Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Analysis of Dynamic Stall Through Chirp Signal Pitch Excursions

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— An augmentation of the typical pitching airfoil experiment has been performed where the pitching frequency and amplitude are dynamically varied in a short-time event to produce a "chirp" trajectory, $\alpha(t) = \alpha_0 + \alpha_1(t)\sin(t\omega(t))$. The frequency evolution followed a Schroeder-phase relation, $\omega(t) = \omega_{min} + K(\omega_{max} - \omega_{min})$. The frequencies ranged from 0.5Hz to 30Hz, resulting in reduced frequencies from 0.02 to 0.1. The free-stream Mach number ranged from Mach 0.4 to 0.6, giving chord Reynolds numbers from 5×10^5 to 3×10^6. The airfoil was a NACA 23012 section shape that was fully instrumented with 31 flush-mounted high-bandwidth pressure transducers. The pressure transducer outputs were simultaneously sampled with the instantaneous angle of attack, $\alpha(t)$. The motivation for this study was to compare dynamic stall under non-equilibrium conditions. A particular interest is on the flow features that occur when dynamically passing between light and deep stall regimes. The results include phase analysis of aerodynamic loads, wavelet-based spectral analysis, and the determination of the intra-cycle aerodynamic damping factors.

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Date submitted: 01 Aug 2013

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