearing absorbs the axial force, while the second angular ball bearing, the so-called “backup bearing”, is relieved (Fig. 11).

However, roller bearings always need a certain minimum load for a trouble free operation - and there is a high risk that the bearing will be under load when the bearing is relieved. This can cause a disrupted rolling behaviour of the balls (with sliding movements

in rolling contact). This causes so-called “lubrication”, which leads to an increase in temperature and early bearing failure due to surface damage (Fig. 12) and / or cage breakage (Fig. 13).

**Advantages of mixed bearing sets**

So far, bearing sets consisting of two identical 40° single bearings have often been used in such applications with dominant one-sided axial loads. However, this arrangement is not optimal since the large 40° angle is more susceptible to minimum load problems when unloaded.

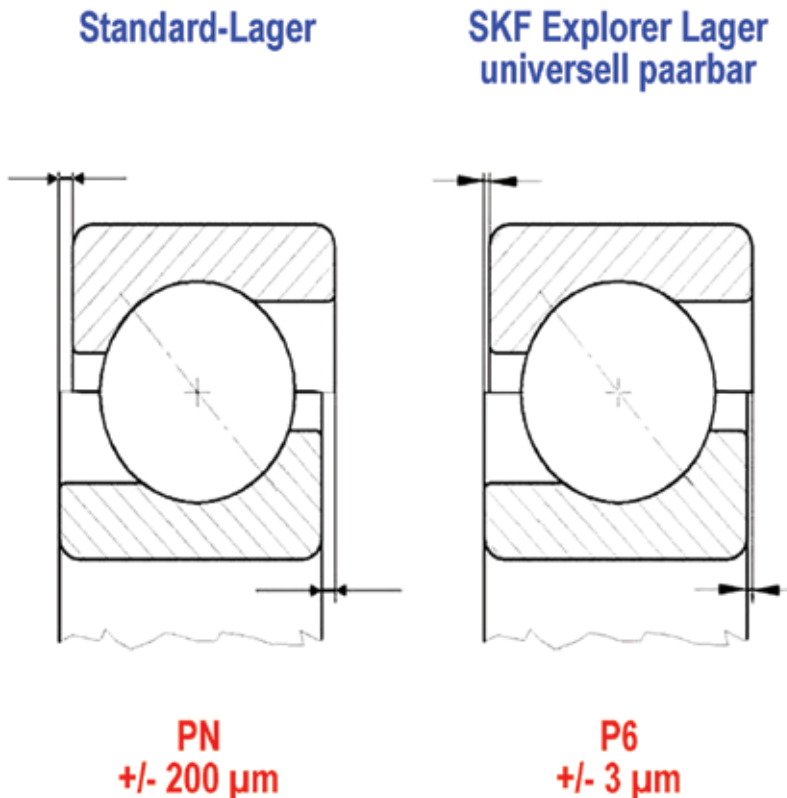


– Fig. 8: Block gap when installing single-row universal bearings with preload before clamping.

To reduce the mounting cost, the new AC angular ball bearings with a 25° contact angle are directly available in universally pair able versions according to the SKF Explorer performance class. Upon request different preload and internal clearance classes can also be implemented.

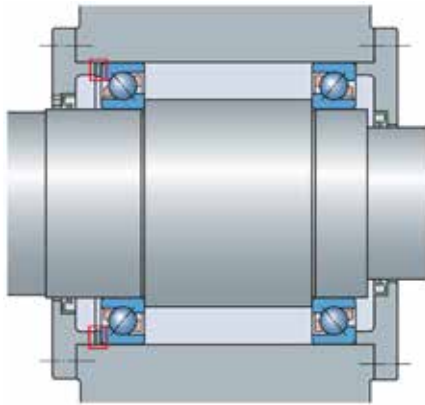
**Mixed bearing sets**

In angular ball bearing sets, the axial



– Fig. 9: Difference between standard bearings and universal bearings.





– Fig. 10: Single bearing, X order- bearing set in the housing via an intermediate ring (marked in red).



– Fig. 13: Cage fracture

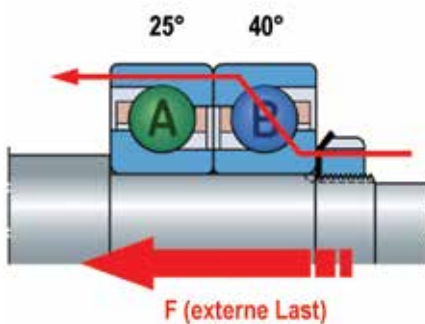
completely relieved and the minimum load required is no longer guaranteed.

Specifically, this means that with the smaller contact angle of 25°, the backup bearing is less relieved with the same external load (Fig. 14). This drastically reduces the risk of early bearing failure, which in turn increases operational safety.

#### Deflection and power distribution in the asymmetrical, preloaded bearing set

An example with a preloaded bearing set consisting of two angular ball bearings in an O order, which is subjected to a pure axial force F (red arrow) illustrates the advantages of an asymmetrical bearing set with regard to the internal load distribution (Fig. 14): The bearing with a 40° contact angle absorbs the axial force, while the bearing with a 25° contact angle is relieved by the axial force.

The coordinate system illustrates the deflection on the x-axis and the force on the y-axis. The green curve shows the bearing at 25° -; the blue curve shows the bearing with 40° contact angle. Position 1 marks the load conditions without external load; Position 2 represents the load conditions with



– Fig. 11: Bearing A with a 25° contact angle as so-called “Backup Bearing”.

The new series with a 25° contact angle enables the realization of asymmetrical sets of 40° and 25° bearings. Such a pairing of bearings offers great advantages: In the asymmetrical bearing set, the dominant axial force is absorbed over the large contact angle (B = 40°), while the unloaded bearing with a smaller contact angle (AC = 25°) reduces the risk of greasing - because this increases the threshold for the lifting force. The lifting force is the external axial force from which a backup bearing in a preloaded bearing set is



– Fig. 12: Lubrications on the ball.

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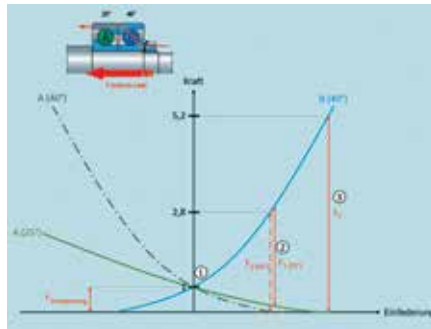
external axial force  $F_1$  ... at the height of lifting force of the  $40^\circ$  bearing and position 3 reflects the load conditions with external axial force  $F_2$  at the height of the lifting force of the  $25^\circ$  bearing

**For position 1; Load conditions after montage without external load:**

No external force acts at the intersection between the blue and green lines (exactly on the y axis). Both bearings are only loaded by the set preload. For simplicity, this example assumes a preload force with  $F_{\text{preload}} = 1$ .

**For the positions 2 and 3 in general; Load conditions when an external axial force acts in addition to the preload:**

If an external axial force  $F$  acts in addition to the preload, is to move from the intersection in the middle to the right in this diagram. The force  $F$  loads the  $40^\circ$  bearing (blue) in addition to the set preload, so the blue curve rises. Simultaneously the force  $F$  relieves the  $25^\circ$  bearing (green), so the green curve drops. As soon as the green curve lands on the x-axis, the



— Fig. 14: Preload and deflection in angular ball bearings.

particularly obvious: The external force is exactly the same in both cases ( $F_1(40^\circ) = F_1(25^\circ) = 2,8 \times F_{\text{preload}}$ ); but the bearing sets deflect differently.

The force  $F_1(40^\circ)$  is shown with a broken line, and the force  $F_1(25^\circ)$  with a drawn through line. With the conventional set with two  $40^\circ$  bearings, the point of lifting force would have been reached at this point. This can be seen from the fact that the dashed gray curve, which shows the deflection of a  $40^\circ$  backup bearing, intersects the x-axis. Here the preload is

backup bearing is shown here. It is noticeable that the force  $F_2$  is significantly larger than the force  $F_1$ . Specifically, this point is around 5.2 times the preload force. So with the asymmetrical bearing set - compared to a homogeneous bearing set - almost twice as high axial forces can be absorbed without relieving the load on the backup bearing.

Therefore the  $25^\circ$  bearing is much more suitable as a backup bearing.

**Conclusion**

The new generation of SKF angular ball bearings with a  $25^\circ$  contact angle represents an ideal backup bearing solution. Specifically in applications with dominant axial force from one direction, it is advisable to provide an asymmetrical bearing set in the design to prevent problems with the minimum load not being reached and to avoid early bearing failures.

In addition, the bearings with a  $25^\circ$  contact angle can also be used in applications in which high numbers of revolutions and / or increased radial rigidity are required.

The expansion of the SKF angular contact ball bearing range by the  $25^\circ$  contact angle opens up new possibilities for the designers to optimize the bearings for the most varied of applications. For individual projects, the technical advice service of SKF can also help you by choosing the most suitable bearings.



— Fig. 15: The new SKF angular ball bearings with  $25^\circ$  contact angle and optimized brass cage are an ideal backup bearing solution.

preload is depleted and the bearing is relieved. This case must be avoided. The dashed gray curve is used for comparison with a  $40^\circ$  backup bearing: It shows the deflection in the case of a conventional bearing set with identical contact angles ( $40^\circ + 40^\circ$ ).

**Position 2 in detail; force  $F_1(40^\circ)$  and force  $F_1(25^\circ)$ :**

Here the difference between a conventional set ( $40^\circ + 40^\circ$ ) and an asymmetrical set ( $40^\circ + 25^\circ$ ) becomes

completely used up (intersection of the dashed lines, yellow box). This point is approximately 2.8 times of the preload.

However with the asymmetrical set there is still a certain residual preload in the bearing with the same force: In this case, the green curve still runs above the x-axis (intersection of the drawn through lines, yellow box).

**Position 3 in detail; force  $F_2$ :**

The point of lifting force for the  $25^\circ$



Achim Schmidt, Application Engineer at the Department "OEM & Distribution" of SKF in Schweinfurt.





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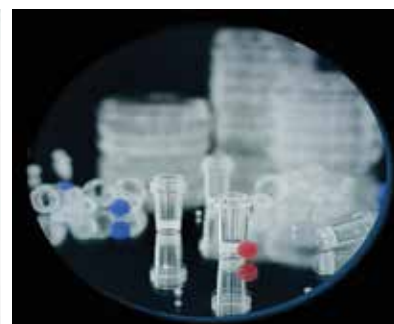
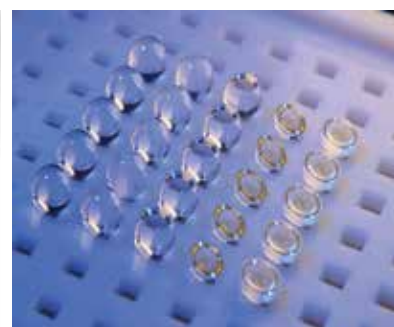
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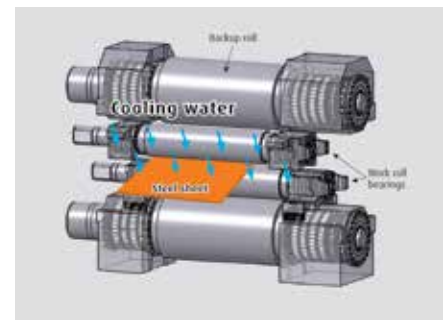
# New **NSK** bearings for rolling mills offer long service life

NSK has developed its latest four-row tapered roller bearings for rolling mills to offer a number of class-leading performance and environmental benefits. The work roll bearings use newly developed, water-resistant grease that is fully sealed into the confines of the bearing. With the new bearings, service life is typically doubled in challenging conditions such as those where there is a high risk of water penetration. In addition, the sealed design means that grease consumption is far less than that exhibited by a conventional 'open' bearing, while the risk of contaminating the environment is greatly reduced.

NSK's new long-life, four-row, sealed tapered roller bearings with new AQGRD grease deliver on a primary demand of rolling mill applications: the requirement for work roll bearings that last. Rolling mills typically use pairs of work rolls to roll slabs of steel or other metals into specific shapes, such as sheets. This work is particularly demanding on the bearings, which have to bear heavy loads at high speeds and temperatures, and endure constant exposure to

combat such issues is the newly developed AQGRD water-resistant grease. Optimised grease composition creates a thicker oil film and protective layer between the raceway and rollers, inhibiting direct contact without lubrication, as well as preventing corrosion. Rust prevention is important as harmful defects such as flaking, which compromise bearing life, stem from areas of corrosion. Ultimately, longer service life reduces maintenance costs and increases operational efficiency. Moreover, since the bearings need less frequent replacement, they help to minimise carbon footprint and resource consumption.

Aside from the long service life benefits, reduced material and energy consumption will also result in relation to the replacement cycles of conventional bearings, which in turn helps to lower CO2 emissions.



— A working schematic of a rolling mill showing the work rolls and back-up rolls

## About NSK Europe

NSK Europe Ltd. is the European organisation of the Tokyo-based bearing manufacturer NSK, which was founded in Japan in 1916 and today employs around 31,000 people in its worldwide operations. The products and solutions provided by the industrial and automotive supplier can be found wherever things move. In addition to nearly all types of rolling bearings, the company's portfolio includes housed bearings, linear technology, wheel bearing units, transmission and engine bearings and steering systems. The company is oriented to perfection in all of its business activities. Its aim is quality leadership in its industry, which it strives for through a continuous process of improvement, excellent product development, optimised production processes and customer-oriented service processes.

[www.nskeurope.com](http://www.nskeurope.com)

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NSK Deutschland GmbH

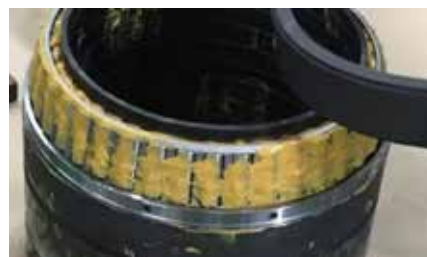
Harkortstraße 15 PR



— NSK's new sealed four-row tapered roller bearing for work rolls in rolling mills

water sprays and metal particles. These severe operating conditions can lead to premature bearing failure due to flaws such as flaking. Flaking occurs when fatigue causes small pieces of bearing material to separate from the smooth surface of the raceway. This effect creates coarse regions that eventually make the bearing inoperable.

The principal innovation designed to help



— NSK's latest sealed four-row tapered roller bearings packed with water-resistant AQGRD grease, which offers double the service life of conventional bearings

Moving forward, NSK will continue developing and manufacturing products geared toward realising a sustainable society.

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Poor greasing practices are a leading cause of bearing failure.

Many lube departments re-grease on a wasteful calendar-based schedule. This leads to over and under greased bearings that fail to deliver their engineered value.

LUBExpert tells us when to grease... and when to stop.

Grease reduces friction in bearings. Less friction means longer life. LUBExpert alerts you when friction levels increase, guides you during re-lubrication, and prevents over and under lubrication.

## Grease Bearings Right



**Right** Lubricant



**Right** Location



**Right** Interval



**Right** Quantity



**Right** Indicators



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**SCHAEFFLER**  
**AT THE THIRD EDITION OF**  
**BEARING WORLD 2020**

**Dr. Oliver Koch,**  
*Vice President Bearing Analysis Tools  
at Schaeffler*

FVA – The German Research Association for drive technology is organizing the third International Bearing Conference in Hannover on 31 March – 01 April 2020.

The FVA always focuses on areas where something is driven, controlled and moved. Research projects concentrate on mechanical and electrical or mechatronic drive technology in stationary industrial plants, in motor vehicles and mobile machines, through to aircraft. All links in the value added chain are put to the test, from materials, production technologies and quality assurance, components and systems and their calculation, lubricants, through to environmental compatibility, quality, costs and innovation management. Currently approx. 180 ongoing projects are coordinated each year by 25 active working groups.

Schaeffler is one of the main sponsors and supporters of the Bearing World conference, and sees it as a leading event to exchange state of the art technology and latest research results in order to make machines more powerful and more reliable.

We tried to reveal why Schaeffler, the global bearing supplier and leading company in bearing research and technology is sponsoring the Bearing World Conference during an interview with Dr. Oliver Koch, Vice President Bearing Analysis Tools at Schaeffler.

**1. What is the purpose of your sponsorship of the bearing world conference?**

Knowledge is one of the most important resources in our times. We strongly believe that an exchange of experts is necessary to generate new knowledge – also in the field of bearing technology. The FVA Bearing World is the biggest international bearing conference, so it's just consequent to sponsor this event.

**2. What is your role at the company and why are you chosen for this function?**

To increase the R&D efficiency, computational simulations becomes more and more important. Schaeffler started to develop the well-known and established tool called BEARINX more than 25 years ago. With BEARINX we can simulate single bearings, shaft systems or whole drive trains under consideration of all relevant boundary conditions. Nearly every bearing we sell has been simulated

using BEARINX. In addition, we also have tools for dynamic simulations, system simulations and very detailed contact simulations. These tools are embedded to the BEARINX SIMULATION SUITE. In my organization I'm responsible for the development of those tools – including the physics, software developments and cloud integrations. Before joining Schaeffler, I did my Ph.D. in a bearing simulation topic as well. I developed a model for predicting friction in the rib contact of cylindrical roller bearings. After joining Schaeffler, we

*“With more than 2,400 patent applications in 2018, Schaeffler is Germany’s second most innovative company”*



implemented this model into BEARINX, and generalized the model for all kind of contacts. So my heart is still beating for bearings and simulations.

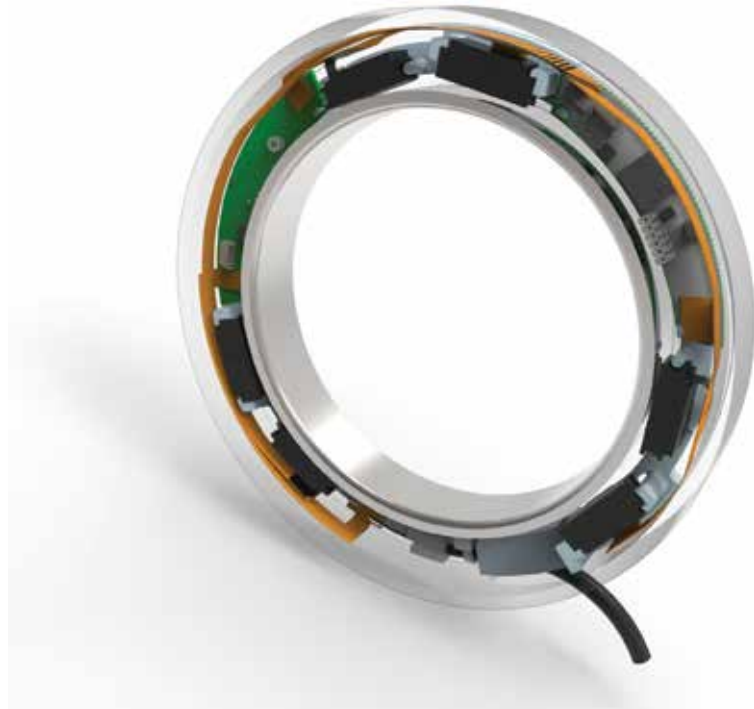
### 3. What are the differences between your company and other competitors in the market?

There are four main aspects which lead to the fact that Schaeffler is one of the world's leading bearing suppliers. First of all, we focus on good engineering. This means for us that we must have a very good knowledge about our customers' applications and needs. Second, we need excellent domain know-how and simulation possibilities to provide the right products for each customer's needs. Third, we have great manufacturing know-how for highly precise productions. And last but not least we are a very innovative company. With more than 2,400 patent applications in 2018, Schaeffler is Germany's second most innovative company according to the DPMA (German Patent and Trademark Office).

### 4. Can you tell us more about your presentation topic at the Bearing World?

We have several presentation topics. Let me give you two examples. In the context of e-mobility, noise and vibration behavior of all kind of machine elements is becoming more important. So it would be necessary to predict the noise of bearings in the system at the early stages of product development. Bearing noise simulations are complex and very time consuming. Now we have developed a new method in BEARINX which allows us to predict the running noise of bearings within a few seconds. This is unique in the world and will be presented at the FVA Bearing World for the first time.

Another presentation is about the influences of non-metallic inclusions (NMIs) on white etching cracks (WEC). According to literature, it's still not clear if NMIs are the root cause of WEC or not. For an adequate interpretation of this matter, a mechanical evaluation of NMIs under rolling contact conditions is desirable. One option for an analytical evaluation of internal defects could be



— Schaeffler integrates sensor technology into its spindle bearings

explained by Linear Elastic Fracture Mechanics (LEFM). With understanding of LEFM, experts could determine critical defect sizes depending on the stress distribution and the defect position in a component, and the calculation of a permissible stress for a given defect size.

However, the required consideration of the complex stress state under rolling contact conditions is challenging. A combined approach for the analysis of subsurface fatigue initiation and the development of – so called – butterflies has been developed. The comparison with test results and determinations in different standards (e.g. ISO 281) shows a good accordance. So we'll discuss in our talk about the influences of NMIs on different damage mechanisms including WEC formations.

### 5. What can your company add to the reduction of Co2 content?

Schaeffler's high precision products have been facilitating and shaping mobility for decades. The continuous optimization of our product solutions, e.g. with regard to the reduction of friction losses and the extension of the product life-cycle (predictive maintenance,

remanufacturing), enables our customers to realize significant efficiency gains during the use-phase, and thus, provides contributions to reduce the overall climate impact. In order to additionally mitigate the carbon footprint of our products along the entire value chain, the Schaeffler Climate Program aims on further increasing energy efficiency in our own operations, the upscaling of the share of renewables in our power mix and the engagement with our suppliers to identify and realize reduction potentials.

### 6. How important is the exchange between research at universities and industry for you?

This exchange is very important because you need to get new ideas in the company to stay innovative. We have a very good worldwide university network and for special topics we have established so called Schaeffler Hubs for Advanced Research (SHARE). The research at the SHARES is oriented towards the main future topics, which Schaeffler has identified. So we have for instance a SHARE for interurban mobility at Southwest Jiatong University China, a SHARE for urban mobility at Nanyang Technological

University Singapore and a SHARE for digitalization at the Friedrich Alexander University in Erlangen Germany. At the Karlsruhe Institute of Technology the SHARE focuses on e-mobility.

*“There are a lot of opportunities, especially for the bearing industries.”*



## 7. What does Schaeffler mean by smart bearings and how far is your company in implementing them?

When digitalized machines and equipment are designed, the rolling bearing generally represents an ideal “measuring point” for recording operating loads, process parameters, and the condition of machines. These variables occur directly in the bearing in most machines. It therefore makes sense to develop sensor systems for determining operating loads mainly in the rolling bearing. A very compact design can be achieved by clustering several sensor elements in a single, compact sensor unit. Schaeffler has implemented this approach in its VarioSense sensor bearings. The sensor unit can be flexibly configured with various measured variables such as speed including rotation direction detection, shaft position, bearing temperature, vibration, and the resulting radial shaft displacement. The radial shaft displacement is determined with micrometer precision and correlated with the internal forces and torque in many machines. These measured variables enable the intelligent, i.e., data map-oriented operation of machines and equipment, for example. The bearing load and thus the machine load can also be determined from the displacement measurement using the bearing model. This opens up entirely new possibilities in the fields of machine control and condition and process monitoring.

— The FAG VarioSense is a rolling bearing system that is based on standard products and can be configured in a modular fashion using a range of different sensors, which allows virtually every desired bearing position to be equipped with sensors. Schaeffler is thus paving the way towards a future in which even simple assemblies and machines will have access to digitalization and the Internet of Things.

Customers are already using our service range comprising condition monitoring products, smart rotary and linear products, digital services, sector-specific solution packages, and new, data-based business models in different project stages. In the next stage, Schaeffler will use this experience to further develop its range of platform-based services and thus respond to customer requirements in a quick and flexible manner.

## 8. What consequences will the upcoming economic situation have on the bearing industry?

We all know that the next few years will be challenging. The economy is cooling down and we have technology changes in the automotive industries at the same time. But I’m convinced that there are a lot of opportunities, especially for the bearing industries. Of course, we would need less parts and less bearings in electrical cars, but the requirements especially for the electrical motor bearings are quite high in terms of speed and electrical resistance, which means we have the chance to generate USPs with excellent and innovative products for the new technology. In addition, the global bearing market is still growing and a lot of new trends are arising. One example for the industrial business is robotics,

which provides opportunities not only for mechanical products, but also for smart bearings and bearing systems.

## 9. What challenges will the bearing industry have to face in the future?

As bearings are needed nearly everywhere where motion occurs, the spread of applications would increase. One of the main challenges would be to handle the wide range of applications in an effective and competitive manner. In many applications, a bearing is the place, where all information such as speed, load, and temperature of a device is available and therefore the additional purpose of bearings is to act as an information generator. The future bearing is more than just a bearing; it would become an integrated sensor. Therefore, the importance of bearings would increase in the future with digitalization and industry 4.0.

One example of a bearing as information generator is the Schaeffler SpindleSense, which is a very compact solution from Schaeffler for main spindles. It integrates the sensor technology, the evaluation unit for determining the measured values and the overload message output into a single unit.





**SKF**

AT THE THIRD EDITION OF

**BEARING WORLD 2020**

**Ruediger Sontheimer,**

*Director Sales Industrial Seals & Strategic Account Management at SKF*

FVA – The German Research Association for drive technology is organizing the third International Bearing Conference in Hannover on 31 March – 01 April 2020.

The FVA always focuses on areas where something is driven, controlled and moved. Research projects concentrate on mechanical and electrical or mechatronic drive technology in stationary industrial plants, in motor vehicles and mobile machines, through to aircraft. All links in the value added chain are put to the test, from materials, production technologies and quality assurance, components and systems and their calculation, lubricants, through to environmental compatibility, quality, costs and innovation management. Currently approx. 180 ongoing projects are coordinated each year by 25 active working groups.

SKF is one of the main sponsors and supporters of the International Bearing World conference and supports the platform to exchange latest research results on Global level. It is for SKF the place to be to learn about capabilities and future opportunities of bearings. We tried to reveal more details about SKF's participation during an interview with Mr. Ruediger Sontheimer, Director Sales Industrial Seals & Strategic Account Management at SKF.

**1. Over 250 participants from industry and research meet at the international BEARING WORLD Conference. So how important is the exchange between research at universities and industry at conferences like this for the whole industry?**

Germany is home of world class industrial drives technology, in terms of international leading companies as well as research and development performed by international recognized universities. Since more than 50 years FVA has built up an industrial drives community and connected industry

expertise and university science in order to strengthen this community and to develop future solutions. The international BEARING WORLD Conference taking place for the 3rd time in 2020 is a fantastic opportunity to share the expertise on a global level. It is THE place to go to learn about capabilities and future opportunities of bearings, a key component of industrial drives.

**2. Smart bearings are still an interesting topic in the rolling bearing industry. What do you mean by smart bearings and how far is your company in implementing them?**

Smart bearings are a symbiosis of standard bearings and sensors, electronics, analysis and evaluation software, etc. to offer condition monitoring as well as process control capabilities. SKF is offering a wide range of respective solutions contributing to increased safety and predictability of machine operations as well as implementation of Industry 4.0 principles.

**3. It is always a matter of identifying the major trend themes of the coming year in order to be appropriately prepared for them. Which trend topics are currently occupying the bearing industry?**

*“The main purpose of rolling bearings has always been to reduce friction and though to increase the efficiency of machines and aggregates.”*

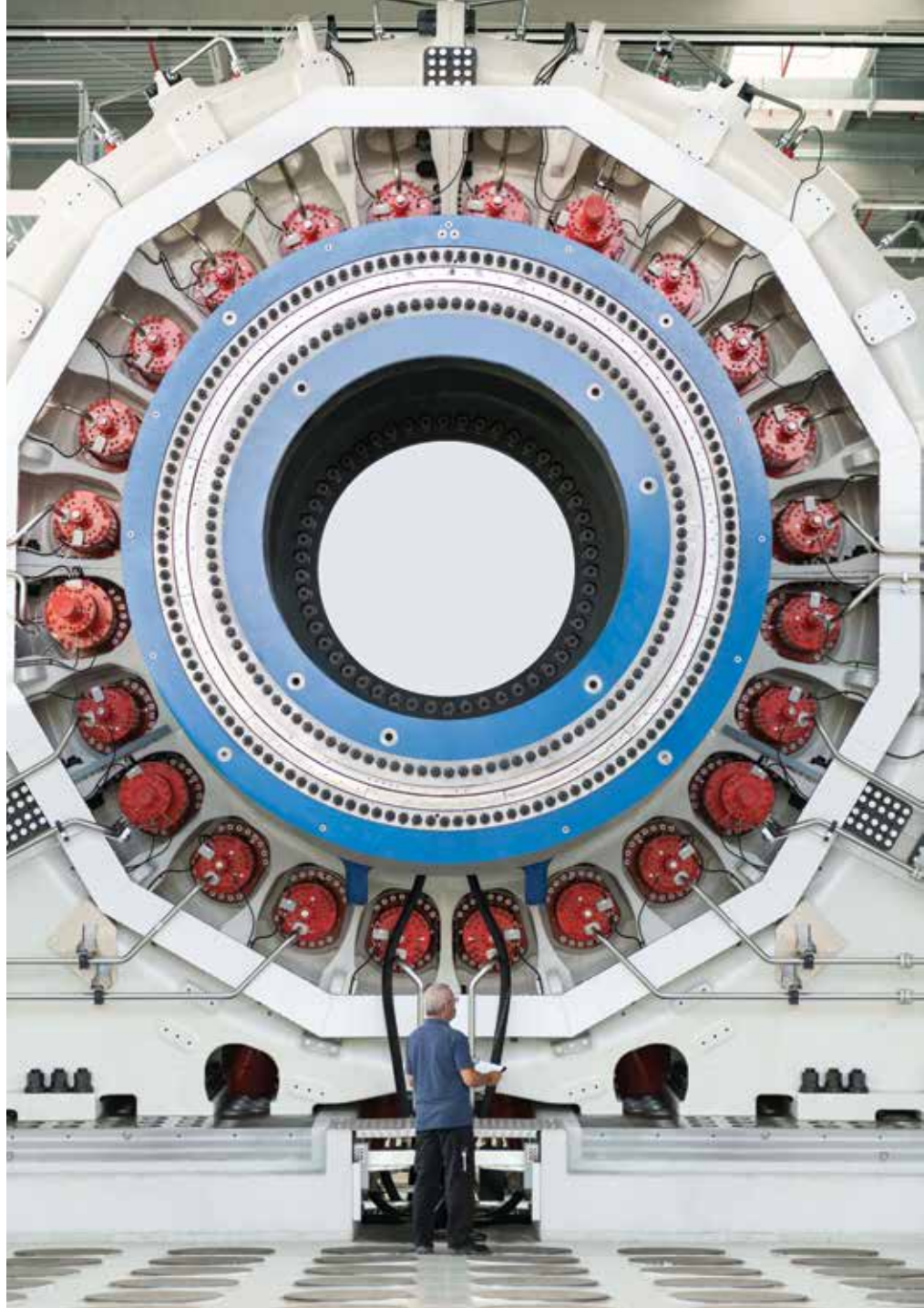


Technologies like AI and IoT are major trend themes defining the current research and development topics. New materials and manufacturing technologies like 3D printing are in the focus as well. Furthermore, all aspects of environment protection are in the consideration.

**4. An increasingly important topic is sustainability and what everyone can do for a climate-neutral future. Therefore, the question arises what your company can add to reduce the Co2 content?**

The main purpose of rolling bearings has always been to reduce friction and though to increase the efficiency of machines and aggregates. This is why it is in the genes of the bearing industry to contribute to sustainable solutions reducing energy consumption and CO<sub>2</sub> emission. New materials and coatings, higher carrying capacity offering opportunities for downsizing, improved lubricants with optimized/ reduced consumption, reconditioning of oils, etc. do contribute heavily to support the development into a climate-neutral future.

The SKF approach to environmental, health and safety management is based on a Group-wide certification to the requirements of ISO 14001 (environment), OHSAS 18001 (health and safety) and ISO 50001 (energy management). SKF is continuously increasing the recycling rate of all consumables in the SKF factories (as of now > 90%) and investing in energy efficient manufacturing processes resulting



— Large Size Bearing Test Center: Validation and Testing of Large Size Bearings with an outer diameter up to 6 meter

*“We foresee that most likely the ramp up will happen in the 2nd half of 2020 “*

in a continuous reduction of the total energy consumption in spite of an ongoing capacity increase. Last not least it is more than 10 years ago that SKF has decided to only invest in new buildings with a minimum standard according to LEEDS Gold.

SKF’s first environment report was published in 1994, and with time, this turned into a sustainability report. Since 2002 the Sustainability Report has been integrated into the Annual Report, to emphasize that sustainability issues are embedded in SKF’s operations.

**5. Also, of interest are the future challenges of the bearing industry. What challenges do you think will the bearing industry have to face in the future?**

There will be 2 major trends, i.e.  
a) cost down for standard components through design principles as well as more efficient production processes connected according to Industry 4.0 principles  
b) smart bearings including condition monitoring, load sensing, speed



—Hybride angular contact ball bearing - with ceramic balls



—Rotor positioning Sensor-Bearing unit

rotation”, the mission is to be “The undisputed leader in the bearing business”. The strategic priorities are

1. Create and capture customer value
  2. Application- driven innovation
  3. World-class manufacturing
  4. Cost competitiveness
  5. Maximize cash flow over time
- SKF Care – Sustainable business and operations

This is reflected in:

**Strong customer offering: right product, right cost, right time**

The product proposition meets performance requirements of specific

detection, communication and data exchange capabilities

**6. In the same context how does SKF address the increasing demands for durability and reliability in the face of rising cost pressures?**

This is requiring new business models and approaches such as performance-based contracts for high end solutions. SKF is offering so called REP (rotating equipment performance) contracts especially to users of high value machines in the process, paper and metals industry. We are confident that this trend will further develop and will be established also in other industries.

**7. 2020 is likely to be a difficult year for the German economy. What consequences do you think will the upcoming economic situation have on the bearing industry?**

Following a recession of the automotive industry the mechanical engineering has shown a slow down beginning in the 2nd half of 2019. At the same time the OEM’s have started to reduce their stocks and though further reduced their purchase volumes. Once the economy is turning the opposite effect will be noticed. In addition to the increased needs additional volumes will be required to build up stocks again to avoid shortages. This



— SKF sensor- bearing-steering-encoder-unit

is reinforcing the slow down as well as the speed up effect for the concerned component suppliers which we call the bull whip effect. We can already foresee that most likely the ramp up will happen in the 2nd half of 2020 and we are doing our very best to be prepared for this.

**8. In the following can you share with us SKF’s future strategy focus areas?**

The vision of SKF is “A World of reliable

parameters such as speed, load, noise or physical environment.

**Total cost of ownership**

The Rotating Equipment Performance proposition meets the needs of customers operating critical machinery by maximizing performance.





# BEARING WORLD

by FVA

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The Expert Forum for Bearings –  
Rolling and Plain Bearings!

31 March – 1 April, 2020 in Hannover, Germany

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## Ladies and gentlemen,

In technology, wherever there is movement, rolling an plain bearings are an essential.

**BEARING WORLD presented by FVA** connects experts from all over the world in a unique way. Industrial research and development meets science. This platform links all topics relating to bearings in theory and practice.

This is what makes the international FVA-Expert Forum BEARING WORLD a special event you shouldn't miss. Be part of it.

**See you in Hannover!**

The BEARING WORLD Programme Committee



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## Scientific Board

More than thirty renowned scientists from 11 countries from all over the world are gathered here. They review and evaluate the conference presentations before they are published in the Bearing World Journal. In addition, some of them will be available at the conference as moderators, speakers and discussion partners.



Tuesday, 31 March 2020

## Conference Room 1



9:30

Opening



Prof. Gerhard Poll (Leibniz University Hannover, Institute of Machine Design and Tribology (IMKT), Hannover, DE)  
Christian Kunze  
(Forschungsvereinigung Antriebstechnik e.V., Frankfurt, DE)

### Keynotes



10:00

Does mechatronics need bearings or bearings mechatronic?  
Benefits from symbiosis!

Dr. Tomas Smetana  
(Schaeffler AG, JPN)



10:30

Beyond simulations – using AI on process data to predict performance

Dr. Victoria Van Camp  
(SKF AB, SWE)



11:00

Fives Flexible Grinding Manufacturing

Mark Stocker  
(Fives Landis Corp., Hagerstown, US)

## Premature Rolling Element Bearing Failures

Session chair: to be announced

11:30

Influences on the Cathodic and Energetic WEC-Fatigue

Dr. Joerg Loos (Schaeffler Technologies AG & Co. KG, Herzogenaurach, DE)

12:00

Lunch

Exhibition

Expo

You will find all exhibitors at <https://bearingworld.org/exhibition/>

### Technical exhibition

Present your company in the accompanying technical exhibition at the conference 2020.

This provides your company with an excellent platform to:

- » Present your business to a technical audience of approximately 300 participants from research and industry.
- » Establish new contacts with decision makers and to strengthen existing ones.
- » Acquire the talents of well-trained young engineers, such as PhD and graduate students.

Contact: Brigitte Becker T +49 69 6603 1597 [brigitte.becker@fva-service.de](mailto:brigitte.becker@fva-service.de)

Tuesday, 31 March 2020

## Conference Room 1

### Premature Rolling Element Bearing Failures

Session chair: to be announced

- 13:00 White Etching Cracks in oil lubricated rolling/sliding contacts – Drivers and their effects  
Dr. Ralf Dinter (Flender GmbH, Bocholt, DE)
- 13:30 The lubricant formulation: one driver for early damage associated to WECs in thrust and radial bearings  
Dr. Arnaud Ruellan (SKF, Houten, NL)
- 14:00 The influence of mechanical stresses on the diffusion and accumulation of hydrogen in a cylindrical roller thrust bearing  
Dr. Iyas Khader (Fraunhofer Institute for Mechanics of Materials (IWM), Freiburg, DE)
- 14:30 Investigations of ZDDP tribofilm formation regarding temperature influences  
Dennis Mallach (University of Münster WWU, Institute of Physics, Münster, DE)
- 15:00 Calculation method to evaluate the Risk on WEC failure occurrence in Industrial Applications  
Dipl.-Ing. Dirk-Olaf Leimann (Edegem, BE)

15:30 Coffee break

### Electric Drive Technology and Challenges to Bearings

Session chair: to be announced

- 16:00 Surface mutation of the bearing raceway during electrical current passage in mixed friction operation  
M.Eng. Simon Graf (University of Kaiserslautern, Institute of Machine Elements; Gears and Transmissions (MEGT), Kaiserslautern, DE)

## Conference Room 2

### NVH (noise, vibration, harshness)

Session chair: to be announced

- Investigation of the damping characteristics in the dry lubricated rolling element – cage contact of deep groove ball bearings  
M.Sc. Rahul Dahiwal (University of Kaiserslautern Institute of Machine Elements; Gears and Transmissions (MEGT), Kaiserslautern, DE)
- Reconstructing shaft orbit using angle measurement to detect bearing faults  
PhD Guillaume Bruand (NTN-SNR Roulements, ANNECY, FR)
- Bearing raceway waviness induced noise in applications  
Angelico Approsio (SKF Industrie S.p.A., Moncalieri (Turin), IT)
- Noise Calculation in BEARINX– dynamics in the kinematic regime  
Dr. Hannes Grillenberger (Schaeffler Technologies AG & Co. KG, Herzogenaurach, DE)
- Balls characteristics impact on bearing noise generation  
Dr. Stefano Pagliassotto (Tsubaki Nakashima Co., LTD, Pinerolo, IT)

Coffee break

### Condition Monitoring and Sensors

Session chair: to be announced

- An analytical approach for the Influence of the Real Film Thickness Distribution on the Capacitance of an EHL Contact  
Volker Schneider (Leibniz University Hannover, Institute of Machine Design and Tribology (IMKT), Hannover, DE)



Tuesday, 31 March 2020

### Conference Room 1

#### Electric Drive Technology and Challenges to Bearings

Session chair: to be announced

- 16:30 Low Temperature Test Methods for Electric Car Bearing Greases  
Thomas Litters (FUCHS SCHMIERSTOFFE GmbH, Mannheim, DE)
- 17:00 Enhancement of the insulation properties of thermal sprayed ceramic bearing coatings  
M.Sc. Elisa Burbaum (RWTH Aachen University, Surface Engineering Institute (IOT), Aachen, DE)
- 17:30 Experimental High Frequency Analysis of the Electric Impedance of Rolling Bearings  
M.Sc. Tobias Schirra (Technische Universität Darmstadt, Insitute for product development and machine elements (PMD), Darmstadt, DE)
- 18:00 End of presentation day 1
- 19:30 **Evening Event:**  
Restaurant XII Apostel, Pelikanplatz 2-4, 30177 Hannover

### Conference Room 2

#### Condition Monitoring and Sensors

Session chair: to be announced

- Monitoring load and lubrication in a wind turbine gearbox rolling bearing in the field  
Ben Clarke (The University of Sheffield, The Leonardo Centre for Tribology, Department of Mechanical Engineering, Sheffield, GB)
- An intelligent hybrid plain bearing as a smart machine component  
Robin Kurth (Fraunhofer Institute for Machine Tools and Forming Technology (IWU), Chemnitz, DE)
- Research on Improvement of Quantum Dot Temperature Sensor for Bearing Rotating Components Monitoring  
Master student Panting Liang (Xi'an Jiaotong University, Xi'an, Shaanxi Province, CHN)
- End of presentation day 1



*„Market trends for eMobility, autonomous driving, digitalization and robotics result into completely new requirements on system level and on component level. Bearing World offers ideal platform to challenge the current technical status quo and to discuss new development trends for bearings in team of experts from research and industry.“*

Dr. Tomas Smetana (Schaeffler AG)



Wednesday, 1 April 2020

## Conference Room 1

### Rolling Contact Fatigue and Materials I

Session chair: to be announced

8:30 Evaluation of the influence of non-metallic inclusions on the high and very high cycle fatigue life of inductive hardened bearing steel in multi-megawatt wind turbines

Felix Stern (TU Dortmund University, Department of Materials Test Engineering (WPT), Dortmund, DE)

9:00 Fracture Mechanical Assessment of Inclusions in Bearing Steel

Dipl.-Ing. Jörg Binderszewsky (Schaeffler Technologies AG & Co. KG, Herzogenaurach, DE)

9:30 Effect of material anisotropy on the fatigue life of bearing steel under dry and lubricated point contact condition: a numerical study

Binbin Zhang (University of Twente, Engineering Fluid Dynamics, Enschede, NL)

10:00 Fatigue damage development in bearing steel: modelling and measurement

Dr. Ir. Erik Vegter (SKF, Houten, NL)

10:30 Coffee break

## Conference Room 2

### Bearing Selection and Design

Session chair: to be announced

Cost efficient Design of Wind Turbine Main Bearing Systems

Dr. Bernd Lüneburg (thyssenkrupp rothe erde GmbH, Lippstadt, DE)

Validation of a novel conical sliding bearing for the main shaft of wind turbines

M.Sc. Tim Schröder (RWTH Aachen, Chair for Wind Power Drives, Aachen, DE)

If form deviation than correct – The utilization of production-related defects for improving operating properties of journal bearings

Lars Friedrich (Chemnitz University of Technology, Institute of Design Engineering and Drive Technology (IKAT), Chemnitz, DE)

Bearing selection for high efficiency worm gear drives

Jun. Prof. Dr.-Ing. Manuel Oehler (University of Kaiserslautern, Institute of Machine Elements; Gears and Transmissions (MEGT), Kaiserslautern, DE)

Coffee break



Wednesday, 1 April 2020

## Conference Room 1

### Rolling Contact Fatigue and Materials II

Session chair: to be announced

- 11:00 Development of optimized nitrided bearing and transmission components for a better application performance: from process parameters to functional performance properties  
Dr. Christine Sidoroff-Coicaud (NTN-SNR Roulements, ANNECY, FR)  
Simon Thibault (SAFRAN, Magny les Hameaux, FR)
- 11:30 Finite Element Analysis of Two-step Deep Rolling of Bearing Steel for Expansion and Equalization of Compressive Residual Stress Profiles  
Joshua Simon (University of Applied Science Würzburg-Schweinfurt, Faculty of Applied Natural Sciences and Humanities, DE)
- 12:00 Progression of rolling contact fatigue damage from artificial indents in hybrid and steel-to-steel bearing contact  
Yuri Kadin (SKF GmbH, DE)
- 12:30 Microstructural Analysis of Bearing Steels by a Statistical Nanoindentation Technique  
Prof., PhD; Docent (Hab.) Esteban Broitman (SKF, Houten, NL)

13:00 Lunch

### Bearing Durability and Dimensioning

Session chair: to be announced

- 14:00 Application-dependent bearing preload in planetary gear units – application, design and assembly  
Ermalt Lamaj (SEW-Eurodrive GmbH & Co. KG, Bruchsal, DE)

## Conference Room 2

### Tribology and Fluid Dynamics

Session chair: to be announced

- 3D CFD modelling of textured hydrodynamic journal bearings  
M.Sc. Patrick Wieckhorst (Otto-von-Guericke-University Magdeburg, Chair of Machine Elements and Tribology, Magdeburg, DE)
- Study on Oil-Air Two-Phase Flow Characteristics in Microscale Ball-Raceway Contact Zone  
Ph.D. Postgraduates Fei Chen (Xi'an Jiaotong University, Shaanxi, CHN)
- Extension of a Reynolds equation based solver to calculate axially-flown journal bearings of pumps  
M.Sc. Vincent Hoffmann (Otto-von-Guericke-University Magdeburg, Institute for Machine Construction, Magdeburg, DE)
- Frictional properties of grease additivated by graphene platelets in angular contact ball bearings  
Dr. Florian Pape (Leibniz University Hannover, Institute of Machine Design and Tribology (IMKT), Hannover, DE)

Lunch

### Bearing Mechanics

Session chair: to be announced

- Investigations on the rolling bearing cage dynamics with regard to different operating conditions and cage properties  
M.Sc. Sebastian Schwarz (Friedrich-Alexander-University Erlangen-Nürnberg, Department of Mechanical Engineering, Engineering Design (FAU), Erlangen, DE)





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In April 1938, Senju Lead Factory Co., Ltd was established in Adachi-ku, Tokyo, Japan, as a manufacturer of processed lead and tin products such as lead seals, lead foil, and tin foil. The following year, Senju's product portfolio was expanded to include solder wire, solder bars, rosin cored solder wire and water pipes. Over the course of the next years, business was continually developed and expanded into other areas, so that in 1944 the company name was finally changed to Senju Metal Industry Co., Ltd. to reflect this diversification.

Today, plain bearings are one of SMIC's main business areas besides soldering materials and FA equipment. The company is engaged in manufacture of products

related to electronics, automobiles and construction machinery. In order to meet the needs of our customers, production plants and sales offices have been established in Asia, North America, and Europe and SMIC is further developing business to provide high quality and creative technologies around the world.

## **Decades of experience in plain bearing development and manufacture**

SMIC started manufacturing plain bearings in 1952 with the first product being the "Kelmet Bush" for scooters using Kelmet, a copper-lead alloy for bearings. In 1955, bimetal materials made from steel with a sintered layer

of leaded bronze were independently developed, and in 1956, mass production of bushings in the same material began. Various bearing products using this bimetal material have been rated highly for their performance, quality and durability, and continue being used by renowned international automobile, construction equipment, and hydraulic components manufacturers. In 1995, SMIC developed and introduced the Clean Metal series, a range of lead-free metal-polymer composite bearings, in reaction to rising environmental awareness. The Clean Metal material CB90 became an instant success and due to increasing demand, SMIC subsequently developed the patented Clean Metal CBE series, which excellent

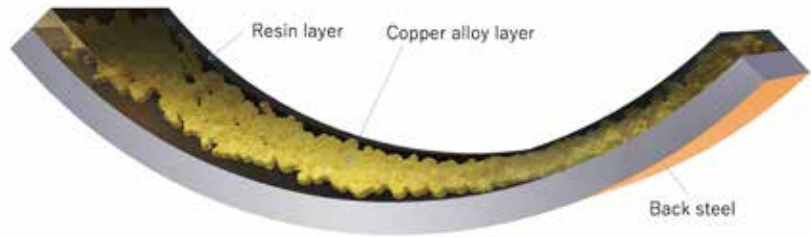


friction characteristics made it popular with shock absorber manufacturers.

SMIC's plain bearings are developed using the latest technologies for all production steps, including powder sintering, high-precision processing and bonding. The finished product is subject to severe friction and wear tests, and a thorough inspection is conducted to ensure a consistently high level of quality. In addition, a comprehensive quality management system based on IATF16949 certification has been implemented and is applied to all stages of the production process from design and development over verification and manufacturing to improvement.

**Metal-polymer composite and bimetal bearings for Automotive applications**

SMIC offers two types of plain bearings: "Clean Metal" metal-polymer composite bearings (Photo 1) and bimetal bearings. Metal-polymer composite bearings consist of a porous bronze sinter layer on a steel back, which is impregnated with fluorine-based polymer to achieve a low coefficient of friction (Figure 1). The permissible temperature ranges from -200°C to 280°C. The original polymer layer shows high lubricity and can be used without additional lubrication. In order to meet requirements specific to application, performance and operational environment, SMIC has developed products responding to different needs, e.g. low friction, high load or high rotation, suitable for a multitude of automotive applications including shock absorbers (Figure 2, Figure 4).



— Figure 1 : Three layered structure of Clean Metal material

Bimetal bearings consist of copper-based metal powder, which is sintered onto a steel back. SMIC has a wealth of experience in providing side plates and valve plates for hydraulic pumps and bushes for undercarriage of construction machinery in this material and is additionally developing lead-free products compliant with ELV Directive and RoHS.

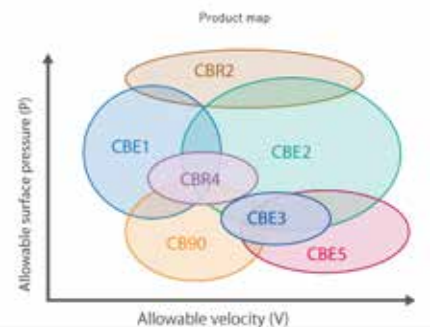
**Expertise in shock absorber rod guide bushes**

With shock absorber rod guide bushes accounting for almost 40% of SMIC's plain bearing sales, the company has especially rich experience in this field and cooperates with customers to develop new and innovative materials to meet specific requirements.

Shock absorbers are responsible for damping shocks and vibrations that occur when tires capture irregularities in the road surface. The rod guide bush supports the shaft of the shock absorber and is the first component to dampen shock and vibration (Figure 3). By choosing the material according to the required performance, Clean Metal bushes contribute to a comfortable ride



— Figure 3 : Shock absorber sketch with rod guide bush detail

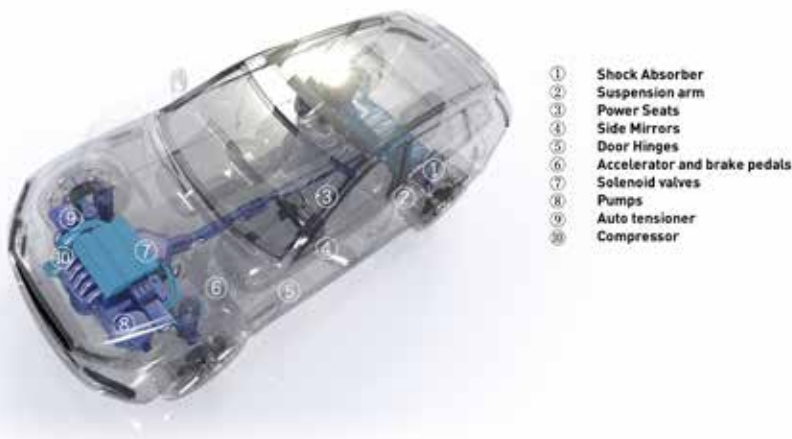


— Figure 4 : Product map

by adjusting the damping force through specified friction characteristics.

The preferred damping performance varies depending on vehicle type and personal preference of the driver. In order to meet diverse needs, SMIC continues to develop new materials using the latest technology backed by extensive experience and expertise in the industry.

Should you be interested to learn more, please do not hesitate to contact SMIC's European Sales office Senju Metal Europe at [de-info@senju.com](mailto:de-info@senju.com) or +49 (0)69 29 80 15-0.



— Figure 2 :Examples for Automotive applications of Clean Metal



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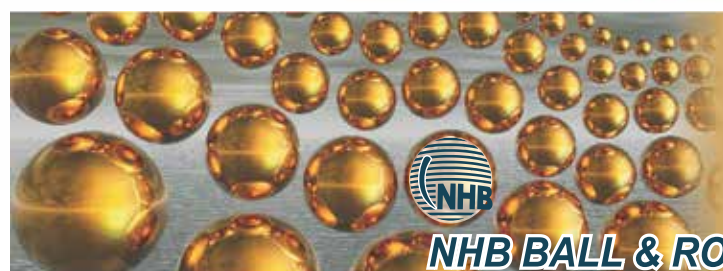


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# RKB Optimized Engineering Solution for Concrete Mixer Gearbox

*Alberto BARILI, Ciprian RADU, Catalin DANAILA, Spiridon CRETU  
RKB Bearing Industries – Department of Advanced Software Engineering*

**Abstract:** In an increasingly competitive sector, the RKB Group, with Executive Headquarters and Technological Center in Balerna (Switzerland), has decided heavy investments in Research & Development to efficiently satisfy the requirements of the power transmission industry, which is becoming more and more demanding in terms of performance and costeffectiveness. The present article illustrates the steps taken by the RKB Group to develop a customized rolling bearing in co-engineering with a leading European manufacturer of gearboxes for concrete mixers. As usual, the whole engineering process was supported by the use of in-house developed software systems (MTDS, RRLC and NON-HERTZ), 2D and 3D CAD tools, and FEM analysis systems. The WOR bearings designed for this special project were finally manufactured by RKB using the latest machining technology and the best raw materials and heat treatments.

## 1 INTRODUCTION

Concrete mixer gearboxes are part of transit mixing trucks and transmit the rotational movement from a hydraulic motor to the drum. As the concrete payloads are charged into the drum, also while traveling to the work site, the drum is rotating and continuously mixes the load in order to prepare it and avoid its consolidation. During the transport, the gearbox rotates the drum in one direction (charge direction) and by using internal helical drum fins the concrete load is kept away from the discharge opening. When discharging, the direction of rotation is reversed.

The latest generation of gearboxes features innovative solutions that increase reliability, eliminate limitations and ineffectiveness from the old designs, and reduce costs and maintenance. With the purpose of driving the drum and carrying the torque forces and a part of the drum weight, the concrete mixer gearbox represents the key element of the application. The main bearing that supports the load transmitted from the drum has a crucial role in achieving maximum performance and reliability. For this reason, the design of the bearing was the main focus of the whole engineering process.

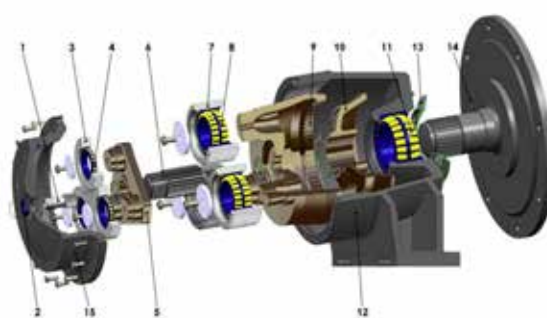
## 2 APPLICATION DESCRIPTION

The exploded arrangement in Fig. 1 highlights the main components of the double stage planetary gear speed reducer through which a hydraulic motor drives the mixing drum.

The hydraulic motor transfers the rotational movement to the input pinion shaft 1, that drives the 1st stage planetary gear 3, with deep groove ball bearings 4 that rotate the pinion shaft 6 of the 2nd stage planetary gear 7 sustained by SRB 8 inside it. The 2nd stage planetary carrier 9 couples the crown gear 10 that transmits the torque forces to the output flange 14,

also absorbing misalignment. The main SRB WOR design 11 is protected against contaminated environment by the seal 13. The gearbox has to be mounted on a rigid, free distortion support. If the mounting is not rigid, it can damage the internal gears, the seals, and finally the bearings.

The configuration of this design is engineered to withstand the application requisite operating conditions in a safe and reliable way. This objective is attained with described gearboxes, which drive and pivotally support the mixing drum, compensating the motion between the mixing drum and the main bearing case.



No.	Component
1	Input pinion shaft
2	RKB deep groove ball bearing
3	1 <sup>st</sup> stage planetary gear
4	RKB deep groove ball bearing
5	1 <sup>st</sup> stage planetary carrier
6	Pinion shaft
7	2 <sup>nd</sup> stage planetary gear
8	RKB spherical roller bearing (SRB)
9	2 <sup>nd</sup> stage planetary carrier
10	Convex gear
11	Main RKB SRB WOR design bearing
12	Main housing
13	Seal
14	Output flange
15	Rear cover

– Fig. 1 – Two-stage planetary gearbox explosion



### 3 BEARING SELECTION

Due to the drum installation angle and its applied load, the main bearing that supports the application needs to be able to absorb heavy radial and axial forces combined with important misalignment induced by the drum. This condition directly leads to a customized solution for spherical roller bearing design.

In general, distinct heavy engineering applications incorporating spherical roller bearings may need different bearing configurations, such as the CA, ECA, CC, MA and MB, showed in Fig. 1, just to mention the most common. The differences primarily lie in the design of the inner ring and cage. Because of the technical characteristics of the present application, such as low rotational speed, high thrust load, moderate shocks and increased misalignment, the bearing design must feature a cage made of two pieces that enable the two rows of reinforced rollers to move independently from each other.

The mixing drum is supported on the one hand by two guiding rollers 2 and on the other hand by the drive 3, Fig. 2. Because of its loaded weight and installation angle, the main bearing 4 must be capable of accommodating higher values of misalignment than standard spherical roller bearings. Moreover, if the transit vehicle travels on uneven terrain, the main bearing 4 must be able to transfer the mixing drum weight 1 to the bearing bracket 5 that is connected to the vehicle frame 6. In such extreme conditions, the vehicle frame deforms, leading to a relative motion between the bearing bracket and the mixing drum, which induces shocks in the main bearing. In order to protect the main bearing from excessive shocks during operation, the bearing bracket should be mounted on shock absorbers.

### 4 BEARING DESIGNS

In order to accommodate higher values of misalignment the bearing outer ring is redesigned and optimized, bringing about an increased outer ring width. The main differences between the outer rings of normal design spherical roller bearings and those of special WOR



– Fig. 1 – Different RKB spherical roller bearing designs



– Fig. 2 – Mixing drum assembly

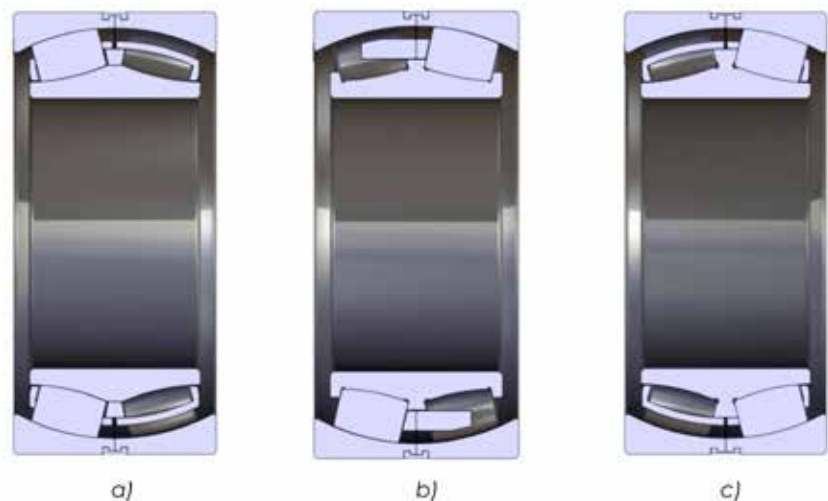
design are pointed out in Fig. 4. The resulting optimized surface geometry of the outer ring allows the bearing to accommodate higher angular misalignment than standard spherical roller bearing, maintaining the bearing performances. In addition to heavy radial loads, this bearing design supports heavy axial loads and demanding misalignments, making it irreplaceable for concrete mixer applications. WOR bearing series is a special design, having two separate outer raceways connected with a clamping ring that facilitates mounting and dismounting.

Separate cage, reinforced rollers and increased outer ring width are only a few of the design features that made the bearing suitable for the above mentioned application.

Since the main bearing is a key element in the gearbox running performances, the attention is focused on designing the proper bearing that will satisfy the application requirements. Based on the main boundary dimensions, the load capacities and the application particularities, three bearing designs



– Fig. 4 – Differences in SRB executions: a) standard design; b) WOR design



– Fig. 3 – 3D models of different RKB SRB designs: a) 24122 WOR82A; b) 24122 WOR82; c) 24122 WOR82AA

(Fig. 3) have been developed and involved in the current study: 24122 WOR82A, 24122 WOR82, and 24122 WOR82AA. A 3D computer analysis has been further carried out to validate the bearing design for the concrete mixer gearbox.

All three designs have been configured with separate brass or steel cages. Compared to the machined brass cage design (Fig. 3 b) the window-type design (Fig. 3 a, c) incorporates more rollers for the same main boundary dimensions, affecting the load rating capacities of the bearing.

on both sides. In addition, this type of cage eliminates the need for the inner ring retaining flanges and allows for more and larger rollers, which remarkably increases the load carrying capacity.

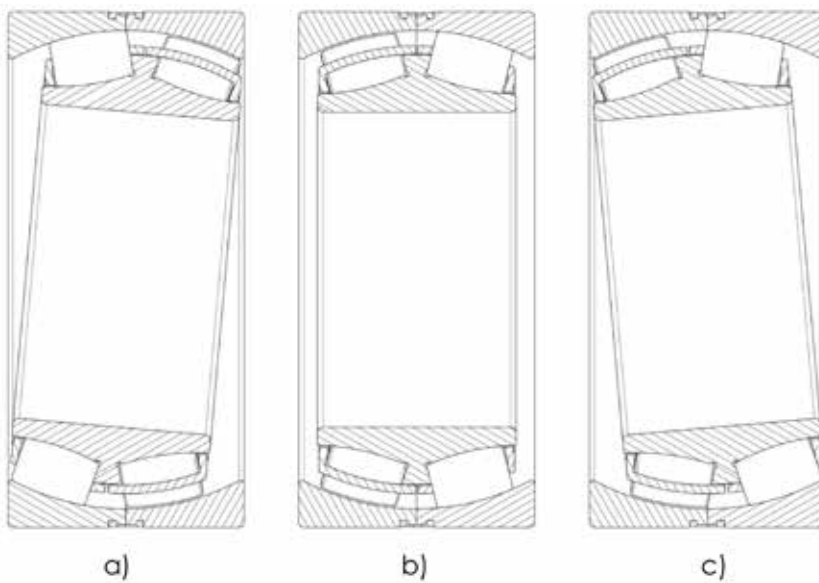
RKB 24122 WOR82 design (Fig. 3 b) is a bearing with asymmetrical rollers, a two-piece machined brass cage guided on the fixed central inner ring rib and retaining flanges on the inner ring. In case of asymmetrical roller design, the rollers are pushed into the central fixed rib. This enables to attain smoother running of bearings, reducing sliding friction and heat generation, which is extremely

a two-piece pressed steel window-type cage for each row of rollers guided on the inner ring central fixed reinforced rib. This design encompasses the previous 24122 WOR82 design featuring an increased numbers of rollers and length for a greater load rating. The central fixed inner ring rib is reinforced to sustain additional load and friction.

In addition to this special design, a high cleanliness steel and RKB Isothermal Bainitic Hardening Treatment (HB) for the inner ring come to reinforce the bearing strength and resistance to high tensile interference fits and high shock loads, reducing at the same time the occurrence of ring cracking.

Due to their design and macro-geometry, all of the three bearing designs are able to withstand the application particularities, but care has to be taken on the magnitude of axial loads applied combined with big shocks and variable misalignment. Under extreme operating conditions the misalignment value between the inner ring and outer ring is variable and consequently additional sliding motions will be generated in rollers-raceways contacts as well as rollers-cage contacts. These supplementary motions occur in a poor lubrication regime that leads to increased friction and temperature, causing abrasive and adhesive wear and finally determining bearing failure. Therefore, it is highly recommended that the misalignment of the inner ring with respect to outer ring not exceed the designed, permissible angular misalignment value (Fig. 6). According to the application operating conditions, the right choice of lubricant type and quality is fundamental (suitable viscosity and cleanliness) to achieve the necessary elastohydrodynamic film thickness.

For any roller bearing, the dynamic radial load rating  $C_r$  appears as a function of the

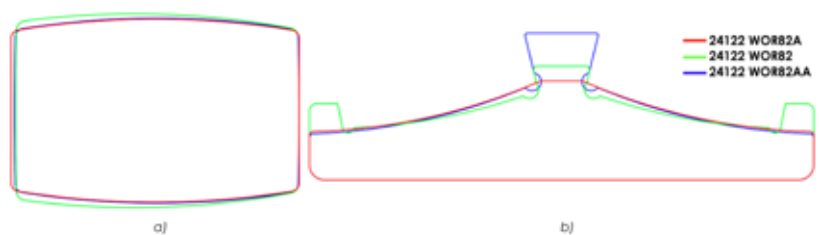


— Fig. 6 – Maximum permissible misalignment of RKB SRB WOR design: a)  $-6^\circ$ ; b)  $0^\circ$ ; c)  $+6^\circ$

RKB spherical roller bearing 24122 WOR82A design (Fig. 3 a) is a bearing with symmetrical rollers, flangeless inner ring, a non-integral guide ring between the two rows of rollers centered on the inner ring and pressed steel windowtype cages for each row of rollers. The two-piece cage enables the two rows of rollers to move independently from each other, which is beneficial in applications with extreme thrust loading. Moreover, the non-integral ring centered on the inner ring acts as a guiding ring for the rollers, that are correctly driven into the loaded zone. The separate cage keeps the rotating rollers in a stable condition, allowing for minimum temperature rise and improved operating time. This design permits to obtain a significantly reduced cage section because the bridge is supported

beneficial in low speed applications, and providing longer lubricant life. If the application is subjected to high thrust loads and if the magnitude of the shock loads is pronounced, additional load and higher internal friction on the rib will be generated.

RKB 24122 WOR82AA design (Fig. 3 c) is a bearing with symmetrical rollers,



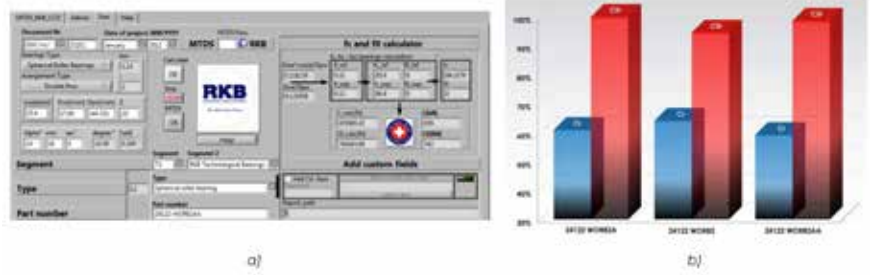
— Fig. 4 – SRB WOR design differences for: a) rollers; b) inner rings

number of rollers Z, the effective length of rollers Lwe and roller diameter Dwe. Consequently, the varied cage designs act as endeavors to improve as much as possible the values of these parameters (Fig. 4 a). Moreover, by changing the nominal contact angle with the inner ring designs (Fig. 4 b), one obtains various internal geometry parameters that lead to a better accommodation for axial loads and differences in bearing load rating capacities. The load rating capacities of the three bearings were calculated with RKB MTDS software based on the properties and characteristics of the parts.

The RKB MTDS software (Fig. 5 a) offers consistent background information on the calculation of the bearing static and dynamic load ratings according to the latest versions of ISO 76 and ISO 281. The differences in static and dynamic load ratings, due to the internal macro-geometry particularities of the three bearings, are normalized and shown in Fig. 5 b.

**5 APPLICATION OPERATING CONDITIONS**

According to the application design and requirements, the operating conditions of the mixer can be different. On the other hand they have to be found within the limits established by the ASTM Specification for Ready Mixed Concrete or other similar authorities. Depending on the concrete requirements to obtain the requested performances on the working site, the truck variable operating conditions are to be set. Since the concrete is an alterable product exposed to possible loss of properties as a consequence of certain factors (e.g. temperature and delivery time), the proper proportioning of the selected concrete ingredients along with a correct mixing cycle are to be established by the concrete producer based on its previous experience. Depending on the mixture type and drum capacity, raw materials (cement, sand, water, aggregates and other materials) are simultaneously introduced in the drum, at medium to high speed. Once the charging procedure is completed, the mixing method is initiated. There are several required operating procedures for the concrete to be properly mixed and reach the desired properties such as



— Fig. 5 – RKB MTDS software: a) user interface; b) Cr and Cor results of 24122 WOR82A, 24122 WOR82, and 24122 WOR82AA designs

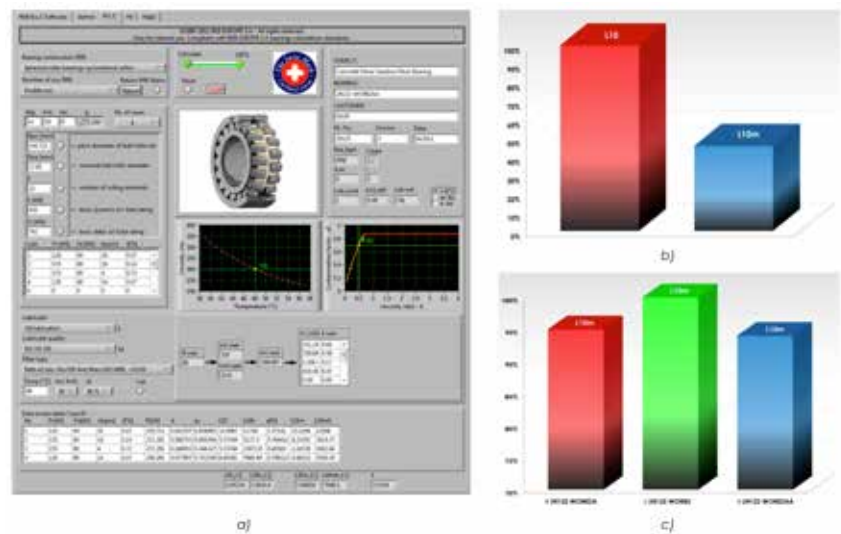
strength, durability and, workability.  
 -In the yard. This practice imposes a concrete mixing for about 50 revolutions at high speed between 10-15 rpm. After completing this stage, concrete is agitated at a lower speed, which is 2-4 rpm, up to the moment when it reaches the work site.  
 -In transit. The concrete is mixed for about 70 revolutions at medium speed between 8-10 rpm while driving

to the work site, then the speed is decreased.  
 -In work site. During the concrete transportation to the work site, it is maintained at agitating speed, whereas, at the moment it is brought to the work site, speed is increased to 18-20 rpm, for about 70-100 revolutions.

If, for any reason, the mixed truck operator

Table 1 – Concrete mixer estimated operating conditions and cycles

Mixer operating conditions	Time (min)	Speed (rpm)	Revolutions
Loading at plant	3	20	60
Mixing	6	18	108
Travel time	30	4	120
Discharge	3	14	42
		<b>Average revolutions</b>	<b>330</b>
Daily cycle (trips per day)			<b>4</b>
Revolutions per day			<b>1320</b>
Revolutions per year (200 operating days)			<b>264000</b>
Revolutions per drum life (5.6 years)			<b>1478400</b>



— Fig. 6 – RKB Rating Life Calculations software: a) user interface; b) difference between the basic rating life L10 and modified rating life L10m of 24122 WOR82AA design; c) L10m results of 24122 WOR82A, 24122 WOR82, and 24122 WOR82AA designs



decides to add water after the concrete has been mixed, additional 30 revolutions at maximum speed should be performed. Depending on the mixture type, job conditions and drum size, the mixture is discharged at a drum speed of 10-14 rpm. Since the mixer is loaded and water was added to the cement, up to the time when the discharging sequence is accomplished, the revolution counter shouldn't record more than 350 revolutions or 90 minutes.

The lifetime of the drum is limited by the inner helicoidal fins strength and shape. Therefore selecting the proper working cycle is crucial in the concrete performance and will be in time reflected in practical and economic efficiency.

The drum weight and part of the weight generated by the concrete volume act directly on the drive main bearing as a combined radial and axial force. The variable operating conditions imposed by the drum mixing cycles have a direct influence on the main bearing life. In order to evaluate the bearing life it is necessary to reduce the described working conditions to a limited number of cases (Table 1). In this case, each different load level from the variable loads is accumulated and reduced to a constant load. These duty intervals are averaged in given percentages of time fractions, speed intervals, temperature differences, lubrication conditions and levels of contamination.

To calculate the bearing life under the above mentioned percentages and considering the applied loads, variable speed, operating temperature, lubricant influence and the requirements regarding service life, reliability and safety index, RKB RRLC in-house developed patented software system was used. The modified rating life  $L_{10m}$  (Fig. 6 c) calculated with RRLC software (Fig. 6 a), for all of the three bearings, taking into account the application specifications, satisfies the required design life of the complete gearbox-drum system. As shown in Fig. 6 b, the difference between the basic rating life  $L_{10}$  and the modified rating life  $L_{10m}$  of the 24122 WOR82AA design is considerable. The modified rating life decreases because the bearing is subjected to low operating speeds, using the same lubricant quality as for the gear of the input shaft that runs at high

rotational speed. In this case, extreme pressure additives will be used to provide boundary or mixed lubrication and anti-scuffing protection. Also, according to the gearbox manufacturer, the first change of the lubricant is to be performed at 100 operating hours so as to remove any metal particles that can damage the bearings. The following lubricant change must be made after every 1000 operating hours or within one year.

## 6 FINITE ELEMENT AND SEMI-ANALYTICAL SIMULATIONS

Two groups of numerical methods are commonly involved in solving the non-Hertzian contact problems: the finite element method (FEM) and the semi-analytical method (SAM). The FEM can simulate complex material behaviors and is today's most used numerical method to solve problems in solid mechanics. However, it needs an extremely fine mesh of the volume surrounding the contact zone, which means a major increase in computing time and costs. Moreover, to diminish the computation time, providing a quicker response to customer requests, SAM needs only a very small contact region to be involved in the numerical analysis. A specific SAM and the corresponding software tool, called NON-HERTZ, have been developed in the RKB Engineering and Research Department to analyze the non-Hertzian contacts running in the elastic-plastic range and the depth distributions of von Mises equivalent stresses.

RKB engineers subjected the three different bearing designs to FEM and SAM analysis to achieve maximum performance and reliability. With a numerical approach, all the analyzed bearing designs (24122 WOR82A, 24122 WOR82, and 24122 WOR82AA) have been evaluated in terms of reaction forces, von Mises equivalent stresses, and contact pressure distributions. For this purpose, several static structural analyses have been performed by using Ansys 13, the leading finite element software tool. In particular, the following steps have been taken:

- Pre-processing of the models starting from the importing of their 3D geometries from Catia V5R19 to Ansys Design Modeler module to the final

settings before launching the analysis in Ansys Mechanical module.

- Processing of the input data executed by the direct solver of Ansys Mechanical module to reach the static equilibrium state solution.
- Post-processing of the results obtained in Ansys Mechanical module.

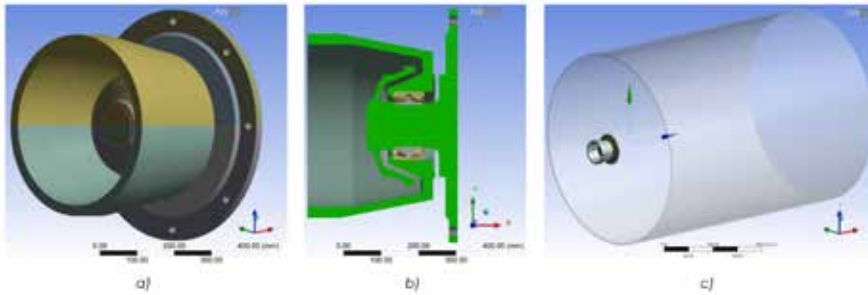
### 6.1 Pre-Processing Stage

The following procedures have been closely applied to each of the three spherical roller bearing designs. In particular the application using 24122 WOR82AA design will be analyzed in detail. Since only the bearing mounted on the output shaft is the subject of our study, only a part of the 3D model of the concrete mixer gearbox has been used for the finite element analysis. The following 3D components have been used:

- Main RKB spherical roller bearing WOR design,
- Shaft and output flange,
- A part of the main housing,
- Convex gear.

The Catia 3D model of the concrete mixer gearbox, containing the 24122 WOR82AA design, has been imported in Ansys Design Modeler module. Operations such as merging of surfaces and edges, geometry simplification, and body splitting have been performed in order to obtain a valid model for a correct analysis. Moreover, in order to simulate the geometry and operating characteristics of the mixing drum, a beam structure with tubular cross-section has been used (Fig. 7). The remaining pre-processing operations have been performed in Ansys Mechanical module.

For each deformable body an elastic material behavior has been assigned, meaning that to a single admissible stress value corresponds only one strain value. The plastic material behavior was not purposely assigned for this evaluation in order to decrease the analysis computational time. The mechanical properties of the steel assigned to the model components are presented in Table 2. Steel has been used as a material for all metallic components, while rubber has been selected for the clamping ring between outer ring split parts. Only the cages have been modeled as rigid or



– Fig. 7 – Concrete mixer gearbox geometry preparation: a) studied assembly; b) assembly section; c) drum simplified model (beam structure)

Table 2 – Material mechanical properties

Symbol	Parameter	Material	
		Steel	MU
		Value	
$\nu$	Poisson's ratio	0.30	-
$E$	Young's modulus	$2.10 \cdot 10^5$	MPa
$K$	Bulk modulus	$1.75 \cdot 10^5$	MPa
$G$	Shear modulus	$0.81 \cdot 10^5$	MPa
$\rho$	Density	$7.80 \cdot 10^3$	kg/m <sup>3</sup>

undeformable bodies, since their behavior is not part of the present evaluation. The next step in the pre-processing stage involved the definition of the contact between components. The nonlinear contact problem is a complex mechanical phenomenon arising from the interdependency of the machinery parts.

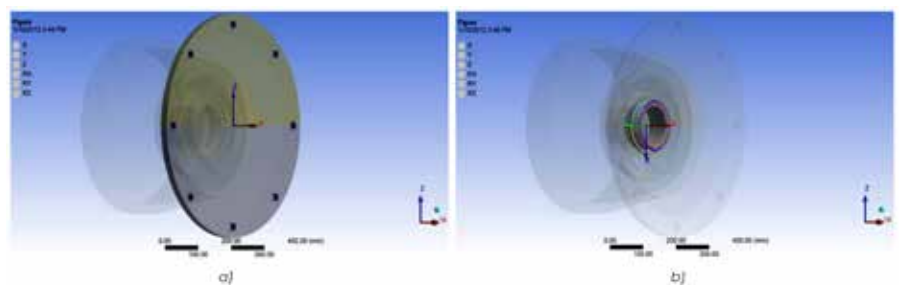
The analyzed model comprises many interacting parts. Every interaction generates a mechanical contact that has to be included in the analysis as it is in the real operation of the concrete mixer gearbox. For the components in contact, where the relative sliding is allowed, a frictional contact has been assigned with a pure penalty algorithm. For the others, where no relative motion is permitted, a bonded contact with pure penalty or MPC algorithms has been assigned.

The applied settings for each contact comprise the surfaces being in contact (the contact surface in red color and the target surface in blue color, Fig. 8), the coefficient of friction between two surfaces in contact (if any), the contact algorithm, and the normal stiffness factor (to control the penetration between bodies in contact).

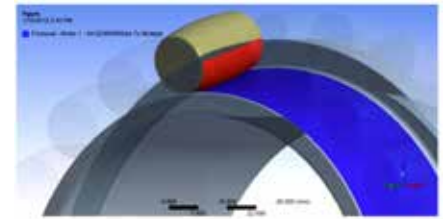
For the frictional contact with pure penalty algorithm, normal and tangential contact stiffnesses are automatically calculated by the program based on the geometry and

mesh density. The normal stiffness has a paramount importance in achieving an accurate solution, since the penetration between two surfaces in contact depends on it. Although higher stiffness values decrease the amount of penetration, it is possible to obtain an ill-conditioning global stiffness matrix creating difficulties in getting the final solution. On the contrary, lower stiffness values can lead to an improper solution characterized by a high amount of penetration. Considering these assumptions, many simulations have been performed in order to find the highest normal stiffness and ensure the highest quality of the results.

To simplify the situation, but without introducing errors in the final solution, bonded contacts with pure penalty algorithm have been considered between both roller rows and cages. Even if the contacts are bonded, the pure penalty algorithm, with a studied normal stiffness



– Fig. 9 – Definition of joints between: a) drum and output flange; b) cage and inner ring



– Fig. 8 – Contact and target surfaces

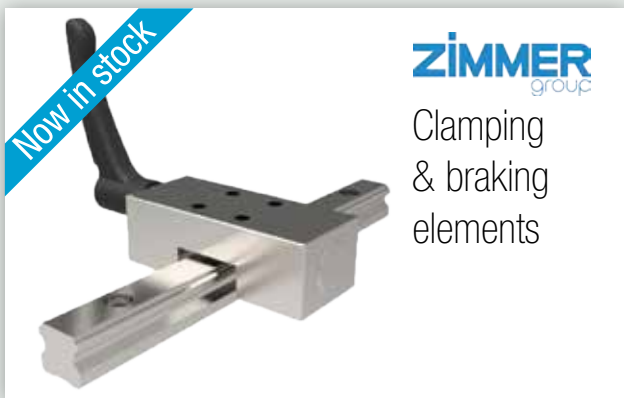
factor, will permit the rollers to have a relative small movement inside cage pockets, adjusted to be equal to the admissible play. The contacts between rollers and inner and outer ring raceways, where the rolling motion exists, have been simulated as frictional contacts. In this way, a rolling coefficient of friction and a pure penalty algorithm have been adopted. Further on, for the contacts between roller side faces and inner ring integrated flange faces, the same frictional contacts have been used but with a sliding coefficient of friction.

As for the contacts between inner ring bore and shaft and outer ring outer surface and main housing, both of them have been modeled as frictional contacts with pure penalty algorithm. For inner ring bore and main shaft contact, an interference fit has been simulated to introduce the typical stress field with radial compressive stress for inner ring and shaft, a tangential traction stress for inner ring, and a tangential compressive stress for shaft.

After implementing the contact definitions for the rolling bearing components, other connections have been established for the rest of the model components. To simulate the actions of the bolts, which connect the mixing drum and output flange, the beam structure with tubular cross-section representing the drum has been connected with the flange by using a rigid joint. As Fig. 9 shows, a coordinate system has been created in the center of the flange to relate all the degrees of freedom

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(three translations and three rotations) of the beam edge with the holes of the drum. To let both cages move according to the inner ring, the same type of rigid joint has been applied, but having as a reference a coordinate system located in the bearing center of rotation (Fig. 9 b).

One of the most important steps in the pre-processing was the discretization (meshing) of the geometrical model. The entire geometrical model has been discretized into disjointed components with simple geometry called finite elements, characterized by distinguishing points named nodes.

A particular attention has been paid to the meshing method, involving a set of tests to determine which is the minimal dimension and density of the elements that does not revise the final results.

Initially, the discretization of the geometrical model in finite elements has been performed automatically with the default settings of the Ansys Mechanical module. As is evident in Fig. 10 a, the finite elements are not regular and are distorted in the case of rollers. Moreover, all of the bearing components present a low density mesh that may affect the accuracy of the solution, especially in the contact regions where the contact area between rollers and inner and outer ring raceways is a point. Thus, further mesh operations (Fig. 10 b) have been performed in order to obtain a uniform element distribution with a high density population only in the bearing interest areas. For the rest of the components, meaning the main shaft with the output flange, a part of the main housing, the convex gear and the drum, a coarse mesh has been used to reduce the total number of elements, speeding up the analysis solving time.

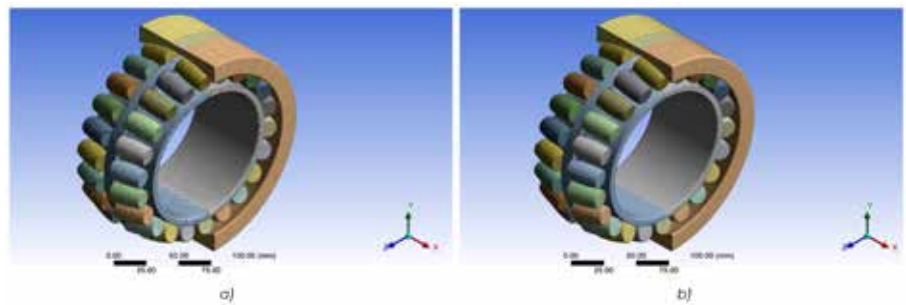
To prepare and optimize the model for the meshing process, the bearing geometry has been previously sliced in many regions in the Ansys Design Modeler module. All the model components have been meshed as deformable bodies, except for the cages which have been considered rigid bodies. For each deformable body, different 3D elements have been assigned, while in the contact areas of the rigid bodies only 2D elements have been used. The imposed 3D structural elements are the 2-node beam

element for the drum and the 20-node brick element for all the remaining deformable bodies. The assigned 2D structural element is represented by the 8-node quadrilateral shape element. Due to the complexity of the model geometry, other degenerated meshing elements have been used such as: 10-node tetrahedron, 13-node pyramid, 15-node wedge, and 6-node triangle elements.

The boundary conditions will be taken into consideration later in the present article. They are of a great importance for the static structural analysis because,

The reaction forces of the hinged support are generated by the concrete mixer gearbox main housing, which in turn has been constrained with a fixed support.

To maintain the structure in isostatic state, the roller support, representing the second support of the drum, has been modeled to constrain only the radial displacements of the drum, leaving it free to displace along the axial direction. The total load applied to the model compounds the weight generated by the maximum volume of concrete



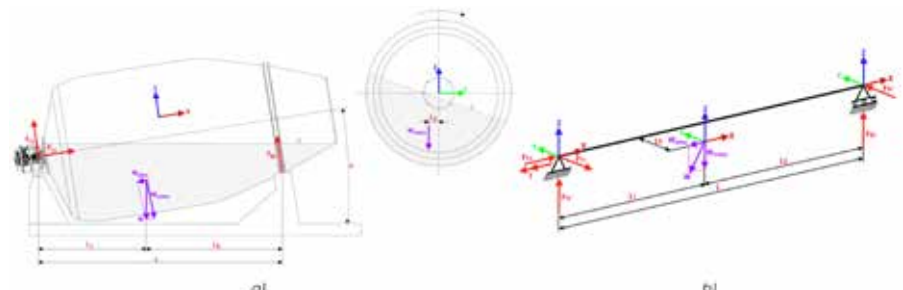
— Fig. 10 – Geometrical model discretization: a) automatic; b) optimized

under different kinds of boundary conditions, the structure behaves in different ways. In order to represent schematically the imposed boundary conditions and the applied force, the entire model was reduced to a hinged support, a beam, and a roller support (Fig. 11). These schemes have been the main guidelines to constrain the model with Ansys Mechanical module bringing it closer to reality as much as possible.

The hinged support is represented by the main spherical rolling bearing inside the

inside the drum and the drum weight.

In Fig. 11 a, the application point of the total load is out of the drum median plane and for a better understanding two views in different planes are given (Z-X and Z-Y planes). Due to the fact that the drum axis of rotation is inclined with an angle, with respect to horizontal axis, the total load affects the structure also with an axial component, taken entirely by the hinged support. The total load ( $W$ ) has been projected, on the Z-X plane, along Z and X directions taking



— Fig. 11 – Force representation on: a) entire model; b) simplified model

concrete mixer gearbox housing. This support has been modeled to constrain the displacements of the drum along the axial and radial directions (X, Y and Z axis).

into account the inclination angle of the drum. The resulting components produce reactions called  $F_{1x}$ ,  $F_{1z}$  on the hinged support and  $F_{2z}$  on the roller support.

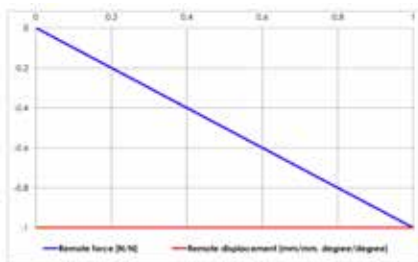
The present study has been conducted in static conditions, but a dynamic effect has been implemented to the model. As can be seen from Fig. 11, the total load acts in a parallel plane with respect to the median plane of the drum, displaced with  $L_3$  length, generating a bending effect on the X-Y plane and a resistant torque.

The composed weight component on Z direction transmits a resistant torque on the drum that, in static conditions, has to be balanced by the hydraulic engine coupled with the gearbox. To balance the resistant torque, generated by the concrete weight, a boundary condition has been applied to the convex gear, by blocking the rotation around its X axis. Two reaction forces named  $F_{1y}$  and  $F_{2y}$  (Fig. 11 b), acting in the X-Y plane, are generated by the composed weight component on X direction, eccentric by  $L_3$  length with respect to the axis of the drum.

### 6.2 Processing Stage

Once all the boundary conditions have been implemented and the analysis settings established, the processing stage starts. Due to the frictional contacts, the simulation is governed by non-linear equations. The solution of the non-linear analysis has been determined by the Newton-Raphson method, in which the total load has been incrementally applied (ramped effect, Fig. 12).

In Fig. 12, on the horizontal axis, the total time required by the solver to apply



– Fig. 12 – Incremental effect of the applied load

the total load magnitude, represented on the vertical axis as a normalized value, is shown. At the beginning of the analysis, the force (blue line) applied to the model is equal to 0 but it reaches its maximum value when the step time is equal to 1. In the same time, the boundary

conditions (remote displacements) are applied, with the imposed values, throughout the simulation.

### 6.3 Post-Processing Stage. Comparative Study

In order to validate the results and the boundary conditions applied, a checking procedure has been performed. In this way, the total load applied to the structure has to be completely balanced by the reaction forces and moments generated by the constraints described above. As input data, the material mechanical behavior considered for the analysis has been assigned to be linear elastic. This assumption has been proved valid due to the fact that the obtained maximum von Mises equivalent stress is lower than the yielding stress of the bearing material utilized (SAE 52100 or 100Cr6) equal to 1700 MPa.

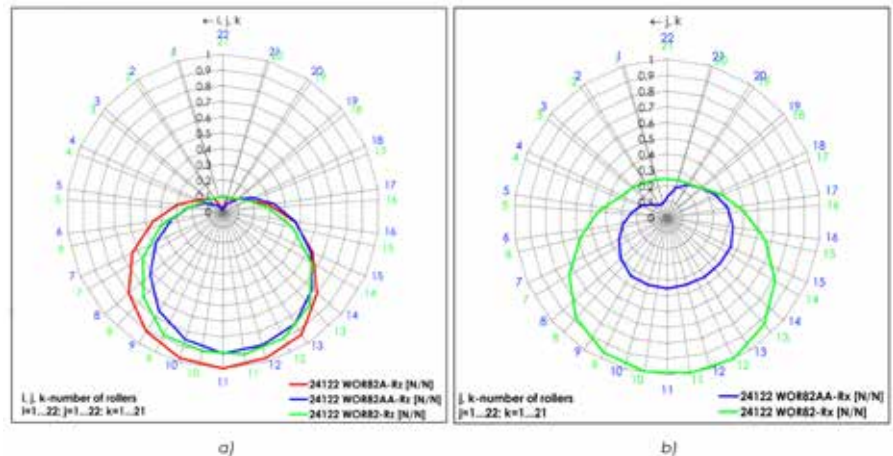
In this paragraph a comparison between the three different bearing designs will be described in terms of reaction forces, von Mises equivalent stresses, and contact pressure distributions.

Taking into account the maximum load and the constraints applied to the studied model, a series of reaction forces of the most loaded row of rollers, for each bearing design, has been illustrated in Fig. 13, after retrieving Ansys post-processing data. In order to be compared, the reaction forces have been normalized considering the maximum reaction force value of 24122 WOR82A design. Fig. 13 a represents a comparison between

normalized reaction forces distribution ( $R_z$ ) of the contact between the most loaded row of rollers and inner ring raceways of the three rolling bearings.

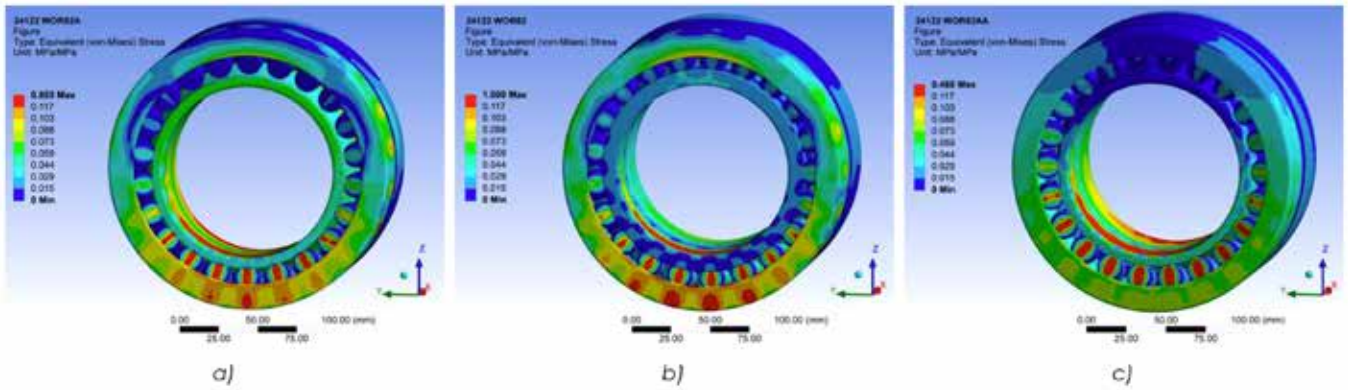
Because of the high angular misalignment of the application, these spherical roller bearings are able to accommodate the same load applied on the structure, but, due to different internal geometrical parameters of inner rings, the internal reaction forces distribution ( $R_z$ ) will vary in magnitude, according to Fig. 13 a. Comparing the results of 24122 WOR82A and 24122 WOR82 designs a difference can be observed in terms of reaction forces values. That is because the bearing loads pass entirely through the raceway due to the ribless design (24122 WOR82A design), generating in this way higher normal reaction forces ( $R_z$ ) in the contacts between rollers and inner ring raceway. Reversely, the reaction forces  $R_z$  of 24122 WOR82 design have lower values due to the small amount of load transmitted to the central fixed rib and due to the difference between contact angles. In order to diminish the reaction forces  $R_z$  and consequently the stresses, an improvement in internal geometry design of inner ring has been made by reinforcing the central fixed rib and increasing the contact angle. The normal reaction forces distribution ( $R_z$ ) of the 24122 WOR82 and 24122 WOR82AA designs can be observed in Fig. 13 a.

Moreover, the change of inner ring contact angle brings more benefits in terms of reaction forces ( $R_x$ ) generated in the contact between the side faces of rollers on



– Fig. 13 – Reaction force distribution graphics: a)  $R_z$ ; b)  $R_x$





– Fig. 14 – Von Mises normalized equivalent stress distribution of assemblies: a) 24122 WOR82A; b) 24122 WOR82; c) 24122 WOR82AA

the most loaded row and the lateral face of the central fixed rib (Fig. 13 b). Since 24122 WOR82A design has a non-integral rib design, reaction forces Rx are not present but are included in reaction forces Rz.

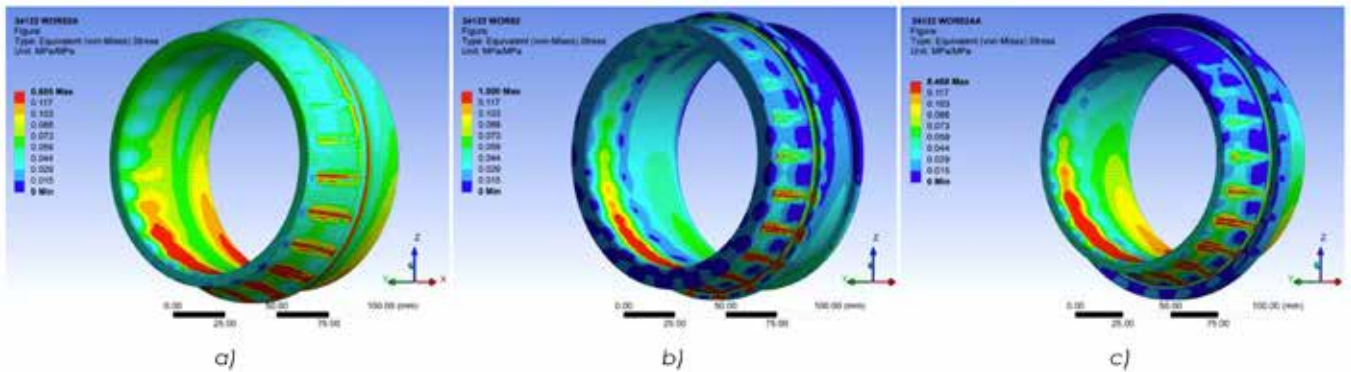
The general behavior of the bearings in terms of von Mises normalized equivalent stress distributions (Fig. 14) has been evaluated without taking into account the values in the shallow layers of contact areas. To correctly assess the contact pressures distribution it is necessary to assign a huge amount of finite elements to each contact zone leading to unacceptable computational time. To reduce the computational time,

the NON-HERTZ software has been used to solve the contact pressures between the rollers and inner ring raceway. Considering the reaction force distributions depicted in Fig. 13 a, b and the internal geometrical peculiarities, the bearing subjected to the highest stress is the 24122 WOR82 design, due to the fact that its Rx force magnitude contributes to increase the stresses inside the inner ring. By using these results as a reference, a normalization method has been applied for the three designs.

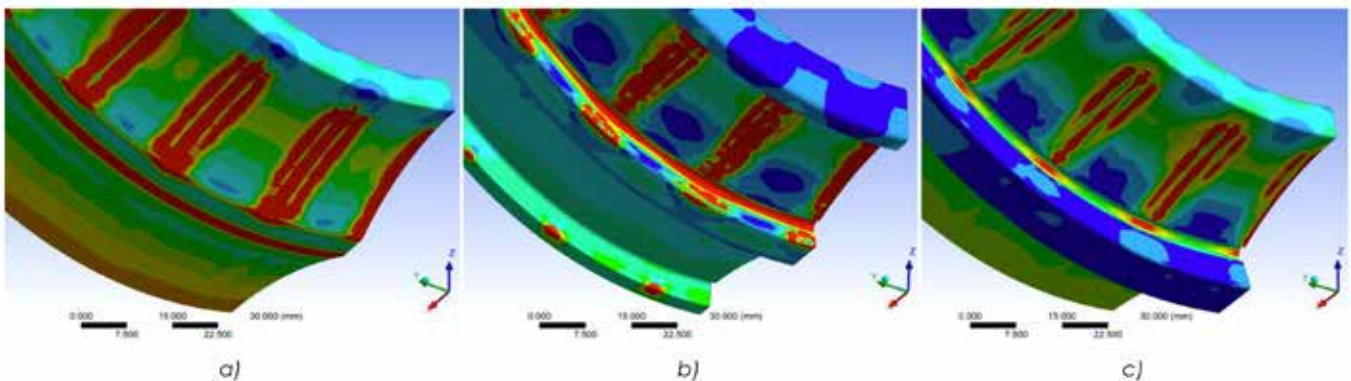
The same concept followed in case of bearing assemblies has been used also to evaluate von Mises normalized

equivalent stress distributions inside the inner rings (Fig. 15). Analyzing the von Mises stress graphics related to the inner ring, it can be observed that the central fixed rib is subjected to load. 24122 WOR82AA design presents a reduced stress magnitude than 24122 WOR82. These results are confirmed by the graphic from Fig. 13 b, where the reaction forces Rx of the 24122 WOR82AA are significantly lower than those of 24122 WOR82.

Regardless the magnitude of the load acting on the central fixed rib, a reduction of it is beneficial for the bearing life. A slight difference of reaction force Rx causes high differences in stresses inside the



– Fig. 15 – Von Mises normalized equivalent stress distribution of inner rings: a) 24122 WOR82A; b) 24122 WOR82; c) 24122 WOR82AA



– Fig. 16 – Von Mises equivalent stress distribution of inner ring for: a) 24122 WOR82A; b) 24122 WOR82; c) 24122 WOR82AA

central fixed rib because of the undercut, which acts as a stress concentrator that increases the stress in this zone. This concept can be observed in Fig. 16, where the detailed views of the inner rings are reported. 24122 WOR82 design presents highly stressed areas in the proximity of the undercut and central fixed rib. On the contrary, in the case of 24122 WOR82AA design this effect is significantly reduced due to the contact angle modification and central fixed rib reinforcement.

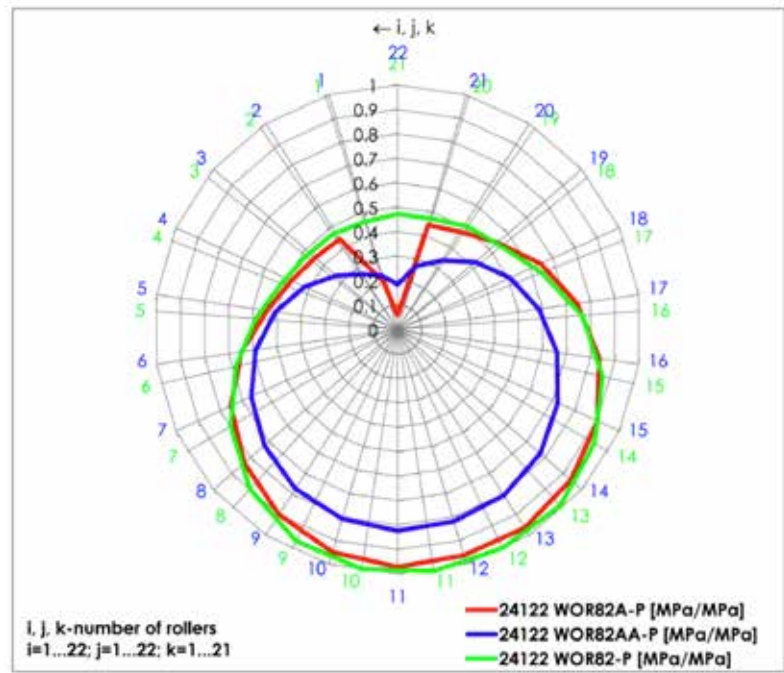
Moreover analyzing in detail the inner ring stress distributions from Fig. 17 a, the presence of edge stress concentrations on the proximity of the inner raceway edge of 24122 WOR82A design can be observed. A possible explanation of this effect is connected to the rotation of the rollers around an axis perpendicular to the main axis of the bearing, induced by the high misalignment of the mixing drum and the heavy axial load, that tend to modify the contact area between rollers and raceways. This effect is reduced in the other two designs (Fig. 17 b, c) by the central fixed rib, which guides the rollers during bearing operation. Still, high forces act on the central fixed rib of 24122 WOR82 design (Fig. 17 b), which induces, as mentioned before, undesirable stresses inside the rib. As for 24122 WOR82AA design, very low edge stresses on the inner ring raceway and a proper guidance of the rollers are ensured without causing undesired stresses inside the central fixed rib.

The normal reaction forces ( $R_z$ ) have been used as input data for the calculation of the contact pressures between the

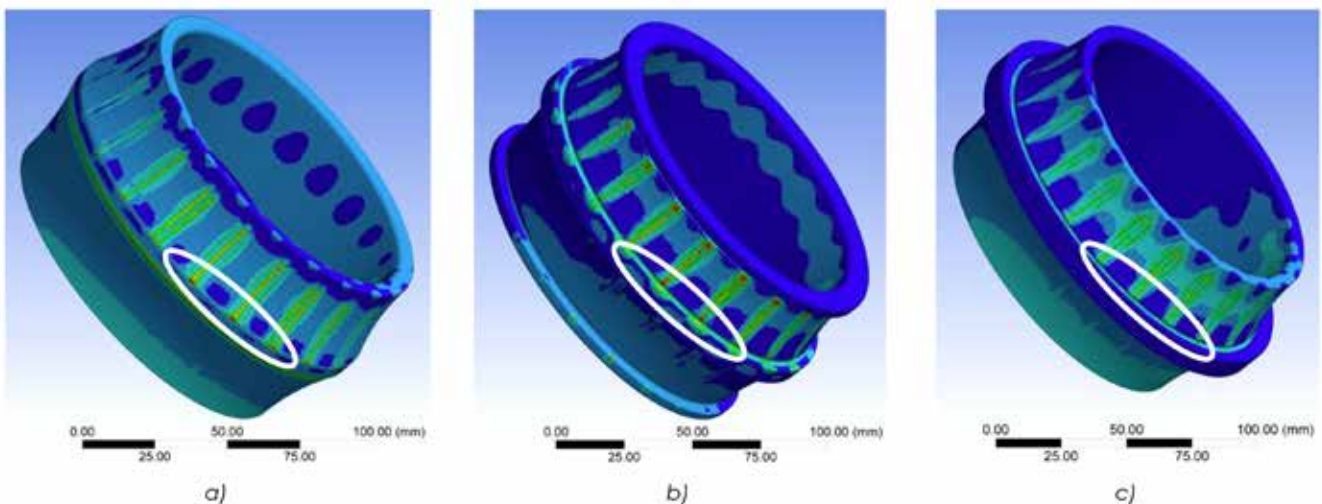
most loaded row of rollers and inner ring raceways by using a semi-analytical method through RKB NON-HERTZ software. This numerical technique involves the conjugate gradient method (CGM) coupled with discrete convolution fast Fourier transform (DC-FFT). The efficiency of the GCM and DC-FFT algorithms in both computation time and storage, without sacrificing the accuracy of the results, has been proved by a comparison with the analytical values obtained in a Hertzian contact problem.

The pressure distributions of the three bearing designs, obtained with NON-HERTZ software, are depicted in Fig. 18.

For this representation, all the contact pressure values have been normalized by using the maximum value of the most loaded roller of 24122 WOR82 with all designs. As can be seen, there is a slight difference between 24122 WOR82 and 24122 WOR82A designs in terms of contact pressures distribution, but a major difference in the upper part of the pressure distribution graphic of 24122 WOR82 design. This seems due to the different contact angle, number of rollers, both smaller in case of 24122 WOR82 design, and implicitly to the normal reaction forces ( $R_z$ ) depicted in Fig. 13 a. On the contrary, the 24122 WOR82AA design presents a lower contact pressure distribution of all rollers



– Fig. 18 – Contact pressure distributions of 24122 WOR82A, 24122 WOR82AA, and 24122 WOR82 designs



– Fig. 17 – Von Mises equivalent stress distribution of inner ring rib for: a) 24122 WOR82A; b) 24122 WOR82; c) 24122 WOR82AA



compared to the other two designs. These are the results of the improved internal geometry design in terms of contact angle and central fixed rib reinforcement.

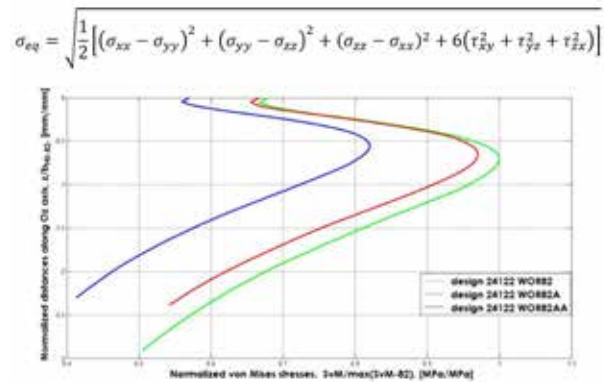
Furthermore, the maximum normalized values of contact areas (major and minor axis of the contact ellipse) and contact pressures are represented in 2D and 3D graphics (Fig. 19). Analyzing the graphics of the major and minor axis of ellipse contact area of 24122 WOR82 and 24122 WOR82AA designs, a significant difference in terms of values and shape can be noticed. This fact can be considered as an effect of the applied normal load magnitude, different radius curvature of inner ring raceway and geometry of rollers.

Having the pressure distribution values on the contact area of the most loaded row of rollers, the NON-HERTZ software has been further involved in obtaining the depth distributions, inside the shallow layer, of all six components of the stress tensor and finally the depth distribution of von Mises equivalent stresses of all three inner ring designs (Fig. 20 d). The components of the stress tensor, induced by the entire pressure

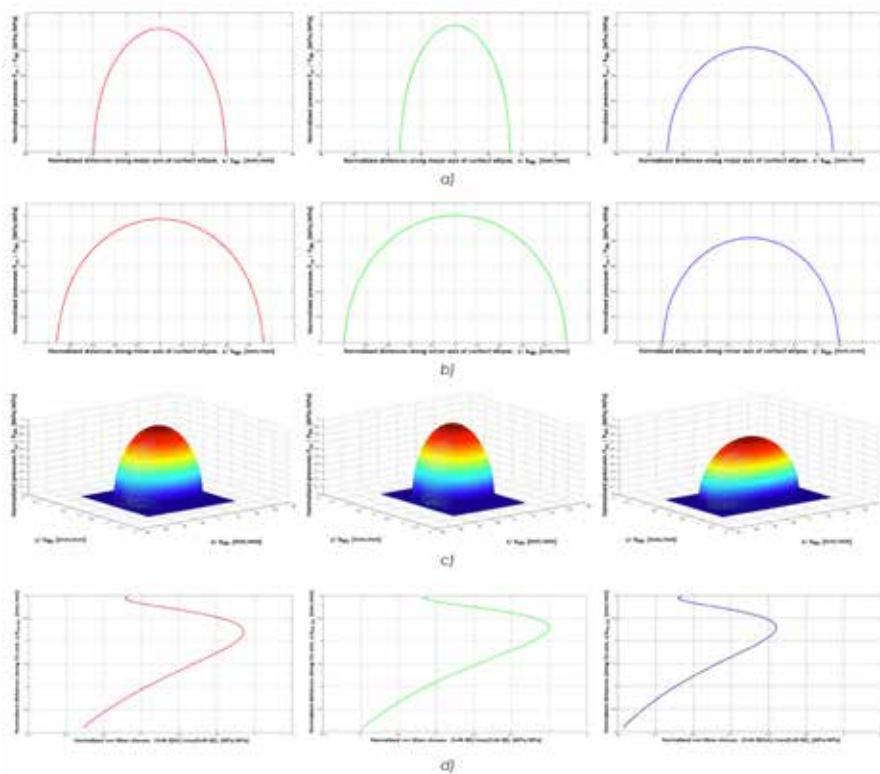
over the contact area, in a generic point  $M(x, y, z)$  are obtained by superposition and using the convolution products:

$$\sigma_{ij}(x, y, z) = \sum_{k=0}^{N_x-1} \sum_{l=0}^{N_y-1} (C_{ijkl} \cdot p_{kl})$$

where the influence function  $C_{ijkl}(x, y, z)$  describes the stress component  $\sigma_{ij}(x, y, z)$  due to a unit pressure acting in patch  $(k, l)$ . This is a Neumann type problem of the elastic half-space theory. Based on stress tensor components



– Fig. 20 – Von Mises equivalent stresses distribution in the inner ring shallow layers of 24122 WOR82A, 24122 WOR82, and 24122 WOR82AA designs



– Fig. 19 – 2D ellipse contact area: a) major axis; b) minor axis; c) 3D contact pressure distributions of the most loaded rollers; d) von Mises equivalent stresses distribution in the inner ring shallow layers of 24122 WOR82A, 24122 WOR82, and 24122 WOR82AA designs

the von Mises equivalent stress can be obtained using its definition:

Fig. 20 reveals significant differences in terms of von Mises equivalent stress magnitude through the whole inner ring thickness between 24122 WOR82AA and the other two designs. It is evident that the geometrical characteristics and contact pressures distribution of 24122 WOR82AA design result in a lower equivalent stress, thus leading to a better overall performance of the bearing.

## 7 CONCLUSIONS

Examining the concrete mixer gearbox technical requirements, the RKB Group has studied its most critical component, the main spherical roller bearing, in three different designs. After evaluating the results, the best solution for this project has been found by the RKB Technical Department in SRB 24122 WOR82AA design, which succeeds in accomplishing all of the application operating conditions. Among other things, this special bearing type has been optimized to sustain additional loads and friction at low operating speeds (max 20 rpm), increase permissible misalignment up to  $\pm 6^\circ$  and ensure a longer rating life.





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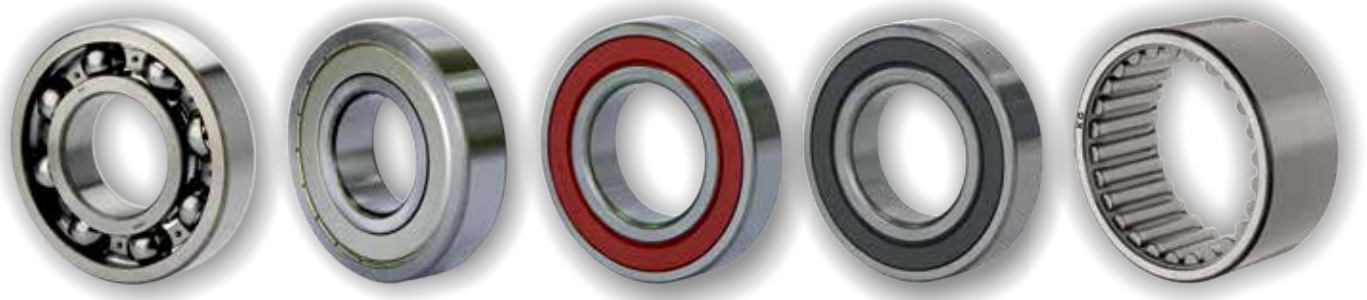
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# Koyo's new anti-creep ball bearings

Koyo Bearings, a division of JTEKT Corporation, is introducing a new range of ball bearings with creep-resistant features to reduce housing wear and extend component life. The design lends itself well to installation in next-generation vehicles, in particular in the transmissions of hybrid vehicles (HV/PHV) and electric vehicles (EV/FCV), as well as continuously variable transmissions (CVTs) in conventionally-powered cars.

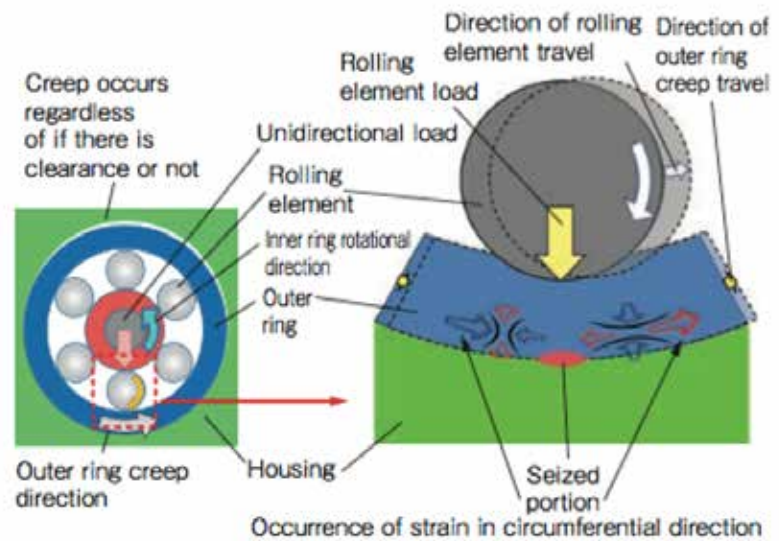
## What exactly is bearing creep?

Bearing creep is a phenomenon whereby the inner or outer ring rotates in relation to the housing or axis during operation. A pinch point forms and as the balls pass over it on each rotation it moves. It's undesirable because it causes accelerated wear, discolouration and scuffing. If that wasn't bad enough, if a bearing tilts on its centre line axis it can lead to problems like excessive noise, poor gear engagement or even catastrophic failure of a whole system.

There are two types of creep: strain and corotation. In the first type, a large unidirectional radial load causes circumferential strain on the outer ring, resulting in a small, slow moving area of strain. In the second type, which can occur when loads are light, rotational torque causes the outer ring to move due to insufficient friction between it and the housing. This is also potentially very destructive and the creep speed can be much higher.

## How is bearing creep prevented?

Various measures have been tried in the past, such as using a thicker outer ring or a more solid lubrication film, however there are size, weight and cost implications here. Simply altering the housing dimensions to tighten the fit causes more problems than it solves as this excessively preloads the bearing's internals causing heat, friction and wear. Also this approach often doesn't work where an aluminum housing is used due to the material's thermal properties. So in 2016 JTEKT decided to approach the

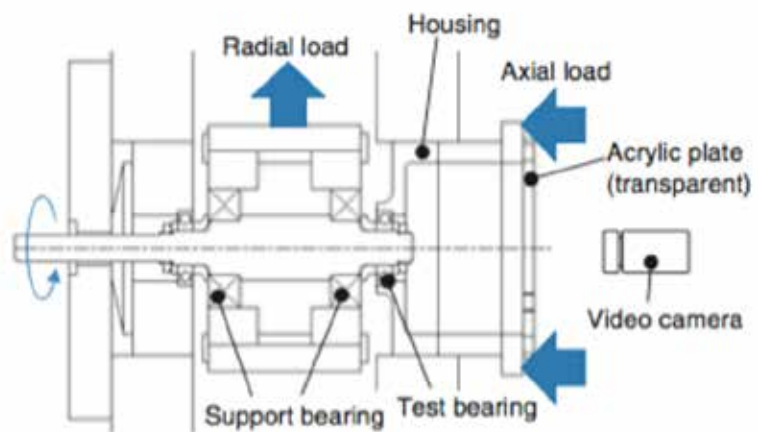


— Figure 1: Outer Ring creep explained

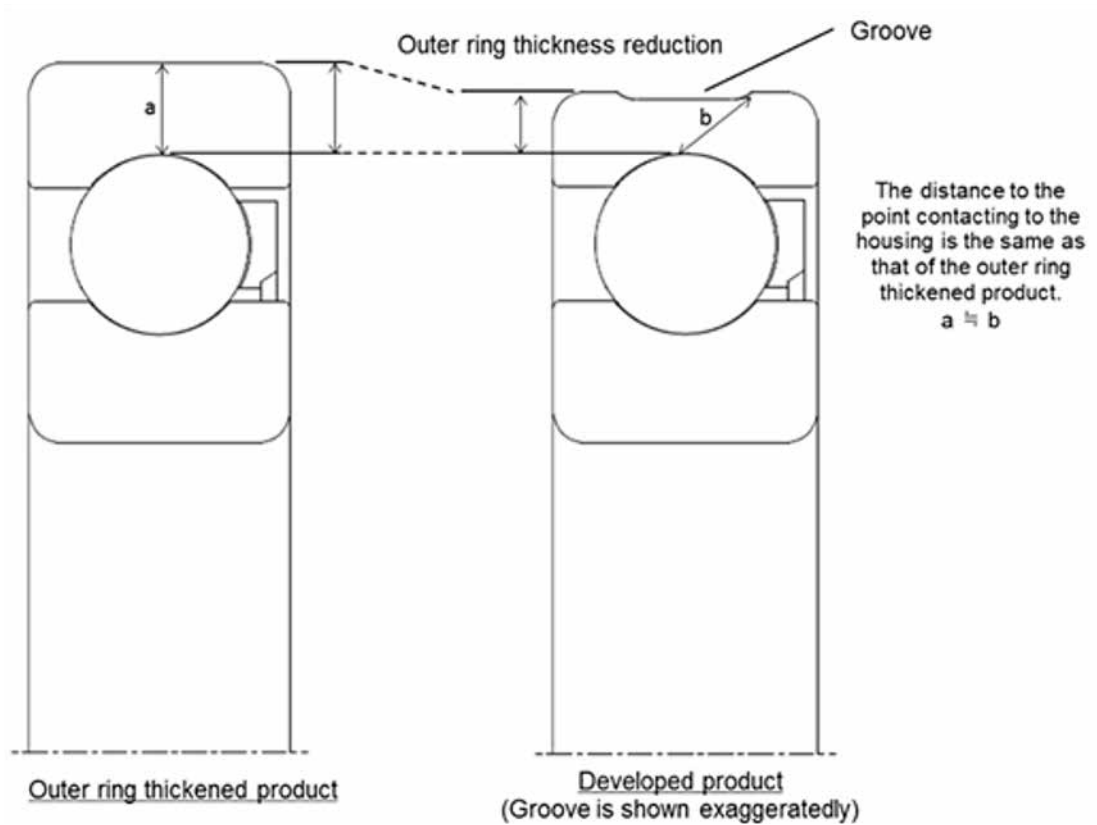
problem from a new angle, developing the New Structure Anti-Creep Ball Bearing.

The design features a circumferential groove in the centre of the outer ring's outside diameter to tackle the strain

creep. To be sure of the perfect contour, the company conducted extensive CAE analysis using a simulation model based on the actual test device which was used to check the results. Results were confirmed by a video analysis.



— Figure 2: Anti-creep test set-up



— Figure 3: Thick outer ring vs. equivalent thinner outer ring with groove (special coating on the developed outer ring not shown)

The research proved that the design offers an equivalent to an increase in bearing thickness by 35%, which could equate to a 50% reduction in housing wear.

In addition to this groove, JTEKT engineers recently developed a new special coating to be used around the entire outer ring which is able to suppress housing wear caused by co-rotation creep.

This clever combination means the bearing can perform like an equivalent with a thicker outer ring, but without the size and weight penalty. This is particularly important for industries like automotive, but also increasingly important in various other industries like machine tool manufacturing where creep-related wear can be problematic. JTEKT has also noticed increasingly strict requirements in other industries too, such as agricultural and construction equipment. By saving on material, the design also keeps costs down.

These enhanced features mean the



— Figure 4: The new Koyo ball bearing with the special anti-creep groove

bearings are more durable and longer lasting, giving the products they are installed into a longer life, exactly what OEMs look for when ordering components from suppliers.

For further general information on Koyo's products; please do not hesitate

to contact your local Koyo office or Koyo distributor. You can also visit our European website: [www.koyo.eu](http://www.koyo.eu). For more technical details about ball bearings with anti-creep features we refer to the JTEKT Engineering Journal from May 2017 and May 2019, which can be obtained via our global website: [www.jtekt.co.jp](http://www.jtekt.co.jp)



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Tochigi Works, Japan

## Senju Metal Europe GmbH

# The Influence of Rolling Bearing Profiling on Rigidity and Rating Life

## Software for gearbox development

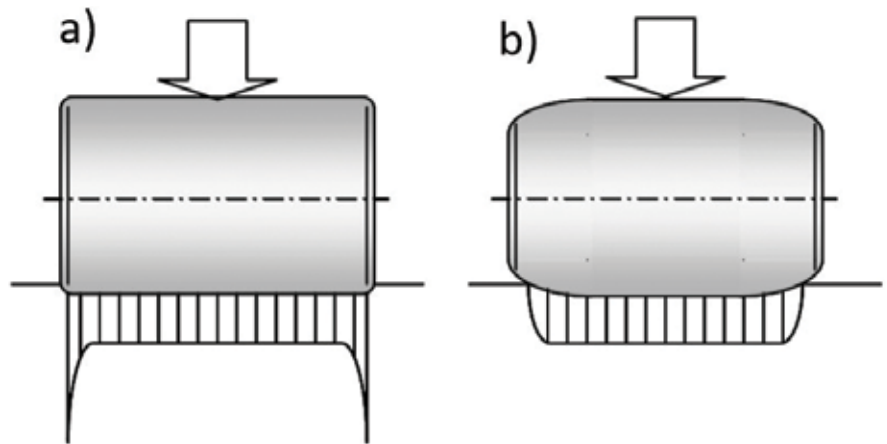
The FVA-Workbench is a manufacturer-neutral tool for the simulation and calculation of transmission systems. As product development cycles become shorter, powerful modeling approaches and calculation algorithms become increasingly important. The predominantly analytical approaches in the FVA-Workbench deliver fast and reliable solutions to all important issues related to drive technology. For bodies that cannot be accurately described analytically, the results are supplemented by suitable numerical methods. The intuitive modeling techniques in the FVA-Workbench guarantee simulation of consistent, valid, and manufacturable gears every time.

The calculations are developed, analyzed, and validated in research projects by Forschungsvereinigung Antriebstechnik e.V. (FVA, the Research Association for Drive Technology). Through member contributions and public funding, the FVA is able to organize 17 million euros annually in research projects at leading German universities, chairs, and research institutions. The FVA-Workbench serves as a knowledge platform, making the results of FVA research projects available and accessible to all engineers. It is no longer necessary to read through and study countless pages of scientific documentation, making the development of innovative gearboxes considerably more efficient and user friendly.

The following article will explain the detailed calculation of rolling bearings in the FVA-Workbench, based on consideration of the profiling of roller bearings.

### Profiling of Roller Bearings

In roller bearings, there is line contact between the rolling elements and the



— Figure 1: Pressure distribution a) without profiling and b) with profiling /1/

raceway. If the rolling elements are perfectly cylindrical (cylindrical roller bearings) or tapered (tapered roller bearings), this leads to local pressure peaks when the end side of the rolling elements comes into contact with the raceway (Figure 1a). This can result in local pitting damage in these areas (Figure 2). To avoid these pressure peaks, roller bearings are always designed with profiling along the longitudinal axis of the roller (Figure 1b). In addition to avoidance of high edge stresses, the profiling also has an influence on the following criteria:

- Maximum roller-raceway contact pressure, especially with tilting
- Modified reference rating life according to /2/
- Tilting and lowering rigidity

Cylindrical and tapered roller bearings typically have a logarithmic profile in accordance with /2/. However, the actual depth and shape of the profiling can deviate significantly and is determined by the manufacturer, based on available knowledge for each bearing type. In order to consider the influence of different profiles on the above criteria in the bearing design phase, the FVA-Workbench

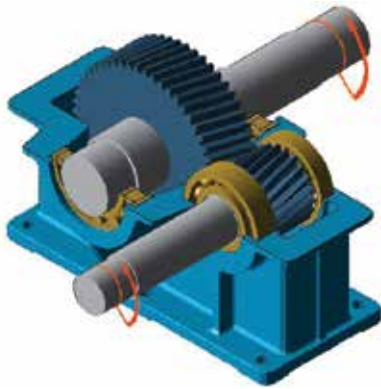
provides the option to adapt the profile for each individual roller bearing. In addition to pre-defined profile shapes, profile curves provided by the bearing manufacturer or based on measurements can also be defined. Therefore, it is recommended to consult the bearing manufacturer in critical cases when making the final bearing selection.



— Figure 2: Local pitting as a result of profiling created by wear

### Calculation Example

The influence of different profiles will be demonstrated, using the calculation of the NJ 230 type motor-side output shaft bearing from the gearbox shown in Figure 3 as an example.



– Figure 3: Example gearbox

Three different profile variations are calculated for the bearing:

- 32 µm logarithmic profile (corresponding to /2/)
- 14 µm logarithmic profile
- No profile

Diagram 1 provides an overview of the calculation results for the 3 variants. The values are all relative to the corresponding profile specified in /2/ (here: 32 µm).

Additionally, the pressure distribution along the longitudinal axis of the roller in the inner ring contact of the most heavily loaded roller element is compared for the three variants in Figure 4, below.

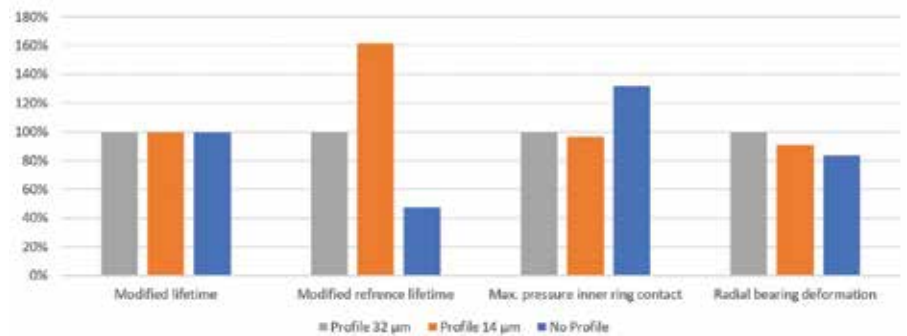
that slightly different bearing forces may be calculated in the system due to the change in the bearing stiffness.

- The distribution and the maximum value of the local contact pressures in the bearings are decisively influenced by the specification of different profiling. From the curves in Figure 4, it can be seen that the pressure in the middle of the roller increases with higher amounts of profiling. With lower amounts of profiling, the pressure distribution becomes more even. In this case, however, increased edge stresses may occur, especially at high tilt angles.
- Since the value of the modified reference rating life according to DIN 26281 is based on consideration of the local contact pressure, a strong influence

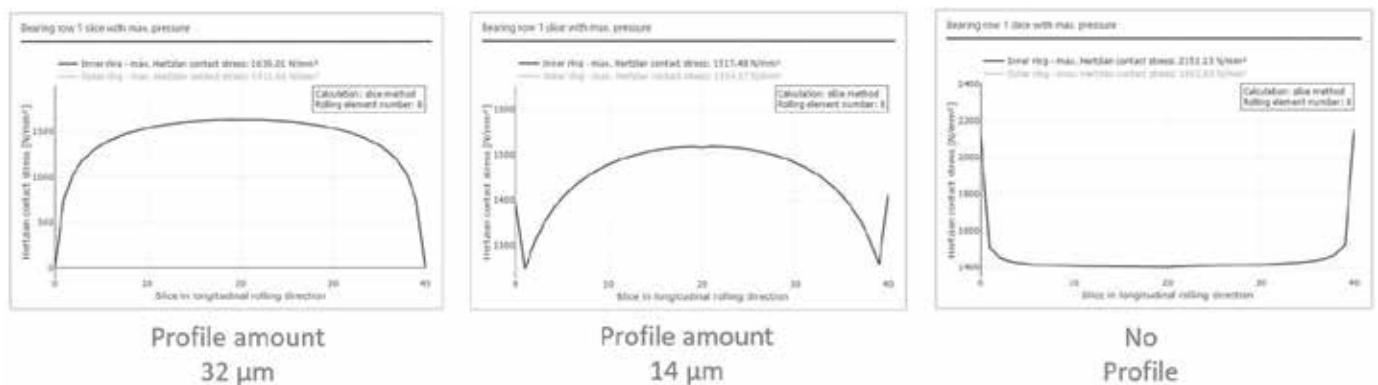
Drive Technology). Founded in 2010, FVA GmbH works hand-in-hand with top-level German research institutions and leading companies from the drive technology industry toward the practical application of knowledge gained from FVA research projects. Our core competencies are the development of calculation and simulation software for drive technology, processing and conversion of legacy code structures into modern software architectures, professional service and support, and hosting technical seminars and conferences.

**List of sources:**

1. A. Kessler: Schiefstellung und Axialschubverhalten von



–Diagram 1: Comparison of the calculation results for different amounts of profiling



– Figure 4: Comparison of the pressure distributions of the most heavily loaded rolling element

The following statements can be derived from the results:

- The profiling has no significant influence on the results of the modified rating life calculations (according to both ISO 281 and bearing manufacturer catalog calculations). Only minor differences may result from the fact

on the rating life values can also be seen here for each specified profile.

**About FVA GmbH:**

FVA GmbH is a joint venture of VDMA (Verband Deutscher Maschinen- und Anlagenbau, the Mechanical Engineering Industry Association) and FVA e.V. (Research Association for

Zylinderrollenlager, Dissertation, Universität Hannover (2010)

2. DIN 26281 – Rolling bearings - Methods for calculating the modified reference rating life for universally loaded bearings, Beuth Verlag (November 2010) [www.fva-service.de](http://www.fva-service.de) #FVAWorkbench #FVADriveTechnology



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The background features a vibrant red field with large, overlapping yellow shapes. A large yellow shape on the left is partially cut off by the top edge. A large yellow shape on the right is partially cut off by the right edge. A large yellow circle is positioned at the bottom center, also partially cut off by the bottom edge.

*What  
Happened*

in the  
Bearing Industry

Second Half of

**2019**

### Mahr Introduces New Precimar® SM 60 Length Measurement System



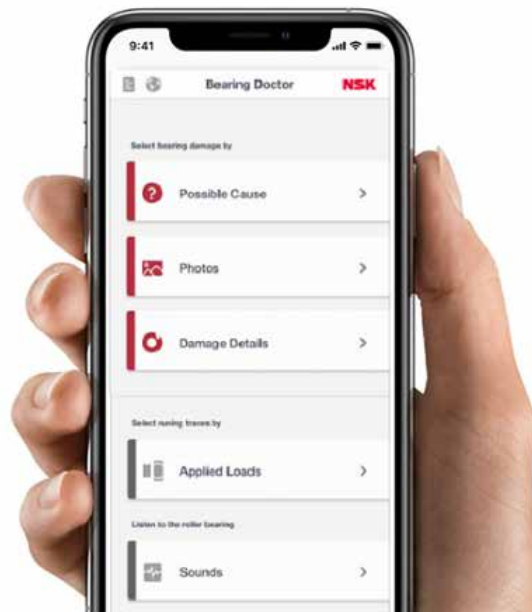
Mahr has introduced the new Precimar® SM 60, an easy-to-use length measurement instrument for fast and precise external measurements on shop floor parts, with a measuring range of 60 mm. The SM 60 is configurable with Mahr readouts, such as digital indicators or LVDT probes, to provide a system tailored to the performance level required for the measurement application. The SM 60 incorporates a 25 mm sensitive contact and a fixed reference jaw with a 35 mm adjustment to obtain the full 60 mm measurement capacity.

The robust construction of the SM 60 demonstrates its design for use in the production environment – right at the point of manufacture of precision parts. “This system fills the demand for high performance gaging at the point of manufacture,” says George Schuetz, Director of Precision Gages at Mahr. “It allows a machinist to easily set up and adapt for new workpieces, while allowing the system to act as either a long-range measuring system or as a very high-performance comparator for sub-micron applications.”

### A new version of NSK Bearing Doctor App is now available!

The app includes many images and sound clips to help users diagnose the different types of bearing damage and possible causes. It also provides useful information about correct hashtagbearing handling, mounting,

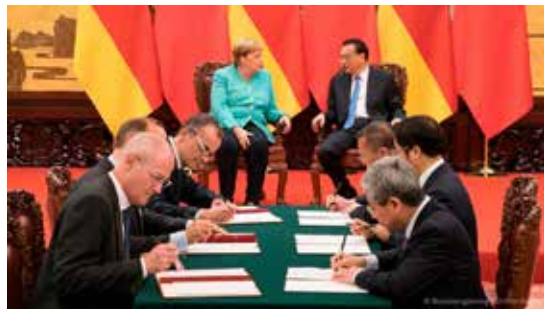
hashtaglubrication, and hashtagmaintenance, which are essential to prevent premature failure. Download it on the App Store or get it on Google Play





## Schaeffler champions autonomous driving in China

Schaeffler has signed an investment agreement with China's Hunan province in a move aimed at supporting and facilitating autonomous driving in China using Schaeffler technologies. Under the agreement, both parties will jointly develop a mobility ecosystem for intelligent vehicles in the provincial capital of Changsha. Schaeffler's role in the venture will revolve mainly around the further development of its Space Drive technology, a key enabler of autonomous driving, and the Schaeffler Mover, a mobility concept featuring Schaeffler Intelligent Corner Module technology. The formal signing ceremony for the agreement was held in Beijing and was attended by German Chancellor Angela Merkel and Chinese Premier Li Keqiang.



— Signing ceremony for an investment agreement aimed at supporting and facilitating autonomous driving in China: Matthias Zink (third from left), CEO Automotive OEM at Schaeffler AG and Hu Zhongxiong, Mayor of Changsha (second from right) during the signing ceremony in the presence of German Chancellor Dr. Angela Merkel and Chinese President Li Keqiang. Image: German Federal Government/Steffen Kugler

## Schaeffler presents electric motors ready for volume production

Schaeffler is entering the electric motor manufacturing sector with a modular, highly integrated technology platform. This family of electric motors is designed for efficiency and a good price/performance ratio, and potential applications range from hybrid modules and dedicated hybrid transmissions (DHTs) through to electric motors for electric axle drives. Voltage ranges from 48V to 800V and performance classes from 15kW to over 300kW are possible. Volume production for a range of customer projects worldwide is set to begin in 2021. Schaeffler's worldwide network of manufacturing plants and special machinery and tool manufacturing facilities will be used to set up and operate the production lines. Schaeffler will be



publicly presenting the electric motors – which were developed in-house and are ready for volume production – as complete systems for the first time at the IAA.

## Timken acquires BEKA Lubrication, expanding its global leadership in Automatic Lubrication Systems

The Timken Company has reached an agreement to acquire BEKA Lubrication (BEKA), a leading global supplier of automatic lubrication systems, for approximately \$165 million. The company serves a diverse range of industrial sectors including wind, food and beverage, rail, on- and off-highway and other process industries. BEKA sales are expected to be around \$135 million for the full year 2019. Family owned and operated since its founding in 1927, BEKA is headquartered in Pegnitz, Germany. The company employs approximately 900 people, with manufacturing, research and development based in Germany, and assembly facilities and sales offices around the world.

Timken first entered the automatic lubrication market in 2013 with the acquisition of Interlube and then significantly expanded its portfolio and global reach through the acquisition of Groeneveld in 2017. With the acquisition of BEKA, Timken



will become the world's second largest producer of industrial automatic lubrication systems 1, which displace manual lubrication methods to improve equipment life and reliability, while reducing the total cost of ownership. The transaction advances the company's strategy, which is focused on growing its leadership position in engineered bearings while diversifying Timken's portfolio into adjacent products and markets.

October

01

### Dr. Ulrich Nass becomes new CEO of NSK Europe Ltd.

The Board of Directors of NSK Ltd. announced the promotion of Dr Ulrich Nass as Chief Executive Officer of NSK Europe Ltd. His appointment is effective since 1 October 2019. Dr Nass was also appointed Vice President of NSK Ltd. on the same date. Since taking over as Chief Operating Officer in February 2019, he has initiated the transformation of NSK Europe for the future.

“On behalf of everyone on the Board of Directors,” said Masatada Fumoto, his predecessor, “I congratulate Dr Nass on his appointment and would like to wish him all the very best and every success in his new key position for the future development of NSK Europe and mastering the tasks that lie ahead.” Masatada Fumoto had joined NSK in 1984 and was appointed Chief Executive Officer of NSK Europe Ltd. in April 2018. He will continue his



— Dr. Ulrich Nass

assignment as Executive Vice President of NSK Ltd. and Head of Automotive Steering & Actuator Division HQ.

October

07

### SKF acquires industrial AI company

SKF has signed an agreement to acquire Presenso Ltd., a company that develops and deploys artificial intelligence (AI)-based predictive maintenance software. Presenso’s AI capability enables production plants to find and act on anomalies that were previously difficult to detect, automatically and without the need to employ data scientists. Presenso’s competence will be used to strengthen SKF’s Rotating Equipment Performance offer.

Victoria Van Camp, CTO and President, Innovation and Business Development, says: “SKF is all about reliable rotation, technology leadership and solving real world challenges. Today, we are welcoming a team of world-class AI developers, with a production-ready analytics solution into SKF. Together we



will change the way industry looks at reliability and make AI an integrated part of production.”

October

13

### Fersa Group expands its productive power in China

Fersa Group’s plant in the Chinese city of Jiaxing expands its manufacturing capacity after the acquisition of machines for the production of large bearings, perfect for industrial applications. With this asset, the plant adds its fifth fully automated production line with the highest quality controls and unit traceability. The new line will have a maximum manufacturing capacity of around 28,000 bearings per year and is specially designed for the manufacture of industrial tapered and cylindrical bearings (with an outer diameter of up to 600 mm), under the brand NKE.

The company is considering adding more machines to the plant, which will allow it to double the production



capacity, resulting in the manufacture of up to 60,000 bearings per year. This is one of the many projects Fersa have invested in this year to increase the manufacturing capacity. Fersa Bearings has been operating in China since 2009, but it was not until 2011 that the company opened its factory in the city of Jiaxing.

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- Unique Materials
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## Fersa Group launches new bearing brand for light vehicles: A&S Automotive Solutions

Fersa Group launches A&S Automotive Solutions, the new bearing brand for light vehicles. It is the newest bearing alternative best adapted to the market needs. It guarantees a high quality product for the automotive spare parts market and focuses on a wide range of part numbers, superior service, and high European quality standards guaranteed.

The first A&S catalog includes over 2400 part numbers for more than 3000 models of about 130 brands. An agile and close customer service is a fundamental part of the new brand identity in order to guarantee the best experience to the customers. A&S online catalog is now available on the website: [www.ASautosolutions.com](http://www.ASautosolutions.com)



A&S joins the rest of the Fersa Group brands to cover all sectors: A&S as the passenger car and light vehicle expert, Fersa specialized in commercial vehicles and NKE covering all industrial applications.

## BNL doubles Thailand manufacturing facility to meet demand in automotive and domestic appliance markets



BNL has completed the expansion of its plastic bearing operations in Thailand, moving operations to a state-of-the-art, larger facility, adjacent to the existing building. BNL Thailand supplies plastic bearings to several industries, including automotive, food processing, photocopiers, domestic appliances and ATM customers.

The new 50,000 sq. ft. facility in Rayong will double capacity to support increasing demand on existing products and new business wins in key markets.

BNL Thailand houses injection moulding, manual and automated assembly functions, mirroring

the established UK HQ operations, with the Knaresborough, North Yorkshire site also housing R&D, engineering, product design, quality, prototyping, tooling design and tool development capabilities. BNL China also offer additional machining services at their Shanghai site.

For the longer term, the new Thailand facility also has the option to not just double, but triple the previous factory footprint, to 75,000 sq. ft., increasing the current number of injection moulding machines on site by threefold, expanding assembly services and tripling the workforce.



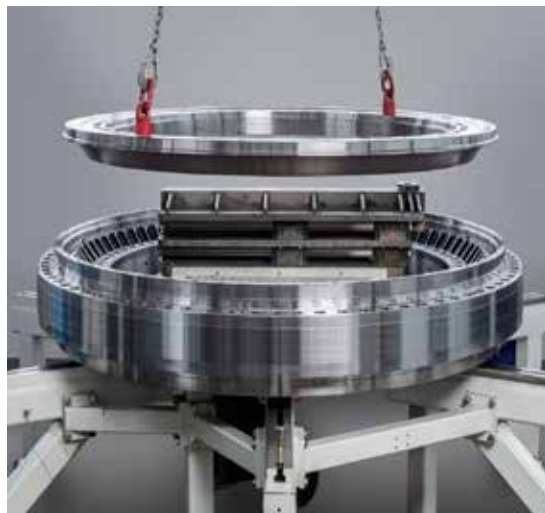
**Liebherr sings cooperation agreement with leading wind turbine OEM in China**

At the international wind energy fair China Windpower in Beijing (China), Liebherr Components signs a cooperation agreement with the leading wind turbine OEM, Mingyang Smart Energy.

Under this serial manufacturing contract, Liebherr will supply the customer with significant quantities of main bearings. This will further secure Mingyang Smart Energy's long-term business success in the Chinese market. "Both sides are aiming for even more intensive cooperation in the field of onshore and offshore wind power," explains Stephan Lausmann, Head of Sales Wind Energy at Liebherr Components.



— Signing of the contract between Liebherr Components and Mingyang Smart Energy



Liebherr main bearings can be used in wind turbines of 2 MW and more. The continuously rotating bearings are optimised in terms of longevity and can, therefore, withstand particularly high permanent loads. Liebherr's customers benefit from its application experience of nearly 30 years in the field of wind energy and can rely on the "Made in Germany" quality it offers.

**ABF expands its range of Siemens electric motors**

**ABF has recently expanded its range of Siemens electric motors. Their warehouse in The Netherlands now holds hundreds of electric motors from this leading manufacturer, all ready for shipment. Each and every one of these Siemens electric motors combine high efficiency with a very sturdy build quality that meets the strictest guidelines, in accordance with IEC standards.**

"The range we carry contains two-pole and four-pole versions in different frame sizes. The power range varies from 0.09 to 18,5 kW. Low-voltage motors are also in stock now", explains Ben van Oosterhout, Commercial Director at ABF.

When it comes to mounting, Siemens also offers a convenient level of flexibility. Models with a removable base can, for instance, be installed when only a flange is required. Is there limited space available to install the motor, but your machine still needs extra power? In such cases a motor with a progressive design



offers a suitable solution. The models with increased power are also available in various IEC frame sizes.



## NSK continues counterfeiting fight with new app



In co-operation with the WBA (World Bearing Association), NSK has developed a new app to help combat the ongoing issue of fake bearings. In recent years, the company has been working closely with the WBA, JBA (Japan Bearing Industry Association) and authorities around the world to enforce law and order on counterfeiters, and eliminate bogus bearings from the marketplace.

With a history that dates back over 100 years, NSK is today recognised around the world for producing high quality and reliable bearings that are deployed in a plethora of important industries, including automotive. As a result, NSK has become a target brand for counterfeiters. Discreditable operators who make their money from copycat bearings not only place their own businesses at risk – by unscrupulously sourcing and selling inferior quality bearings – but that of unwitting end users, who think they are getting genuine bearings at a bargain price. In addition, counterfeit bearings have the

potential to fail prematurely, perhaps catastrophically, therefore presenting an inherent safety risk.

In light of these issues, NSK engages in multifaceted efforts to combat fake bearings, recent results of which include the 'NSK Verify' app. NSK Verify permits customers to assess the authenticity of bearings by scanning a special 2D barcode found on the box.



— Examples of counterfeit NSK packaging recently seized by police

## ZKL Bearings (India) Inaugurates New Corporate Office

The new Corporate Office of ZKL Bearings India Pvt. Ltd. at the iconic, Diamond Heritage building on Strand Road in Kolkata was inaugurated by Mr. Jiri Prasil, CEO, ZKL group in the presence of Mr. George Prasil, Executive Director, ZKL Bearings CZ a.s. and Mr. Zdenek Jares, Area Sales Manager, ZKL Bearings CZ a.s. The occasion was attended by many other dignitaries and a large gathering of distinguished guests. ZKL a.s., Brno Czech Republic – the owners of the ZKL brand – are the largest rolling bearing manufacturers in Central Europe. Besides their Roller Bearing Plant in Brno and the Ball Bearing Plant in Klaserec nad Ohre, they also have an advanced Research and Development Establishment.

ZKL Bearings India Pvt. Ltd., Kolkata, the Master Distributor of the ZKL Bearings and Accessories in India, have been associated with the ZKL Brand since 2002. Entrusted with the task of making ZKL one of the preferred brands of the Indian Industries – ZKL Bearings (India) has set up a sprawling Central Warehouse in Kolkata, and a large network of Dealers across India. Besides the Head Office at Kolkata;



with an area of 20000 sq. ft., this is a semi-automatic facility and strategically located at Bombay road, giving quick access to national and local markets. ZKL Bearings (India) also has branch offices at Gurugram, Mumbai and Chennai, and a number of resident engineers located near most of the industrial hubs in India. Besides the unparalleled delivery services, ZKL Bearings (India) also renders a wide range of Pre-sales and Post-sales Technical Services.

## Axel Johnson extends its power transmission solutions in Slovenia

**Axel Johnson International's business group Power Transmission Solutions has acquired Bell d.o.o., effective 19 December 2019. Bell is a leading Slovenian provider of power transmission products and services since more than 30 years.**

"Entering the Slovenian market by the acquisition of Bell is well in line with our business group strategy for expanded geographical presence and further strengthened market offering in services and technical expertise. The Slovenian market offers many structural advantages for the power transmission industry, which caters for good long-term growth prospects", says Ola Sjölin, Managing Director, Power Transmission Solutions.

Founded in 1989, Bell is a well-positioned multi-brand distributor of bearings and other power transmission products in the Slovene market. Located in Miklavž na Dravskem polju, close to Maribor in north-eastern Slovenia, Bell is able to serve the whole of Slovenia but also its neighbouring countries such as Austria, Italy, Hungary and Croatia. During



the last 30 years, the company has built up long-standing strong relationships with both customers and suppliers in its markets thanks to its technically skilled and experienced workforce. The company represents premium product brands and has a smaller service and repair offering of industrial applications.

## ACORN partners with Petro-Canada Lubricants to enhance productivity in every industry

**Acorn Industrial Services Ltd is proud to announce its new partnership with Petro-Canada Lubricants to distribute their range of over 350 specialist lubrication products, including lubricants, greases and speciality fluids.**

Founded over 30 years ago, Petro-Canada Lubricants boasts one of the world's largest base oil refineries. This refinery produces high quality base oils with outstanding levels of purity, which is used to produce lubricants that improve productivity and reduce equipment downtime in every industry, from food and beverage to mining and quarrying.

ACORN has invested in a large stockholding of Petro-Canada Lubricant's lubrication products to ensure that customers have same day access to a vast range of premium quality lubricants to suit their individual application requirements.







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# ANNUAL BUSINESS CONVENTION 2020

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## Regal Power Transmission Products Migrate to New Website

Regal Beloit Corporation, a leading manufacturer of electric motors, electrical motion controls, power generation and power transmission components, has merged three websites into one. Customers who used to visit [regalpts.com](http://regalpts.com), [grovegear.com](http://grovegear.com) or [hubcityinc.com](http://hubcityinc.com) for bearings, gearing, couplings, conveying and mechanical power transmission products will now find product content, enhanced product CAD information, industry solutions and availability in one place on [www.regalbeloit.com](http://www.regalbeloit.com). This move brings additional tools and ease of use to customers in one mobile-friendly site.

This consolidation of product offerings brings robust functionalities to distributors, original equipment manufacturers (OEMs) and end users, who can now save time while browsing a new and improved product catalog interface. Features include category and product drill-down, high-quality 360-degree images of thousands of products, faceted search, and enhanced 2D and 3D computer-aided design (CAD) tools — all in one environment.

“With these enhanced web tools, we strive to provide both our customers and distributors with better insights for decision making,” said Matthew Clemens, Power Transmission Solutions DCX marketing specialist at Regal. “With this change, all Regal® products — including motors offered by Regal’s Commercial and Industrial Systems business segment, motors and blowers offered by Regal’s Climate Solutions business



segment, and power transmission products offered by Regal’s Power Transmission Solutions business segment — are located in one place. Buyers can quickly browse multiple Regal brands and efficiently compare similar products due to the additional product specifications available. The product images on the site are of such high quality that you can even read the labels.” Existing customers will continue to use eLink for e-commerce and EDGE tools like product selection and Smart Interchange for the next few months as Regal rolls out a new streamlined and enhanced e-commerce platform sometime in late 2020.

## AESSEAL announces 16 million USD investment in manufacturing division

AESSEAL®, the global manufacturer of mechanical seals and support systems, has increased capacity in its US operations with investments totalling almost \$16 million.

Over the past year the AESSEAL group, which is held by Rotherham based AES Engineering Ltd, has ploughed around \$11 million into its US manufacturing facility in Rockford, Tennessee. The plant now has six state-of-the-art nine-axes machine tools.

The company will invest a further \$5 million in its fully owned subsidiary, MS&S, in Odessa, Texas which primarily focuses on the oil & gas industry. Having outgrown its current location, the bulk of the investment will finance the construction of a new \$3.7 million building, which will bring MS&S up to the AESSEAL® standard and further raise its profile in the oil & gas industry.



The increased productivity will mean that 85 per cent of mechanical seals and support systems offered for sale by AESSEAL Inc will be made in the USA.



**PFI Group, Inc. recently opened its 10th RDC (Regional Distribution Center) in Melbourne, Australia, taking another relevant step in its international expansion strategy. The American group (with HQ in Miami, USA and production in China) is already notoriously present in Latin America, with RDCs in Argentina, Bolivia, Brazil, Chile, Colombia, Mexico and Sales Office in Panama, but also in Europe with its RDC in Rotterdam, the logistics hub for all European sales. Current global footprint also includes an RDC in Turkey and the Master Distribution Center in Shanghai.**

As stated by Rami Chirila, Global Sales Director, “PFI’s choice of opening this new RDC in Melbourne was a well thought out decision that came as a natural step in our company’s strategic growth plan. PFI is not new to the Australian market, the brand has been successfully present for many years in Australia and we hope our Australian customers will value our efforts of physically taking the product closer, eliminating the hassle of importing procedures and establishing a single commercial point of access for our full bearing range.”

PFI has been on the global bearing market for more than 26 years, producing and delivering high performance, reliable products, based on

American expertise and according to the most stringent international manufacturing standards.

Well-reputed for its original rotating electric bearings, the current portfolio has been significantly extended to more than 2.200 SKUs, suitable for numerous automotive (light and medium duty, motorcycles, ATVs etc), agricultural and industrial applications. “Our vocation for service and the determination of making this vocation tangible, by implementing a highly efficient network of RDCs, has been instrumental for our success“, says John Cali, CEO and founder of the company.





# 2020 CHINA INTERNATIONAL BEARING INDUSTRY EXHIBITION

## BEARING 2020 BEARING 2020

**MAY 13-16 2020**

National Exhibition and Convention Center (Shanghai)



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## CHINA INTERNATIONAL BEARING INDUSTRY EXHIBITION 2020

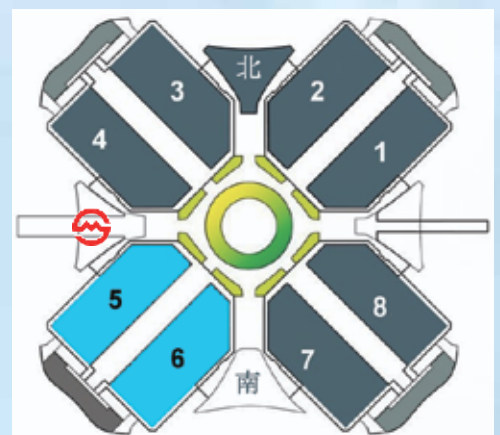
Covering an area of 53000 sqm with estimated 1000 exhibitors and 60000 visitors from all around the world will gather together during China International Bearing Fair between 13 - 16 May 2020.

Apart from previous year's the exhibition will be held this time in the new venue of National Exhibition and Convention Center in Shanghai. The exhibits include all types of bearings, and will cover special bearing industry equipment, precision measuring devices, transmission components, lubricant grease, solutions and accessories.

More opportunities for entering the Chinese bearing market, supplier development, and finding new business partners can be realized for International delegates during the B2B program sessions and at BearingEXPO International pavilion.

**There will be simultaneously 5 different exhibitions in parallel halls at the same date and venue:**

- ✓ The 20th China international Metallurgical Industry Expo
- ✓ The 18th China International Foundry Expo (METAL CHINA)
- ✓ The 18th China International Industrial Furnace Exhibition
- ✓ The 16th China International Refractory Material and Industrial Ceramic Exhibition
- ✓ The 14th China International Die Casting Industry Exhibition





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# Steel purity creates bearing design opportunities

The importance of clean bearing steel is increasing together with the demand for high precision, excellent quality bearings for more and more demanding applications on the market. OVAKO's BQ steel is considered as one of the most clean and suitable within the bearing industry.

BQ-Steel® (Bearing Quality) has for decades been the problem-solver in the bearing industry. It is optimized for fatigue strength by a strict control of steel cleanness. The same approach to fatigue performance is now being applied in many other applications.

The extended performance, higher loads, and high cleanness are a result of the Ovako clean steel program. Purity of production means that the material has significantly smaller inclusions compared to conventional steel and, as a result, the fatigue strength of the steel is increased dramatically.

Component downsizing and increased loading are issues facing manufacturers today as space restrictions and lower operating weight are driven by energy conservation. High strength and high fatigue resistance facilitate the manufacture of components to meet the requirements of today and tomorrow. This is true for industries where high cyclical loading is an issue.

We tried to understand the importance of BQ-Steel specifications for producing high quality bearings during an interview with Mr. Mikael Östman - Key Account Manager Bearing at Ovako Sweden AB.

## 1) What is your role at Ovako?

Leader of the Bearing segment and Strategic Account Manager for one of the major Bearing OEMs.

## 2) Can you shortly brief us about Ovako's evolution and experience in producing bearing steel?

Ovako has produced bearing steels for more than 100 years. The Hofors mill was bought by SKF in 1916 and then became SKF Steel. The steel development was coordinated together with the SKF Bearing plants for the coming century which put Ovako into the very high quality position we have today.

## 3) Why did Ovako start the BQ-Steel program?

BQ is not a program, it is a well-defined quality level which is applied for all kinds of steels. The BQ (Bearing Quality) means a high quality level which is suitable for bearings and other highly demanding applications.

## 4) Which were the biggest challenges you had to deal with during the development of BQ-Steel?

The BQ level has evolved during many years of development, investments and production experience. The major challenge is to maintain a high repeatability and uniform results



*Mikael Östman  
Key Account Manager Bearing at Ovako Sweden AB.*



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TO THE BEARING TRADE,  
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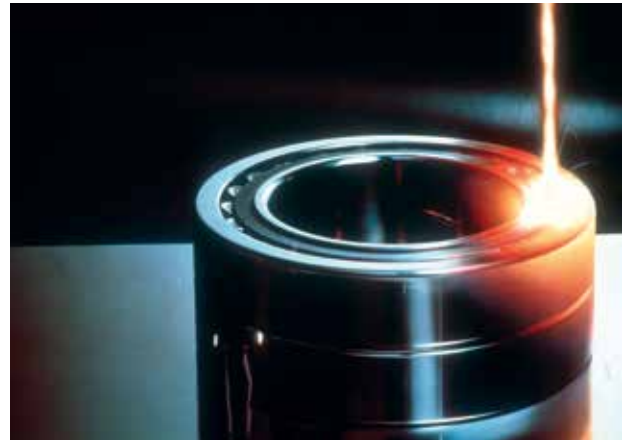
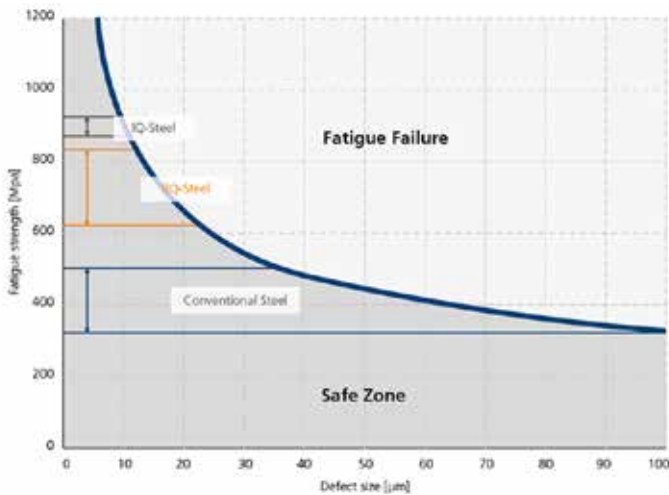
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continuously. Another challenge is to find suitable test methods as the BQ steels are very clean and therefore require more advanced test methods.



**5) What is the difference of BQ-Steel in comparison with other bearing steels?**

All bearing steels produced within Ovako qualify for the BQ quality level. Compared to other bearing steels on the market Ovako BQ is a premium steel with well-defined properties and a very high quality consistency.

**6) How different is the production process of BQ-Steel?**

It is the normal production process in the Hofors steel mill.

**7) Can you tell us more about the quality level?**

It is a well-defined quality level which

**Advantages of BQ-Steel®**

- 30–90 percent higher bending fatigue strength in simple load cases, depending on steel used today
- Up to 70 percent higher bending fatigue strength in multiaxial load cases, depending on steel used today

meets all major Bearing customers' premium steel specifications. It is continuously tested by advanced testing equipment such as Ultra-Sonic to guarantee a high repeatability from one production lot (heat) to another.



**8) Is BQ-Steel also useful for other industries outside the bearing domain?**

Yes, it is used for all kind of highly loaded products, especially in applications with high fatigue demands as gears and mining tools.

**9) Which other bearing steels do you produce?**

All bearing grades are classified

as BQ or even IQ which is an even higher quality level.

**10) Are there any services that you offer for customers?**

Ovako has a large package of different services that are offered to our customers. These include different stocking solutions, IT-solutions as Electronic Data Interchange (EDI) that supports formal communication with customers, material processing services as soft turning, as well as problem solving and development with customers and many more services.

**11) How do you see the future of bearing production?**

Bearings will always be needed and steel will remain as an important component even though other materials as ceramics developing. The quality level of the materials needs to improve further as bearings probably need to downsize to follow industry trends, for example the trend within Automotive power trains. The development of electrical cars is imposing much higher revolutions into bearings, therefore this will lead to demand for higher material quality.



MEET THE NEW

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## Intelligent search, quick entry and overview of shipping options:

Known as specialists in the fields of bearings and linear motion technology, and long-term trailblazers in the industry's e-commerce market, Friedrich PICARD GmbH & Co. KG has a new onlineshop!

The business from Bochum offers more than just its extensive product range. With its brand-new onlineshop PICARD provides a broad range of new features that simplify the shopping process, offer complete transparency when it comes to available goods and their pricing, as well as adding an increased focus on service mentality: all designed for the user's benefit.

As the first in the industry, the PICARD onlineshop enables users to fill three shopping carts at the same time – so that long-term and repeat orders can be purchased and managed completely separately from items the customer might require on a short-term basis. The system has also been optimised in terms of its transparency: different shipping options and their pricing are immediately visible. This way, customers are guaranteed a completely transparent and uncomplicated insight into the

complete costs their order will amount to, and make their calculations more simply and dynamically as a result. Once an order is placed, its delivery is displayed in real time. Orders received from Monday to Friday until 7 pm are dispatched on the same day. And that isn't all: the quick linear configurator lets customers see the price and availability of their order right away after entering quantity, length of the rails and distance to the first and last bores. PICARD offers this solution for customers to incorporate it in their own onlineshop or inventory system as well, further simplifying the order process.



This special offer gives made-to-measure customer support and service a whole new meaning. The new e-commerce platform unites many practical features, and is available at <https://shop.picard.de>.





# CERAMIC BEARINGS: WHAT ARE THE ADVANTAGES FOR CYCLISTS?

Since the first bicycle bearing was patented in 1869 by the French mechanic Jules Suriray, the bicycle market has changed substantially. So much so, in some countries like the UK, this sector is worth three times more than the steel industry.

In recent years, in addition to the traditional steel bike bearings, ceramic bike bearings have become popular to the biking world. The advantages of using ceramic bearings in sectors such as aerospace, performance cars and motorbikes are well known, but what are the advantages for cyclists?

In comparison with steel bearings, ceramic bearings offer the following features:

- 1. Higher limiting speeds:** Ceramic is lighter than steel and can effectively restrain the centrifugal force, therefore enhances the limiting speeds.
- 2. Higher precision usage:** Ceramic has a higher hardness and elastic modulus than steel, which means ceramic bearings are more rigid than steel bearings, so therefore can be used in higher precision conditions.
- 3. Longer life:** Lighter ceramic

leads to a lower centrifugal force, this will extend the life of the bearing. Furthermore, friction coefficient of ceramic is lower than steel, which also extends the life of the bearing.

**4. Higher temperature usage:** Ceramic is more mechanically stable at elevated temperatures, therefore they could be used under higher temperatures.

**5. Temperature-variation usage:** Ceramic has a lower thermal expansion coefficient, the clearance and the tolerance variation is lower than those of steel bearings, which leads to a greater variation in temperature range.

**6. Better seizure resistance:** Ceramic has a smaller thermal expansion coefficient; indicating less thermal deformation, therefore enhancing seizure resistance.

**7. Could run without oil or grease:** Ceramic never rusts and is self-lubricated, therefore can be used in applications that require no oil or grease.

**8. Resistant to acid, alkali and salt:** The chemical industry is the largest potential application industry of ceramic bearings to be exploited.

**9. More suitable for magnetic applications:** ZEN ceramic bearings are non-magnetic, which means it is difficult for magnetic particles to adhere on the

Item	Unit	Steel	Si3N4	ZrO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>
Destiny	g/cm <sup>3</sup>	7.85	3.20~3.30	6.05	3.95
Thermal Expansion Coefficient	10 <sup>-6</sup> /k	10	3.2	10.5	9.1
Elastic Modulus	Gpa	208	300~320	210	380
Passion Ratio		0.3	0.26	0.3	0.27
Hardness	(HV)	700	1500~1800	1200	1800
	(HRC)	62	75~80	70	80
Bending Strength (800°C)	Mpa	2400	200	300	220
Crushing Strength (800°C)	Mpa	/	1400	2100	1500
Fracture Toughness	MPa·m <sup>1/2</sup>	25	6.0~7.0	10	3.5
Thermal Conductivity (500°C)	W/mk	30~40	18	2	25
Specific Resistivity (600°C)	Ω·mm <sup>2</sup> /m	0.1~1	1018	1015	108
Max Usage Temperature	°C	300	800	550	1850
Corrosion Resistance		Worse	Better	Better	Better
Fatigue Stress Recycles (50%Fail)	Times	107	107~109	105	/
Dimension Stability with Temperature		Large	Little	/	/
Centrifugal Force		Large	Little	Large	Mediu
Non-lubrication Friction		Large	Little	Little	Little
Magnetism		Exist	Naught	Naught	Naught

race, therefore reducing particle-abrasion.

This specific features of the ceramic bearings, coupled with the reliability of ZEN Bike Bearings, benefit the cyclists in the following ways:

- 1. Less friction:** Ceramic balls have a smoother surface which makes the roll more freely and with a lower friction.





**2. Less energy required:** As friction is reduced, less energy is required to turn the cranks or spin the wheels.

**3. Durability:** Ceramic bearings are harder than steel bearings and have an excellent sealing system. In addition, they are resistant to corrosion and oxidation, a clear advantage especially in the wheel and bottom bracket bearings where the appearance of these issues are a big problem.

**4. Better riding experience:** Installation of ceramic bearings decreases the feeling of vibration and provides the rider with a smoother riding experience.

#### RIO PARALYMPIC SPONSORSHIP

ZEN Ceramic Bearings, the perfect design solution for the Paralympic bronze medallist Amador Granados.



Amador Granados approached the Zen Group to help him find the perfect wheel bearing with minimal friction. The experienced ZEN engineers team, developed a set of modified full ceramic bearings (6001-CE-Si<sub>3</sub>N<sub>4</sub>-PTFE-ZEN, and 6901-CE-Si<sub>3</sub>N<sub>4</sub>-PTFE-ZEN) that helped Amador go on and win a bronze medal in the Mixed Team Sprint Class C1-5. Amador Granados secured another bronze in the team sprint UCI Para-cycling Track World Championships in 2018.

#### ABOUT THE ZEN GROUP

The ZEN group is a worldwide company with over 50 years of experience in the manufacturing of tailor-made and standard bearings for a wide spectrum of industries.

All its products are manufactured according to DIN standards and all are tested in their ZEN Inspection Centre, awarded with the ISO 9001:2008 Certification.

ZEN's logistics network with 6 warehouses around the world, more than 22 official distributors and 26 official sell points, are sure to provide you with ZEN bearings wherever you are.

Also, its team of Research and Development engineers are able to support you through the entire process, from initial design through to production and delivery of the finished product.



#### New ZEN Bike Bearings Catalogue

Aware of the great business opportunity that constitutes biking world, the ZEN Group put at your disposal over 250 bike bearings references brought together in the New ZEN Bike Bearings Catalogue.

If you would like a printed copy of this catalogue, please contact [sales.uk@zen.biz](mailto:sales.uk@zen.biz) or visit [www.zen.biz](http://www.zen.biz) to obtain a digital copy.



# Automatic lubrication **How it works!**



The availability and optimal utilization of production facilities are among the most important factors for the profitability of companies. These days loss of production and the resulting loss of yield due to idle plants are no longer tolerated. In order to reduce unwanted failures and to make planned maintenance intervals as long as possible, preventive measures must be taken.



36% of all rolling bearing failures are due to insufficient lubrication. A regular and constant supply of the correct lubricant can prevent bearing damage and is therefore essential. The simalube automatic lubricant dispenser from the Swiss manufacturer simatec offers the ideal solution. The customer selects the sizes, lubricants and running times of the dispensers and thus receives a tailor-made solution for each lubrication point. Each lubrication point is supplied independently, reliably and continuously with the daily amount of lubricant selected by the customer - and for up to one year. The lubricant dispenser is TÜV-tested and Ex approved and is therefore suitable for use in all potentially explosive areas (gas, dust and underground mining).

Using simalubes also increases occupational safety by reducing the need for employees to enter dangerous areas. With the help of simalube accessories, the automatic lubricant dispensers can be installed outside the danger zones. The permanent lubrication of up to one year also reduces the number of inspections. Sustainability is also a top priority at simatec. The automatic lubricant dispenser can be refilled up to



three times. The dispensers are supplied by the manufacturer with high quality standard lubricants, but they are also available empty for your own filling. This makes it possible to respond to customer needs in a much more specific way, since the customer can use his own lubricants. The simalube lubricant dispenser contains no toxic substances, is 100% recyclable and therefore unique in terms of environmental compatibility. At the end of its life, it can be disposed of easily and ecologically. The wide range of accessories enables installations of all kinds.

The family of simalube lubricant dispensers comprises five different sizes. The dispensers work independently and reliably in any installed position. They can be set to a delivery period of 1 - 12 months. The standard range includes dispensers with modern high-performance lubricants. More information is available at [www.simatec.com](http://www.simatec.com).





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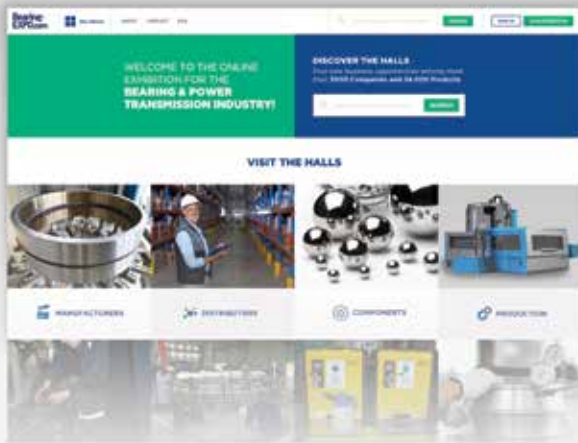
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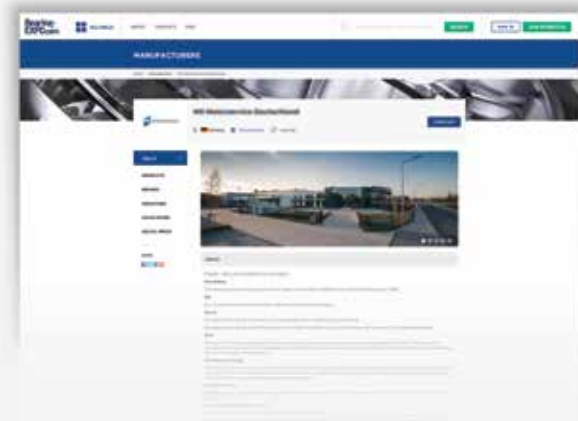


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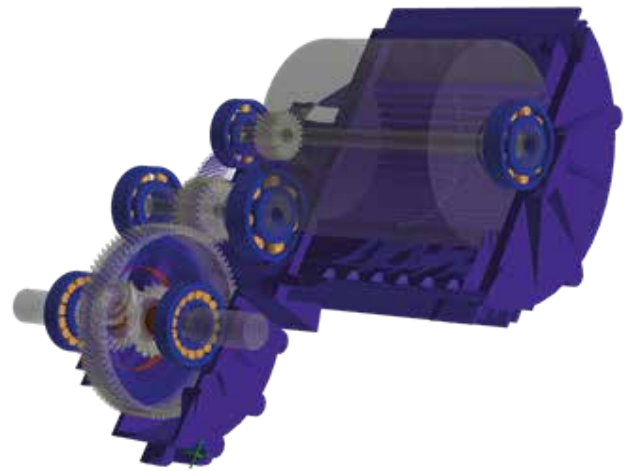
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## Romax Technology launch Romax Spin

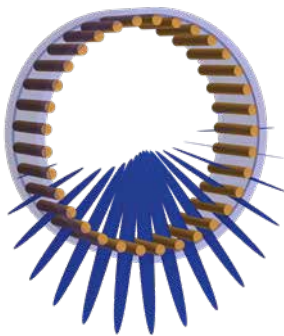
# The optimum bearing design and analysis tool for bearing specialists

Romax Technology was founded by bearing expert Dr. Peter Poon, MBE, over thirty years ago. To this day, they continue to provide bearing specialists with the independent tools they require to perform cutting-edge rolling element bearing analysis. With a proven track record within the bearing industry, Romax Technology are the obvious choice for bearing suppliers and experts, with the world's top six bearing manufacturers using its software and service solutions.



— Bearing analysis as part of a whole system simulation in Romax Spin

Romax have recently launched Romax Spin, a software tool specifically aimed at bearing specialists, which offers accurate simulation of rolling element bearings as part of a full electro-mechanical system. It provides access to more than 60,000 bearings from major supplier catalogs, and its advanced analysis capabilities include prediction of element and raceway stresses, rib contact, edge stress and contact truncation. Utilising Romax's 'full system' approach, Romax Spin ensures holistic understanding of all system interactions, from gear contact to shaft stiffness and housing deflection, and thus gives unrivalled



— Advanced analysis to predict needle roller bearing contact stress in Romax Spin

insight into bearing performance. Its optimised contact algorithms offer an ideal balance of speed and accuracy, and Romax Spin thus empowers bearing specialists with the insight required to design and select bearings for optimum performance and durability.

Romax Spin is one of the six products recently launched on the new product platform, Romax Nexus: an integrated ecosystem of focused products which align with the driveline development cycle from concept exploration to virtual product sign-off. Romax Spin is fully interoperable with the rest of the products on the platform, enabling greater collaboration within organisations and with suppliers.

Alongside developing software, Romax are active in research. The projects they engage with, combined with their in-house expertise, drive the creation of innovative new software capabilities and products. For example, Romax have recently conducted research in the experimental measurements of heat generation and thermal losses in bearings operating at high speeds, common in

electric vehicle applications. These conditions can lead to a phenomenon known as bearing skidding, which can result in generation of excessive frictional heat, high surface shear stress, and subsequently cause efficiency issues or premature bearing failures. As a result of this research, Romax have developed new, innovative bearing simulation methods that predict dynamic bearing behaviour and help avoid these non-conventional failure modes. This capability has been packaged into the first commercially available tool of its kind: Romax Bearing Dynamics.

Cloud-accessed Romax Bearing Dynamics enables time-domain, multibody dynamic roller bearing simulation, which predicts the occurrence of skidding in electric vehicles in a matter of minutes. This novel approach considers structural, thermal and fluid domains, providing understanding of the mechanisms of skidding and helping users to pinpoint potential design improvements. The new product brings an innovative capability to designers and engineers striving to meet the industry's ever-growing challenges.

# Sealmaster® PN Gold™ Mounted Bearings Receive IP69K Certification

Bearings join two other Regal® products to provide complete certified washdown solution for a variety of applications.

Regal Beloit Corporation, a leading manufacturer of electric motors, electrical motion controls, power generation and power transmission components, announced that its Sealmaster PN Gold mounted ball bearings have achieved third party IP69K certification.

Ingress Protection (IP) Marking rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact and water. It is published by the International Electrotechnical Commission (IEC). The IP69K rating is for high-pressure, high-temperature washdown applications. Enclosures conforming to it must not only be dust-tight, but also able to withstand high pressure and steam cleaning.

The Sealmaster PN Gold mounted bearings now join the Leeson® Extreme Duck® Ultra motor and the Hub City® Hera® stainless steel gear drive as third party IP69K-certified products from Regal. Together, these three products provide a complete washdown solution for food and beverage, pharmaceutical and chemical processing applications.

“Traditionally, IP69K and IP69 ratings have been used for electronic components, but the industry is starting to recognize power transmission components such

as bearings with this distinction,” said Ian Rubin, Director of Customer Experience, Regal. “The Sealmaster PN Gold mounted bearings have been proven to outperform competitors’ washdown bearings and are often specified by end users because of their performance in washdown applications, and now they carry the formal IP69K certification.

“It should be noted the industry standards for IP69 and IP69K have been updated in recent years, with IP69K being phased out and a revised IP69 standard that includes the severity of the IP69K becoming standard. For this product, Regal will use the IP69K terminology in its communications based

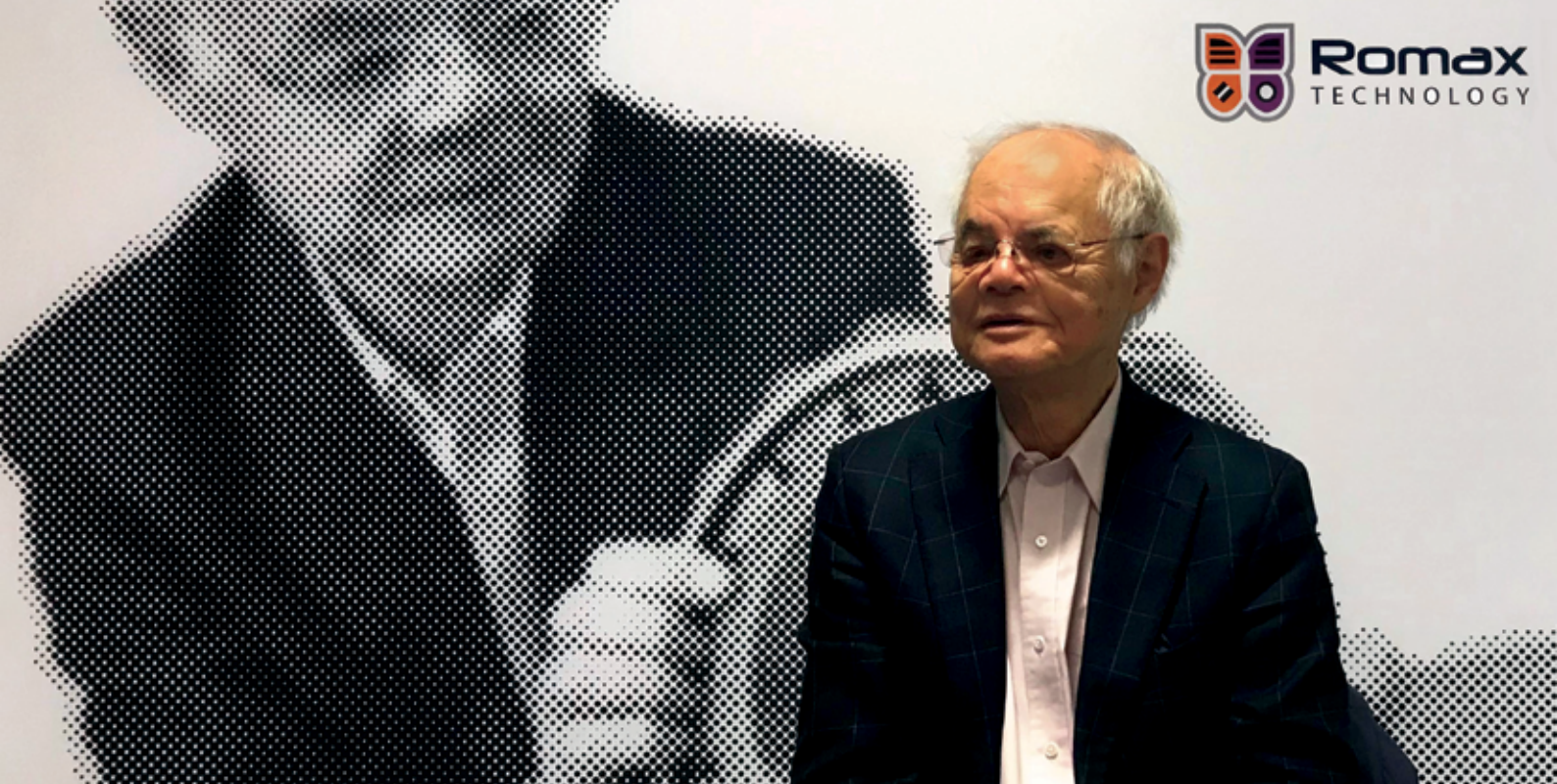
on the years of the industry knowing IP69K was more severe than IP69.”

When compared to competing seal designs, the high-performance, triple-lip seal provides superior resistance to water ingress in laboratory testing. In addition, the high-phosphorous, nickel-coated raceways resist corrosion, and the 316 passivated stainless-steel housing or high-strength composite housing make it a robust washdown solution. Sealmaster PN Gold mounted bearings are available in both setscrew and SKWEZLOC® concentric locking collar designs.

For more information, visit [RegalBeloit.com](http://RegalBeloit.com).







— As we start a new decade, we ask the founder of Romax Technology Dr. Peter Poon, MBE, about what advice he would give to new businesses and individuals looking to advance in the engineering industry. Here are some of his take-aways....

## Be Curious, and Curiouser - An Interview with the founder of Romax Technology

### 1. What was the best part of creating Romax Technology?

Coaching new people, see their ideas and making an impact on the world.

### 2. And the worst part?

Making mistakes! My advice is to be tenacious to recover from your mistakes, but, don't let this stop you from taking risks – you need risks to enable innovation! The important thing is how you recover from your mistakes.

### 3. As an innovator, you are always working with ideas, what are you currently working on?

Now I am enjoying coaching three start-up companies: a restaurant, a software company and a technology company.

### 4. Where does your inspiration come from?

Everything around me: be curious, ask questions, and break things down to the underlying principles to understand – once you understand the problem you can find a solution! Our ecosystem of partners that forms these intricate webs for nurturing

collaboration and the sharing of knowledge, which has given rise to a network of leading global businesses. This is what allows us to optimise everything globally, from people, processes and products; to the very core of Right First Time.

### 5. What skills do you think are vital for an inventor?

You need to think inter-disciplinary, especially going into the future. Engineering is no longer split into “Mechanical” “Electrical” etc, you need to learn a bit of everything and bring that to your work.

This is a new approach, and one must understand the base physical principles of the problem you are dealing with, be it why the dentist drill hurts when it doesn't actually cut anything (current theory: heat), or why a dripping tap can clean a greasy dish overnight, when one on full power could not (current theory: cavitation and distribution in drip size/force). Think for a long time, test your theories, then find solutions.

### 6. How do you decide if an idea is worth pursuing?

Reduce them to fundamental parameters, do some simple calculations, then pass a judgement. You cannot be an impressionist. You must make decisions based off calculations and facts. How does the existing method work, what are its faults, and can it be improved?

And you must be curious, keep asking questions! We are born with curiosity, but we are normally encouraged not to ask questions, must ask questions! Will not get the right answer unless you ask the right question. Ask the fundamental questions!

### 7. What is the impact of each invention on the industry, company and you?

At Romax, we were the first company to develop a systems approach to gearbox analysis; everyone came to see how it works and now everyone does it, but for a long time it was only us. In this way, we have drastically changed the whole industry. We pioneered in research and innovation and heavily invested in the development of innovation and technology advancement. This transformed not only our business, but the entire landscape around us.



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BENTLY BEARINGS™  
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**Offering magnetic bearing  
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## **GAS BEARINGS**



### **THE BEARING IS THE SEAL**

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Load capacity is a function of input pressure. 900 PSI unit loading has been demonstrated with 1000 PSI input pressure.

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Bearings can run "Hot Immersed" on process gas. High temperature bearings are capable of 1000°C in continuous duty.

Don Bently, founder of Bently Nevada, started the Bently Pressurized Bearing Co. See what he had to say about the topic. [bentlybearings.com/chapter23](http://bentlybearings.com/chapter23)

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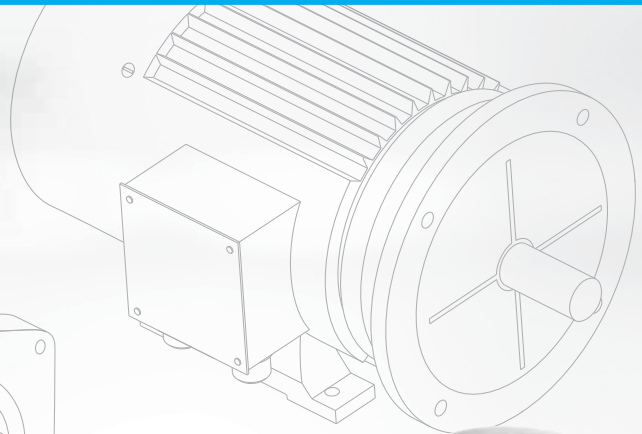
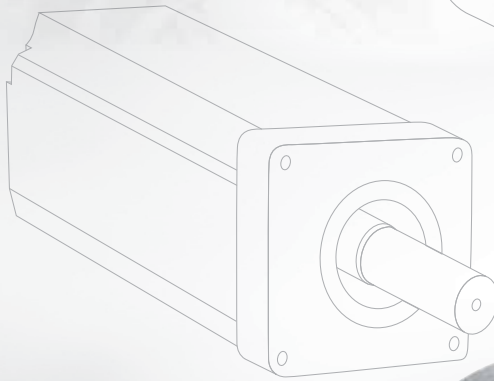
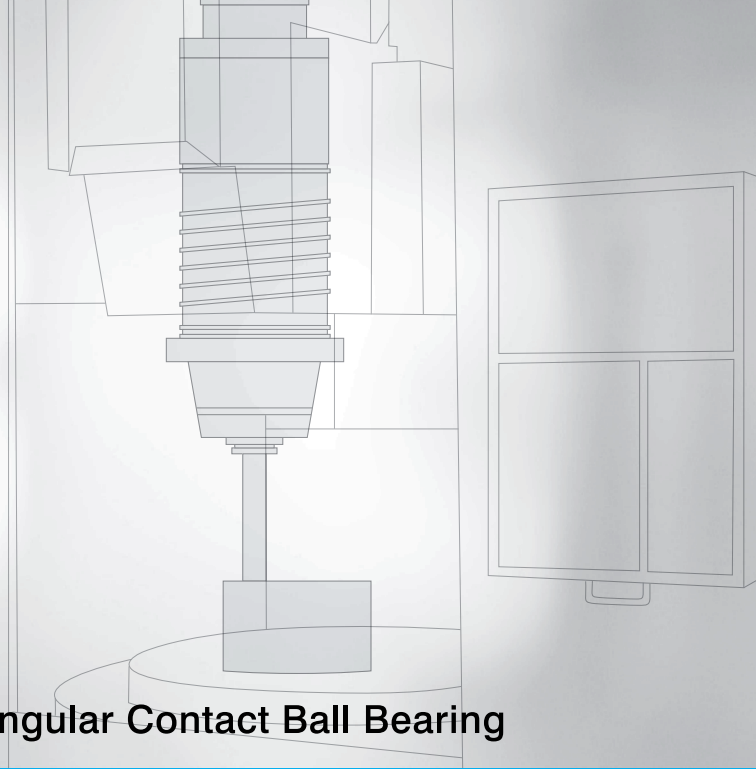
Dr. San Andres of the Turbolab at Texas A&M is a leading expert on gas bearings. View his paper on EPP Gas Bearings. [bentlybearings.com/sanandres](http://bentlybearings.com/sanandres)

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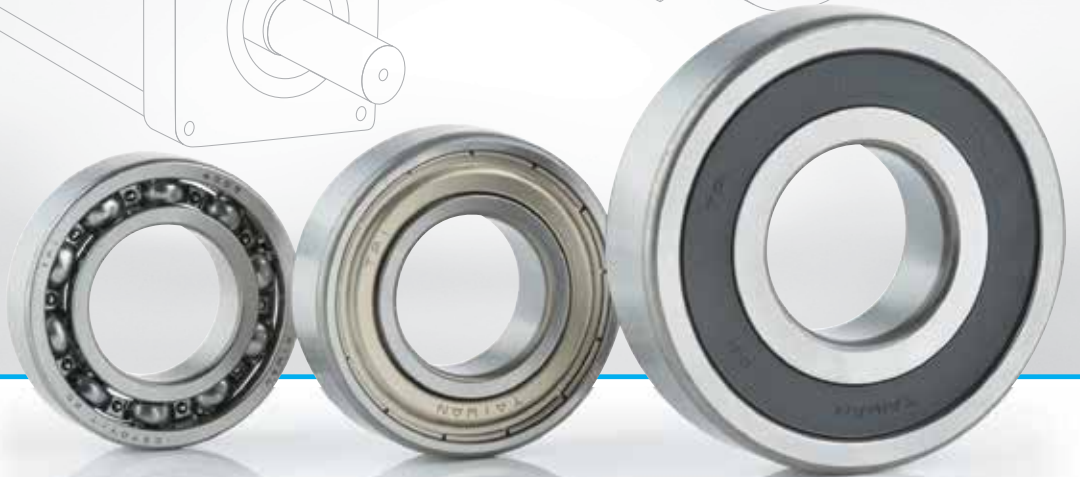




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# Machining of spherical parts in shortest possible cycle times

Based on the high-precision Sphero machine tool, Thielenhaus Micro-finish has now developed a highly efficient two-step solution which performs the entire fine-finishing process for spherical workpieces in short cycle times. The new SpheroStar also builds upon the MicroStar and NanoStar platforms constructively and like these two it is equipped with an indexing table.

The SpheroStar has two tool spindle units that can automatically rotate by up to 90 degrees so that the optimal machining position for the relevant process is always selected, thus enabling the production of flat surfaces as well – with optional cross slides – instead of only spherical surfaces. The units are mounted vertically and are easily accessible for fast changeover. The machine is loaded at the first station by a handling robot in a cycle-time-neutral manner and is later again unloaded after machining. The indexing table then moves to station 2 where the workpiece is aligned axially. Pre-finishing takes place in-process in station 3 under size-controlled conditions, and the end-finishing with a flexible stone is done in station 4. This operation too is IPM-monitored. A MicroSens force sensor is used for both work steps with work-piece contact detection and brick wear compensation.



– The SpheroStar has two tool spindle units that can automatically rotate by up to 90 degrees so that the optimal machining position for the relevant process is always selected. photo: Thielenhaus Technologies GmbH

The clamped workpiece rotates at up to 4,500 revolutions per minute during machining. The spherical surfaces

are created in a reliable manner in terms of process in connection with a corresponding contour of the Microfinish tools. Depending on pre-machining, the cycle time is only 12 to 13 seconds, so that the machine can be properly integrated into efficient production lines.

Since the most important assemblies are from approved platforms that have already been on the market for long, the new machine also features a high level of failure safety. This means that the indexing table comes from Nano-Star, the spindle unit from Sphero and the lining together with the tensioning system are from MicroStar.

This new SpheroStar enables machining of surface topography, spherical roundness, spherical diameter and sealing surfaces. Plus the improvement in supporting components enables tribological requirements to be fulfilled. In just a few installation steps the machine can be converted from outer machining to inner machining, i.e. from a sphere to a sealing ring or a socket. Since the workpiece remains in the clamp until it is completely finished, the operator influence is reduced and errors due to repeated clamping are ruled out. This increases process repeatability considerably.

Workpieces can be machined up to a diameter of 75 mm on

the ergonomically designed machine. It is typically used in the automotive industry for machining the joint heads of wheel suspension and steering components that require a high level of freedom and movement for the associated assembly units. Metal-lically-sealing valve balls and seating rings for valves in the chemical industry, through which aggressive or very hot media travel, are able to be machined with a high degree of dimensional and surface accuracy. Another instance are the axial piston pumps found in all fields of hydraulics. The axial piston has a spherical sliding surface at the end, and the dimensions of this component must be accurate to 1 µm or less in order to guarantee safe operation at great strain – such as in aviation. More information can be found at [www.thielenhaus.com](http://www.thielenhaus.com)



– The new SpheroStar by Thielenhaus Microfinish makes it possible to machine spherical workpieces in short cycle times efficiently and with great precision. photo: Thielenhaus Technologies GmbH

vol.06

# TOP 100 TIPS for BEARING RELIABILITY

by Per Arnold Elqvist



## Bearing Tip 60: The importance of the correct internal clearance of the bearings!

An incorrect internal clearance of a bearing can cause one of the following problems:

1. Overheating or even the mooring of the bearing due to lack of internal clearance.
2. Increased vibration levels caused by mechanical looseness due to excessive internal clearance in the bearing.

What is the objective of the internal factory clearance of the bearings, i.e. “Normal”, C3, C4, etc.? The internal factory clearance

of the bearings has the following function:

Absorb expansions or contractions of the rings by:

- a) The interference fits of the mountings of the rings on the arrow and housing.
- b) Differences in operating temperatures between bearing inner and outer rings.

At least one of the bearing rings is mounted with interference fit to prevent its rotation by the dragging of a rotating load. This interference will logically expand the inner ring almost in the same magnitude in the case of solid shafts, so that it could completely eliminate the internal radial clearance.

**Example:** A 6308 bearing mounted on an electric motor.

The tolerance for the factory internal radial clearance of this bearing is from 6 to 20 microns, that is, an average of 13 microns.

The tolerance of the inner diameter of the ring is from 0 to -12 microns, that is to say average of -6 microns.

The recommended setting for this bearing mounted on an electric motor is k5, that is +2 to +13 microns, giving an average of +7.5 microns.

The combination of the +7.5 adjustment and the average internal diameter

measurement of -6 microns results in a total expansion of the inner ring of  $+7.5 + 6 = 13.5$  microns.

Therefore, this expansion of the inner ring would completely eliminate the radial internal clearance of 13 microns of the bearing, so that there would be no remaining internal clearance to absorb thermal expansion.

In the application of bearings in electric motors, the inner rings have an operating temperature of 10 to 15 °C higher than the outer rings due to the cooling of the housing by the fan, which results in a greater expansion of the inner rings than the outer rings. Therefore, a C3 internal clearance is recommended for deep groove ball bearings used in electric motors. For the 6308/C3 bearing in this example, the C3 set would be 15 to 33 microns, that is, an average of 24 microns, which would result in a remaining internal clearance of 11 microns after assembly to absorb thermal expansion in operation.

I have often encountered the misunderstanding that the internal clearance serves to provide space for the lubricating film, which is totally wrong: In a radial bearing subject to a radial load, the clearance in the loading area is eliminated in the load zone where it is essential to have a lubricating film to avoid metal-to-metal contact. Instead, the lubricating film is created by elasto-hydro-dynamic lubrication.

**Bearing Tip 61: What Greases are inside the Factory Lubricated Bearings?**

Factory lubricated bearings have huge advantages:

1. They are maintenance free.
2. They have the optimal amount of grease.
3. They are sealed, with 2 protective shields or 2 contact seals.
4. Internally they are utmost clean.
5. They facilitate their handling without contamination risks.

But which grease do they contain?

The type of grease varies according

to the bearing manufacturer, since each manufacturer uses different grease as Standard grease.

When the nomenclature of the bearings does not indicate the type of grease it means that they contain the standard grease of the corresponding manufacturer.

In cases where grease is indicated, it means that it is a different grease than the manufacturer's standard grease.

Standard greases (not indicated in the nomenclatures) are mostly greases with lithium thickeners and with the normal temperature range of -30 to +110 °C. But as the manufacturers use different greases as standard grease, it is important to confirm which grease they use. Example: Now when Timken took over Torrington, their new design of deep groove ball bearings contain the Mobil Polyrex EM as standard grease which is a high temperature grease.

As soon as the grease is different from the standard it must be indicated in the nomenclature with the corresponding suffix. Example: 6205-2Z/C3GJN from SKF, where the suffix GJN indicates a Polyurea

grease with very special characteristics (Recommended grease for electric motors with a temperature range up to +150°C).

**Conclusion:** It is very important to determine and specify the grease that is required for the corresponding application, since the standard grease may not always meet your needs!

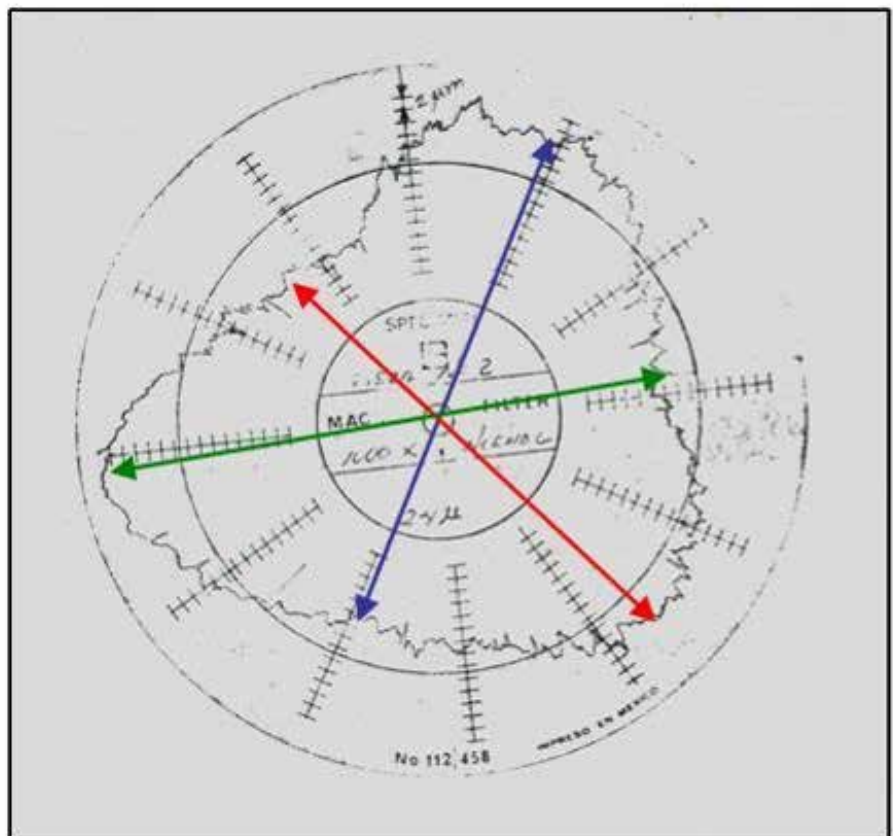
**Bearing Tip 62: Be careful with the quality when you repair the housings of the caps of your electrical motors!**

What problems can be encountered when the caps of electric motors are repaired with a sleeve?

Several times I have received the question: Why do the bearings last less after repairing the caps of the electric motors?

The answer is very simple: It is very difficult to maintain the original quality of the bearing housing when a cap is repaired for 2 reasons:

1. This work is generally done in general workshops and no general workshop will achieve the quality as the original motor manufacturer.
2. A very serious and very common





defect is the deformations caused by the fasteners of the caps for the machining. The worst cases are when heads with 3 jaws are used to support the cap for machining because they cause deformations at 3 points which cannot be measured diametrically:

How can we avoid these problems?  
There are several solutions:

1. Use the correct tolerances and measurement instruments for the machining.
2. Use heads with 4 jaws.

**But first of all, avoid having to repair the caps avoiding the bearings to rotate in the housing using Predictive Maintenance to detect bearing failures in time to avoid collateral damages!**

**Bearing Tip 63: Avoid Bearing Failures - use the ABC for Bearing Reliability!**

Use a structured method in a very logical and simple way to avoid bearing failures that as an “ABC for Bearing Reliability” according to the excellent idea of the Management in a Customer’s plant.

This ABC should work as follows:

- A: The correct bearing.
- B: The correct lubrication.
- C: The correct mounting.



A. Verify that the bearings are the most suitable for each and every application.

In my experience, the second biggest cause of premature bearing failures is the use of incorrect bearings. The main cause of this error is the enormous lack of knowledge of the nomenclatures of the bearings. For example the ignorance of the importance of the internal clearance. Another is the misunderstanding that 2Z bearings are sealed. A third is the importance of the differences between different types of cages and their performance. These 3 characteristics must be clearly indicated in the corresponding bearing designations!

B. Select the correct lubrication:

1. Use the correct lubricant.
2. Apply the lubricant with the correct system.
3. Apply the lubricant in the right place.
4. Apply the correct amount of the lubricant.
5. Relubricate or change the lubricant at the correct time.
6. Use trained and trained personnel for lubrication, preferably true Tribologists.

C. Perform the correct mounting:

1. Use the correct seats in terms of fit and dimension quality.
2. Keep the new bearings as virgins in their original packaging unopened until the moment of mounting.
3. Carry out the mounting in such a way that no damage is caused to the new bearings, using the most appropriate methods and tools. For mounting on the shafts the best tool is undoubtedly the induction heater.

**Bearing Tip 64: It is very easy to avoid Damages at the Mounting of Bearing!**

It is very easy to avoid damage to the bearings during their mounting by taking certain care and using the right mounting methods and tools!

The care must be:

1. Keep the virgin bearings in their original packaging unopened until the moment of assembly. Contamination can reduce bearing life by more than 90%!

2. Apply the mounting force to the ring that is being mounted or to the 2 rings evenly, so that the mounting force never passes from one ring to the other through the rolling elements.
3. Any wrong impact to the bearings causes impacts between the rolling elements and the raceways. A bearing that falls to the hard floor is no longer useful! Always take into account: “Impacts on the balls hurt”!

The most appropriate methods and tools are:

1. Preferred method: Thermal using induction heaters. Induction heaters have the following 6 huge advantages:
  - Security for personnel
  - They do not cause damage to the bearings
  - Cleanliness
  - Efficiency
  - Does not cause any wear to the shafts
  - Perfect control of the heating temperature

As this method does not cause any wear on the shafts, these can be used many times while maintaining the perfect quality from the Original Manufacturer.

2. Mechanical method. With this method, the mounting force must always be applied directly to the ring that is being mounted, preventing it from passing from one ring to the other through the rolling elements so that they do not cause marks on the raceways. The great disadvantage of this method is that it causes considerable wear on the shafts due to interference fits.
3. Hydraulic method. This method is not widely used since the equipment must be prepared for this by the manufacturers. This method makes assembly much easier but the personnel who use it must be trained since the forces used are enormous.

**Bearing Tip 65: The Bearings have First and Last Name!**

The Bearings have First and Last Name! It is not enough to indicate 7313! 7313 only indicates the Bearing Type and Size, that is, the dimensions, radial and axial load capacities.

Therefore it is also essential to indicate all Suffixes, that is, their Name or Names.



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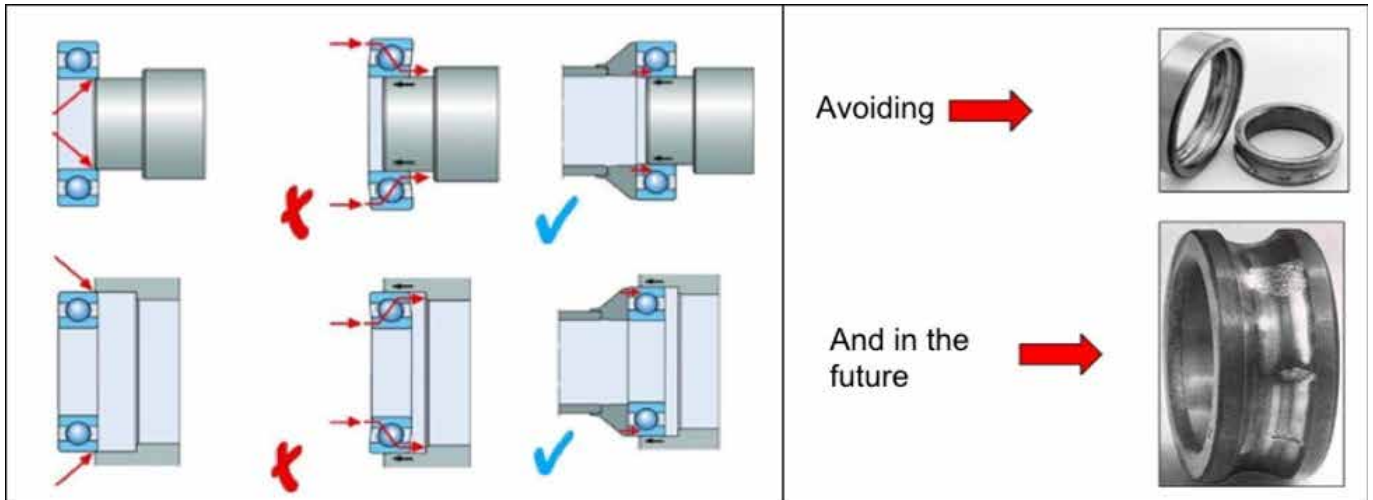


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The correct Suffixes in this case if it is a bearing for an API centrifugal pump must in for example SKF brand be BECBM, that is B + E + CB + M. The letter B indicates the contact angle that is the axial/radial capacity, the letter E a higher capacity design, the letters CB the adjustment done by the manufacturer for universal mounting in pairs and the letter M a mechanized brass cage. Suffixes are what determine characteristics such as:

- Group 1: Internal Design (A, B, C, D, E)
- Group 2: External Design (K, RS1, Z, N, NR)
- Group 3: Cage Design (J, Y, TN9, P, M)
- Group 4: Variants:
  - Group 4.1: Materials, Heat Treatment (HA1, HA2, HA3)
  - Group 4.2: Accuracy, Internal Play, Vibration and Noise Level (C3, C4, P6, P5)
  - Group 4.3: Bearing Set, Paired Bearings (CB, GA)
  - Group 4.4: Thermal Stabilization (S1, S2, S3, S4)
  - Group 4.5: Lubrication (LT, MT, HT, VTXXX)
  - Group 4.6: Other Variants (VAXXX, VBXXX, etc).

Most complicated, this is why incorrect bearing in my experience is the second mayor cause for bearing failures!

**Bearing Tip 66: Should shielded 2Z (ZZ) bearings be relubricated?**

No way! 2Z or ZZ bearings are factory lubricated for life!

I have seen and participated in several discussions about whether 2Z bearings should be relubricated, which are factory lubricated bearings with 2 protective metallic shields.

The intention of these bearings is to have maintenance-free bearings, in this case with non-friction seals to allow maximum speed with minimum friction. As the protective covers are metallic, you cannot have any contact between them and the inner ring, so you have a small labyrinth. Therefore they are not sealed tightly so they should only be used in environments with very little contamination. For environments contaminated with particles and/or moisture, bearings with contact seals (2RS) should be

used (RS stands for Rubber Seal).

During my time in the manufacture in SKF I just saw several redesigns of the 2Z bearings in order to make the sealing as good as possible. Initially the 2Z bearings had grooves turned in the inner ring that formed the labyrinths with the covers. But since this surface was turned it had little precision, which worsened with the distortions generated by the heat treatment of the ring, the opening of this labyrinth was considerable and the sealing was not very efficient.

With the change of the design to the precision grinding of the shoulder of the inner ring and the precision die cut caps with a small bend with a precision inner diameter, the labyrinth could be



reduced to a minimum without risking any contact with the inner ring. With this design the sealing was improved and hardly allows the entry of grease.

Therefore, arguments that the shields are to regulate the entry of grease is totally wrong. Also, if grease gets inside the bearing, who ensures that this grease is compatible with the original factory filled grease? Another risk is that the enormous pressure exerted by the manual grease injection pumps could push the covers into the bearings until they rub against the cages.

**Bearing Tip 67: Cheap lubricants = the worst business for maintenance!**

One of my well-known messages based on 50 years of experience with Bearings is that **“Bearings are as good as their Lubrication.”**

Why do I say this? The reason is very simple, since at the time the lubrication fails, the bearing also fails: No bearing, however good, can work without lubrication. Metal-to-metal contact leads to almost immediate failure. Cheap lubricants will logically have a lower performance. The economic greases are mostly liquefied shortly due lack of mechanical stability, not because of the temperature as it is a very common misunderstanding but because the mixture of the oil with the thickener has not been perfectly homogenized so they are easily separated again.

Apart from the higher consumption of these lubricants (which generally increases the cost much more than what is saved by the price) and the normal risk of bearing failure where the greatest cost is the lost production due to the downtime. That is, here the saying “Cheap is expensive” is most valid.

The worst example I’ve seen: A spherical roller bearing 241/900 CAK30F bearing that only lasted for 4 days in a new type of cement mill! A spherical roller bearing of more than 3 tons that should last for years! The cause: A commercial EP2 grease was used instead of a special high viscosity grease with a calcium sulphonate thickener with excellent EP properties!

I take this opportunity to comment that a very common conclusion seeing this example is the high cost this bearing. But this is not the correct conclusion: The highest cost of this failure was not the cost of the bearing of \$ 32,000, but the loss of production as a result of the failure: 10 days of downtime which represented a loss of production of 32,000 tons of cement with a value of 28 million Usd at that time!

Isn’t lubrication important? Several leading bearing manufacturers indicate incorrect lubrication as the cause of more than 50% of premature bearing failures.

**Bearing Tip 68: Bearing Failures in Electric Motors**



According to the statistics of a world leader in electric motor service, 80% of electric motor failures are caused by bearing failures. And this is a statistic that did not take into account the new NEMA Premium high efficiency motors in which electrical aspects such as magneto wire, insulation, etc. have been improved. That should reduce electrical failures but without changing mechanical aspects or lubrication.

He also indicated that 80% of bearing failures are due to lubrication errors, so in conclusion we can deduce that 2/3 (80% x 80%) of electric motor failures are due to poor lubrication of its bearings. What an opportunity to avoid failures in electric motors by simply lubricating them correctly!

Other opportunities to reduce failures in this type of equipment is to use the most suitable bearings, for example:

- Deep groove ball bearings with

internal radial clearance C3.

- Cylindrical roller bearings when belt transmission is used.
- Use external seals and grease gaskets and/or bearings with -2RS contact seals in environments contaminated with dust and/or water.
- Correct quality of seats on shafts and housings when being repaired.

**Bearing Tip 69: Who is performing training on rolling element bearings?**



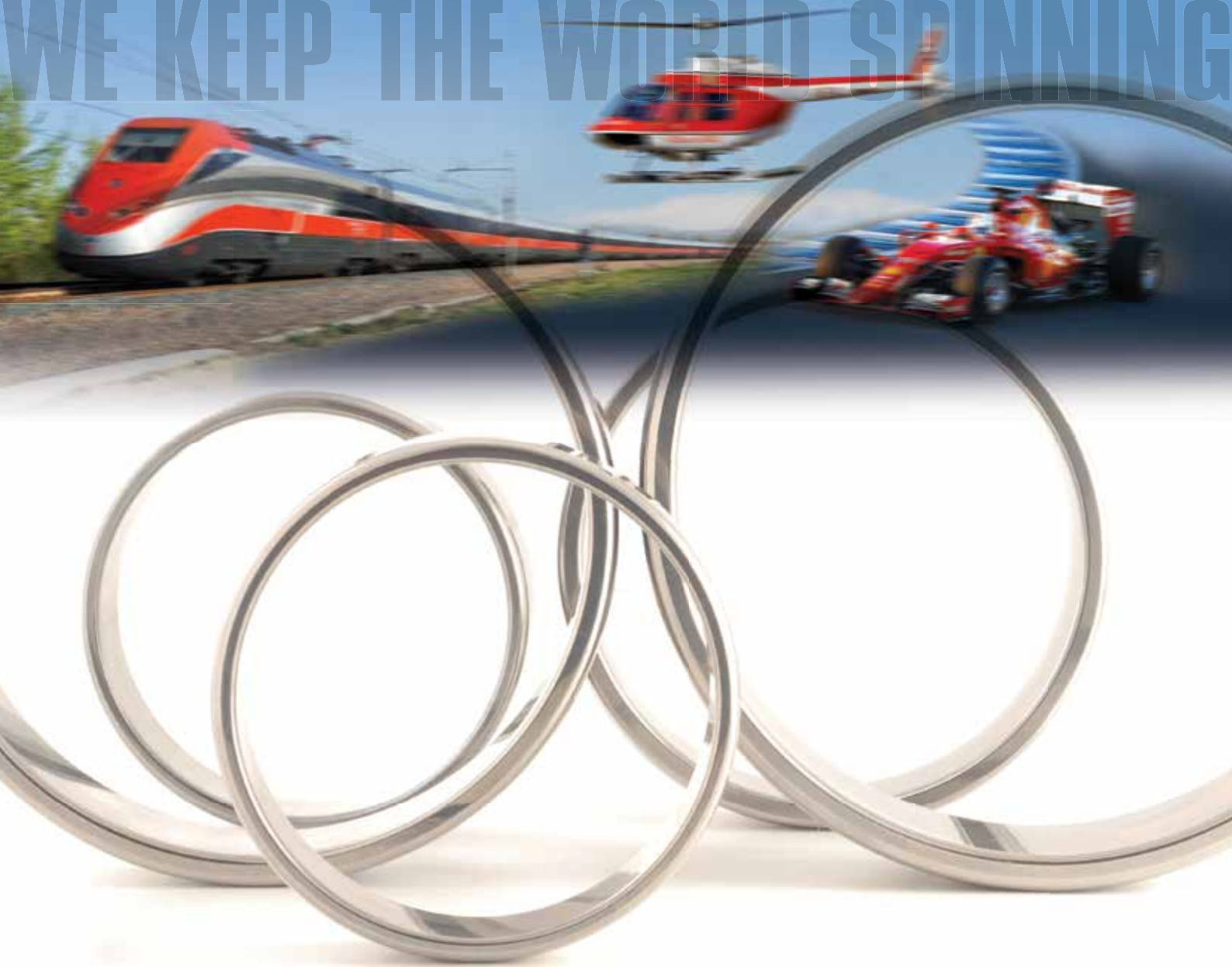
**Do you know the answers?**

In spite of the enormous importance of the bearings, we are very few who perform training the bearings: The bearings are the elements that support the movements in more than 95% of the equipment in the industry! 80% of electric motor failures are caused by bearing failures!

The studies of bearings in technical careers around the world are almost nil. My oldest son studied Mechanical Engineering in a superior category of universities and told me that they only studied bearings for 5 hours: 7 basic types are manufactured and ISO 281 for calculations. And the lubrication that is vital for the reliability of machinery was not even part of the career!

Many of the bearing manufacturers offer direct training on bearings or through their distributors, but these are logically brand marketing focused. On the other hand, we are some independent consultants offering training on the reliability of bearings and as independent able to offer recommendations based on the required performance or on price according to the corresponding customer.

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The basic requirement for any operation in food and beverage, pharmaceutical industries is a clean and hygienic environment. Regular cleaning, often with aggressive chemicals and high pressure cleaners, is a daily standard procedure. Any contamination of the product by oil or grease must be minimized. Production processes, like cleaning - cooling - baking, demand special attention to the bearing lubrication:



The typical challenges for the bearing lubrication are:

- wet environment - process water
- cleaning - (detergents / chemicals)
- pressure cleaning
- hot or cold processing
- food grade lubricant suitable for incidental contact with processed product
- low maintenance costs
- reduced environmental impact

The thb lub-systems Durolub® variants are the high-end solution to all these challenges. We fill our compound lubricants in any type and brand of bearings. You are not forced to buy a specific brand for whatsoever reason.

## WET ENVIRONMENT

Water and moisture inside a bearing decreases the lubrication effectiveness of the lubricant, cause wear and corrosion. The bearing will fail prematurely. Frequent relubrication tends to be unsuccessful and contaminates the environment.

Durolub® DL is a thermally treated polymer compound with a high performance synthetic oil, which cannot be washed out of the bearing. It is extremely resistant to water and resistant

to most acids, leaches and solvents

## PRESSURE CLEANING

Integrated seals will be deflected inward the bearing by the water jet, water / detergent can easily move into the bearing, the lubricant will be washed out of the bearing.

Durolub® DL is filled into all free space of the bearing. After the thermal treatment Durolub® is a solid compound which provides additional support to integrated seals and avoids the inward deflection.

## HOT PROCESSING

Operating temperatures above 100°C reduce the life-time of ordinary mineral-oil based lubricants significantly. Seal and cage material needs to be adjusted, the thermal treatment of

bearing rings should be according to the planned operating temperature range.

thb offers a wide range of products for grease / polyglycol / solid and solid lubricants. There is also a special Durolub® variant called Durolub® SLC.

Durolub® SLC is a special dry lubricant compound filled into the free space of the bearing. During rotation of the bearing, small quantities of the dry lubricant are transferred to the contacting surfaces. This, about 1µm thick lubrication film, lubricates the bearings and can be used for operating temperatures up to 300°C - temperature peaks are causing no problems, only above 350°C the efficiency of DL-SLC is reduced by oxidation.

The typical application in the food and beverage industry are bakery ovens.



— Durolub®DL150 in a spherical roller bearing



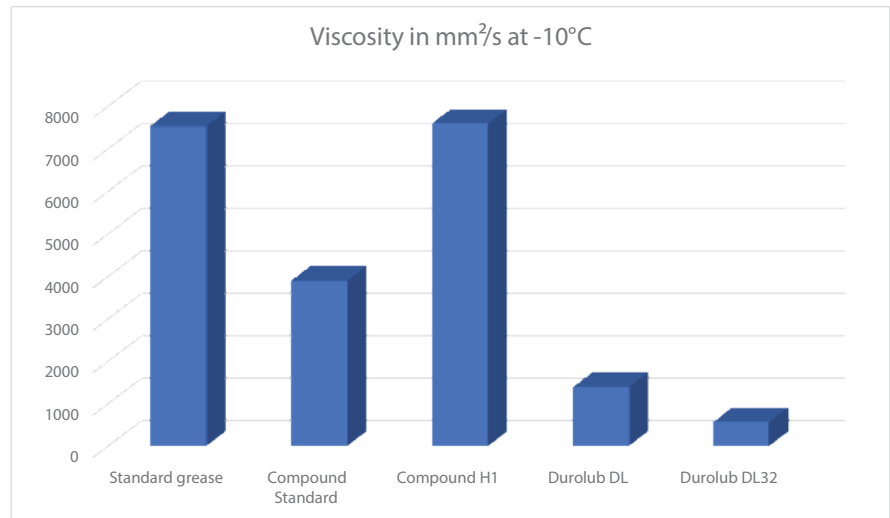
— Durolub®SLC in a ball bearing



## COLD PROCESSING

Operating temperatures around and less than 0°C increase the viscosity of the lubricant significantly. Standard lubricants often reach a critical high viscosity already at +10°C, the lubricant is getting „too thick“ and doesn't lubricate the bearings properly. Mixed friction causes wear and high friction torques, energy costs for operation are high, bearings will fail prematurely.

Durolub® DL32 contains a special low viscosity base-oil which is suitable for operating bearings at very low temperatures. Starting temperatures, as low as -50°C, can be realized.



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Durolub® DL / DL32 / DL150 are certified H1 for incidental contact with food. Furthermore they are Halal and Kosher certified.

Durolub® DL series is optional available with antimicrobial additives to prevent microbial growth. There will be no microbial contamination of the end-product just in case of incidental contact.

Durolub® SLC is not supposed to get in contact with food.



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Bearings lubricated with Durolub® contain up to 5 times more oil than greased bearings. Highest quality synthetic oils, which cannot be washed and the support of integrated seals offer the maximum grease life time. The bearings are practically maintenance free. There is no regular regreasing necessary, no excessive grease is around your applications. This all saves lots of time, money and is the best solution for the environment.



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