INNOVATIVE DESIGNS OF OFFSHORE WIND TURBINE SUPPORT STRUCTURES USING TOPOLOGY OPTIMIZATION

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Offshore wind turbine support structures, such as jackets, are an important cost factor of the capital costs of offshore wind turbine systems [1]. Consequently, there is high potential in using structural optimization techniques, such as topology optimization, to assist in finding innovative designs that reduce the costs. In order to apply topology optimization to jacket design, several challenges need to be addressed. The main challenge is that these structures are subjected to many dynamic loads, and need to satisfy structural criteria on stiffness, strength and fatigue. Dynamic response optimization problems are typically challenging due to the computational expensive sensitivity analysis and memory storage requirements [2].

We apply topology optimization to jacket design considering dynamic loads in a two-step approach; first topology optimization is used in the conceptual design phase followed by a sizing optimization step including relevant structural criteria as prescribed by the design standards [3]. The structures are modelled by beam finite elements. We implemented a ground structure algorithm, which generates nodes inside a truncated cone, after which connections are built between the nodes. Nodes are generated based on a few input parameters, such as the number of nodes in radial-, circumferential-, and vertical direction of the truncated cone. Dynamic response topology optimization is then used to generate jacket designs based on different ground structures. The topology optimization problem is to minimize the dynamic compliance subject to a mass constraint. Subsequently, the optimized design is used as input to a sizing optimization problem, where the structure is further weight-optimized subject to local strength and fatigue criteria, geometric constraints, and buckling assessment constraints as prescribed by the design standards [3]. We investigate the effect of different ground structures and compare the performance of the obtained designs with existing jacket designs.

The results indicate that topology optimization can be used in the conceptual design phase to obtain jacket designs with improved performance compared to existing designs. Additionally, the current study serves as the basis of future research on including for jackets relevant design criteria (e.g., strength, fatigue and buckling) directly in the topology optimization problems.

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