Boundary Element Method Simulation of Tonal Noise From a Wind Turbine

B. Marmo[1]

[1]Xi Engineering Consultants, United Kingdom

Abstract

Modeling the acoustic output of wind turbines presents extreme simulation challenge due to the geometry of rotors and towers requiring very large mesh size with large volumes of empty space between blades. In this paper, the structural-acoustic finite element models that were previously presented at the Munich COMSOL Conference in 2016 (Stuber and Marmo, 2016) will be compared to simulations using the new COMSOL Multiphysics® boundary element method.

Wind turbine towers can often become modal if matched closely in frequency with the excitation associated with rotating components in the drive train, such as gearboxes and generators. When these conditions are met, the modal response is greatly amplified due to the very low structural damping of the steel structure resulting in undesired audible tones. Furthermore, the steel structures have large surface areas making them very efficient at radiating tonal noise. Tonal noise can have adverse effects on neighbouring residences and its emissions can result in strong regulatory penalties that can include the closure of wind farms.

To develop tonal noise mitigation COMSOL Multiphysics® has been used as a virtual prototyping tool, whereby an unmodified wind turbine was modeled and validation using field-based vibration and acoustic measurements. This "baseline model" was then used to test the effectiveness of potential tonal noise mitigation solutions. Previously to overcome the requirement of extremely large 3D meshes, the model was solved in the frequency domain. Surface acceleration of blades and the tower were extrapolated to the far-field using 2D acoustic models that were coupled to the structural model using LiveLink™ for MATLAB®. However, this approach neglects the effects of reflections on the sound field and does not represent the full 3D sound field. The introduction of boundary element methods in COMSOL Multiphysics® overcomes these deficiencies, allowing more accurate calculations of sound levels at any number of receptors and distance from the wind turbine.

Figures used in the abstract

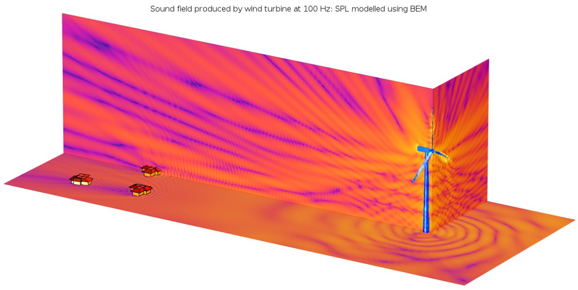

Figure 1: A structural model coupled with boundary element methods to simulate the 3D sound field and sound level experienced by local residence. The sound source is related to 100 Hz gear meshing vibration in the wind turbine's gearbox.