Time Domain Simulation of a Semi-submersible Type Floating Wind Turbine

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ABSTRACT

In this paper, a potential flow based numerical model is proposed for analysis of dynamic response of an offshore floating wind turbine system, with the consideration of hydrodynamic loads on the floating platform by the potential theory, the mooring lines by the catenary theory, and the aerodynamic loads on the wind turbine by the blade element momentum (BEM) theory. A semi-submersible type floating wind turbine which is being developed in Kyushu University is analyzed by the proposed numerical model.

KEY WORDS: Floating offshore wind turbine; semi-submersible; potential theory

INTRODUCTION

The offshore wind resource becomes an important supplement of the traditional ones such as coal, natural gas, oil and even nuclear power. As it is well-known that the great east Japan earthquake followed by the Fukushima nuclear accident in 2011 urges the Japanese government to seek for renewable energy resources with reliable safety, the concept of floating offshore wind turbine (FOWT) tends to be more and more popular thereafter in Japan. Many institutes and universities involving the Research Institute of Applied Mechanics of Kyushu University are taking part into this prosperous research field.

In the world, researches of FOWT in Europe and USA have started much earlier than that in Japan. The collaboration between National Renewable Energy Laboratory (NREL) and Massachusetts Institute of Technology (MIT) enables the nonlinear time-domain aero-hydro-servo-elastic code FAST (Jonkman and Buhl, 2005) interfacing with the three-dimensional panel code WAMIT which has the ability of computing the linear and quadratic transfer functions in frequency domain (Lee and Newman, 2006). For a small amplitude linear wave with an angular frequency ω, the time independent complex velocity potential is decomposed into incident φi, diffraction φj and radiation components φk which are corresponding to 6 rigid body motions φj.

\[ φ = φ_i + φ_0 - iω \sum \xi_j φ_j \]  \tag{1}

The corresponding boundary value problems are defined as

\[ \begin{align*}
\nabla^2 φ & = 0 \quad \text{in } \Omega \\
\frac{∂φ}{∂n} - iωφ & = 0 \quad z = 0 \\
\frac{∂φ}{∂n} = V_s \quad \text{on } S_b \\
\lim \left[ √R \left( \frac{∂φ}{∂R} - iωφ \right) \right] & = 0 \quad R \to ∞
\end{align*} \]  \tag{2}

where \( V_s \) denotes the body velocity. The body boundary condition can be: