Design and processing of structural components in biocomposites – Rotor blade for wind turbine cars

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INTRODUCTION

Composite materials are regarded as an outstanding class of materials for many advanced applications. The growing environmental concern has led to a search of substitutes for the inorganic fibre reinforcement. Biocomposites, using natural fibre reinforcement, offer many advantages such as lower environmental impact, the potentially lower cost and ease of disposal together with satisfying mechanical properties. Three small wind turbine blades have been designed and built using carbon, flax and carbon-flax blended fibres. The three concepts LCAs and aerodynamic properties have been compared using Abaqus FEM.

THEORY

Natural fibres due to their structure and chemical composition have a specific tensile modulus similar to glass fibres. Moreover the energy required for their production is considerably lower than the one of inorganic reinforcement. Among the most performing natural fibres is possible to find flax and hemp ones.

METHODS

Three wind turbine blades were realized through vacuum infusion process: one in carbon, one in flax, and one in a hybrid structure of carbon on the outer layers and flax in the inner layers. The resin used for the composite manufacturing is a 50% biobased epoxy resin. An optimization model was elaborated in order to optimize the composite layer structure and to validate the structural requirements needed for the blades: limits on tip's deflection is imposed and the optimization objective consists on minimizing the blade's torsion in order to keep constant the optimal angle of attack defined in the design stage and maximize aerodynamic efficiency. The MECO principle (Materials, Energy, Chemicals and Others) was used in order to find the energy required for the production of the different blades.

RESULTS

All the blades satisfied the mechanical requirements. In the table is possible to observe the result of the MECO analysis.

Blade Energy Consumption [MJ], angle of torsion [°] and weight [Kg]				
	Flax + Bio-Based Epoxy	Carbon + Bio-Based Epoxy	Carbon + Conventional Epoxy	Hybrid + Bio-Based Epoxy
Reinforcement	1,91	113,27	113,27	64,59
Resin	3,29	1,14	1.85	1,93
Total	5,20	114,41	115,12	67,52
Max Torsion angle	0.9	0.06	0.06	0.13
Weight	450	250	250	300

Table 1: Energy consumption, weight and angle of torsion for the different blades realized

CONCLUSION

The energy required for the construction of the flax blade is 23 times lower than the one in full carbon. The hybrid blade showed mechanical properties comparable with the blade of full carbon and allowed a reduction of 40% of the energy for the production.