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Optimization of a wind turbine tower structure

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ABSTRACT: Optimum design means search for better solutions, which better fulfil the requirements. The main requirements of up-to-date engineering structures are the suitable load-carrying capacity (safety), producibility and economy. A structural optimization system is developed in which the safety and producibility is guaranteed by design and fabrication constraints and economy is achieved by minimization of a cost function.

This design system is now applied for the optimization of a wind turbine tower structure. The aim is to show the optimum design procedure for a 45 m high, slightly conical ring-stiffened shell tower with linearly varying diameter and stepwise varying thickness. The shell can be approximated by three cylindrical parts of 15 m length, having constant average diameter and thickness. For the optimum design of a ring-stiffened cylindrical shell loaded in bending a cost minimization procedure is developed. Design constraints on shell buckling and on local buckling of flat ring-stiffeners are formulated according to Det Norske Veritas design rules.

The wind load acting on the shell tower is calculated according to Eurocode 1 Part 2-4. The wind force and bending moment acting on the top of the tower for a 1 MW wind turbine is given in the literature. To avoid the shell ovalization a domain of stiffener number is selected. In the constraint of shell buckling an imperfection factor is used, which expresses the effect of radial shell deformation due to shrinkage of circumferential welds.

The cost function includes the material and fabrication costs. The fabrication cost is formulated according to the production sequence and includes the cost of forming of shell courses into a near cylindrical shape as well as the cost of cutting of flat ring-stiffeners, cost of assembly and welding. The unknowns in an optimization procedure are the average shell thickness as well as the dimensions and number of ring-stiffeners.

KEYWORDS: Ring-stiffened steel shells, buckling of shells, structural optimization, wind turbine tower.