Hydrodynamic Design of SWATH for Offshore Wind Turbine Transportation and Installation

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ABSTRACT
Continuously strong increase of offshore wind farm development over last decade stimulates the new technology demands on more efficient and safer methodology for wind turbine installation in complex offshore environment. This study aims at developing a SWATH type wind turbine installation vessel for efficient transportation and installation of offshore wind turbine based on a Wind Turbine Shuttle (WTS) concept. Unlike the current practice of wind turbine installation which usually assembles wind turbine components on-site in offshore using jack-up type vessel, WTS transports wind turbine of complete assembly and installs the whole wind turbine in floating condition to fulfill efficient and safe installation target.

KEY WORDS: SWATH; Wind turbine installation; Hull optimization; Resistance and propulsion; Global performance; Dynamic Positioning; Workability.

INTRODUCTION
Concerns of sustainability, the environment and climate change are driving the shift of heavy dependence on fossil fuels towards wider use of renewable energy resources. Wind energy as a cost-effective and clean way of generating energy is seen as one of most viable options in reducing the ecological footprint. The wind power industry is expected to continue growing in the coming decades. In spite of the rapid growth tendency, the industry is facing the challenge of inevitable shifting from onshore to offshore due to the exhaustion of onshore areas for wind farm development in many countries. Although, compared to onshore, offshore has its advantages, such as the high potential of wind energy over the open sea, less visual pollution and the large availability of space for large-scale wind farm development, the more expensive cost is a critical concern and industry is keen on developing new technology and methodology for offshore wind farm development to reduce the cost.

Offshore wind farm development costs are highly project-specific but it is commonly agreed wind turbine, installation and foundation structure are the first three most expensive costs in capital expenditure. To reduce wind farm development cost, applying large power capacity wind turbine (8MW or upper) becomes a general tendency currently. Meanwhile, development of new efficient installation approaches to reduce operation time in offshore environment is highly demanded in industry for saving cost and increasing safety.

In this paper, a previously proposed Wind Turbine Shuttle (WTS) concept (Bereznitski, 2011) is reinvestigated. Unlike the current practice of wind turbine installation which usually assembles wind turbine components on-site in offshore using jack-up type vessel, WTS transports wind turbine of complete assembly and installs the whole wind turbine in floating condition. In this way, the time-consuming operations of lowering and retrieving of jack-up legs involved in current practice can be avoided. Also, the risk of encountering uncertain seabed condition when laying down jack-up legs is eliminated. Instead of days-level-duration installation in current practice, the floating manner complete wind turbine installation method can reduce the installation time to hours-level-duration largely saving expensive offshore operation cost and enhancing the installation efficiency.

WTS aims at large wind turbines with power capacity ≥ 8MW. To fulfill the target of efficient and safe wind turbine transportation and installation, SWATH (Small Waterplane Area Twin Hull) hull is adopted as a baseline and optimized with minimum resistance. For propulsion two MAU CPPs (controllable pitch propellers) are used. Optimal propeller with maximum efficiency is screened out among the CPPs in MAU CPP series through propeller/hull interaction CFD simulations. In addition to bare hull resistance, the design of the CPP also considers the large wind resistance caused by the tall wind turbines and hoist frame on board under head wind condition. Besides propulsion, station keeping capability is critical for reliable installation operations in open sea. By using more advanced direct calculation methods to estimate the wind, current and wave loads, the DP (dynamic positioning) capability can be evaluated more trustworthy. In workability analysis for wind turbine installation of WTS, different water depths with different spectra for North Sea wave climate are investigated. It is found the designed WTS can achieve more than 87%