Accepted Manuscript

Structural optimisation of vertical-axis wind turbine composite blades based on finite element analysis and genetic algorithm

Lin Wang, Athanasios Kolios, Takafumi Nishino, Pierre-Luc Delafin, Theodore Bird

PII: S0263-8223(16)30787-5
DOI: http://dx.doi.org/10.1016/j.compstruct.2016.06.003
Reference: COST 7525

To appear in: *Composite Structures*

Received Date: 1 February 2016
Accepted Date: 1 June 2016

Structural optimisation of vertical-axis wind turbine composite blades based on finite element analysis and genetic algorithm

Lin Wang[a*], Athanasios Kolios[a], Takafumi Nishino[a]
Pierre-Luc Delafin[a], Theodore Bird[b]
[a] Centre for Offshore Renewable Energy Engineering, School of Energy, Environment and Agrifood, Cranfield University, Cranfield, MK43 0AL, UK
[b] Aerogenerator Project Limited, Ballingdon Mill, Sudbury, CO10 7EZ, UK

Abstract

A wind turbine blade generally has complex structures including several layers of composite materials with shear webs, making its structure design very challenging. In this paper, a structural optimisation model for wind turbine composite blades has been developed based on a parametric FEA (finite element analysis) model and a GA (genetic algorithm) model. The optimisation model minimises the mass of composite blades with multi-criteria constraints. The number of unidirectional plies, the locations of the spar cap and the thicknesses of shear webs are taken as design variables. The optimisation model takes account of five constraints, i.e. stress constraint, deformation constraint, vibration constraint, buckling constraint, and manufacturing manoeuvrability and continuity of laminate layups constraint. The model has been applied to the blade structural optimisation of ELECTRA 30kW wind turbine, which is a novel VAWT (vertical-axis wind turbine) combining sails and V-shape arm. The mass of the optimised blade is 228kg, which is 17.4% lower than the initial design, indicating the blade mass can be significantly reduced by using the present optimisation model. It is demonstrated that the structural optimisation model presented in this paper is capable of effectively and accurately determining the optimal structural layups of composite blades.

Keywords: Vertical-axis wind turbine; Composite blade; Structural optimisation; Finite element analysis; Genetic algorithm

Acronyms	
APL	Aerogenerator Power Limited
CBCSA	Composite Blade Cross-Section Analysis
CLT	Classical Lamination Theory
COE	Cost of Energy

* Corresponding author. Tel.: +44(0)1234754706; E-mail address: lin.wang@cranfield.ac.uk