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Title

Comparison of Tiltrotor Whirl Flutter Analyses with Gimballed and Hingeless Hub Models

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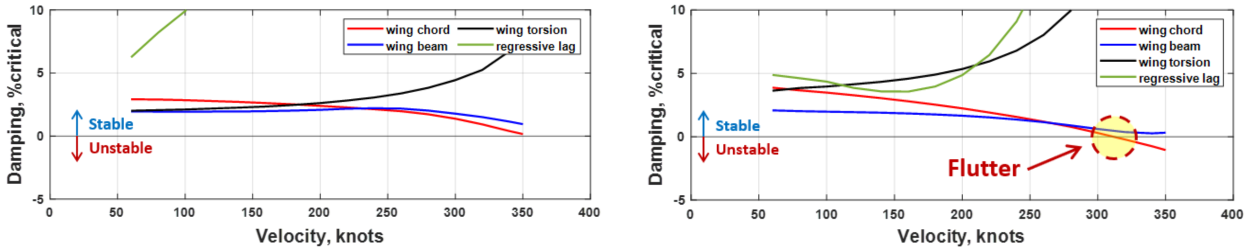
Abstract

Whirl flutter is an aeroelastic instability phenomenon of tiltrotors in airplane mode, which is caused by coupled motions of the proprotor and the flexible wing/pylon structure in high-speed flight. The present study conducts tiltrotor whirl flutter analyses considering two hub types for the proprotor and wing/pylon model of the unmanned tiltrotor aircraft developed by KARI (Korea Aerospace Research Institute). A rotorcraft comprehensive analysis code, CAMRAD II, is used for the present whirl flutter analyses with the proprotor with three blades and semi-span wing. The blade unsteady aerodynamic loads are calculated using the lifting-line theory along with the uniform inflow for high-speed axial flow. The proprotor is first trimmed to zero torque at a given wind velocity to represent the windmill state. Then, through the eigenvalue analysis, the frequency and damping for the aeroelastic system are calculated. Both the gimballed and the hingeless rotors are investigated numerically and their aeroelastic instability characteristics are compared. The flutter speed of the gimballed proprotor is higher than that of the hingeless proprotor (Figure 1). Figure 1(a) shows the damping variations of the gimballed hub model, and it is investigated that all the rotor and wing/pylon modes are stable in the entire speed range examined. For the hingeless hub model (Fig. 1(b)), the wing chord mode becomes unstable at 320 knots. It is considered that the instability of the wing chord mode is caused by interaction with the rotor regressive lag and wing chord modes. In the full paper, the results of the whirl flutter analyses with two different types of hubs will be described in detail for various rotor and wing/pylon models.



(a) Gimballed rotor (b) Hingeless rotor

Figure 1. Whirl flutter analysis results for gimballed and hingeless tiltrotors