INTRODUCTION

Offshore wind turbines (OWTs) are becoming more and more popular in the quest for renewable sources of energy. While the offshore wind technologies have been developed rapidly over the past 2 decades mainly in Europe, other regions in the world are currently also exploring their potential of offshore wind energy [Westgate and DeJong, 2005, Zaatjer, 2006]. As a consensus within the OWT industry, monopiles are the preferred solution for the support structures of OWTs in water depths up to 20-25 meters [Schaumann and Böker, 2005], but alternative support structures must be pursued for deeper water locations. Installing monopile structures in water depths more than 20-25 meters might require monopiles with the diameter exceeding the limitation imposed by the modern technologies and/or construction equipments.

Experiences from the offshore oil and gas industry have led to the application of braced or lattice support structures for OWTs. Jacket-type substructures, which are lighter and stiffer in comparison to sufficiently designed monopiles, are attractive solutions in water depths of about 20 to 50 meters. As a jacket-type substructure provides the required structural stiffness through extending the base of the support, it also has advantages for the global load transmission in weak soils [Schaumann and Böker, 2005]. While the monopile transfers the loads by bending to the soil, the jacket dissolves the global moments to pairs of forces and transfers them as axial loads to the soil.

As jacket structures have been commonly used in the offshore oil and gas industry, many traditional design procedures can be transferred to the design of jacket OWTs, but some aspects require special consideration in the design process [Seidel, 2007]. The most visible and persistent source of excitation in a wind turbine system is from the rotor. The constant rotational speed of the rotor has been often referred to as the 1P frequency, and the rotor blade passing frequency as the 3P frequency for a three bladed rotor. Whereas the natural frequencies of a jacket platform for the offshore oil and gas industry are usually designed to be well above the main wave frequencies, the first natural frequency of an OWT should be wedged between wave and rotor excitation frequencies [van der Tempel and Molenaar, 2002].

A jacket-type offshore wind turbine consists of three major components: rotor-nacelle assembly (RNA), tower and jacket-substructure (including foundation). Their inter-relationship and influence on the first structural frequency of the OWT have not been systematically investigated. The main objective of this paper is to gain quantitative knowledge about the fundamental frequencies of jacket-type OWTs under various combinations of these three components based on simplified models for OWTs.

KEY WORDS : offshore wind turbine; natural frequency; sensitivity analysis; dimensional analysis

ABSTRACT

In order to ensure safe designs for jacket-type offshore wind turbines (OWTs), the fundamental frequencies of the OWTs must avoid the aerodynamic frequencies caused by the operation of wind turbine and the hydrodynamic frequencies originated from sea waves. A jacket-type offshore wind turbine consists of three major components: rotor-nacelle assembly (RNA), tower and jacket-substructure (including foundation). The objective of this paper is to gain quantitative knowledge about the fundamental frequencies of the jacket-type OWTs under various combinations of these three components based on simplified models for OWTs.