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Fluid–Structure Interaction Modeling of Wind Turbines

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Abstract : Knowing that the technological advance is the focus on the efficient extraction of energy from wind, and therefore in the design of wind turbine structures, this work aims the study of the fluid-structure interaction of an idealized wind turbine. The blade was studied as a beam attached to a cylindrical Hub with rotation axis pointing the air flow that passes through the rotor. Using the calculus of variations and the finite difference method the blade will be simulated by a discrete number of nodes and the aerodynamic forces were evaluated. The study presented here was written on Matlab and performs a numeric simulation of a simplified model of windmill containing a Hub and three blades modeled as Euler-Bernoulli beams for small strains and under the constant and uniform wind. The mathematical approach is done by Hamilton's Extended Principle with the aerodynamic loads applied on the nodes considering the local relative wind speed, angle of attack and aerodynamic lift and drag coefficients. Due to the wide range of angles of attack, a wind turbine blade operates, the airfoil used on the model was NREL SERI S809 which allowed obtaining equations for Cl and Cd as functions of the angle of attack, based on a NASA study. Tridimensional flow effects were no taken in part, as well as torsion of the beam, which only bends. The results showed the dynamic response of the system in terms of displacement and rotational speed as the turbine reached the final speed. Although the results were not compared to real windmills or more complete models, the resulting values were consistent with the size of the system and wind speed.

Keywords : blade aerodynamics, fluid–structure interaction, wind turbine aerodynamics, wind turbine blade
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