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Turbulent axisymmetric swirling wake: equilibrium similarity solution and experiments with a wind turbine as wake generator MARTIN WOSNIK, NATHANIEL DUFRESNE, University of New Hampshire — An analytical and experimental investigation of the turbulent axisymmetric swirling wake was carried out. An equilibrium similarity theory was derived that obtained scaling functions from conditions for similarity from the equations of motion, leading to a new scaling function for the decay of the swirling velocity component. Axial and azimuthal (swirl) velocity fields were measured in the wake of a single 3-bladed model wind turbine with rotor diameter of 0.91 m, up to 20 diameters downstream, using X-wire constant temperature hot-wire anemometry. The turbine was positioned in the free stream, near the entrance of the UNH Flow Physics Facility, which has a test section of 6m x 2.7m cross section and 72m length. Measurements were conducted at different rotor loading conditions with blade tip-speed ratios up to 2.8. At U_∞=7 m/s, the Reynolds number based on turbine diameter was approximately 5 $\times 10^5$. Both mean velocity deficit and mean swirl were found to persist beyond 20 diameters downstream. First evidence for a new scaling function for the mean swirl, $W_{max} \propto U_o^{3/2} \propto x^{-1}$ was found. The similarity solution thus predicts that in the axisymmetric swirling wake mean swirl decays faster with x^{-1} than mean velocity deficit with $x^{-2/3}$.

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