Monitoring of Blade Bearings

IWES Offshore R&D Conference

November 2018
Company Portfolio

Eolotec GmbH

- Established 2012
- Bearing knowhow since 2004
- Focused on large wind turbine bearings
- Located in Nuremberg
- 10 employees
- Several awards
- Production in Germany
- Engineering, prototypes, series
- Bearing services and consulting
- On Demand R&D
Eolotec GmbH

Products

- Bearing Systems
  - Ready to mount Main Bearing Units (MBU)
  - Exchange solutions

- Lifting, testing, assembling
  - Rotor-mounting
  - Generator lifting
  - Blade bearing testing

- Sensor systems
  - Premesy: reliable pre-load control
  - BBG: blade bearing monitoring
Load situation in blade bearings

Bearings and geometries

- Up to now: one or two-rowed preloaded ball bearings (four-point bearings)
- Technical design with cage or spacers
- Raceways are induction hardened
- Pitched rings might have gears
- Bolt connection of rings with blade and hub
Load situation in blade bearings

Rotor loads

🌞 Bending moments are dominating loads

→ High alternating bending moments with rotor frequency
Load situation in blade bearings

Influences on bearing deformation

- Calculation of the system with hub, blade and bolts (only rings visualized)
- Deformation visualized in hundredfold enlargement

➡ Strong misalignment of the rings
Ordinary Bearing Monitoring

Blade Bearing Examination

- Recognizable noises during pitching
- Delayed pitching
- Different pitch current
- Offline measurement of axial tilting clearance
- Grease samples
- Ultrasonic measurements
## Ordinary Bearing Monitoring

### Blade Bearing Examination

#### Grease sample

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<th>WEAR</th>
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<table>
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<tr>
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<td>Wasser K. F.</td>
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→ Sample quality depends strongly on sample point  
→ Pollution not comparable with rotating bearings
Damages During Operation

Possible damages

- False Brinelling
- Edge chipping
- Broken rolling elements
- Secondary damages due to overrun
Damages During Operation

Possible resulting damages

- Damages on pitch adjustments
- Sealing damages
- Failure of connecting elements
Damages During Operation

Blade Bearing Cracks

- Outer ring, (geared pitch)
- Outer ring, (hydraulic pitch)
- Inner ring, (geared pitch)

Increasing number of ring cracks in field
Damages During Operation

Blade Bearing Cracks

- 2.5MW turbine: Broken outer ring – working bolt connection
BBG - Blade Bearing Guard

Monitoring Solution BBG

Measurements with at least one sensor per blade bearing

Data processing and automated monitoring

Detailed failure evaluation and planning of replacement
BBG - Blade Bearing Guard

Monitoring of changes in deformation

- Monitoring of load $M_{XB}$ by measuring the deformation of the rings

![Load simulation](image1) ![Real deformation](image2) ![BBG measurement](image3)

- Wear processes within the rings and the rolling elements lead to an increased deformation of the rings

- Ring cracks, ball breakage or outbreaks have direct influence on ring deformation

→ The continuous monitoring allows to detect the probable time of failure
BBG - Blade Bearing Guard

BBG User Platform

- An online platform displays the BBG measurements of all wind turbines

- Customer access to online platform
Exemplary measurement on BBG-Platform
BBG - Blade Bearing Guard

Exemplary measurement on BBG-Platform

Measurement of complete rpm range

Classified 10-13 rpm
Comparison of different measurements

Turbine in operation: 2,4 MW power class new bearings

Turbine in operation: 2,5MW power class with issues
BBG - Blade Bearing Guard

Currently installed on 8 different turbine types
Over 40 systems in field

- BBG Box monitors each single blade bearing
- Independent of controller or CMS
- Minimal power use
- No impact onto turbine structure
- Designed for rough conditions IP54
- Low data rate (< 100 kB/box)

Adaptive assembly enables application in all common turbines
BBG - Blade Bearing Guard

BBG Boxes in different turbines
BBG - Blade Bearing Guard

Sensor installations (examples)
Conclusion

- BBG system provides reliable information to the current condition of blade bearings
- Due to the low slewing rate the damage progress is comparatively slow
- Measured deformation increases with growth of damage
- Appropriate measures can keep a pre-damaged bearing operational
- A potential exchange can be scheduled in advance
- Targeted monitoring by BBG makes further operation possible