TU Delft

Offshore & Dredging Engineering

Technische Universiteit Delft

Sitting up system: a novel concept for large integrated offshore wind turbine installation

It is expected by the EWEA that in the North Sea only the wind energy capacity will increase to 45 GW. In 2015 the capacity was only 5.2 GW. Offshore contractors should be capable of installing lots of turbines and just that is a problem. As turbines increase in size installation vessels need significant upgrades. Therefore, most contractors look for cheaper and better solution for installing these large offshore wind turbines. The Sitting Up System or SUS is a new concept designed by Marine Innovators B.V. and installs fully assembled wind turbines with their foundation. It decreases offshore installation time and decreases operational cost significantly.

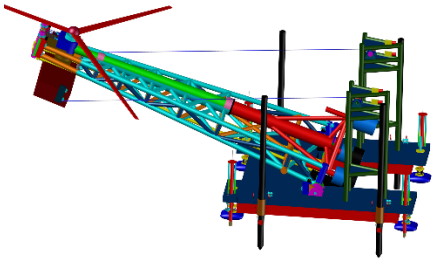
The SUS is designed to transport and upend wind turbines to a vertical position while anchored to the seabed. For now, the SUS is a concept and has multiple design possibilities, using either a hydraulic or a buoyant lifting system. Analysis on these lifting methods and their operational functionality resulted in a buoyant type lifting system. The SUS 3: 'Buoyant upend 2' concept consists of latticed structure and two buoyant modules. The large module is sunk to anchor the SUS and the small buoyancy module is pulled along the lattice to create an upending moment.

Using the software Matlab the upending motion of SUS 3 is modelled as a rigid body to find limiting wave conditions. The model uses second order stokes theorem and Jonswap to simulate waves on the structure. Loads on the structure are calculated using the Morison equation. Two DOFs are considered as the SUS can rotate around a hinge at the seabed and move the buoyancy module.

In the simulation a wind turbine of 200 meters height is upended in 30 minutes, while operating at 40 meters water depth. The first phase of the upending wave loads is most critical. The criteria for the SUS to operate depends on the acceleration of the top tower assemble of the wind turbine, these cannot exceed 0.1 g. In this case the limiting sea state is a H_s of 1 m with a T_p of 4.5 s, leading to a workability of about 16 percent. During the beginning stages of upending the natural frequency of the system operates around 10 seconds. This is critical as waves oscillate near this frequency. Though the simulation does not account for radiation or diffraction, the performance in later stages of upending gives a better result. Here, it can operate with a H_s of 2.5 meters resulting in a workability of 75 percent.

The SUS 3 is anchored with spudcans during upending and shear loads are most significant. These spudcans can experience a shear load of 24 MN, when considering a H_s of 3.5 with a T_p of 8.5. Therefore, anchoring method should be designed such that it can comprehend these shear loads more efficiently.

The work done by the winches pulling the buoyancy module is 13 percent more than the potential energy gained after upending with no waves. When waves are applied, energy is gained due to the uplifting force of waves. As the structure is lifted, resistance of pulling the buoyancy module decreases and can move more efficiently. Considering a H_s of 1.5 m and a T_p of 5.5 s will results in an energy gain of 5 percent. Therefore, this method is quite efficient in upending wind turbines offshore.



Student
Maarten Groen
August 30th, 2019

Sponsor
Marine Innovators B.V.

Thesis committee
Prof.dr. A. Metrikine
Ir. J.S. Hoving
Dr. F. Pisanó
Ir. J. Lanser