A high number of wind turbine gearboxes do not meet their expected design life, despite meeting the design criteria of current bearing, gear, and wind turbine industry standards and certifications. This, in turn, increases the cost of energy generated by wind turbines. To investigate the root causes of these reliability issues, the U.S. Department of Energy and National Renewable Energy Laboratory (NREL) established the Gearbox Reliability Collaborative in 2007, now called the Drivetrain Reliability Collaborative (DRC), of which Romax Technology is an active partner. The collaborative is focused on improving reliability by better understanding loads, improving design tools, and refining testing practices.

A series of gearbox designs have been tested on the NREL 2.5 MW dynamometer in Colorado as part of this effort, with each iteration containing strategic design elements used to validate certain assumptions. Romax Technology and Romax InSight have been involved in the modeling, analysis, design, and testing of these gearboxes since 2008. The final iteration of the test program was Gearbox 3 (GB3), which was tested in late 2016.

The 2.5 MW dynamometer at the NREL National Wind Technology Center allows for accurate replication of field conditions encountered by wind turbines such as transient loading, rotor off-axis non-torque loads (NTL), and grid interface conditions. Romax carried out an engineering assessment of the GB3 test article, focusing on the planetary stage modelling, instrumentation, gearbox assembly, and data analysis.

The design, automotive and off-highway vehicle drivetrain design. The Romax simulation tools allow the complete gearbox system to be analyzed in a fully coupled 6-DOF environment, including the mechanics and stiffness of gears, bearings, housings, shafts, planet carriers and supporting structures. This allows the prediction of misalignment of the gears and bearings, which is one of the key inputs that affect the durability of these components.

The test article was heavily instrumented with strain gauges on the ring gear both internally and externally, strain gauges on the planet bearing, and proximity sensors to measure carrier alignment to the housing as well as housing alignment to the bedplate. The strain gauges placed within the planetary bearing (a pair of tapered roller bearings with the outer races integral to the gear blank) were of particular interest, as this is rarely done. Ten gauges were bonded to the inner races of the bearings (both upwind and downwind) in custom machined grooves. This allowed for the analysis of the variation of the load zone during testing, and correlation with RomaxWind predictions created in the design phase of the project.
As can be seen by comparing the experimental results with RomaxWind analysis, load zones are shifted 20 degrees between the upwind bearing and the downwind bearing rows as a result of the tipping moment created by the axial thrust generated from the helix angle on the planetary gear set.

By employing this more rigid pre-loaded TRB pair in each planet of GB3, compared to the more traditional double row cylindrical bearings used in the predecessor gearbox GB2, great increases in planet bearing reliability are realized.

This more rigid arrangement allows for better load share between the upwind and downwind bearings, which in turn leads to increased L10 life, as predicted in RomaxWind analysis.

It is this combination of advanced analysis tools yielding insight to the design process, backed by innovative testing to confirm these assumptions, that is closing the gap between design-estimated and actual wind turbine gearbox field reliability. Knowledge gained from the Drivetrain Reliability Collaborative is publicly available to facilitate reliability improvements, and ultimately result in improved gearbox design standards and practices.

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