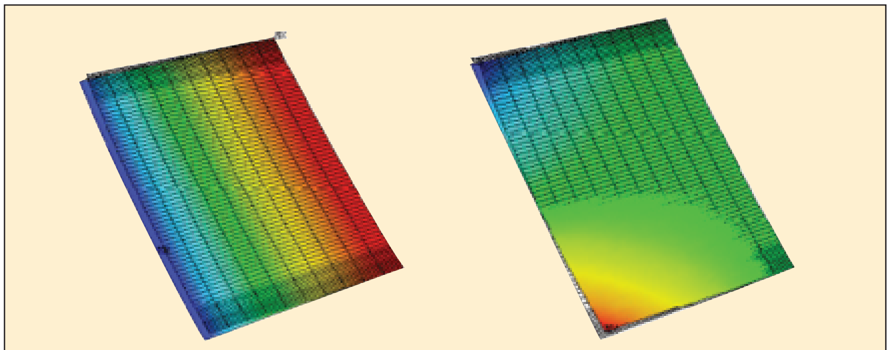
Rapid Aeroelastic Analysis of Blade Flutter in Turbomachines

John H. Glenn Research Center, Cleveland, Ohio

The LINFLUX-AE computer code predicts flutter and forced responses of blades and vanes in turbomachines under subsonic, transonic, and supersonic flow conditions. The code solves the Euler equations of unsteady flow in a blade passage under the assumption that the blades vibrate harmonically at small amplitudes. The steady-state nonlinear Euler equations are solved by a separate program, then equations for unsteady flow components are obtained through linearization around the steady-state solution. A structural-dynamics analysis (see figure) is performed to determine the frequencies and mode shapes of blade vibrations, a preprocessor interpolates mode shapes from the structural-dynamics mesh onto the LINFLUX computational-fluid-dynamics mesh, and an interface code is used to convert the steady-state flow solution to a form required by LINFLUX. Then LINFLUX solves the linearized equations in the frequency domain to calculate the unsteady aerodynamic pressure distribution for a given vibration mode, frequency, and interblade phase angle.



Blade Mode Shapes are shown for first and second modes. The first mode is a bending mode at 822 Hz, and the second mode is a torsion mode at 1,882 Hz.

A postprocessor uses the unsteady pressures to calculate generalized aerodynamic forces, response amplitudes, and eigenvalues (which determine the flutter frequency and damping). In comparison with the TURBO-AE aeroelastic-analysis code, which solves the equations in the time domain, LINFLUX-AE is 6 to 7 times faster.

This program was written by J. J. Trudell, O. Mehmed, G. L. Stefko, and M. A. Bakhle of **Glenn Research Center***; T. S. R. Reddy of the University of Toledo; M. Montgomery of United Technologies; and J. Verdon of Ohio Aerospace Institute. Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17880-1.

General Flow-Solver Code for Turbomachinery Applications

Marshall Space Flight Center, Alabama

Phantom is a computer code intended primarily for real-fluid turbomachinery problems. It is based on Corsair, an ideal-gas turbomachinery code, developed by the same authors, which evolved from the ROTOR codes from NASA Ames. Phantom is applicable to real and ideal fluids, both compressible and incompressible, flowing at subsonic, transonic, and supersonic speeds. It utilizes structured, overset, O- and H-type zonal grids to discretize flow fields and represent relative motions of components. Values on grid boundaries are updated at each time step by bilinear interpolation from adjacent grids. Inviscid fluxes are calculated to third-order spatial accuracy using Roe's scheme. Viscous fluxes are calculated using second-order-accurate central differences. The code is second-order accurate in time. Turbulence is represented by a modified Baldwin-Lomax algebraic model. The code offers two options for determining properties of fluids: One is based on equations of state, thermodynamic departure functions, and corresponding state principles. The other, which is more efficient, is based on splines generated from tables of properties of real fluids. Phantom currently contains fluid-property routines for water, hydrogen, oxygen, nitrogen, kerosene, methane, and carbon monoxide as well as ideal gases.

This work was done by Daniel Dorney of **Marshall Space Flight Center** *and Douglas Sondak of Boston University. Further information is contained in a TSP (see page 1).*
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Code for Multiblock CFD and Heat-Transfer Computations

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The NASA Glenn Research Center General Multi-Block Navier-Stokes Convective Heat Transfer Code, Glenn-HT, has been used extensively to predict heat transfer and fluid flow for a variety of steady gas turbine engine problems. Recently, the Glenn-HT code has been completely rewritten in Fortran 90/95, a more object-oriented language that allows programmers to create code that is more modular and makes more efficient use of data structures. The new implementation takes full advantage of the capabilities of the Fortran 90/95 programming language. As a result, the