INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

Name of the Student	:	Kabita Naik
Roll Number	:	186151102
Programme of Study	:	Ph.D.

Thesis Title: Aerodynamic Performance and Self-Starting Analysis of Darrieus Wind Turbines with J-Shaped Airfoils

Name of Thesis Supervisor(s)	:	Prof. Niranjan Sahoo
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SHORT ABSTRACT

To meet the challenges of the impending energy crisis, greenhouse gas emissions, global warming, and pollution from fossil fuels, it is essential to incorporate different types of renewable energy technologies. From this perspective, wind energy is one of the most abundant and highly contributing renewable sources among other technologies. The Darrieus-type straight-bladed vertical axis wind turbines (SB-VAWTs) have immense potential to extract wind energy as standalone systems, particularly in remote locations to address power shortages and the unpredictability of climate conditions. The SB-VAWTs provide distinct advantages over their counterparts due to their linear blade design and uncomplicated structure. However, the aerodynamic performance of SB-VAWTs is not as good as that of horizontal axis wind turbines (HAWTs). Further, the starting characteristics of the SB-VAWTs are poor, which limits their applicability in low wind speed environments for small-scale power generation. In that context, the present study is focused on analyzing the aerodynamic performance and starting characteristics of Darrieus-type SB-VAWTs with J-shaped airfoils.

The present thesis investigates the uppercut and lowercut J-shaped airfoils with various opening ratios (ORs) through two-dimensional (2D) computational fluid dynamics (CFD) simulations. The J-shaped airfoils are created by removing a portion toward the trailing edge of the conventional cambered NACA 4415 airfoils. The present study demonstrates that the power and torque coefficient of SB-VAWTs improve by about 31% when the ORs of the uppercut J-shaped airfoil are varied from 0.1 to 0.8. In addition, the J-shaped airfoils contribute to the SB-VAWTs to generate torque during the critical starting conditions, which enhances the self-starting characteristics. Moreover, numerical and experimental investigations are conducted on small-scale Darrieus-type SB-VAWTs with a series of cambered airfoils and their J-shaped airfoils to obtain an optimum airfoil to improve the aerodynamic performance and starting torque. The performance of SB-VAWTs improves by about 25% with the J-shaped NACA 4418 airfoil with an OR of 70%. Furthermore, the present work investigated the effect of J-shaped blade numbers (i.e. 2,3 and 4) on the aerodynamic performance and starting characteristics of small-scale Darrieus-type SB-VAWTs. The J-shaped blades with OR of 70% depicted superior performance with an improvement of 25%, 23% and 43% for the case of 2-bladed, 3-bladed and 4-bladed SB-VAWTs, respectively compared to the alternative conventional blades.