Numerical Study of Navier-Stokes Equations in Supersonic Flow Over a Double Wedge Airfoil Using Adaptive Grids

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Abstract

Numerical study of aerodynamic characteristics in steady laminar supersonic flow over a double wedge airfoil is carried out using commercially available finite element based CFD tool COMSOL Multiphysics. The aerodynamic characteristics of double wedge airfoil like lift and drag are analyzed by solving Navier-Stokes equations in the flow field for various thickness to chord ratios (t_c) and angle of attack α at free stream Mach number M=2.5. In the present work the high Mach number flow module with pseudo time stepping methodology and adaptive gridding technique is used to obtain a steady state solution by marching in time and to capture the shocks occurring in the flow field. The simulation were performed for 21 cases and for each case the Euler solution was first obtained and then was made as the initial condition for viscous simulation. The aerodynamic coefficients such as CL, CD and CP are evaluated from both shock expansion theory and numerical simulation of Navier-Stokes for double wedge airfoil with free stream Mach number M=2.5 for different configurations. The CL and CD graphs were obtained from COMSOL Multiphysics simulations for various configurations of airfoil ref Figure1 and Figure2 respectively also for specific cases surface plots of pressure are plotted for t_c=0.1 and angle of attack α=4degrees and 12degrees ref Figure3 and Figure4. The solution obtained from numerical simulation performed with FEM tool COMSOL Multiphysics is in good agreement with shock-expansion theory indicating the fundamental flow field behavior to be same. The error between Shock expansion theory and compressible viscous flow theory indicates the viscous and wake effects that exist in reality and thus COMSOL Multiphysics mimics the realistic effects to acceptable standards providing the users a platform to simulate high Mach number flow along with other required physics.

Reference

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Figures used in the abstract

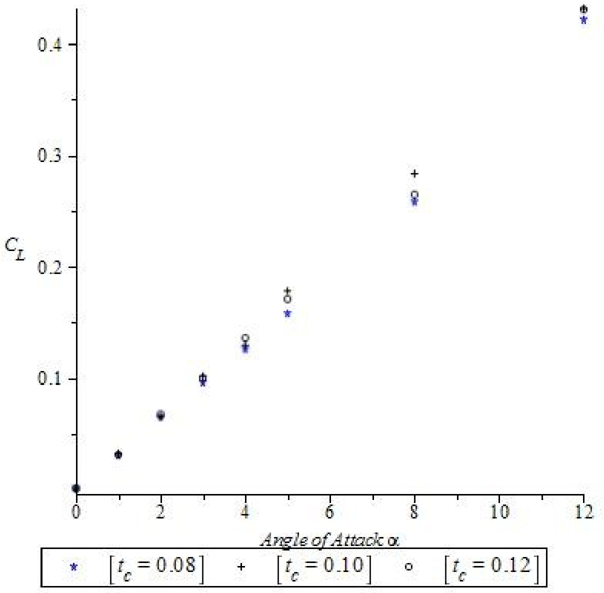

Figure 1: Graph indicates the variation of CL with α which is obtained from solving Navier-Stokes for t_c = (0.08, 0.10 and 0.12).

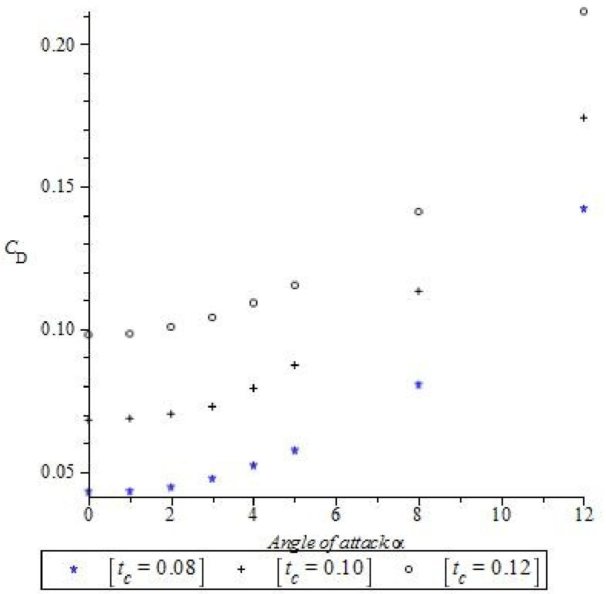

Figure 2: Graph indicates the variation of CD with α which is obtained from solving Navier-Stokes for t_c = (0.08, 0.10 and 0.12).

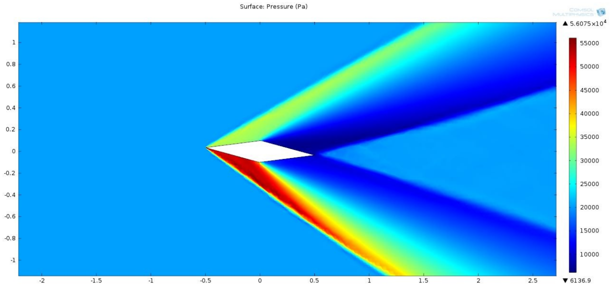

Figure 3: Surface plot of pressure for t_c=0.10 and α=4 degrees.

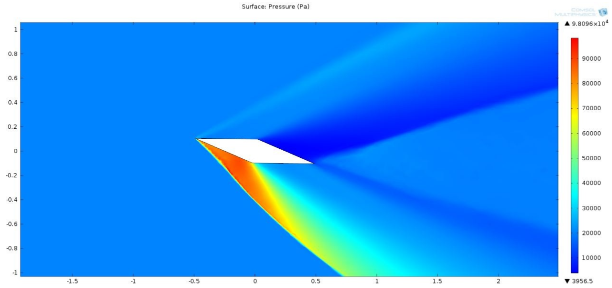

Figure 4: Surface plot of pressure for t_c=0.10 and α=12 degrees.