Hybrid model testing of floating wind turbines: test bench for system identification and performance assessment

Vincent Arnal*[1], Jean-Christophe Gilloteaux[1], Félicien Bonnefoy[2], and Sandrine Aubrun[3]

[1]Laboratoire de recherche en Hydrodynamique, Énergétique et Environnement Atmosphérique – École Centrale de Nantes, Ecole Centrale de Nantes – France

[2]Laboratoire de recherche en Hydrodynamique, Énergétique et Environnement Atmosphérique – CNRS : UMR6598 – France

[3]Laboratoire de recherche en Hydrodynamique, Énergétique et Environnement Atmosphérique – Ecole Centrale de Nantes – France

Abstract

Despite significant progress in the validation of hydro-servo-aero-elastic codes used for floating wind turbine modeling, testing new floating wind turbine concepts by dedicated wave tank experiments is still a required step for the validation and the calibration of the numerical models.

However, reproducing at model scale both representative hydrodynamic and aerodynamic loads acting on floating wind turbines is quite challenging because of conflicts between Froude and Reynolds scaling laws as well as implementation of sophisticated wind turbine control laws. Different experimental methodologies have been developed for the emulation of rotor response during wave tank testing. Recently, hybrid physical – numerical modelling coupled in real time have recently been developed to overtake Froude-Reynolds scaling incompatibilities. This study shows preliminary results of the SOFTWIND project, where such hybrid approach is followed for floating wind turbine wave tank testing. A set of actuators located at the top of the wind turbine tower for emulating loads acting on the rotor. The rotor response is computed in real-time with a full scale simulation of a floating wind turbine using a slightly modified version of NREL's OpenFAST code to get representative rotor aerodynamic and inertial loads.

The originality of the validation procedure adopted in the SOFTWIND project is to use a test bench with imposed platform motions to validate the hybrid physical-numerical coupling. Indeed, the communication protocols, the real-time execution of the numerical model, the motion and force observers and the identification of the actuator performances need to be validated and thoroughly characterised before using this experimental apparatus in wave tank testing campaigns. A 6 degrees of freedom hexapod reproduces at scale 1:30 pre-computed platform motions from fully coupled numerical simulations while an aircraft turbine reproduces in real-time the corresponding rotor force.

Different identification setpoints signals have been used to identify a representative actuator

*Speaker

model. Response to rising steps and white noise identification of the actuator at different working point allow a suitable understanding of the system performances.
An inverse dynamics procedure, based on the identified actuator transfer function, is then applied to improve dynamic response of the actuator. Application in complex load cases with turbulent wind and severe wave frequency motions of the hexapod give promising results, with main frequencies of interest of the rotor loads being relatively well reproduced by the actuator.

Keywords: Floating, Experimental, Hybrid approach