

TIMKEN

WIND ENERGY SOLUTIONS



Around the world, wind turbine designers and operators are turning to Timken for power transmission and friction management solutions that increase uptime and improve total system performance. Through customer collaboration and technical innovation, we are advancing tomorrow's wind turbine designs today.

A TOTAL SYSTEM APPROACH

Timken has more than a century of experience helping customers solve their toughest technical problems. None are more challenging than those facing the wind energy industry. As wind turbines continue to grow in size to increase energy output, systems are subject to greater loads and expectations than ever before.

Throughout the entire lifecycle of a bearing, Timken is there to help maximize equipment performance. We collaborate with turbine and gear drive designers to explore the wide range of operating parameters commonly experienced by wind turbines. Using our proprietary engineering system – Syber Advanced System Analysis – we can identify optimum friction-management solutions for each application. For turbine operators, Timken provides a full range of support to maximize equipment performance and reliability, from replacement bearings and remanufacturing services to condition monitoring and lubrication systems.



DRIVING INDUSTRY CHANGE

We work with customers to apply the right product for the right application. For example, while spherical roller bearings are useful in certain turbine applications, we are leading a design shift toward tapered and cylindrical roller bearings in large megawatt turbines. These bearing designs provide the greatest performance potential in the most compact design possible – reducing system size, weight and manufacturing costs.

INNOVATIVE NEW DESIGNS

We are creating new products and technologies that are transforming the way turbines are designed. Our power transmission advancements have inspired the development of planetary gear bearing assemblies like the Timken® integrated flexpin bearing, which enables smaller, lighter gears for weight-sensitive wind gear drive systems.

GLOBAL CUSTOMER SUPPORT

With nearly 200 technology, manufacturing, sales and distribution facilities in 26 countries, Timken has a global network with a single commitment to meeting customer needs everywhere. Technical and service engineers are stationed worldwide to quickly respond to customer requests.

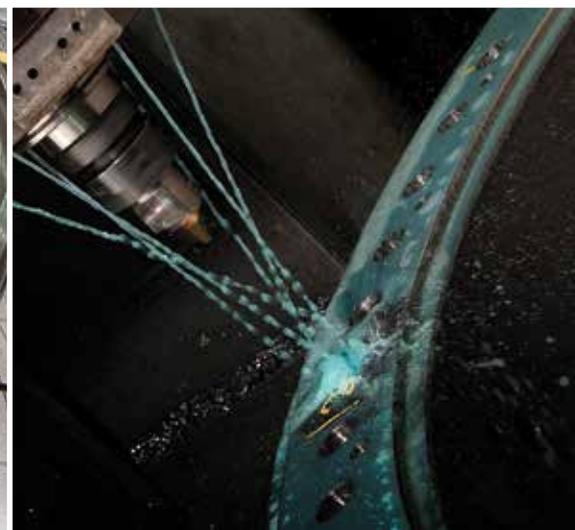


The Wind Turbine Challenge

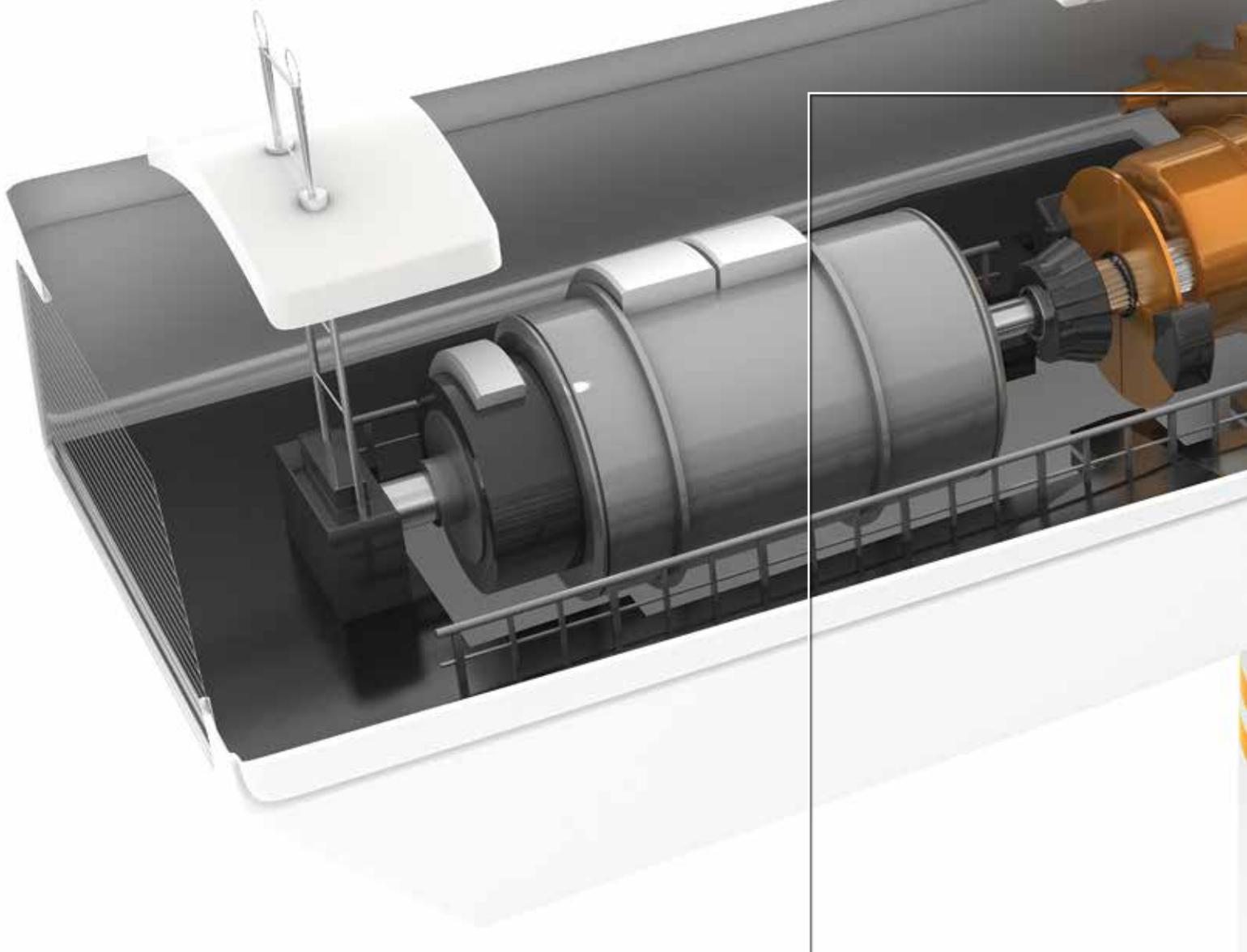
- + Costs associated with turbine operation and maintenance
- + High incidence of bearing-related performance issues and the impact on equipment reliability
- + Managing greater loads as wind turbines grow in size to increase energy output
- + Maintaining a reduced head mass size as turbines increase in megawatt size
- + Supply chain constraints that impact bearing availability

The Timken Solution

- + Our products are designed to improve reliability and performance, helping to increase equipment uptime and productivity
- + To optimize performance, we address the complete wind turbine system, not just the main shaft and gear drive
- + Power dense Timken® bearing designs help reduce wind turbine capital costs
- + Our total lifecycle approach supports customer needs for the duration of a bearing's useful life and beyond
- + Timken service engineers provide on-site troubleshooting, technical assistance and training
- + Our global manufacturing footprint allows us to supply products locally, simplifying logistics



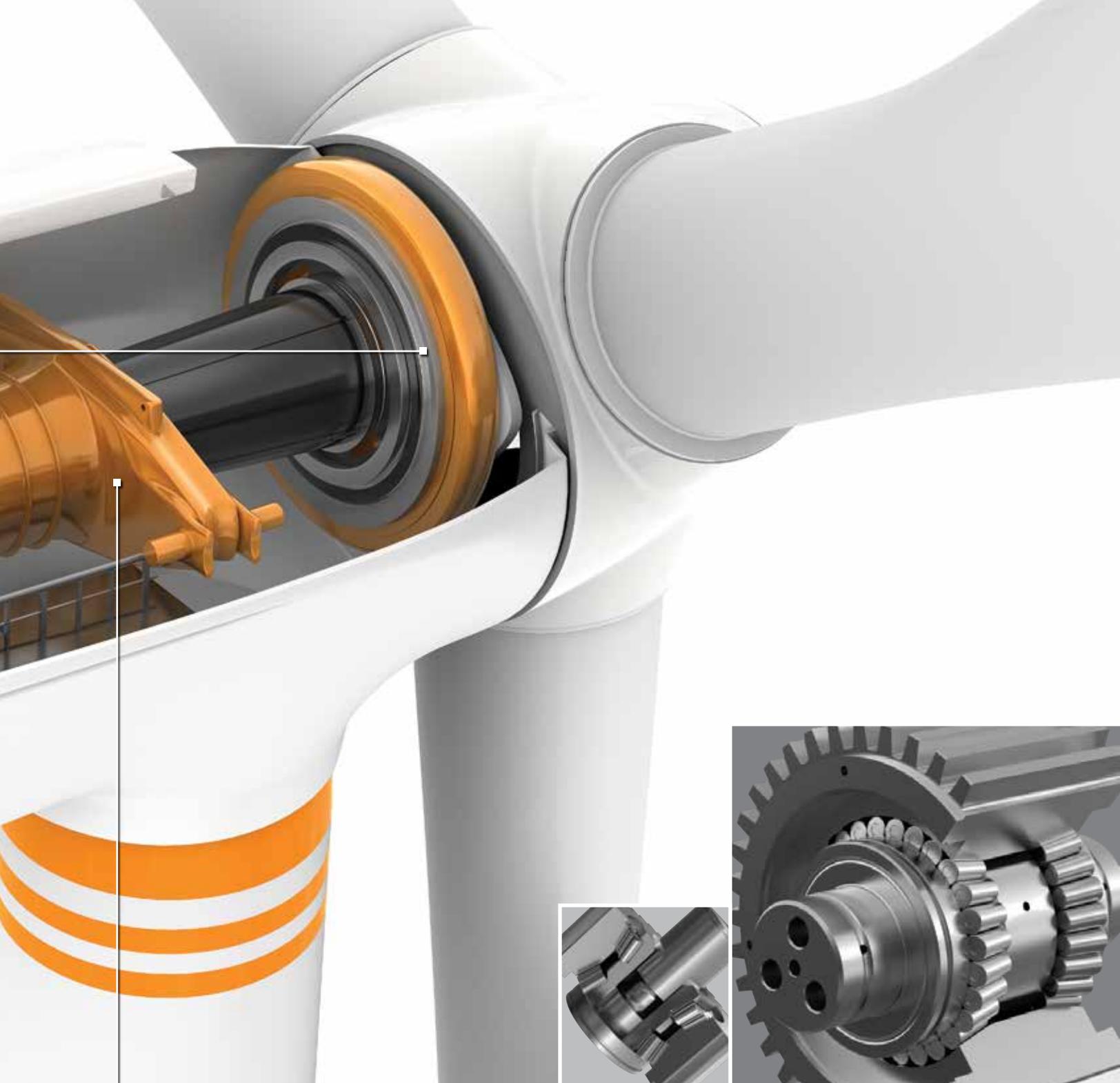
TIMKEN® BEARINGS FOR MODULAR WIND TURBINES



MAIN SHAFT

Pillow Block

- + Double-Row Tapered Roller Bearing (Type TDI) with Cylindrical Roller Bearing
- + Tapered Double-Outer-Row Roller Bearing with Spherical Outside Diameter (Type TDODA)
- + Single-Row Tapered Roller Bearing (Type TS)



MAIN GEAR DRIVES

Parallel Shaft

- + Tapered Roller Bearing for Locator Position
- + Double-Row Tapered Roller Bearing (Type TDI)
- + Cylindrical Roller Bearing
- + Single-Row Tapered Roller Bearing (Type TS)

Planetary

- + Integrated Flexpin Bearing
- + Planet Pac Bearing
- + Single-Row Tapered Roller Bearing (Type TS)
- + Cylindrical Roller Bearing

Carrier Support

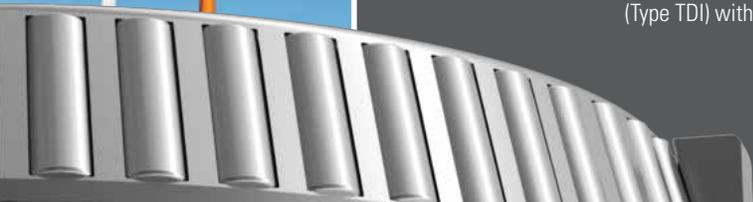
- + Cylindrical Roller Bearing
- + Single-Row Tapered Roller Bearing (Type TS)

TIMKEN® BEARINGS FOR DIRECT DRIVE WIND TURBINES



Direct Drive

- + Ultra-Large Double-Row Tapered Roller Bearing for Main Shafts
- + Single-Row Tapered Roller Bearing (Type TS) System
- + Double-Row Tapered Roller Bearing (Type TDI) with Cylindrical Roller Bearing



TIMKEN® BEARINGS FOR HYBRID WIND TURBINES



Hybrid

- + Ultra-Large Double-Row Tapered Roller Bearing for Main Shafts
- + Cylindrical Roller Bearing
- + Single-Row Tapered Roller Bearing (Type TS)
- + Double-Row Tapered Roller Bearing (Type TDI)



TIMKEN® BEARINGS

TAPERED ROLLER BEARINGS

Designed to bear both thrust and radial loads, tapered roller bearings are ideally suited for managing application stresses as the wind changes in both velocity and direction. They are also power dense, providing the greatest performance in the most compact design possible.

Single-Row Tapered Roller Bearing (Type TS)

This bearing design supports all combinations of radial and thrust loading with true rolling motion on the raceway contacts. Internal clearance can be set during assembly. Separable inner and outer races make assembly easier during equipment builds and routine maintenance.

Double-Row Tapered Roller Bearing (Type TDI)

With two rows of rollers and a one-piece inner race, these direct-mount tapered roller bearings support all combinations of radial and thrust loading without inducing additional loading on the main shaft. This bearing design is excellent for locating positions on the main shaft and in gearboxes.

Tapered Double-Outer-Row Roller Bearing with Spherical Outside Diameter (Type TDODA)

This unique design is preloaded to minimize vibration and wear on the main shaft. It also deters false brinelling while the rotor is stationary. Preloading reduces main shaft axial movement, which helps minimize gearbox thrusting. These bearings also can be retrofitted to most wind turbines already in operation.

Ultra-Large Double-Row Tapered Roller Bearing for Main Shafts

This single, compact bearing design is ideal for direct drive wind turbines. The double-row tapered roller bearing is preloaded to help maximize system stiffness, load zones and bearing L10 fatigue life. The versatile race construction can accommodate seal-riding surfaces, bolt circles, pilots and other special features.

Tapered Roller Bearing for Locator Position

These tapered roller bearings are designed specifically to fix the location of parallel shafting in a compact axial space within helical and spur gear drive systems. The single-row construction is designed to improve bearing efficiency and supports all radial loading and bi-directional gear thrust. Locator bearings operate with 360° roller contact in positive torque power generation conditions, which helps maintain continual gear contact.



CYLINDRICAL ROLLER BEARINGS

Cylindrical roller bearings are a popular choice for several wind turbine applications because they offer greater radial load carrying capability than other bearing types. They are the preferred bearings for non-locating bearing positions and provide outstanding float capability along the true-rolling-motion surfaces between the raceways and rolling elements.

SPHERICAL ROLLER BEARINGS

Timken currently manufactures a broad range of spherical roller bearings, which are designed to manage high radial loads even when misalignment, poor lubrication, contamination, extreme speeds or critical application stresses are present. Spherical roller bearings are only suitable for certain wind applications.

ADVANCED PLANETARY GEAR ASSEMBLIES

For highly challenging planetary gear drive applications, Timken offers two advanced assemblies that provide more power than traditional system designs.

Integrated Flexpin Bearing

This assembly helps gear designers reduce system weight and size while increasing power throughput. The integrated flexpin bending pattern also equalizes load distribution among planets and the gear face for greater bearing life and performance. Load distribution is improved through flexible pins that help equalize force distribution among the planets while transmitting torque at various levels. The preset bearing clearance range helps simplify installation and handling.

Planet Pac Bearing

Integrated planet gear bearing assemblies feature finished races that maximize resistance to gear pitting fatigue. The fully-integrated design helps reduce wear, debris and added clearances created by the outer bearing races precessing inside of the planet gears. One- and two-piece straddle carriers help maintain structural performance and provide enough space for bearings while keeping the design compact enough to reduce system weight and costs.



TIMKEN® INTEGRATED FLEXPIN BEARING IMPROVES PLANETARY GEARBOX LOAD DISTRIBUTION AND RELIABILITY

While planetary gearbox designs offer higher power density and greater performance than other configurations, they can also cause high bearing loads and design complexity. The Timken integrated flexpin bearing offers a solution.

Greater power density is achieved by integrating the bearing components, gearing and shafting. The integrated flexpin bearing also offers design flexibility because it can be used with a variety of gearing system

configurations. Additional surface treatments to gear faces and rolling elements are available for improved equipment life and efficiency.

RELATED PRODUCTS AND SERVICES

HIGH PERFORMANCE BEARING SOLUTIONS

Timken® high performance bearings feature advanced materials, surface finishes, internal geometries and coatings. These products are ideal for the most demanding bearing applications.

Engineered Surfaces

Timken's coatings and surface finishes can be applied to wind turbine bearings and gears for enhanced fatigue life, corrosion resistance and friction reduction. For example, topographical modifications help reduce friction in low-lubricant environments, while extremely hard coatings provide resistance against abrasion caused by normal wear.

Debris Solutions

Bearing raceways in wind gear drives are frequently required to operate in lubricants that are contaminated with large-particle debris emitted from gears and other sources. These large particles dent bearing raceways and typically reduce the fatigue life of standard bearings. To combat these problems, Timken offers debris-resistant bearings.

Timken debris-resistant bearings are created through proprietary heat-treat processing, material selection and unique process controls. The result is an optimized combination of strength, ductility and toughness. In fact, our test results show that Timken debris-resistant bearings offer up to three times more fatigue life than standard bearings in a high-debris environment.

We also use computer-based analysis tools to help customers identify the type and source of debris in a system. Based on this analysis, designers and operators can choose the appropriate debris solution for their application.

LUBRICATION

Our full line of Timken® grease offers a variety of consistencies and additives to suit specific application needs. We also offer single- and multi-point lubricators that deliver grease at preset intervals, helping to reduce maintenance and ensuring that a proper supply of fresh lubricants is delivered to the bearings. They are particularly useful in applications like wind turbines, which can have more than 70 points of lubrication. Common applications include lube points in generators, main bearings,

yaw and pitch bearings, fan blade bearings, yaw and pitch gears, blade switch drives and slewing rigs.

Timken M-Power lubricators are mechanically powered and provide lubrication to a single point, while our centralized C-Power system manages up to six points of lubrication for bearings, gears and non-rotating parts, helping to reduce service intervals. For example, using a remote installation, the C-Power system can lubricate a main shaft bearing for a 12-month service interval.

SEALS

Timken® seals are developed using innovative material and process solutions to help protect machinery, prevent contamination and minimize wind turbine downtime. Our high-performance industrial seals and bearing isolators help keep lubrication in and contaminants out.

RELIABILITY SOLUTIONS

As wind velocity and direction changes, turbines are subjected to variable speeds, loads and operating temperatures. Timken's reliability solutions help predict unforeseen mechanical



problems so you can get the most out of your equipment. We combine our engineering expertise with advanced condition monitoring equipment to help improve the reliability of your wind turbine system.

For example, the Timken Online Intelligence System for wind applications looks at vibration, shock pulses and a number of optional analog and digital inputs to discover potential problems before they occur in gear drives, generators or shaft bearings. The Timken system is ideal for wind applications because it addresses monitoring challenges such as short data windows, transient vibrations, signal challenges and slow speeds. Alarms can be adjusted for current conditions, but can still handle inevitable fluctuations with precise readings. Then when a problem is detected, highly-trained and certified reliability engineers analyze the data, conduct onsite testing and prescribe corrective actions.

Additional reliability solutions that are tailored to the unique demands of wind turbines include:

- + Vibration analysis
- + Infrared thermography
- + Oil analysis

- + Video imaging
- + Ultrasonic testing
- + Balancing and alignment
- + Root cause failure analysis

MAINTENANCE TOOLS

Proper handling and maintenance procedures are critical to bearing performance. We carry a complete line of easy-to-use tools that help decrease downtime and operating costs associated with routine maintenance. Timken maintenance tools are designed to make maintenance quicker, easier and safer. Our offering includes:

- + Induction heaters
- + Hydraulic and self-centering hydraulic bearing pullers
- + Mechanical bearing pullers

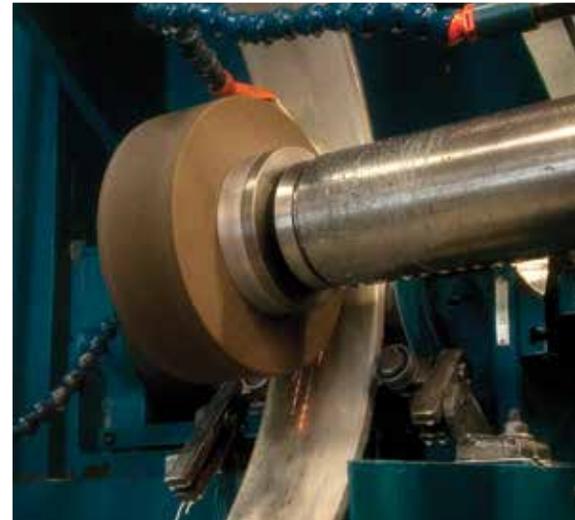
BEARING REMANUFACTURING

Our comprehensive bearing remanufacturing services help turbine operators save both time and money. Lead times for remanufactured bearings are much shorter and can save you up to 60 percent off the cost of purchasing new.

Timken provides repair services for all bearing types, including tapered, spherical, cylindrical, ball and thrust – and we accept all premium brands for remanufacturing.

Timken's capabilities for the wind energy industry include bearing remanufacturing for gear drive applications. During this process:

- + Bearing assemblies are cleaned and examined
- + Raceways are reground
- + New roller sets are manufactured
- + Internal clearances are reset



IMPROVE RELIABILITY WITH THE TIMKEN ONLINE INTELLIGENCE SYSTEM FOR WIND

Avoid unplanned downtime and costs by identifying potential issues before they cause a problem. The Timken Online Intelligence System for wind features a flexible modular design, allowing for a broad

combination of measurements to meet your operating requirements.

This system is composed of a Commander Unit and up to four shock pulse, vibration and/ or analog measuring units, allowing for up to 32 channels. Since the units operate

separately, any number can be installed. Measurement results are transferred via Ethernet to diagnostic software on your computer – so you or a Timken reliability engineer can monitor turbine conditions 24/7.

TIMKEN

The Timken team applies their know-how to improve the reliability and performance of machinery in diverse markets worldwide. The company designs, makes and markets high-performance mechanical components, including bearings, gears, belts, chain and related mechanical power transmission products and services.

Stronger. **Commitment.** Stronger. **Value.** Stronger. **Worldwide.** Stronger. **Together.** | Stronger. **By Design.**

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