Allianz Global Corporate & Specialty

Allianz Center for Technology

Investigation into the dynamic behaviour of drive trains in wind energy converters

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The Allianz Center for Technology (AZT) has been investigating damage in the field of wind energy for more than 15 years. To obtain further insights into damage mechanisms of drive train components, we began measuring operational behaviour and drive train loads approximately 10 years ago. Since then, we have conducted extensive measurements for different wind energy converters ranging from 600 kW to 5 MW, including prototype units.

As the air flow over the rotor blades is irregular due to gusts, turbulence and inclined flow, wind energy converters are subject to highly dynamic loads. The design of the drive train significantly influences how loads affect individual components.

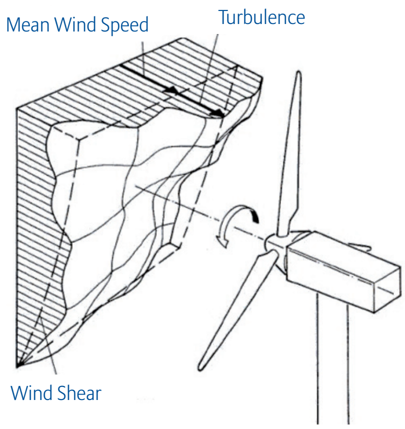

Image 1
Source: Erich Hau: Windkraftanlagen, Springer Verlag 2003

Three-point rotor suspension

In wind energy converters with gear boxes of up to around 2.5 MW, the three-point rotor suspension is a common drive train design. The three support points are formed by the main bearing and the two torque arms fitted to the sides of the gear box (see image 2). In this bearing design, bending moments are supported by the gear box. Transverse forces enter the first planetary stage of the gear box, which affects both load distribution in the tooth mesh, as well as, load distribution onto the individual planet gears and their bearings.

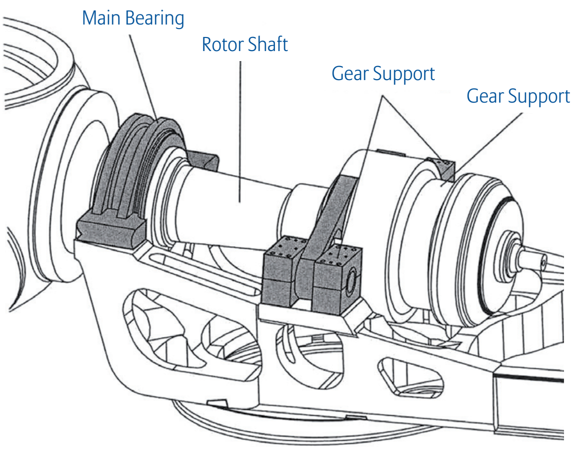

Image 2
Source: Erich Hau: Windkraftanlagen, Springer Verlag 2003

Measuring the relative axial and radial movements between rotor shaft and gear box shows highly dynamic displacements of the rotor shaft that prevail for significant parts of the measurement period. Image 3 shows an example of the path of movement described by the rotor shaft relative to the gear box.

Image 3

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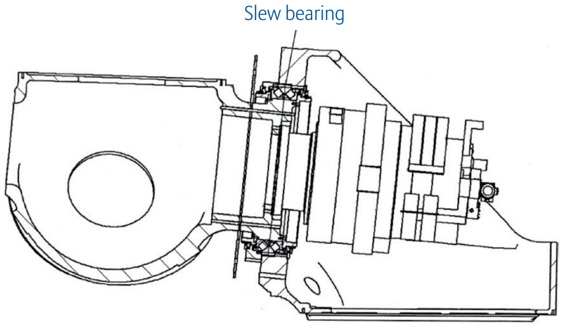
Summing up, we can see that the displacements introduced in the first planetary stage cause significant local strain, thus explaining untimely fatigue of gears and bearings. However, this applies only to the test cases- no general assumptions can be made at this point. The pronounced axial momentum of the rotor shaft that we have also found can be explained by the relatively large axial play of the main bearing manufactured as a spherical roller bearing.

Drive train with separate rotor bearings

In multi-megawatt wind energy converters with separate rotor bearings, we currently find designs with two main bearings, e.g. Repower 5 M, as well as, with a single bearing, e.g. BARD 5.0 (image 3). The latter is also called a slew bearing, which absorbs radial and axial loads and tilting moments from the rotor.



Source: BARD Emden Energy

We conducted extensive operational measurements on the BARD 5 MW prototype on behalf of BARD Emden Energy in order to investigate the gear strain. Over the course of a year, a total of approximately 90 measurement signals were captured and recorded. The impact on the bending moments behind the slew bearing recorded in this wind energy converter is low compared to the excessive bending moment increases seen in rotors with three-point suspension. A significant deviation (especially considering that the investigation lasted longer than one year) from the sinusoidal pattern of the bending moment is represented in the 21 rotor revolutions in image 4. The development of the blade root bending moments confirms the excitation by rotor input, which is caused by wind speeds varying at different locations across the rotor area.

Our investigation into the 5 MW wind energy converter BARD 5.0 has shown that the combination of separate rotor bearing and a special elastomeric hydraulic gear box carrier is effective in reducing external constraining forces acting on the transmission input stage.

Are you interested in reading the full technical paper?

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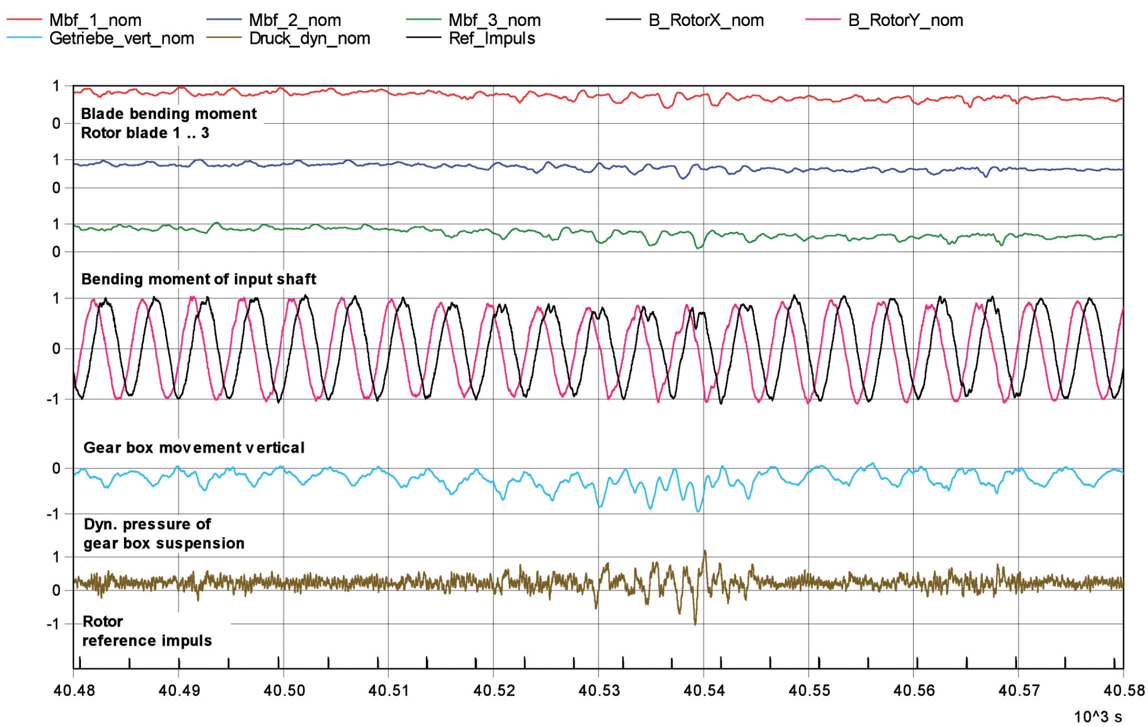
Image 4



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