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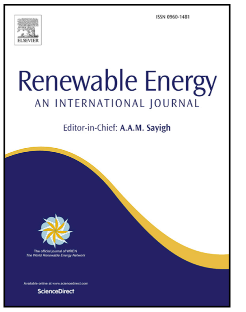

Reduced frequency effects on combined oscillations, angle of attack and free stream oscillations, for a wind turbine blade element

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ACCEPTED MANUSCRIPT

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Abstract

The dynamic stall phenomenon in horizontal axis wind turbines causes significant energy waste and sometimes wind turbine failure. For modeling a deep dynamic stall phenomenon of a horizontal axis wind turbine blade element, a numerical simulation of an oscillating NREL's S809 airfoil has been performed at Reynolds number of 10^6 in an unsteady incident velocity; the velocity oscillates with the same frequency as the airfoil oscillation but with different phase difference (ϕ). Since the sliding mesh technique has been applied for the airfoil oscillation, an O-type grid is created resulting in the reduced number of mesh layers. A specific correction improves the quality of the O-type mesh near the sharp trailing edge. For the combined oscillations, the effects of the reduced frequency (k) in the range of $0.05 \leq k \leq 0.15$ are investigated with the phase differences of $\phi = -\frac{\pi}{2}, +\frac{\pi}{2}, \pi$. The results show their significant dependency on k at specific ϕ values in particular at $\phi = -\frac{\pi}{2}$. Combined effects of k and ϕ can change the aerodynamic loads during dynamic stall significantly compared to loads from a case with a steady incident velocity. These significant changes in the flow structure and aerodynamic loads can affect the wind turbine performance during the dynamic stall phenomenon.

Keywords: reduced frequency, phase difference, dynamic stall, pitch oscillation, unsteady free stream

1. Introduction

While the Horizontal Axis Wind Turbines (HAWTs) work under yaw loads, the angle of attack (AOA) of an individual blade section differs at each azimuth angle. These variations can cause unexpected aerodynamic forces. Dynamic stall (DS) is an event which occurs after the static stall angle, when the airfoil AOA is rapidly changed or has an unsteady motion [1]. The unsteady AOA due to motions of an airfoil has various types [2]. In addition to DS occurrence in helicopter blades and pitching wings, DS plays an important role in wind turbines. Many researchers have studied the performance and energy production of wind

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