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Design and Analysis of Box-type Floating Wind Turbine Structures with Large Motion Damping Plates

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ABSTRACT

A box-type floating structure is considered for a candidate of floating wind turbine structures. The platform is consisted of a box structure and large damping plates for enhancing global performance characteristics. Numerical analysis is conducted by using higher-order boundary element method. The numerical results were validated through a series of convergence test and model tests data. The global performance of the model structure is compared with same class spar-type structure. Finally technical feasibility of the structure is discussed considering construction cost and installation procedure.

KEY WORDS: Wind power, floating wind turbine, novel structure, 9-node HOBEM

INTRODUCTION

Offshore floating wind turbine has been paid attention due to better quality of offshore wind and a large amount of potential source in deeper water region. Due to more powerful and high quality offshore wind resources than those on lands and less environmental issues associated with noise and view, floating offshore wind farm will be more popular and dominant solutions for utilizing wind energy(Hong et al., 2012). There is three types of floating structures being considered for floating wind tower substructures; a spar type structure, TLP type and semisubmersible platforms(Justin Wilkes et al., 2012). Blue H which has 80 kW floating wind turbine installed at 113 km off the coast of Italy was the first pilot utilizing tension-leg platform design. The first large-capacity, 2.3 megawatt floating wind turbine is Hywind spar, which was installed in the North Sea off of Norway. In October 2011, Principle Power's WindFloat Prototype was installed 4km offshore of Aguçadoura, Portugal fitted with a 2.0MW offshore wind turbine is the first offshore wind turbine installed in open Atlantic waters and make use of a semi-submersible type floating foundation.

Those three concepts have long been adopted for deepwater oil production platform successfully due to their excellent global performance in waves. The main reason for such a good global performance is the design concept of avoiding motion resonance from sea waves. There have been a number of conceptual design studies on floating wind turbine structures, to name a few; Jonkman(2010), Robertson et al.(2011), Myhr et al.(2011) and Shin(2011). Most of the studies were on spar type structures like OC3-Hywind and variations of mooring system of spar platform, barge and semi-submersibles. For spars, a series of systematic studies have been conducted for validation of analysis tools, bench marking and design parametric studies including numerical analysis and model tests (Ormberg and Bachynski, 2012; Lee et al., 2012; Shin and Dam, 2012). Recently a semi-submersible type platform such as 'Windfloat' is emerging, which is based on semi-submersible design concept with high damping plate(Roddier et al., 2010; Kvittem and Moan, 2012). Recently tension leg type platform designs have been studies for variation of tension leg concept as well as change of floater type(Bachynski and Moan, 2012; Copple and Capanoglu,2012; Myhr and Nygaard, 2012).

Hong et al.(2012) proposed a box-type floater with damping plate for floating wind turbine platform, which is not directly categorized as spar, semi and TLP. In their study, the truss spar concept was adopted but the draft was shortened compared with spar to allow installation water depth less than 100m. Large damping plates were employed both in vertical and horizontal directions to make natural period of heave and pitch outside of wave period range.

The spar, however, has a very deep(larger than 100m) draft which limits the water depth of installations. The TLP is the most expensive solution compared with other types because of high construction and mooring cost, semi-submersible platform is also expensive compared with simple shape spar.

In the present study, the performance enhancement of a box type floater(Hong et al., 2012) was conducted. The wind turbine capacity is 5MW, same as the previous study but size was increased from 5,000m^3 displacement to 7,000m^3 to reduce overall motion responses. The shape of the main floater was changed as from rectangular box to circular cylindrical shape with tapering and the draft was increased to reduce wave exciting forces and moments.

A 9-node HOBEM was employed for numerical parametric study. Its