NREL Next Generation Drivetrain

Mechanical Design and Test Plan

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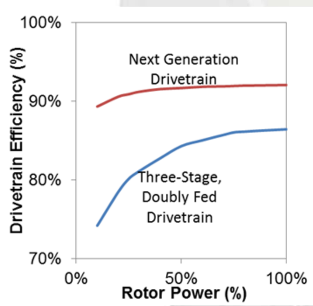
The U.S. Department of Energy and industry partners are sponsoring a $3-million project for design and testing of a next generation wind turbine drivetrain at the National Renewable Energy Laboratory (NREL). This poster focuses on innovative aspects of the gearbox design, completed as part of an end-to-end systems engineering approach incorporating technology advances that minimize capital costs and increase drivetrain reliability, efficiency, and torque density.

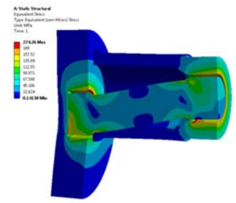
The gearbox features a unique combination of hydrodynamic journal bearings used in the rotating planet pins and "flex-pins" for the planet gear support. Because rolling-element planet bearings are typically the life-critical part of a gearbox, journal bearings that perform effectively reduce the gearbox size, decreasing weight and increasing life. Wind turbine operating loads, however, are challenging for journal bearings and the risks associated with their use at low speeds and frequent starts-stops will be the subject of dynamometer testing. The gearbox utilizes four–planets to strike a balance between achievable ratio and torque density. The flex-pins allow each planet to deflect a small amount circumferentially to permit equal load share. This removes the "oversizing" that is required in conventional designs to account for unequal load share caused by manufacturing variability.

Justification of the gearbox design is presented, followed by a description of the large-scale prototype and the test program that will be used for simulating realistic operating conditions in NREL's 2.5-MW dynamometer.

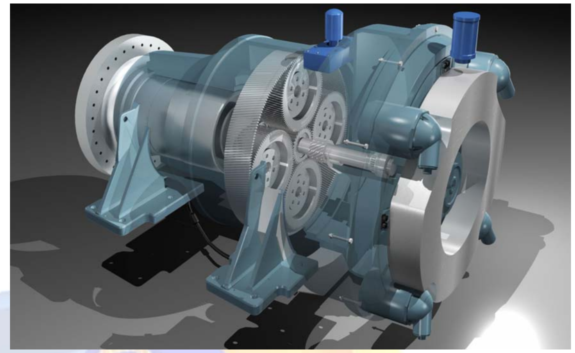


Drivetrain capital costs were estimated for the single-stage, medium-speed configuration and compared to other common configurations. Both direct drive and traditional three-stage gearboxes with induction generator configurations had higher capital costs. The levelized cost of energy was also estimated for each configuration. The expected maintenance costs of a single-stage gearbox are much lower than those of a three-stage configuration, resulting in the lowest cost of energy.

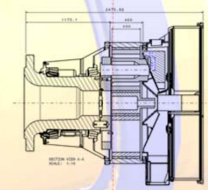
Efficiency is much improved over three-stage doubly fed drivetrains because fewer gear meshes are generating heat. The medium-voltage approach allows for lower currents, which reduce losses. The silicon carbide switches operate more efficiently than typical silicon switches. The test article will be adapted from an earlier prototype built for a 2005 WindPACT project. The main bearing and generator will be reused.



The gearbox design utilizes flex-pins to support the planets. These have been used in Romax and other designs. Additional parts and interference fits are added to the gearbox, but the benefit is in equalizing the load share between the planets. The flex pins are carefully designed to bend in a manner to prevent misalignment of the tooth flanks.



CAD of the drivetrain showing the four-planet gear arrangement



Miba is supplying the journal bearings and carrying out elasto-hydrodynamic simulation of the oil film. The particular concern is with start-up and low-speed operation. These operating regimes will be tested thoroughly in the dynamometer.

A further focus of the dynamometer testing will be on transient electrical loading of the drivetrain with grid-fault conditions. NREL's controllable grid interface enables this testing.

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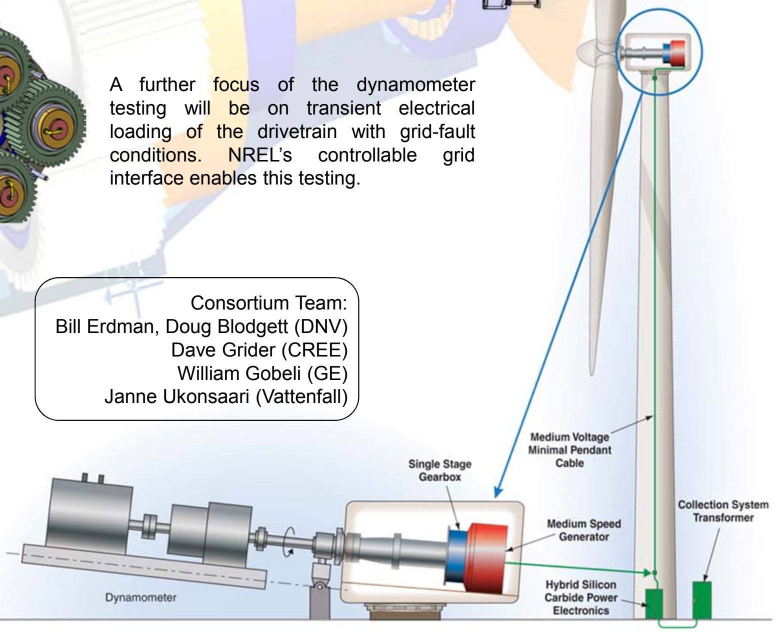

The prototype drivetrain will be tested in NREL's 2.5-MW dynamometer.