Selection of Lubricating Greases for Wind Turbine Pitch Bearings

Fabian Schrack, Norbert Bader, Fabian Halmo, Steffen Hellmedag, Gerhard Poll
Leibniz Universität Hannover, Institute of Machine Design and Tribology

Introduction

The pitch bearing allows the rotor blade the required oscillation to control the power and loads of the wind turbine. All modern turbines use this control strategy.

Wear phenomena like false brinelling and fretting corrosion may occur due to the oscillation. These effects can occur after a few pitch cycles. Particles and abrasive wear can be the consequence. In the worst case, the occurrence of wear can lead to a loss of bearing function and thus to a turbine shutdown or loss of pitch control.

Grease Lubrication

The selection of proper grease lubricants could help to avoid wear in blade bearings.

The greases used in pitch bearings differ greatly.

Which grease should be selected for pitch bearings under individual pitch control conditions?

Grease Lubricants 101

- **Thickener**: Thickeners are usually based on Lithium, Calcium, Barium or Sodium soaps.
- **NLGI consistency number**: The NLGI number characterizes the grease consistency. 000 is very fluid while 6 is does not flow easily.
- **Base oil types**: Synthetic or mineral oils are used as base oil.
- **Viscosity**: The viscosity of the base oil varies between 18 cS and 460 cS for pitch bearings.
- **Additives**: Mostly anti-wear additives are used in greases for pitch bearings.

Properties of greases used in experiments

<table>
<thead>
<tr>
<th>Grease 1</th>
<th>Thickener</th>
<th>Base oil</th>
<th>NLGI</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium complex</td>
<td>Mineral</td>
<td>1</td>
<td>130 mm²/s</td>
<td></td>
</tr>
<tr>
<td>Grease 2</td>
<td>Lithium</td>
<td>Synthetic</td>
<td>2</td>
<td>50 mm²/s</td>
</tr>
<tr>
<td>Grease 3</td>
<td>Lithium</td>
<td>Estar</td>
<td>1-2</td>
<td>300 mm²/s</td>
</tr>
</tbody>
</table>

Methods

**Downscaling**

The ratio of pressure and path of rolling element (x/2b) is constant for both bearing sizes. This leads to similar tribological behavior. 3 operating parameters where tested under downscaled conditions.

Different grease lubricants are tested under downscaled IPC conditions on a special test rig. All greases are used in wind turbine pitch bearings. The right table gives an overview on the properties.

Surface analysis with Laser-Scanning microscope

- **Amplitude 1.5°**
  - Frequency 6.0 Hz
  - Small oscillating amplitudes and high frequencies promote the occurrence of false brinelling.
  - With increasing number of oscillation cycles, the mild wear may escalate into vast wear which can diminish the service life of the bearing.
  - On first sight it is hard to determine the differences between the wear marks. Detailed analysis of the roughness and the height profiles show that Grease 2 shows the lowest wear rate.
  - For these test conditions, a lubricant with low viscosity shows the best results due to the better replenishment behavior.

- **Amplitude 20°**
  - Frequency 2.5 Hz
  - The large oscillating amplitude and high frequency lead to high rolling element speed. This leads to oscillation, i.e., insufficient replenishment.
  - Under these test conditions none of the greases could avoid wear.
  - Grease 2 shows the best results.
  - This behavior is attributed to the solid lubricants contained in the grease.
  - These test conditions are very challenging. To minimize wear it seems best to change the controller by decreasing the pitch speed, thus avoiding problematic operating conditions.

- **Amplitude 40°**
  - Frequency 0.2 Hz
  - The oscillating amplitude and low frequency lead to moderate speeds and big rolling distances. Grease 1 and grease 2 show a good surface which is close to the production state.
  - Grease 3 shows extensive wear, which was not expected due to the high viscosity, i.e., superior high film thickness.
  - A possible explanation for the high wear could be a too low oil bleeding capability of grease 3.
  - For these conditions a high viscosity is useful. However further parameters (oil bleeding, additives) may contribute to a system with low wear.

Conclusion

- None of the greases could avoid wear for all test conditions
- Possible positive effect of solid lubricants
- Possible effect of amount of oil bleeding
- Different root causes and different phenomena of wear
- Requirements for different operating conditions mutually exclusive
- Controlling concepts need to be more tribological friendly to implement individual pitch control

References


Partners

Federal Ministry for Economic Affairs and Energy

Project: Highly Accelerated Pitch Bearing Test

windeurope.org/confex2017

#windeurope2017