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Vibration Analysis of Composite Airfoil Blade using Orthotropic Thin Shell Bending Theory

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ABSTRACT

In this paper, starting with the thin shell theory, the governing partial differential equation of motion for the transverse deflection of a rotating pre-twisted airfoil is derived. Strain-displacement relationships include the effect of warping of the cross-section due to twist-bend coupling effect introduced as a result of varying stagger angle and camber radius of the blade. The equation of motion, thus derived, is used to formulate the free vibration of a typical turbo-machinery cantilevered airfoil by considering it as an anisotropic shell in full curvilinear coordinates subjected to a centrifugal force field. The analytical derivation considers both the stress-stiffening as well as stress-softening effects of the centrifugal forces on the spinning airfoil. The fourth-order partial differential equation characterizing the flexural motion of the airfoil is transformed into a matrix- eigenvalue form using a Rayleigh-Ritz technique. The blade deformations are represented by a set of "admissible" sinusoidal trial functions, which fully satisfy all the clamped-end constraints as well as the free-edge boundary conditions. The numerical results presented in a non-dimensional parametric form are directly applicable in determining the static and running frequencies of typical composite blades used in the fan module of an aeroengine**.**

Keywords

Composite fan blade, Airfoil vibration, Centrifugal stiffening, Natural frequency, Eigenvalue solution, Rayleigh-Ritz technique, Orthotropic curved shell theory, Curvilinear coordinates

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