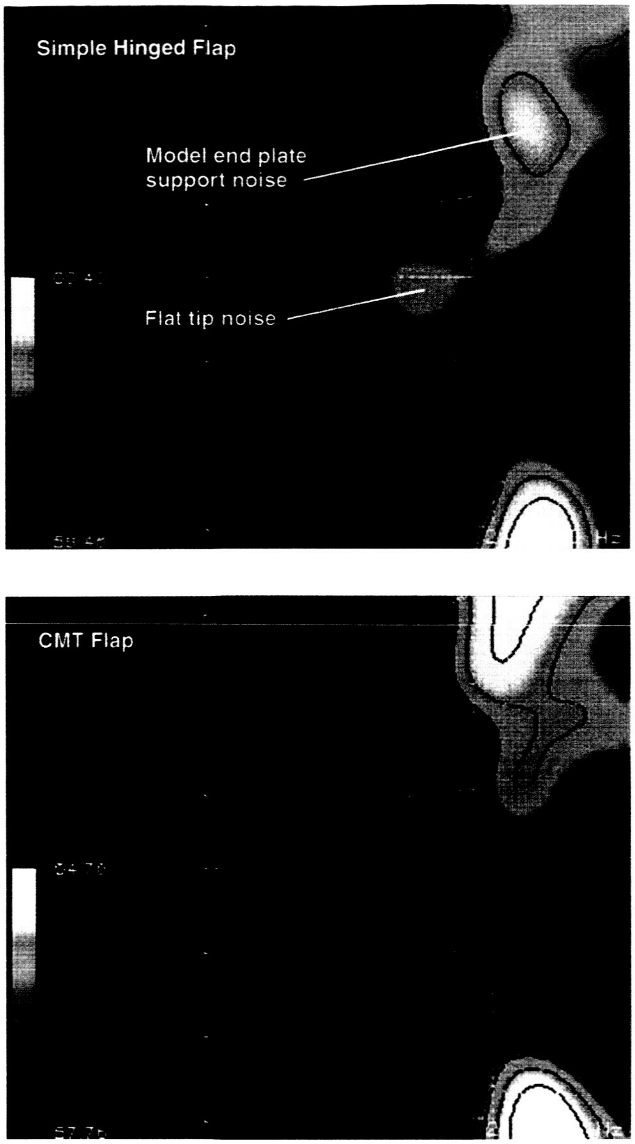

Fig. 2. Noise source images at simple flap tip (upper) eliminated by CMT flap (lower).

REVOLUTIONARY TECHNOLOGY

Improved Rotorcraft Airfoil Designs Using Genetic Algorithms

David W. Fanjoy, William A. Crossley, Anastasios Lyrintzis, Sesi Kottapalli

Genetic algorithms (GAs) are an optimal search technique based on "evolutionary programming" techniques that mimic Darwin's idea of "natural selection." Ongoing research has demonstrated that GAs are useful tools in aerospace design. Recent research has centered on using GA-based-methods for airfoil design. A "practical" problem of rotorcraft industry origin that involved the vertical tail (NACA 63-418 airfoil section) of a current Army helicopter was considered. The vertical tail was experiencing buffeting within its normal flight envelope, and excessive flow separation at moderate angles of attack was a suspected cause. The objective of this effort was to design a new GA-based vertical tail airfoil section that maintained attached flow. The associated shape-design problem was as follows: minimize airfoil drag while retaining the thickness, lift, and moment of the NACA 63-418 airfoil. An additional constraint ensured that the new airfoil design retained attached flow at three flight conditions (at angles of attack of -2, 4, and 12 degrees, and at a Mach number of 0.06). A simplified aerodynamic analysis, the panel method, was to be used to keep computational expense low.

Compared to the NACA 63-418 airfoil, the new GA-based airfoil (figure 1) featured a maximum thickness location that was farther forward; it also had a more complex camber distribution. Results showed that the new GA-based airfoil exhibited similar lift, a smaller pitching moment, and less flow separation than the NACA 63-418. Figure 2 shows that at an angle of attack of 12 degrees, the separation location improvement for the new GA-based airfoil was 18% of the chord. Further analysis using two more advanced codes (Ames' ARC2D and the Massachusetts Institute of Technology's XFOIL) confirmed the above improvement (however, the three codes predicted different improvement levels). To summarize, it is believed that the present GA-based procedure can be used for solving rotorcraft–related problems of a practical nature.

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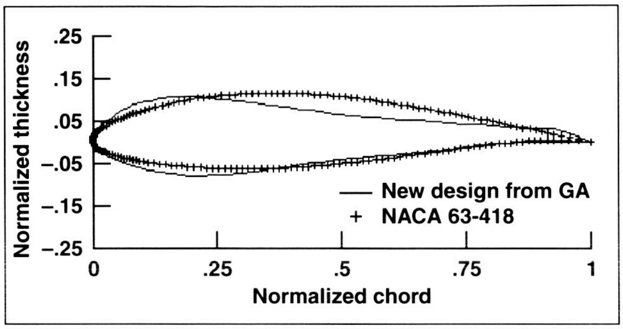

Fig. 1. NACA 63-418 design and new, genetic-algorithm-based design.

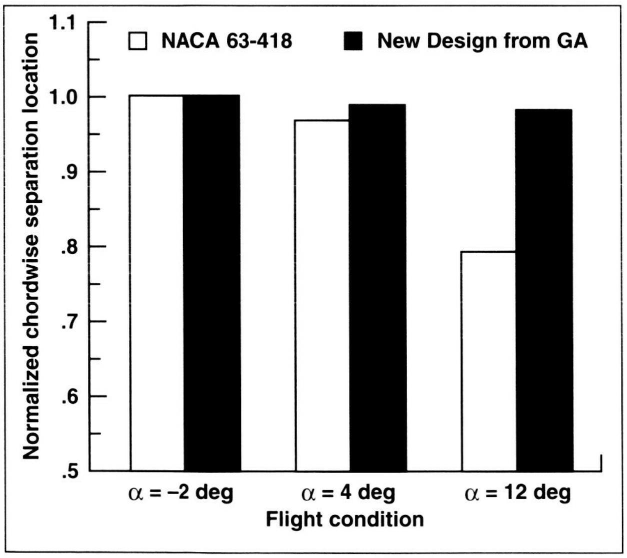

Fig. 2. Upper surface separation locations: angle of attack = 12 degrees (NACA 63-418 design and new design).

Overset Structured Grids for Unsteady Aerodynamics

Robert L. Meakin

The Department of Defense is supporting the development of robust adaptive refinement methods for unsteady geometrically complex moving body problems by means of the High Performance Computing Modernization Program (HPCMP) Initiative known as CHSSI. The object of the work is to exploit the computational advantages inherent in structured data to solve this important class of problems on parallel scalable computer platforms.

The physical domain of complex problems is decomposed into near-body and off-body regions. The near-body domain is discretized with "Chimera" overset grids that need extend only a short distance into the field. The off-body domain is discretized with overset structured Cartesian grids (uniform) of varying levels of refinement. The near-body grids resolve viscous boundary layers and other flow features expected to develop near body surfaces. Off-body grids automatically adapt to the proximity of near-body components and evolving flow features. The adaptation scheme automatically maintains solution accuracy at the resolution capacity of the near-body system of grids. The approach is computationally efficient and has high potential for scalability. Grid components are automatically organized into groups of equal size, which facilitates parallel scale-up on the number of groups requested. The method has been implemented in the computer program known as OVERFLOW-D.

For example, OVERFLOW-D was used in FY99 to obtain a time-accurate simulation of the V-22 tilt-rotor aircraft in high-speed cruise conditions. Temporal resolution of the simulation provided 2,000 time-steps per revolution of the rotor blades. Nearly 30 million grid points are used to spatially resolve the problem domain. An important result of the simulation is the capture of the rotor-tip vortices as part of the solution. As indicated in the figure, the vortices are evident in the field a full body length downstream of rotors. The simulation was carried out using 65 processors on an IBM-SP. Post-process analysis of the large unsteady data set was carried out on an SGI Origin 2000.