

NSAERO APPLICATION

Buffet Onset of 18% Circular-Arc Airfoil

Introduction

This application note demonstrates the capability of NSAERO to predict shock induced oscillation (buffeting). NSAERO is a multi block computational fluid dynamics software package available from Analytical Methods, Inc. The current application is the prediction of the transonic unsteady flow field around an 18% circular-arc airfoil.

Problem Description

Transonic buffet appears in many aeronautical applications, the aerodynamic performance depends strongly on the unsteady shock/boundary layer interaction due to the self excited shock oscillations. The assessment of NSAERO is performed against experimental results from McDevitt¹ with an 18% circular-arc airfoil at zero angle of attack and at Reynolds number of 11 million.

Problem Setup

Structured meshes are generated in 3 blocks fashion. According to McDevitt¹, unsteady flow occurs at about Mach number 0.765. The time step refinement was found to be critical for the accuracy of the unsteady pressure amplitude prediction. A time step of 1 μ s with 3 sub-iterations was found to be adequate, this finding is consistent with the conclusion from Barakos². Table 1 resumes the mesh size, CPU time and memory requirement.

Results

The hysteresis effects is tested by computing the flow solution in a steady-state fashion for different freestream Mach Numbers from 0.76 to 0.78 with 0.005 increment. Unsteady results for Mach number of 0.765 is reported here in more details. Figure 1 shows a snapshot of the Mach number contours. The shock-boundary layer interaction exhibit a separation and the oscillation pattern is depicted in Figure 2. The time history of the shock location is compared with experimental results in figure 3. Good correlation is obtained as well as for the frequency of the periodic oscillation: 188 Hz compared to 190 Hz¹.

Surface points	160 x 2
Off-body points	20,000 (201x81, 201x81, 41x81)
CPU Time	11 min (AMD 1.4 GhZ)
Memory	8.7 kB

Table 1 Grid size, CPU time and memory requirement

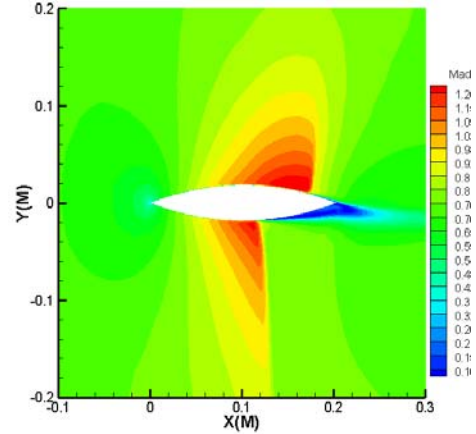


Figure 1 Instantaneous Mach Number contours

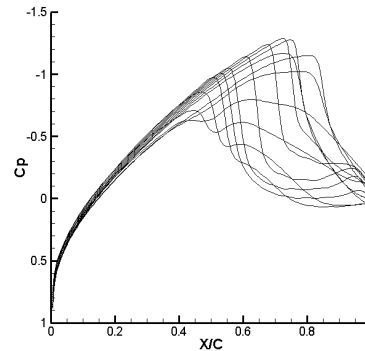


Figure 2 Cp profile on the upper surface at different instant in time.

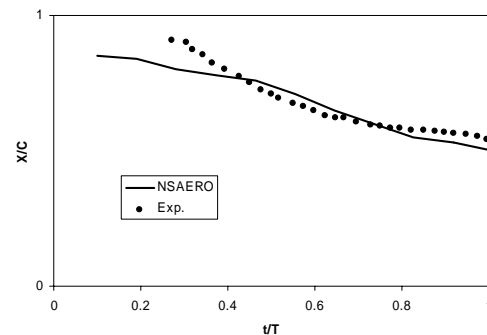


Figure 2 Shock location versus time

¹ McDevitt, J. B., Levy, L. L. and Deiwert, G. S., "Transonic flow about a thick circular-arc airfoil", AIAA J., V. 14, No. 5, 1976, pp 606-613.

² Barakos, G. and Drikakis D., Numerical Simulation of Buffeting Flows Using Various Turbulence Closures. Presented at the First International Symposium on Turbulence and Shear Flow Phenomena (TSFP1), Santa Barbara, Ca, USA, September 1999.