N95- 23317

Thin Tailored Composite Wing For Civil Tiltrotor

by

Professor Masoud Rais-Rohani
Department of Aerospace Engineering
Mississippi State University
Mississippi State, MS 39762

The tiltrotor aircraft is a flight vehicle which combines the efficient low speed (i.e., take-off, landing, and hover) characteristics of a helicopter with the efficient cruise speed of a turboprop airplane. A well-known example of such vehicle is the Bell-Boeing V-22 Osprey. The high cruise speed and range constraints placed on the civil tiltrotor require a relatively thin wing to increase the drag-divergence Mach number which translates into lower compressibility drag. It is required to reduce the wing maximum thickness-to-chord ratio t/c from 23% (i.e., V-22 wing) to 18%. While a reduction in wing thickness results in improved aerodynamic efficiency, it has an adverse effect on the wing structure as it tends to reduce structural stiffness. If ignored, the reduction in wing stiffness leads to susceptibility to aeroelastic and dynamic instabilities which may consequently cause a catastrophic failure.

By taking advantage of the directional stiffness characteristics of composite materials the wing structure may be tailored to have the necessary stiffness, at a lower thickness, while keeping the weight low. The goal of this study is to design a wing structure for minimum weight subject to structural, dynamic and aeroelastic constraints. The structural constraints are in terms of strength and buckling allowables. The dynamic constraints are in terms of wing natural frequencies in vertical and horizontal bending and torsion. The aeroelastic constraints are in terms of frequency placement of the wing structure relative to those of the rotor system. The wing-rotor-pylon aeroelastic and dynamic interactions are limited in this design study by holding the cruise speed, rotor-pylon system, and wing geometric attributes fixed. To assure that the wing-rotor stability margins are maintained a more rigorous analysis based on a detailed model of the rotor system will need to ensue following the design study.

The skin-stringer-rib type architecture is used for the wing-box structure. The design variables include upper and lower skin ply thicknesses and orientation angles, spar and rib web thicknesses and cap areas, and stringer cross-sectional areas. These design variables will allow the maximum tailoring of the structure to meet the design requirements most efficiently.

Initial dynamic analysis has been conducted using MSC/NASTRAN to determine the baseline wing's frequencies and mode shapes. For the design study we intend to use the finite-element based code called WIDOWAC (Wing Design Optimization With Aeroelastic Constraints) that was developed at NASA Langley in early 1970's for airplane wing structural analysis and preliminary design. Currently, the focus is on modification and validation of this code which will be used for the civil tiltrotor design efforts.