RealCoE

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Developing the Next Generation 12+ MW Offshore Wind Turbine for Clean and Competitive Electricity

Assessment of generator airgap sensitivity under non-torque loads for hybrid testing

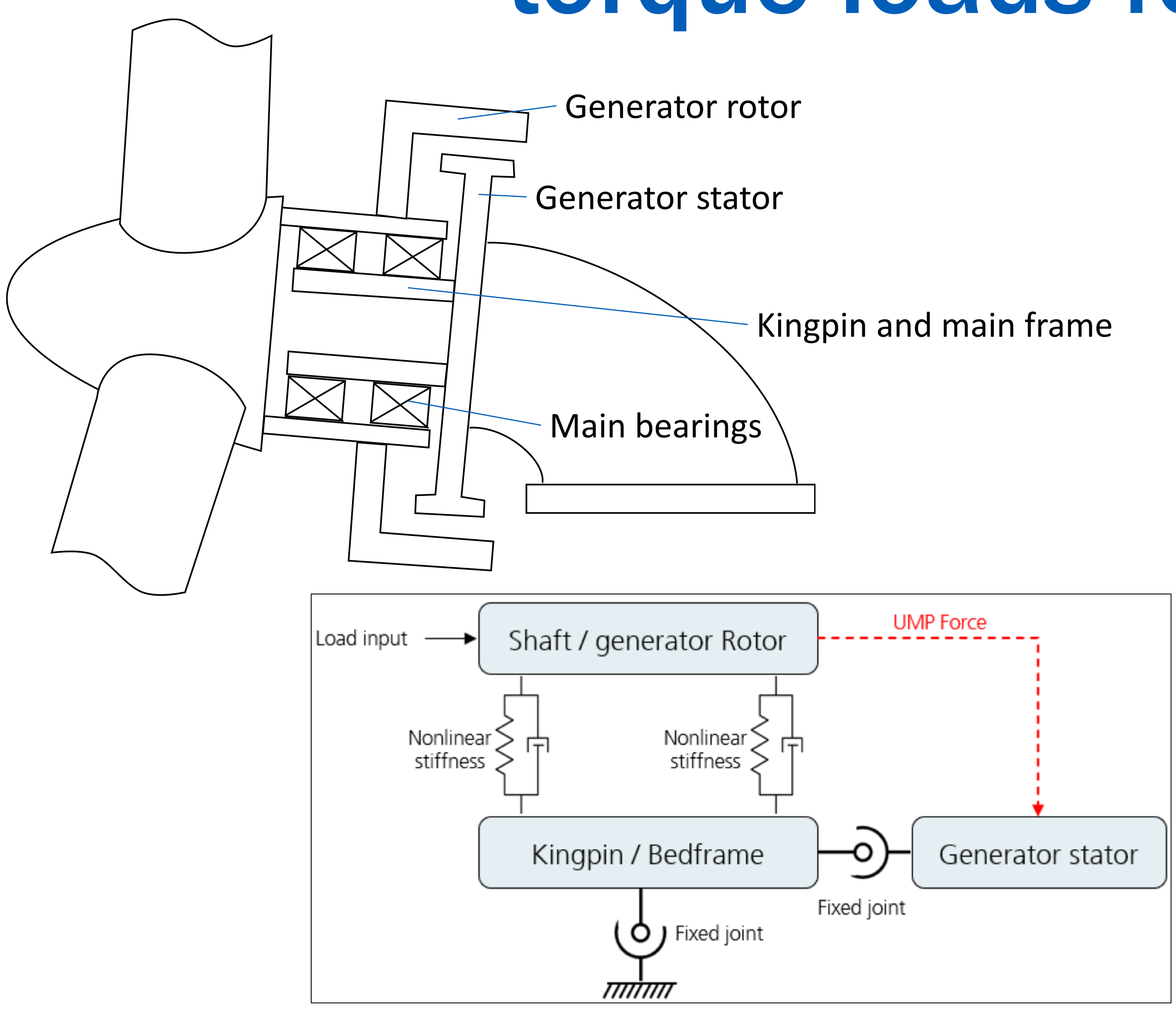

Figure 1: Modified direct drive topology (top) and simulation model setup (bottom)

Hybrid testing for direct-drive turbines

Since the GE Haliade-X uses a specific „pure torque" drivetrain design that decouples non-torque loads from the generator rotor, the drivetrain structure was slightly modified in the simulation model by rigidly coupling main shaft and generator rotor (Figure 1). All major structural parts were modeled as flexible 3D bodies, the main bearings and the unbalanced magnetic pull (UMP) force are implemented as nonlinear force elements. UMP forces can occur in case of non-uniform generator airgap distribution (eccentricity of the rotor), as caused e.g. by large non-torque rotor loads (Figure 2).

Load cases for all NTL directions (axial/radial forces, yaw/tilt bending) have been investigated in the analysis. The results show a comparably low influence on the generator airgap even for extreme loads. The changes in the airgap were proportional to the applied load both in terms of direction and magnitude. This finding shows the general applicability of the hybrid testing approach to the airgap response.

In a further analysis, the influence of the UMP forces was assessed by comparing simulations with and without the effect of UMP forces. This study revealed close to no differences in airgap deflections, since the resulting UMP forces are negligible compared to the acting rotor loads.

Hybrid testing for direct-drive turbines

The development of modern offshore wind turbines requires extensive testing and validation throughout the development process. One major validation step is the full powertrain test on a system test bench, which is typically performed right before or in parallel to the prototype deployment and field measurement campaign. To facilitate such system tests and reduce testing cost, the concept of hybrid testing offers great potential[1]. In hybrid testing, physical experiments of the specimen can be conducted on less powerful and less expensive test benches which don't need to meet the full load application requirements; instead, a validated simulation model of the test setup is used to extrapolate the loads and assess the full-load behavior (and above). This hybrid procedure combines physical and virtual testing, but requires profound knowledge of the nonlinear system behavior, Since partial load data is used to tune and validate the simulation models, the expected nonlinear response at full load needs to be correctly predicted by the virtual model.

Within the research project ReaLCoE, the nonlinear behavior of the generator airgap at various non-torque rotor loads (NTL), one of the most important parameters of a direct-drive, has been investigated with means of flexible multi-body simulation to assess its suitability for the hybrid testing approach.

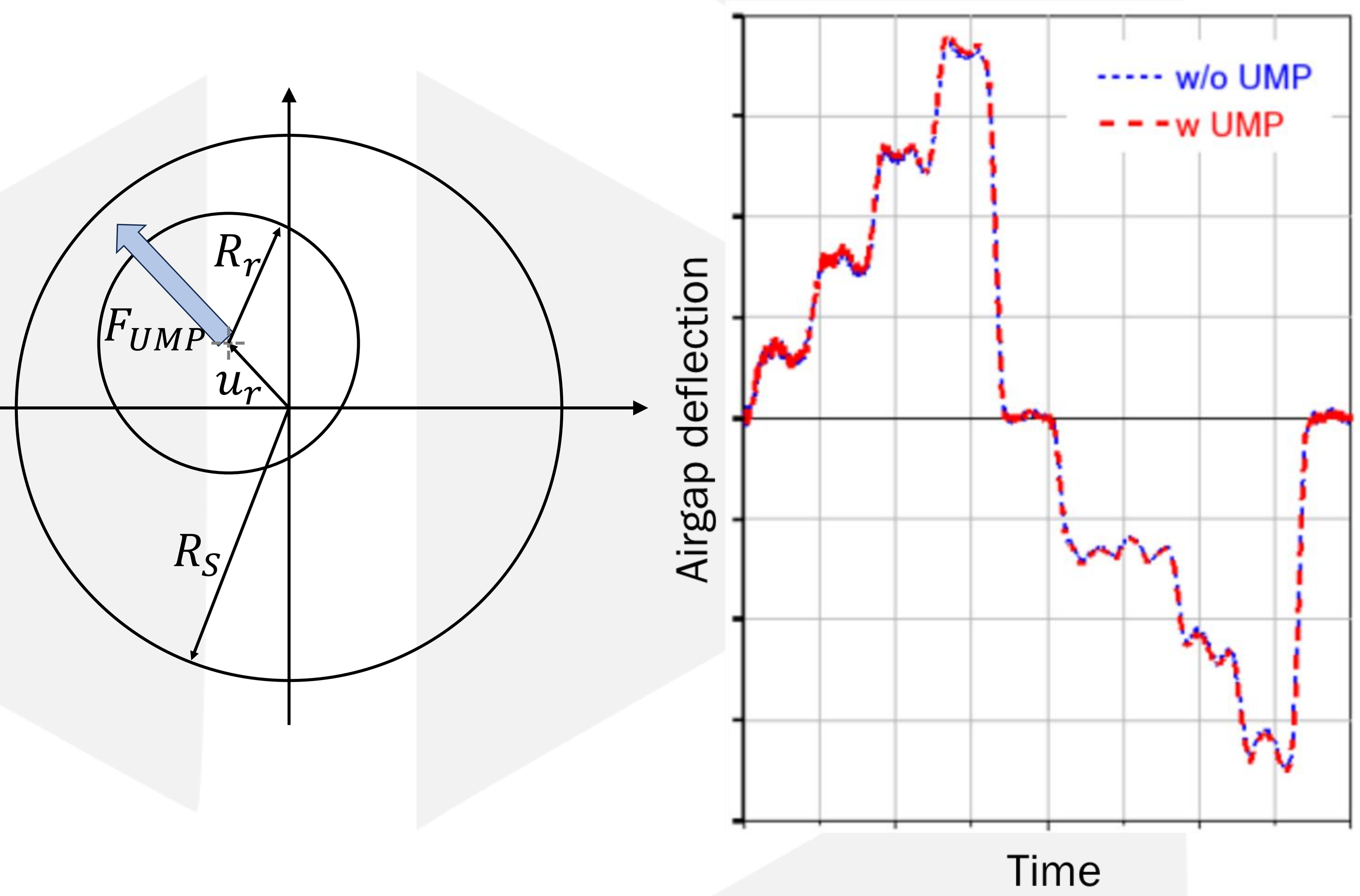

Figure 2: eccentric UMP forces (left) and airgap deflection for bending loads (right)

Source

1. Siddiqui, M.O., Nejad, A.R. & Wenske, J. On a new methodology for testing full load responses of wind turbine drivetrains on a test bench. Forsch Ingenieurwes 87, 173–184 (2023). https://doi.org/10.1007/s10010-023-00629-y

ReaLCoE's vision is to unleash the full potential of offshore wind energy

€35/MWh LCoE Goal, +12MW WEC Capacity, ~32 mio € Total Budget, 42 month project duration

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