Prediction of Aerodynamic Behaviour of a 3D Rectangular Blade with Airfoil-Shaped Vortex Generators By Modeling Wind Tunnel Data

Hariprasanth Palanivel
Aerodynamics & Flow-Physics Laboratory, Department of Applied Mechanics & Biomedical Engineering, Indian Institute of Technology Madras, Chennai, Tamil Nadu, India
Metacomp Technologies Private Limited, Chennai, Tamil Nadu, India

Rinku Mukherjee
Aerodynamics & Flow-Physics Laboratory, Department of Applied Mechanics & Biomedical Engineering, Indian Institute of Technology Madras, Chennai, Tamil Nadu, India

Abstract

Passive flow control strategy using airfoil-shaped vortex generators are designed for offshore wind turbine applications. Aerodynamic characteristics are measured using a three-component force balance for a rectangular blade in a low-speed wind tunnel when clean and also attached with miniature wings or airfoil-shaped vortex generators (AVGs). Response Surface Methodology and an Analysis of Variance are performed such that given any/all geometric parameter(s) of the vortex generators, the aerodynamic response of a given blade with vortex generators can be predicted. A maximum of 10% increase in C_L-α = 12° is achieved when a blade has an AVG of minimum height placed near the leading edge. The resulting drag penalty is lower than the clean baseline blade for $\alpha \leq 10°$. It has the highest C_L/C_D ratio at α = 10° with peak values of ≅11.7% for E423 and 11.9% for LNV109A AVGs. The addition of AVGs did not adversely affect longitudinal stability. Overall, both E423 and LNV109A. AVGs hold strong potential for practical applications to enhance aerodynamic performance in wind turbine blades, aircraft wings and UAVs by delaying flow separation with minimal drag penalty.