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Publication date: 2016

Document Version
Peer reviewed version

Citation (APA):
Abrahamsen, A. B., & Natarajan, A. (2016). Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System. Poster session presented at The Science of Making Torque from Wind, Munich, Germany.
Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System

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The drivetrain of a 10 MW wind turbine has been designed as a direct drive transmission with a superconducting generator mounted in front of the hub and connected to the main frame through a King-pin stiff assembly. It is found that the initial generator weight of 363 tons must be reduced by 25% in order not to result in higher extreme loads on main and yaw bearing than the 10 MW geared reference drive train. A weight reduction of 50% is needed in order to maintain main bearing fatigue damage equivalent to the reference drive train. Thus a target mass of superconducting direct drive generators is found to be between 183-272 tons.

Front mounted 10 MW superconducting generators
- Superconducting generators can provide high shear forces
- A 10 MW generator design based on MgB2 as start (m = 363 t)
- Length scaled to obtain the 10 MW light weight design of GE based on the NbTi low temperature superconductor (m = 142 t, table A2)
- King-Pin nacelle configuration with two main bearings (10-20 MW)
- 10 MW INNWIND.EU onshore reference turbine (table A1)
- Design Load Cases (DLC): 1.2 Normal operation, 1.3 Normal operation under extreme turbulence and 2.3 Gust + Grid loss

Results & Discussion
- Extreme loads of DLC 2.3 on main and yaw bearing are shown for m = 40, 50, 75 and 100% of initial generator mass as well as reference medium speed drive train in fig 2 and 3. A reduction to 75 % mass gives equal main bearing extreme. Yaw bearing extreme are high, but within the design envelope.
- Fatigue loads of DLC 1.2 on yaw and main bearing are shown in figure 4. A reduction to 50 % is needed to obtain main bearing fatigue similar to the reference medium speed drive train.

Conclusion
The mass of the front mounted superconducting generator should be reduced to 75% to provide equal extreme loads, whereas the fatigue load on the yaw bearing indicate a reduction to 50 %. Thus aero-elastic simulation indicate a target mass of 183-272 tons.

Acknowledgement
The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement No. 308974 (INNWIND.EU). The authors acknowledge the sharing of the nacelle design by Ewoud Stehouwer at GL Garrad Hassan Nederland B.V.