

### Single lift blade alignment for large offshore wind turbines

In 2022 the first 12 MW offshore wind turbines are expected to be installed. Due to the continuous upscaling of wind turbine generators new problems are expected to arise during the installation of the turbines. Especially the workability of the installation of larger wind turbine blades, which are already causing problems during the installation of 8.4 MW turbine blades, are questioned by Van Oord. This research focuses on the alignment process of the blade with the hub, which is considered to be the limiting factor in installing wind turbine blades. The ultimate goal is to reduce single blade installation times by facilitating the alignment process.

To investigate how different environmental conditions influence the dynamic behavior of the blade in the alignment process, a numerical model is developed. The motions of the blade, forces in the taglines and aerodynamic forces on the blade are evaluated for different environmental conditions during 30-minute simulations in the time domain. Wind velocity, turbulence intensity and the angle of the incoming wind relative to the blade are environmental parameters that influence the motion of the blade. Results for a 8.4 MW reference turbine blade are compared to a 12 MW turbine blade and conclusions are made concerning the installation workability for larger turbine blades.

Results show that the displacement of the blade root is caused by the rotation of the blade and installation tool around its x- and z-axis. The response spectrum of the blade root motions contains a significant amount of energy at the lower frequency part of the spectrum. In this part the first and second natural frequency of the system occur, which correspond to the rotations that are the main causes of the blade root

effect of wind speed, incoming wind angle the blade is. Furthermore conducted for angles of the blade in tool, which can result around 50%, of blade responses of larger 107 metre) increase smaller turbine blade Workability is due to the increase



displacement. The turbulence and on the response of significant. simulations are different rotation the blade installation in large reduction, root motions. The turbine blades (length compared to a (length 80 metre). expected to decrease in blade root motions.

Based on the results several proposed for

root motions using the existing tagline set up. Using a different angle of the blade in the installation tool and increasing the tagline tension both decrease blade root motions. A solution using an extra tagline is proposed and discussed to show how the current setup could be improved.

of the analysis, improvements are decreasing the blade