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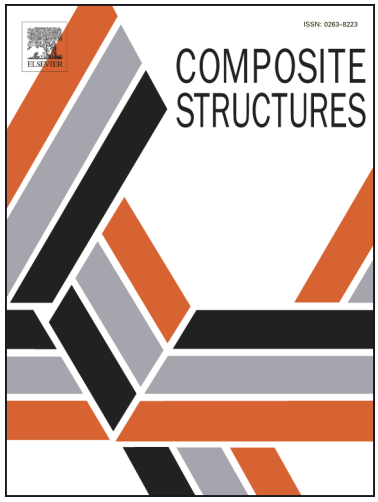

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Application of the inverse finite element method to design wind turbine blades

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Abstract

This paper presents a novel methodology to design wind turbine blades using the Inverse Finite Element Method (IFEM). IFEM takes as domain of analysis the geometry of the blade after large elastic deformations caused by given service loads. The deformed shape of the blade is that determined to be efficient using an aerodynamics analysis. From this analysis, the aerodynamic loads on the blade are known.

Then, we choose the materials to manufacture the blade. As usual, the blade is assumed to be made of multiple layers of composite materials. After materials selection, the stationary inertial loads on the blade are known.

Finally, given the desired deformed shape and all the service loads, we use IFEM to compute the manufacturing shape of the blade. This is a one-step, one-direction strategy where the aerodynamics analysis feeds the structural (IFEM) analysis, and no further interaction between both solvers is required.

As an application of the proposed strategy, we consider a medium power 40-KW wind turbine blade, whose whole design is detailed along this work.

Keywords: Wind turbine blade, inverse finite element, large elastic deformation, degenerated solid shell, multilayered shell, composite layer

1. Introduction

Energy is a vital element for the economic growth of most countries. The rising concern about climate change and pollution has led to the development and improvement of renewable energy sources. Wind energy is the fastest-growing renewable source, and the World Energy Council (WEC) [1] has predicted that it will continue its expansion in any of the given policy scenarios to the year 2050. The most common device to convert the kinetic energy of the wind into electrical power is the horizontal axis wind turbine (HAWT), typically having a three-blade rotor, the so-called Danish concept.

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