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Formulation for Time-resolved Aerodynamic Damping in Dynamic Stall[1] THOMAS CORKE, University of Notre Dame, PATRICK BOWLES, United Technologies Research Center, DUSTY COLEMAN, FLINT THOMAS, University of Notre Dame — A new Hilbert transform formulation of the equation of motion for a pitching airfoil in a uniform stream yields a time resolved aerodynamic damping factor, $\Xi(t) = (\sqrt{(C_m^2(t) + \tilde{C}_m^2/\alpha_{max}}) \sin\psi(t)$, where $C_m(t)$ is the instantaneous pitch moment coefficient, and $\tilde{C}_m(t)$ is the Hilbert transform of $C_m(t)$, α_{max} is the pitching amplitude, and $\psi(t)$ is the time-resolved phase difference between the aerodynamic pitch moment and the instantaneous angle of attack. A $\Xi(t) < 0$ indicates unstable pressure loading that can be considered a necessary condition to excite stall flutter in an elastic airfoil. This will be illustrated in experiments with conditions producing "light" dynamic stall for a range of Mach numbers from 0.3-0.6. These reveal large negative excursions of $\Xi(t)$ during the pitch-up portion of the cycle that correlates with the formation and convection of the dynamic stall vortex. The fact that the cycle-integrated damping coefficient is positive in all these cases underscores how the traditional diagnostic masks much of the physics that underlies the destabilizing effect of the dynamic stall process. This new insight can explain instances of transient limit-cycle growth of helicopter rotor vibrations.

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