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CAN TRANSIENT LOADS OCCUR INTERNALLY IN A PLANETARY GEARBOX?

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Introduction

Since gearbox problems became severe with the upscaling of wind turbines from the beginning of this century and years ahead, there has been a substantial effort to investigate, clarify, understand and solve this problem or possibly shed light on phenomina related to its occurrence. Numerous actions have been taken to remedy these problems, and all together the reliability of gearboxes does not nowadays suffer from mistrust. However, in order to obtain confidence, it is still important to analyse, if unconsidered phenomina were involved in these problems, in order to avoid repetitions. Furthermore, the conclusions on the origin of such serious problems, affect the selection of future concepts for development and upscaling.

Approach

The investigations here are related to the drive train concept where the planetary gearbox also works as the second main shaft bearing.

Main body of abstract

It is the conclusion from our analysis involving full aeroelastic simulations that a single parameter representing the clearance between the gearwheels inside a planetary gearbox is decisive for whether rotor shaft bending moments and wind turbine dynamic response are transferred to large internal loads inside the gearbox. If the gearbox is designed with a sufficiently small backlash in the planetary stage (which would normally be considered attractive) this will be the case due to double contact between the gearwheels. This condition destroys the load sharing between the planetary wheels and creates large bearing forces in the drive direction due to radial forces.

In this condition the radial forces transferred between the planetary wheels and the ring are approximately added directly to the planet bearing forces in the driving direction. As a result of this condition torque ripples occur in the output shaft (sun) that transfers the torque to the next gear stage, which means that this transformation of radial loads from the rotor bending moment to internal load variations are affecting also the high speed shaft and thus the whole gearbox. These torque ripples are thus real, however only happening inside the gearbox, and therefore not easy to detect.

The additional planet bearing loads originating from the rotor bending moments are dependent upon how the three planets in the gearbox are positioned on the shaft relative to the three blades. The difference on loads is about 20% from the most favorable to the worst case. This might contribute to the explanation of gearbox failures seen in the past and explain the variability in failures of apparently identical turbines as the mounting azimuth position is random. Furthermore, it explains why the high speed stages are subject to increased loadings of the order of 15% under such conditions.

Conclusion

The learning is easy: In order to avoid the problem, the planetary stage should be designed with sufficient clearance to avoid double contact due to deflection from any load condition.