Technische Universiteit Delft

European Wind Energy Master
Offshore & Dredging Engineering

Substructure models for dynamic analysis of floating wind turbines and the effect of hull flexibility

While pursuing large size wind turbines with a steel-efficient floater, a traditional rigid body assumption for the floater might not be valid anymore. However, up to date, the flexibility of the hull still cannot be efficiently included into state-of-art aero-servo-elastic-hydro simulation tools. As a result, it is necessary to identify the significance of the effect of hull flexibility.

The effect of hull flexibility has just been studied in recent years. There were work focused on the influence on substructural internal load, global responses and dynamics of the system. However, it was found that little has been done from a tower design point of view. It was then further found that the design of a tower on a floating foundation has also seldom documented. In order to fill the knowledge gap, two research questions are accordingly defined: What is the difference in tower design with a floating foundation and What is the effect of hull flexibility on tower design?

To answer the first research question, a FEM model with rigid hull is built based on four different floating concepts which are designed for large size wind turbines. Structural analysis is then implemented and the 1st tower bending natural frequency is compared between a fixed foundation and a floating foundation. For the second research question, a FEM model with flexible hull is built based on a spar-buoy concept. The rigid hull model and flexible hull model are compared by implementing structural analysis and fatigue damage analysis under waves load.

From the implemented analysis, it was found that the 1st tower bending natural frequency will significantly increase (except for TLP) if the foundation changed from a fixed foundation to a floating foundation, which leads to the difficulty of a soft-stiff tower design for floating wind turbines. Furthermore, it was found that the extra flexibility from the hull can lead to decrease in the 1st tower bending natural frequency and the magnitude of the decrease can depend on the design of the tower. For a stiff-stiff tower design, the decrease is significant, meaning there will be a high uncertainty in the 1st tower bending natural frequency if hull flexibility is not considered.

Therefore, it is concluded that for a large size wind turbine, inclusion of hull flexibility is necessary when evaluating the dynamic properties of the tower and is certainly important for dynamic response analysis.

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July 23rd, 2019

Sponsor
Siemens Gamesa

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