Mechanical Engineering Thesis Defense

Investigation of transition and vortex systems of a dynamically pitching airfoil under the free-stream turbulence conditions

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abstract

The effect of reduced frequency on dynamic stall behavior of a pitching NACA0012 airfoil in a turbulent wake using Direct Numerical Simulations is presented in the current study. Upstream turbulence with dynamically oscillating blades and airfoils is associated with ambient flow unsteadiness and is encountered in many operating conditions. Wake turbulence, a more realistic scenario for airfoils in operation, is generated using a small solid cylinder placed upstream, the vortices shed from which interact with the pitching airfoil affecting dynamic stall behavior.

A recently developed moving overlapping grid approach is used using a high-order Spectral Element Method (SEM) for spatial discretization combined with a dynamic time-stepping procedure allowing for up to third order temporal discretization. Two cases of reduced frequency (k =0.16 and 0.25) for airfoil oscillation are investigated and the change in dynamic stall behavior with change in reduced frequency is studied and documented using flow-fields and aerodynamic coefficients (Drag, Lift and Pitching Moment) with a focus on understanding vortex system dynamics (including formation of secondary vortices) for different reduced frequencies and it's affect on airfoil aerodynamic characteristics and fatigue life.

July 12, 2017; 10:00 AM; ERC 490