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”DYN2#4 - Determining Loads for Down-scaled Testing of Wind Turbine Pitch Bearings using an Augmented Kalman Filter and Reference Measurements”

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This article proposes an approach to determine the loads to apply during down-scaled testing of wind turbine pitch bearings. These bearings present unique challenges and failure modes due to their large size, their limited range of motion, and their loads. Because of these particularities, learnings from more common bearing applications cannot be relied upon. On the other hand, accelerated full-size testing of this type of bearings is lengthy, up to 5 months for one bearing, and expensive, due to the specialized infrastructure required, the assembly costs of the test-bench and the manufacturing cost of the prototype bearing itself. For these reasons, a trend is emerging in the wind industry to down-scale tests with the goal of using already existing, more affordable test-benches to design and test new larger bearings. This raises the question of what loads to apply on the down-scaled test-bench bearing in order to reproduce the fatigue life and defect formation of the larger reference bearing. Manufacturers currently use proprietary methods to determine the loads for down-scaled testing as there is no established standard. Given a specific failure mode, the goal of this work is that the down-scaled testing reproduces stresses at key locations around that failure mode. This ensures that the down-scaled testing is representative of the operation of the reference bearing. First, these key stresses are computed using design loads and a model of the reference bearing. Then, a load-estimation problem is solved around the model of the scaled bearing to determine the loads to apply on this scaled bearing to replicate those key stresses. The resulting inverse problem is solved using an Augmented Kalman Filter, which has proven successful for this type of load-estimation problem. The novelty is that this estimator uses as measurements those key stresses, which, while relevant, cannot be physically measured. Finally, this is validated in simulation by showing that the down-scaled testing replicates the stresses at the chosen key locations. This article demonstrates the proposed approach on the industrial case of testing a 3.4MW wind turbine pitch bearing for ring structural failure using a 1.5MW bearing test-bench.

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