Design study of a double skinned composite tubular offshore wind turbine tower

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Positioning of the thesis

As of 2023, the Dutch offshore wind industry has reached its government target of 4.5 GW of installed capacity. However, with the government recently raising the target for offshore wind capacity to 21 GW by 2030/2031, there is potential to find material savings in the construction of horizontal axis wind turbines (HAWTs). As the tower comprises 20 - 30 % of the total cost of a HAWT, reducing material usage could lead to cost savings, a reduced environmental impact and/or the use of less resources. It could also increase the number of suppliers for wind-turbine tower materials. This study aims to achieve this goal by reducing wall thickness, ultimately designing a thin-walled (max. 25 mm steel thickness) HAWT tower. Challenges to this are however found in the fact that a HAWT is a complex construction subject to different operational loads, environmental loads and vibrations. This combination could lead to buckling and material fatigue.

Tata Steel currently manufactures steel on roll up to 25 mm thickness. The company is looking to expand the application possibilities of their steel into wind turbine towers. Current wind turbine towers are most often made of S355 construction steel with thickness larger than 25 mm, in the range of 50-100 mm. To use thinner steel, the tower diameter could be increased. However, current tower diameters are already nearing practical limits. Furthermore, increasing diameter to thickness ratios in current wind turbine towers rapidly leads to buckling issues. A new tower design is necessary to enable the use of steel produced by Tata Steel.

Objectives

The main issue of increasing the diameter to thickness ratio, is that buckling is a geometric problem, where the critical buckling stress is usually lower than the yield stress. This limits the effect of using higher strength steels. The use of a double skinned composite tubular (DSCT) design (Figure 1), can help to prevent buckling and the use of multiple materials could assist in combining the advantages that both materials offer individually. This study will focus on the use of sandwich walls in wind turbine towers. A parametric study will be performed, constrained by a maximum steel plate thickness of 25 mm. The focus will be on the influence of the different geometries on the ultimate strength (ULS) of the tower under combined loading. Other effects, such as the effect of material bonding will be considered. The bottom sections of the NREL 15 MW turbine tower will be used as a reference design. The study will be limited to the weight resting on top of the tower and the aerodynamic loading of the tower by the wind turbine.

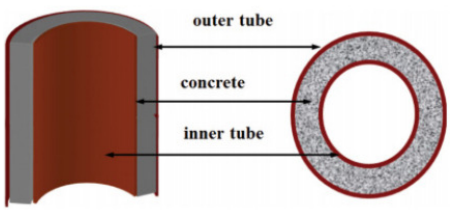

Figure 1: DSCT tower (Korea Institute of Ocean Science and Technology)