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Structural Analysis of a Composite Wind Turbine Blade

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Abstract : The design of an optimised horizontal axis 5-meter-long wind turbine rotor blade in according with IEC 61400-2 standard is a research and development project in order to fulfil the requirements of high efficiency of torque from wind production and to optimise the structural components to the lightest and strongest way possible. For this purpose, a research study is presented here by focusing on the structural characteristics of a composite wind turbine blade via finite element modelling and analysis tools. In this work, first, the required data regarding the general geometrical parts are gathered. Then, the airfoil geometries are created at various sections along the span of the blade by using CATIA software to obtain the two surfaces, namely; the suction and the pressure side of the blade in which there is a hat shaped fibre reinforced plastic spar beam, so-called chassis starting at 0.5m from the root of the blade and extends up to 4 m and filled with a foam core. The root part connecting the blade to the main rotor differential metallic hub having twelve hollow threaded studs is then modelled. The materials are assigned as two different types of glass fabrics, polymeric foam core material and the steel-balsa wood combination for the root connection parts. The glass fabrics are applied using hand wet lay-up lamination with epoxy resin as METYX L600E10C-0, is the unidirectional continuous fibres and METYX XL800E10F having a tri-axial architecture with fibres in the 0,+45,-45 degree orientations in a ratio of 2:1:1. Divinycell H45 is used as the polymeric foam. The finite element modelling of the blade is performed via MSC PATRAN software with various meshes created on each structural part considering shell type for all surface geometries, and lumped mass were added to simulate extra adhesive locations. For the static analysis, the boundary conditions are assigned as fixed at the root through aforementioned bolts, where for dynamic analysis both fixed-free and free-free boundary conditions are made. By also taking the mesh independency into account, MSC NASTRAN is used as a solver for both analyses. The static analysis aims the tip deflection of the blade under its own weight and the dynamic analysis comprises normal mode dynamic analysis performed in order to obtain the natural frequencies and corresponding mode shapes focusing the first five in and out-of-plane bending and the torsional modes of the blade. The analyses results of this study are then used as a benchmark prior to modal testing, where the experiments over the produced wind turbine rotor blade has approved the analytical calculations.

Keywords : dynamic analysis, fiber reinforced composites, horizontal axis wind turbine blade, hand-wet layup, modal testing
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