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Vertical Axis Wind Turbines - Numerical Optimization of Design and Operating Conditions

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The depletion of global fossil fuel reserves combined with mounting environmental concern has served to focus attention to the development of ecologically compatible and renewable alternative energy sources like wind turbines. One efficient way to convert wind energy into electrical or mechanical energy is offered by wind turbines, which operate as a lifting-device. Vertical-axis wind turbines can capture wind from any direction but have not yet benefited from the years of development undergone by horizontal-axis wind turbines. The optimization of design and operating conditions require accurate numerical solutions for aerodynamic forces. First objective of the present investigation is the numerical prediction of the unsteady flow around a vertical-axis wind turbine in viscous turbulent flows. Having obtained this result, further research aims to increase the aerodynamic efficiency using genetic algorithms in different procedures. On the one hand, the shape of the airfoil is modified to achieve a better integral torque to drag ratio for vertical-axis wind turbine kinematics. On the other hand, the aerodynamic operating conditions of a vertical-axis wind turbine are investigated using computational fluid dynamics results. To be more precise, the study covers a range of Reynolds numbers, diverse rotor solidities, various tip speed ratios, different numbers of blades, and unpitched as well as pitched blade configurations. By comparing incremental and integral torque for one revolution, the efficiency of the rotor, and the flow field in general, the aerodynamic possibilities of vertical-axis wind turbines are discussed in detail.