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TURBULENT FLOW COMPUTATIONS USING UPWIND RANS TECHNIQUE FOR A FLAT PLATE AND AN AIRFOIL

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Abstract.: Reynolds-Averaged Navier Stokes (RANS) equations are solved using a third-order upwind biased Roe's scheme for the inviscid fluxes and second order central difference scheme for the viscous fluxes. The Baldwin & Lomax turbulence model is employed for the Reynolds stresses. The governing equations are solved using a finite-volume implicit scheme in body-fitted curvilinear coordinate system. Computations are reported for a flat plate apart from RAE 2822 and NACA 0012 airfoils. Results obtained for the flat plate at M=0.3, $R_c = 4.0 \times 10^6$ compare favourably with the analytical solution. Computational results obtained for the two airfoils are compared with experiment. For both airfoils there is a good agreement in surface-pressure distributions between computational results and experiments. However, resoanable agreement is obtained between computational and experimental skin-friction distributions for the RAE 2822 airfoil.

Keywords. RANS Equation, finite-volume method, turbulence model, flux difference splitting, airfoil.

1 Introduction

A numerical algorithm has been developed to predict the aerodynamic characteristics of airfoils at low Reynolds numbers, including laminar separation bubble, using a finite-volume scheme by solving compressible Navier-Stokes equations [7] in body-fitted curvilinear co-ordinates based on an O-grid system. The flow encountered is complex with flow transition, separation and reattachment which required the capability of the code to be extended to higher Reynolds numbers by introducing a turbulence model. The present paper describes the Reynolds Averaged Navier-Stokes (RANS) equation and the numerical procedure adopted to solve the equations, which is of interest in aeronautical applications. Computations are carried out for a flat plate apart from RAE 2822 and NACA 0012 airfoils and the results are compared with experiments and known analytical solutions. It has been found that comparison is excellent for surface pressure distributions and reasonable for skin-friction distributions. Reasons for the discrepancies in the comparisons