STATE-SPACE INFLOW MODELING FOR LIFTING ROTORS WITH MASS INJECTION

Ke Yu and **David A. Peters**
Department of Mechanical Engineering
Washington University, Campus Box 1185, St. Louis, MO 63130-4899, USA

Abstract

In the field of rotorcraft dynamics, it is significant that the induced inflow field is well understood and modeled. A large number of methodologies have been developed in the past years, among which the state-space model is recognized for its advantage in real-time simulation, preliminary design, and dynamic eigenvalue analysis. Recent studies have shown success in representing the induced flow field everywhere above the rotor plane even with mass source terms on the disk as long as they have zero net flux of mass injection when integrated over the disk. Nevertheless, non-zero net mass influx is expected in numerous situations, such as ground effect, tip drive rotors, etc; and the incapability of previous models limits the utilization of the methodology in these cases. This work presents an extended potential-flow, state-space model derived from the potential-flow momentum equation by means of a Galerkin approach. The induced velocity and pressure perturbation are expanded in terms of closed-form, time-dependent coefficients and space-dependent associated Legendre functions and harmonics. Non-zero net mass flux terms are represented by the involvement of associated Legendre functions with equal degrees and orders. Validation, as well as discrepancies, of the inclusion of such terms is investigated. Numerical simulation of frequency response in axial and skew-angle flight is presented and compared with exact solutions obtained by the convolution integral. Also the study shows that, unlike other pressure distribution responses, non-zero mass influx exhibits a high sensitivity to the choice of the number of states in the velocity expansion. Error analyses are performed to show this sensitivity.