Structural design optimization of a morphing trailing edge flap for wind turbine blades

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ABSTRACT

A flap actuation system, the Controllable Rubber Trailing Edge Flap (CRTEF), for distributed load control on a wind turbine blade had been developed in the period from 2006 to 2013 at DTU (http://www.induflap.dk/). The purpose of the presented work is to optimize the structural design of the flexible part of the CRTEF based on a realistic blade section geometry in order to meet the required objectives and constraints. The objectives include the deflection requirements and the energy efficiency, while the constraints include the bending stiffness of the structure, the local shape deformations, critical material strength, and manufacturing limitations. A model with arches forming concave on the flap surface and enclosing the voids to be pressurized results in the bending movement of the flap when pressure is applied on the voids to straighten the arches. The model is designed using SolidWorks for the parameterization of the design and ANSYS Workbench for the static structural Finite Element Analysis (FEA) simulations. The built-in parametric optimizer of ANSYS Workbench, Direct Optimization of Design Exploration is used to optimize the design with the parameters of the geometry. The surface pressure loads during operation of the turbine with the flap installed are evaluated with XFOIL and included in the simulations. The model is developed first by qualitative analyses to obtain a reasonable preliminary design, and then by parametric optimization to have the final design. The parameterization of the design is improved on the way of optimizations, in order to expand the design space to solve the problem of stress concentration, so that it covers the design with an acceptable material safety factor. With the consideration of surface pressure loads during operation of the turbine, the optimum design fulfills the requirements for flap angle of 15° and -15° with the actuation pressure of 0.428 MPa and 0.386 MPa, and the material safety factor of 1.58 and 1.71, respectively (Fig. 1). The design also meets the objective for energy efficiency by the lower actuation pressure than in earlier designs and by the small volume of the voids. Besides, the constraint of the bending stiffness is fulfilled with the deflection of less than the flap angle of ±5° when the turbine is operating without the actuation pressure, and the constraints of the local shape deformations and manufacturing limitations are also fulfilled.

REFERENCES

