

System and technology expertise

Components for Wind Turbines



LIEBHERR

A strong partner for the wind industry





As a strong partner for the wind industry, Liebherr offers the ideal solution for various requirements ranging from individual components used for turbines to excavators, concrete technology, mobile cranes, tower cranes and offshore cranes used not only to erect turbines but to construct entire wind farms.

Liebherr works together with virtually all well-known turbine manufacturers and to date has supplied components for more than 15,000 wind turbines. The product portfolio covers components for 800 kW installations up to solutions for multi-megawatt turbines for offshore wind farms.

Advantages

Liebherr is the only manufacturer worldwide that is not only able to supply individual components as large diameter bearings, slewing drives, electric motors and hydraulic cylinders, but able to supply hydraulic and electromechanical pitch systems and electromechanical yaw systems for

wind turbines. An important element of the cooperation with customers from all over the world is the applied application-specific engineering necessary for adapting and matching the individual components to each other.

Wide product range

Large diameter bearings, drives and hydraulic cylinders - Everything from one source

Product and system expertise

Competent design and analysis

Quality-oriented

Complete quality management assures the high standard

Integrated lubrication systems

Economic and efficient

High vertical integration

Optimal process harmonization

Wide product range

Pitch systems

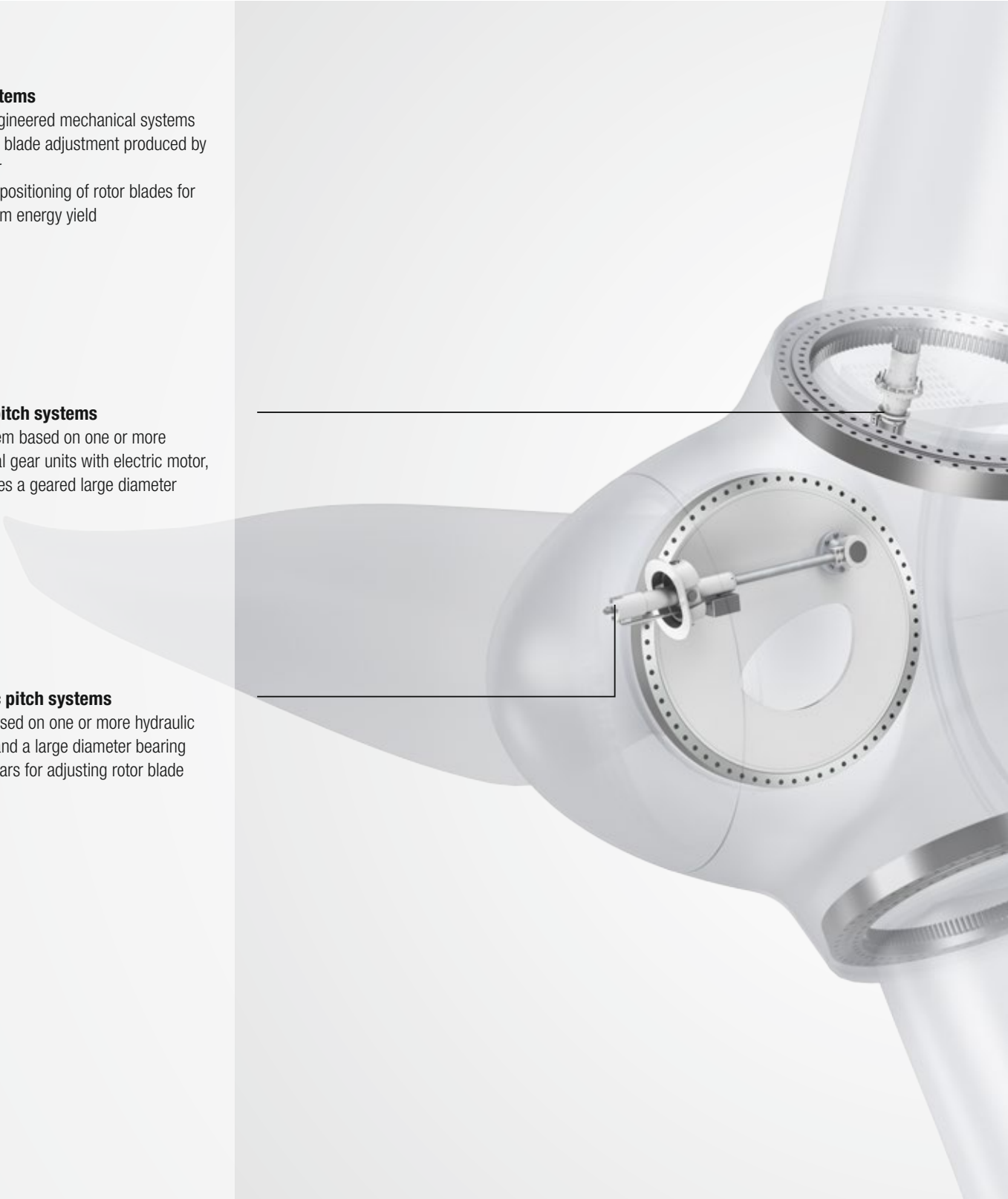
- Well-engineered mechanical systems for rotor blade adjustment produced by Liebherr
- Precise positioning of rotor blades for maximum energy yield

Electric pitch systems

Pitch system based on one or more mechanical gear units with electric motor, which drives a geared large diameter bearing

Hydraulic pitch systems

System based on one or more hydraulic cylinders and a large diameter bearing without gears for adjusting rotor blade position



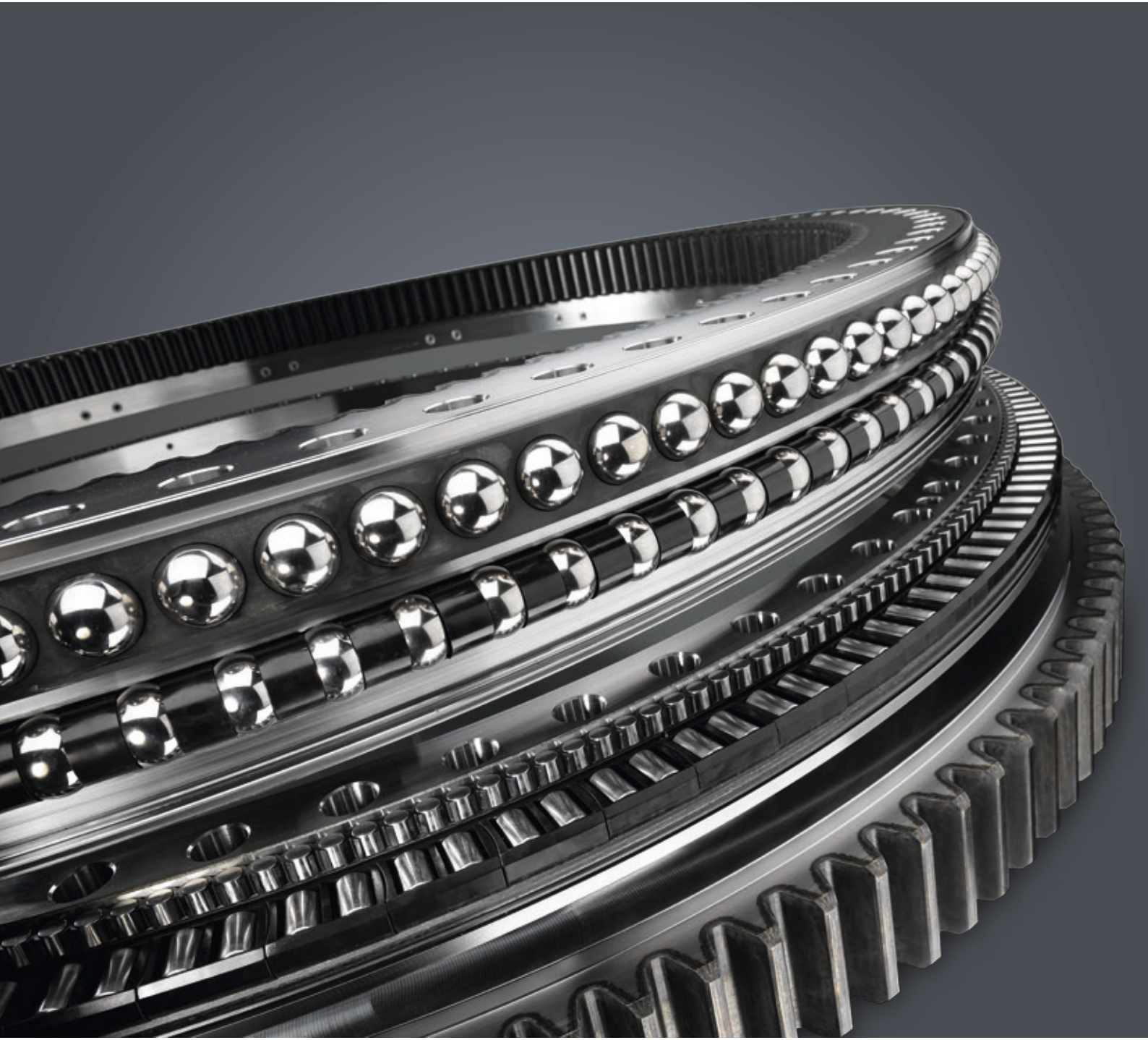


Yaw systems

- Depending on the specific system design, comprising of up to twelve or more high-performance planetary gearboxes which drives a large diameter bearing
- Alignment and supply of entire system, including electric motors, by Liebherr

Large diameter bearings

The range of Liebherr large diameter bearings covers bearings with a diameter of up to 6,000 mm. For wind turbine pitch- and yaw systems this include single-row and double-row four-point bearings and three-row roller bearings with internal or external gear. For yaw systems, the portfolio also includes gear rings.



Excellent quality and reliability

Long service life

The hardening process is decisive for the service life of a large diameter bearing. Liebherr achieves a consistently high quality using state-of-the-art system technology and in-house developed inductors. The degrees of hardness and the depths of hardness of raceways and gearing are subject to continuous quality testing.

Corrosion protection

Reliable corrosion protection is indispensable particularly for large diameter bearings for offshore applications. Liebherr uses different processes for surface treatment. These processes include sandblasting the areas with subsequent automated flame spray galvanising, as well as LCP coatings for protecting the gearing.

After the galvanising a two-component coating is applied for the C5 corrosion protection class. Specially treated sealing surfaces offer good operating properties and additional corrosion protection. The sealings are also ozone- and UV-resistant. Liebherr works with leading manufacturers in order to be able to offer every customer the optimal sealing solution.

Highest quality, down to the last detail

Calculation engineers examine all relevant details in the design of the large diameter bearings. This includes the forces acting on the rolling elements and their contact angle, bolt calculations, as well as the shape of sealing gap expansions. The strength assessment against the detachment of the hardened case (core-crushing) is also tested.

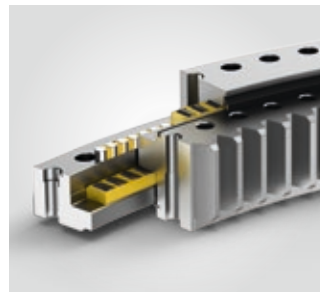
Examples of bearing designs:



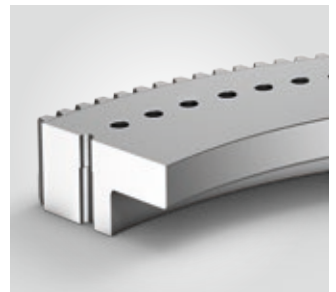
Four-point bearing – with external gear



Double-row four-point bearing – with internal gear



Triple-row roller bearing slewing ring – with internal gear



Gear ring – with external gear

Planetary gearbox

Reliability and precise positioning are the crucial factors for the rotor blade and yaw adjustment drives. Liebherr offers multistage planetary gearboxes for the rotor blade adjustment. If required by the installation constraints, they can also be fitted with an angled increment. Three- to four-stage planetary gearboxes are usually used for yaw adjustment. Up to twelve or more yaw drives per system are installed to transmit the high torques encountered in wind turbines in the multi-megawatt class.



High power density under high dynamic loads

Reliability and availability

Yaw adjustment and pitch drives are based on tried-and-tested technology: Liebherr has been supplying components for the wind industry for almost 20 years. Their high reliability and availability are the result of a variety of intelligent design solutions, such as special sealing concepts, corrosion protection systems, as well as optimised anti-friction bearings and gearing.

Optimum use of installation space

The integral design of Liebherr's gearboxes allows for compact shapes and an optimum power to weight ratio.

High-quality design

Liebherr planetary gearboxes boast a very high-quality design. For instance, the planetary supports are forged and the case-hardened output pinions have ground involute gearing. Meshing errors are also avoided with a very rigid mounting of the one-piece output shaft.

Compatible electric motors

As a system supplier, Liebherr offers electric motors with power between 1.1 and 11 kW for the gearboxes. The larger motors from 4 kW are developed and also produced by Liebherr.

Pitch gearboxes

A distinction is made between the three main designs: With short output shaft, with long output shaft or alternatively as bevel gear.



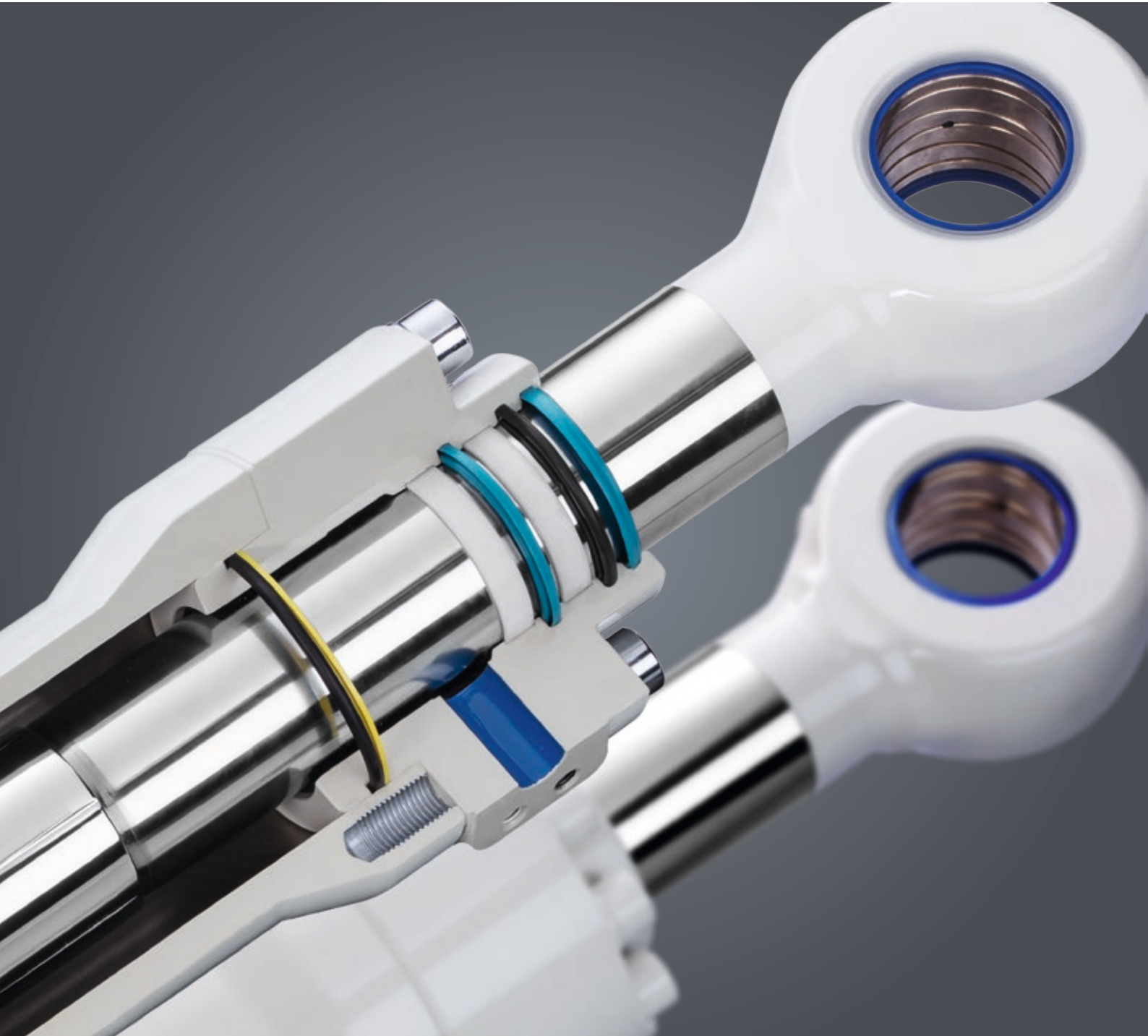
Yaw gears

The high-performance yaw gears are also designed with short or long output shafts.



Hydraulic cylinders

Since 1958, the Liebherr Group has been developing and producing hydraulic cylinders at the main site in Kirchdorf an der Iller. The product portfolio ranges from highly durable hydraulic cylinders for dynamic applications, large heavy-duty cylinders and dampers to lightweight and special cylinders. Liebherr benefits from its vast experience in the maritime sector also in the development of cylinders for wind turbines.



Precise and reliable work under demanding conditions

Longlife and high availability

Liebherr hydraulic cylinders achieve maximum efficiency in non-stop operation thanks to a flexible design which is adapted to the respective application - for example a screwed cylinder version. The sealing systems are designed to withstand continuous vibrations and high-frequency short stroke operations with low friction and are leak-free.

Liebherr cylinders are suitable for both onshore and offshore applications. There is a wide range of special piston rod surface treatments and cylinder coatings available for optimal corrosion protection.

Development and quality

State-of-the-art analysis and simulation methods are used during the development stage. These methods provide information about the material behaviour and the vibration resistance in realistic operating conditions, thus allowing the right material and sealing to be selected. In order to demonstrate the service life of several decades, hydraulic cylinders for wind turbines are subject to high-speed endurance tests at spe-

cial test benches. Furthermore, Liebherr meets its own high quality requirements through continuous material testing, as well as continuous process monitoring. The acceptance of hydraulic cylinders is possible through various classification bodies, for example the DNV Type Approval.

From the individual product to the complete system

In addition to the individual hydraulic cylinders, Liebherr also offers its customers complete hydraulic systems from a single source. Customised hydraulic power units and piston accumulator systems are developed and produced in-house for this purpose.

Designed to suit the requirements

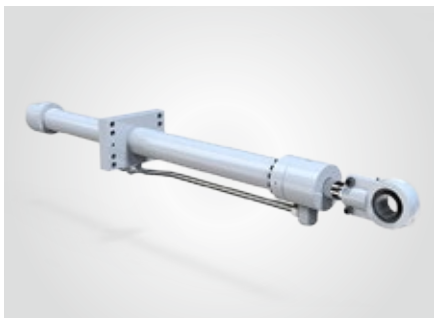
Hydraulic cylinders from Liebherr cope well in extreme ambient conditions and under dynamic loads in wind turbines.

Low-maintenance design

All individual components, such as the sealing packages, are optimally designed to meet the respective requirements. Maintenance work is thus avoided.

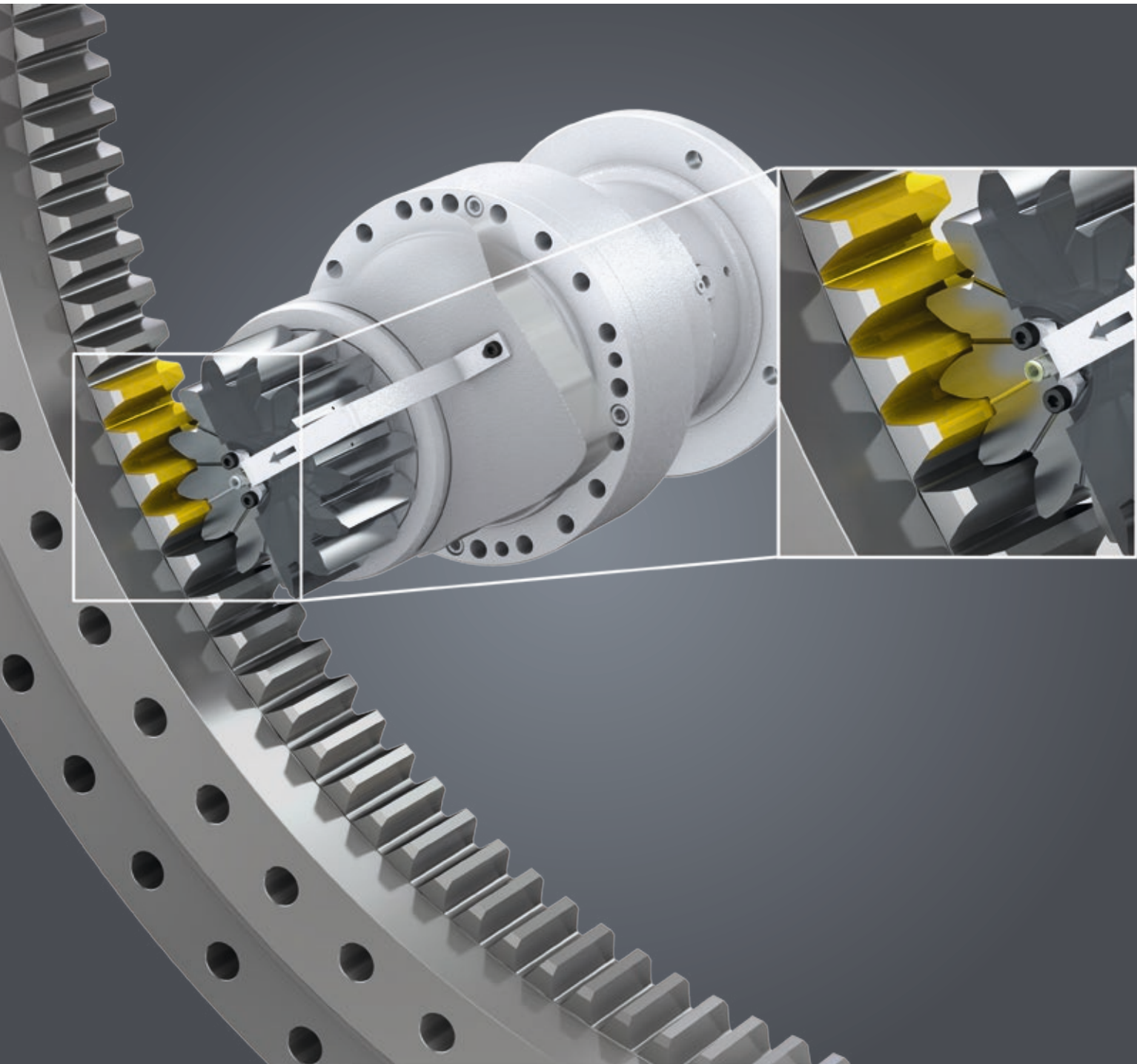
Various equipment options

The cylinders can also be optionally equipped with various sensors, dampers, as well as specific interfaces and hydraulic connections.



Integrated lubrication system

An integrated lubricant supply for pitch and yaw adjustment gears are an ideal complement to Liebherr's offer in the area of gearboxes. The lubrication system can be used with minimum implementation effort and offers considerable savings compared to the existing systems.



Economic and efficient

0° tooth problem

High level of wear of 0° tooth pair owing to limited adjustment of rotor blade setting angle and displacement of lubrication during tooth engagement.

With an integrated solution, the 0° tooth engagement is supplied with lubrication in the best possible way.

Function and configuration

The lubricant is fed via a lubrication supply line to the front of the pinion gear and escapes directly at the root of the respective tooth of the output pinion currently engaged. In this way, a targeted supply of lubrication is assured between the gear and pinion. Converting to Liebherr's lubrication supply has absolutely no affect on the configuration of the system. Depending on the type of lubrication, adjustments may need to be carried out on the controls and dosage as necessary.

Installation and maintenance

The system can be implemented with very little effort. By integrating the lubrication system in the pinion of the gear mechanism, external lubrication pinions and additional components are no longer necessary. The measures needed for maintenance can be reduced in this way.

Economy

With this approach from Liebherr, the lubrication runs that were previously necessary are now no longer required. As such, greater return can be gained from the wind energy and thereby more profitable operation of the plant. The simple design of the system also leads to lower procurement costs of the components.

No external lubrication pinion

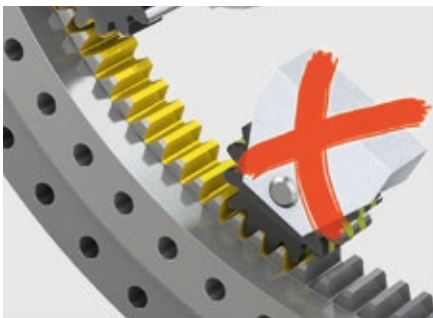
With the integrated lubrication system there is no need for an additional external lubrication pinion and maintenance measures can be reduced significantly.

Comparison with and without the lubrication pinion

Through targeted and constant re-lubrication, wear has been reduced to a minimum.

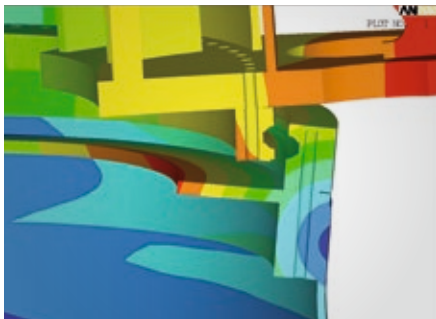
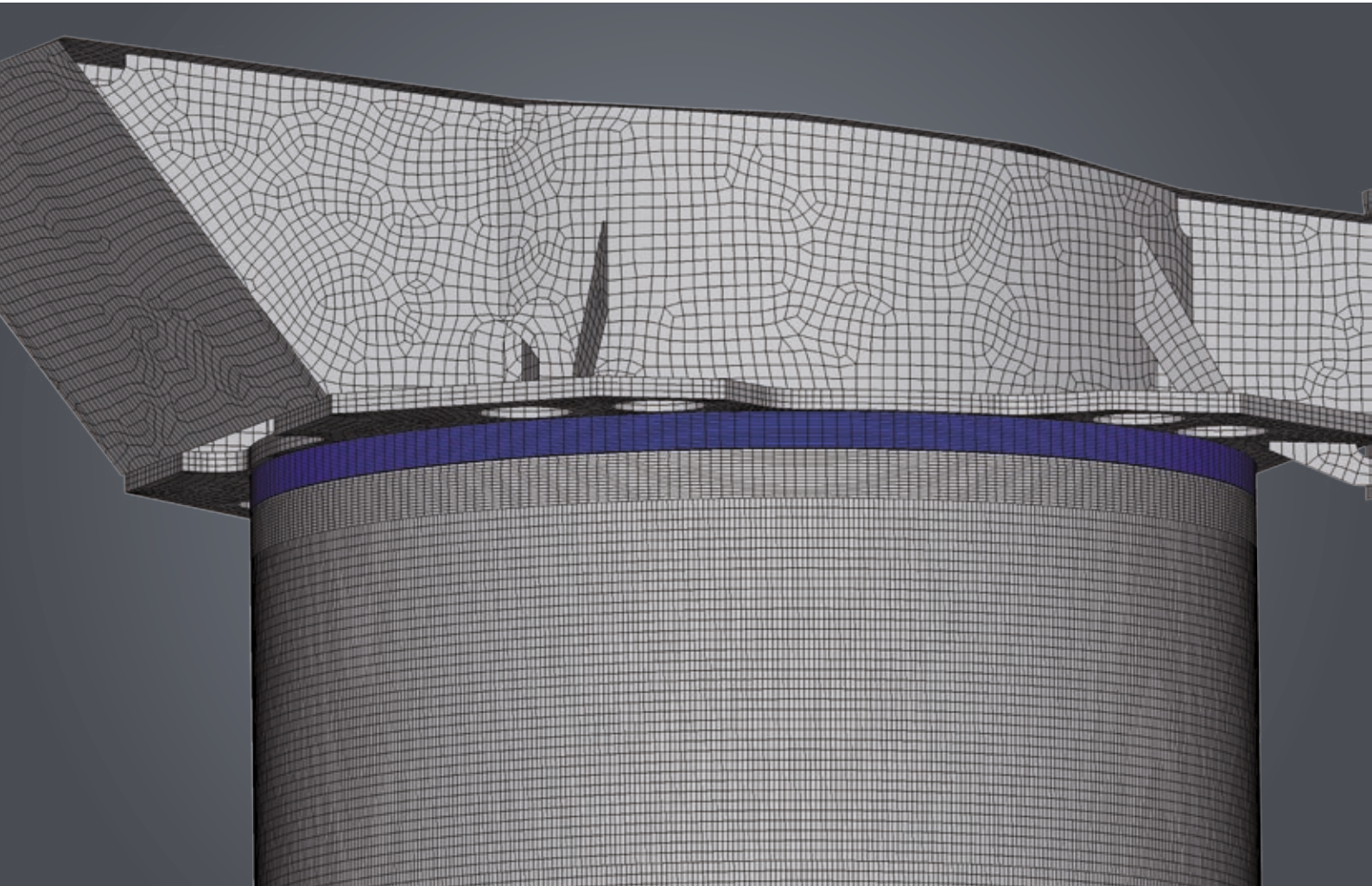
Extensive tests

The safety of the gear geometry was safeguarded by various load tests and calculations.

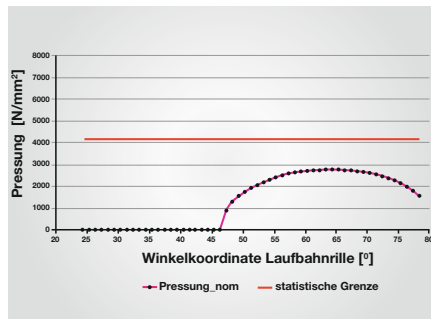


Product and system expertise

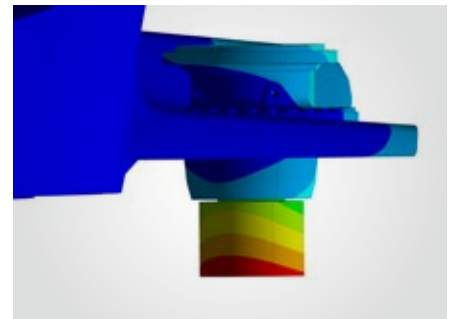
The right design and analysis of a component is decisive for its reliability and service life. For multi-megawatt wind turbines a design using Finite Element Methods (FEM) is essential, as the sensitivity to strain increases the larger the system gets. In addition, defined approval processes for new and further developments ensure optimal product configuration and thus high reliability.



Bolt calculations taking into account preload and contact area



Hertzian pressures in raceways taking into account the contact angle and raceway edge



Strain on the output shaft for the calculation of the gearing correction

Competent design and calculation

Holistic assessment

During the product design the design engineers analyse all influencing variables in close consultation with customers to ensure that the overall system is optimised. The basis for calculation is the modelling of all parts that affect the component – for example, components that affect the yaw bearing of a wind turbine include the complete main frame and the head of the tower.

Detailed testing

A FEM analysis comprises a wide range of individual calculations. For large diameter bearings this also includes strength assessments of raceways, bolts and rings, as well as strain tests at the sealing points. In addition to the influence of the adjacent construction, contact angles in the rolling elements which also change under load, as well as the raceway edges, are taken into consideration. Gearboxes are examined with regard to strength of gearing, bearings, shafts and housing parts. Comprehensive strain calculations, which form the basis of the design of gearing corrections, are required for the assessment of the load distribution in the gear contacts. For cylinders all radii, bolts, weld seams and large threads such as the piston connection, are verified using FEM. The function of the sealing systems is guaranteed with strain analyses.

Comprehensive testing and laboratory equipment

Verification and improvement of calculation models is an essential prerequisite for useful results and therefore a decisive factor in the development of the long-term reliability of components - including in offshore facilities. Various highly specialised measuring and test benches are available to the development engineers, which can be used to measure, for example, the behaviour of gearboxes or hydraulic cylinders under alternating loads, as well as check the service life.

All influencing variables in sight

There is close consultation with customers, marketing, design, quality assurance and production at all stages of design and manufacture.

Special test bench

Among other things, strains calculated by means of FEM are verified here, and friction and breakaway torque are examined.

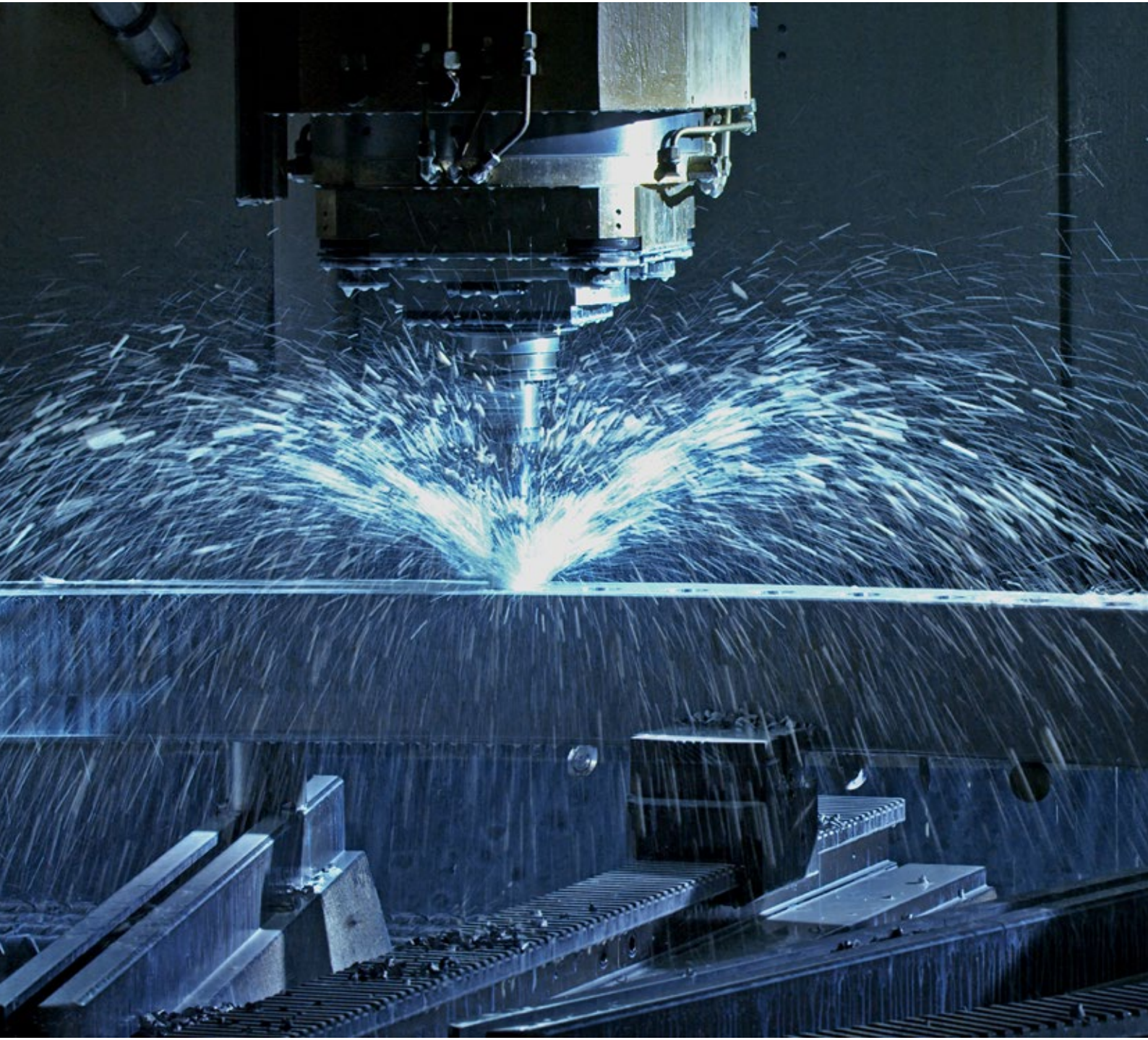
Stress tests in real conditions

Stresses throughout the entire service life of the gearbox are simulated in test runs.



High vertical integration

In order to ensure consistently high quality and reliability, all manufacturing processes must be optimally aligned. Hence why Liebherr improves all production processes on an ongoing basis and continually invests in cutting-edge production facilities.



Optimal process harmonization

High vertical integration

Liebherr has always attached great importance to a high level of vertical integration in the company group. This also applies to the components division. Customers benefit from consistent processes that assure quality and on-time delivery. State-of-the-art production systems ensure that manufactured workpieces are always identical and enable economical manufacture of both large and small components.

Reliable management of critical processes

In addition to the use of excellent materials, the design and management of critical production processes, e.g. friction welding of cylinders or hardening of large diameter bearings, are also important for the service life of a component. With state-of-the-art system technology and in-house developed inductors, Liebherr produces consistently high quality, even for segmented bearings with a diameter over 6,000 mm. The degrees of hardness and the depths of hardness of raceways and gearing are subject to continuous quality testing.

Comprehensive logistics

Upon request Liebherr assumes the entire handling of heavy-duty transport for the transportation of the components to the destination. This includes secure packaging of the component, appointment of a suitable transport company, procurement of all required approvals and scheduling in addition to all other requirements.

Global production network

A global network of production facilities ensures fast availability and low logistics costs. In all plants in Germany, Mexico, China and Brazil work is performed according to the same guidelines and using the same modern system technology, thus ensuring consistent quality across all plants.

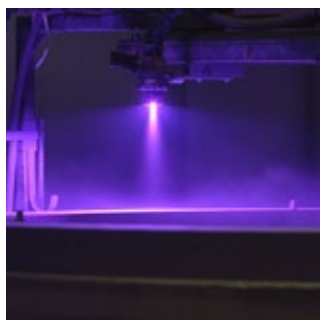
Manufacturing process for gear milling

The gear milling is effected on machines developed and produced by Liebherr.



Surface treatment

Liebherr sets standards in terms of surface protection thanks to the use of state-of-the-art system technology in the coating of components.



Economical production

Production and assembly of Liebherr components are effected in optimised economical batch sizes.



Maximum production accuracy

State-of-the-art and reliable production conditions ensure the production of customised shape and positional tolerances at a high level.



Quality-oriented

Reliable components with a consistently high quality are particularly important for wind turbines in order to avoid long production downtimes and high logistics costs. To ensure that the quality standards achieved in the construction using Finite Element Methods (FEM) and Failure Mode Effects Analysis (FMEA) are also maintained in subsequent processes, all company processes are designed to maintain quality.



Complete quality management assures the high standard

FMEA processes

Design and process FMEAs (Failure Mode and Effects Analysis) are an integral component of development processes and production planning for new parts to reduce the costs of monitoring and error tracking.

Consistent quality management

All production and assembly processes are documented in a computer-supported production data acquisition system. This is also used as a central quality management system that records production and assembly measurements. This makes possible comprehensive control, monitoring and subsequent tracking. A wide range of evaluations not only quickly detects and corrects process deviations but also contributes to the continuous improvement of processes. The quality management of Liebherr is certified according to DIN EN ISO 9001:2000, starting with the selection of the supplier right up to the after-sales service.

Unique measuring equipment

In addition to the standardised measuring equipment used during production, Liebherr also has a wide range of highly specialised measuring equipment. For instance, in recent years at the Biberach facility there was an investment in a fully climate-controlled large diameter bearing measuring chamber for the 3D measurement of large diameter bearings with diameters of up to 6,000 mm. This is unique worldwide.

Testing critical characteristics

Uncompromising assurance of delivery quality includes 100% testing of particularly critical dimensions and surface values of our components, e.g. in the area of the hardened raceways and gearing. Using modern measuring equipment pinion gear wheels are not only measured, but also examined for grinding burn.

Examination of hardness and hardness depth

- By means of 100 % measurements
- In-house-developed inductors



Unique measuring equipment

- 3D measurement
- High-frequency magnetisation



Classification companies

- Bureau Veritas
- Lloyd's Register of Shipping
- Det Norske Veritas
- and others

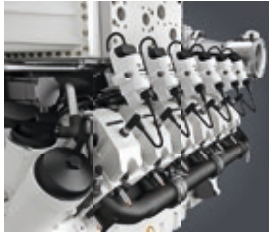


Use of state-of-the-art measuring and testing methods

Complete documentation of manufacturing and test processes guarantees top quality.



Liebherr Components



Gas engines



Diesel engines



Fuel injection systems



Axial piston hydraulics



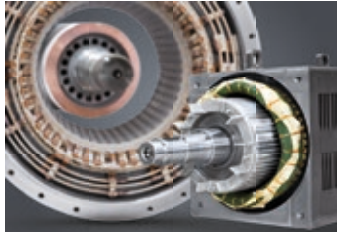
Hydraulic cylinders



Large diameter bearings



Gearboxes and winches



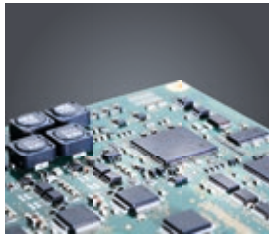
Electric machines



Remanufacturing



Human machine interfaces



Control electronics



Power electronics



Switchgear



Software

From A to Z – the components division of the Liebherr Group offers a broad range of solutions in the area of mechanical, hydraulic, electric and electronic drive system and control technology. The efficient components and systems are produced at a total of ten production sites around the world to the highest standards of quality. Central contact persons for all product lines are available

to our customers at Liebherr-Components AG and the regional sales and distribution branches.

Liebherr is your partner for joint success: from the product idea to development, manufacture and commissioning right through to customer service solutions like remanufacturing.

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