PO.161

Controlling loads in a wind turbine drivetrain
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1: Abstract

Wind turbine drivetrains are subjected to large dynamic loads, coupling two high inertia components with rapidly changing aerodynamic and generator loads. Events including emergency stop, gust, and grid changes cause torque overload, torque reversal and non-torque gearbox loads.

Driveline reliability continues as an issue, with evidence from insurers showing the claims remain high for gearbox failures in offshore wind turbines.

Ricardo proposes controller and mechanical solutions to control loads into wind turbine gearboxes, and therefore attain controlled reliability.

2: Objectives

- Show the importance of understanding the true failure mechanisms
- Show the importance of understanding transient effects
- To show a means of reducing or avoiding damaging transient overloads

3: Understanding the true failure mechanisms

Bearing fatigue life can be assessed to ISO standards 281 & 16281. However, these only consider conventional high cycle fatigue damage.

These standards have not adequately predicted failure of bearings in wind turbine applications. These effects are particularly important in the case of short term overloads in increasing localized damage, including factors such as local damage, material inclusions, inevitable in large bearings, as studies in [3], a Ricardo sponsored PhD thesis.

4: Causes of transient overloads

Wind turbine drivetrains couple two high inertia components, the rotor and generator. With a variable speed generator, the resistance from the mechanical inertia of the generator still causes large transient torque spikes through the drivetrain.


Impact loads during torque reversal also cause intense transient load spikes, for example during emergency stop or generator events.

5: Controller approaches to reducing transient drivetrain overload

One approach is to reduce overloads by compensating for the generator's mechanical inertia during the short transients when overload would otherwise occur. This is done by transiently reducing the generator electromagnetic torque [6].

This can reduce damage from overload in normal running, but is unable to reduce loads when the generator is not in a normal control mode, such as emergency stop.

6: Avoiding overload: TorqLife™ eliminates transient overload and off-axis force and moment

Industrial gearboxes with well controlled loads do not suffer the failure issues that continue to be seen in the wind industry.

Therefore if we can control torque and off-axis loads to avoid overloads during gusts, grid events and torque reversal impacts, we can attain this level of durability for wind turbine drivetrains.

Ricardo has developed the TorqLife design to do this, and has shown its functionality through simulation and testing.

TorqLife operates between the rotor shaft and gearbox input shaft, transmitting torque through 6 hydraulic cylinders, with articulation to avoid off-axis torques and forces on the gearbox.

Short-term slip in TorqLife controls torque before the pitch system is able to respond, so torque overloads are eliminated.

Multibody and aerelastic simulation has been carried out to show the combined operation of TorqLife with the pitch system, showing the ability to avoid overload with the design proposed.

7: Summary

Understanding loads and metallurgical response allows us to understand issues in wind turbine gearboxes, but we need a means of avoiding conditions that cause failure.

A way to limit damaging loads has been devised, analysed and validated on a scale rig.

Fast hydraulic response works with the pitch system for short and long-term torque control. With controlled torque and no off-axis loads, a 5MW design has been identified and is an enabler for a long-term drivetrain warranty.

This work has been part-funded by the UK Department of Energy & Climate Change, who have audited our calculations for a LOEC reduction of 5-13% [7].

For further information, please contact James Packer (james.packer@ricardo.com)

8: References & Patent application


