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3D Numerical Investigation of Savonius Vertical Axis Wind Turbine using Fluid-Driven 6DoF Motion Solver

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Abstract

This study presents a 3D numerical investigation of a Savonius vertical axis wind turbine (VAWT) rotor using a fluid-driven approach with OpenFOAM's 6 Degree of Freedom (6DoF) rigid body motion solver. Unlike traditional prescribed motion methods, this work employs the `sixDoFRigidBodyMotion` solver coupled with transient AMI sliding mesh techniques and a spherical angular damper to simulate realistic turbine dynamics under aerodynamic loading. The rotor motion is constrained to rotate about a vertical axis through point and axis constraints, while a calibrated damping coefficient achieves equilibrium at a tip speed ratio (TSR) of 0.59. A comprehensive mesh independence study validates the computational setup across three mesh resolutions. Performance characteristics including power coefficient (C_p), torque coefficient (C_q), and thrust coefficient (C_T) are analyzed at the equilibrium TSR value.

Keywords: Vertical Axis Wind Turbine, Savonius Rotor, 6DoF Rigid Body Motion, Spherical Angular Damper, Computational Fluid Dynamics, OpenFOAM, Mesh Independence Study