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Program of Study: Ph.D.

Thesis Title: **Aerodynamic Design and Wind Tunnel Tests of Novel Blade Shapes for the Savonius Wind Rotor**

Thesis Supervisor(s) : Prof. Ujjwal K. Saha
Department : Mechanical Engineering
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Abstract

Wind turbines are increasingly used worldwide to generate electricity without contributing to global warming. The Savonius wind rotor is widely known for small-scale power generation devices. However, the Savonius rotor, a simple type of vertical-axis wind turbine, suffers from low efficiency due to a high negative torque from the returning blade. To address this issue, extensive research has been done on enhancing various design parameters, geometric parameters, implementing augmentation techniques and other aspects. However, there is always scope for further investigation to contribute better. In view of this, the present study aims at generating blade profile through optimization techniques (OTs). The optimal blade profile is developed considering the power coefficient as an output function using the optimization techniques, viz., simplex search method (SSM), non-dominated sorting genetic algorithm-II (NSGA-II). Moreover, a novel parabolic blade profile is developed analytically considering the sectional cut angle (θ) of the parabola as a design parameter.

The flow physics of both the developed blade profiles are then studied using ANSYS Fluent software with shear-stress transport (SST) $k-\omega$ turbulence model. The solver setup employs the finite volume method to simulate the transient 2D flow around the blade profile. A direct comparison is made between the developed blade profiles and the conventional semicircular profile over a range of tip speed ratios (TSRs). The effects of TSR and Reynolds numbers (Re) on the performance are also investigated. The blade profile developed through OTs has showcased maximum performance coefficient (C_{Pmax}) of 0.283 at a TSR of 0.8. While the parabolic blade profile generated at $\theta = 32.5^\circ$ has showcased the highest C_{Pmax} amongst all the blade profiles generated at various θ values. The C_{Pmax} obtained from the parabolic profile is 0.319 against the semicircular counterpart with a C_{Pmax} of 0.266. Thereby it can be seen that the parabolic profile has shown an improved C_{Pmax} by 20% over the semicircular counterpart. The lift and drag analysis of the parabolic profile reveals an improvement of maximum drag coefficient (C_{Dmax}) by 18.18% over its semicircular counterpart. The best performance of the parabolic profile is obtained at TSR of 0.8 and at Re of 0.97×10^5 . Moreover, the parabolic profile has showcased the better performance against the blade profile designed through OTs by 13%. Finally, the wind tunnel tests are performed to check the practical feasibility of the parabolic bladed rotor where it shows C_{Pmax} of 0.165 against C_{Pmax} of 0.138 for the semicircular-bladed rotor.
