# ENE 503 – Computational Fluid Dynamics

## WEEK 7: COMPRESSIBLE MODELLING

***COMPRESSIBLE MODELLING:***

- **Contents:**

  - The turbulent flow past a transonic airfoil at a nonzero angle of attack is modelled and simulated by using the Spalart-Allmaras turbulence model.
  - The simulations are conducted by using the same boundary conditions specified in the Tutorial. The same mesh configuration is also employed.
  - Parametric study is conducted at different Mach numbers and viscosity ratios as below:

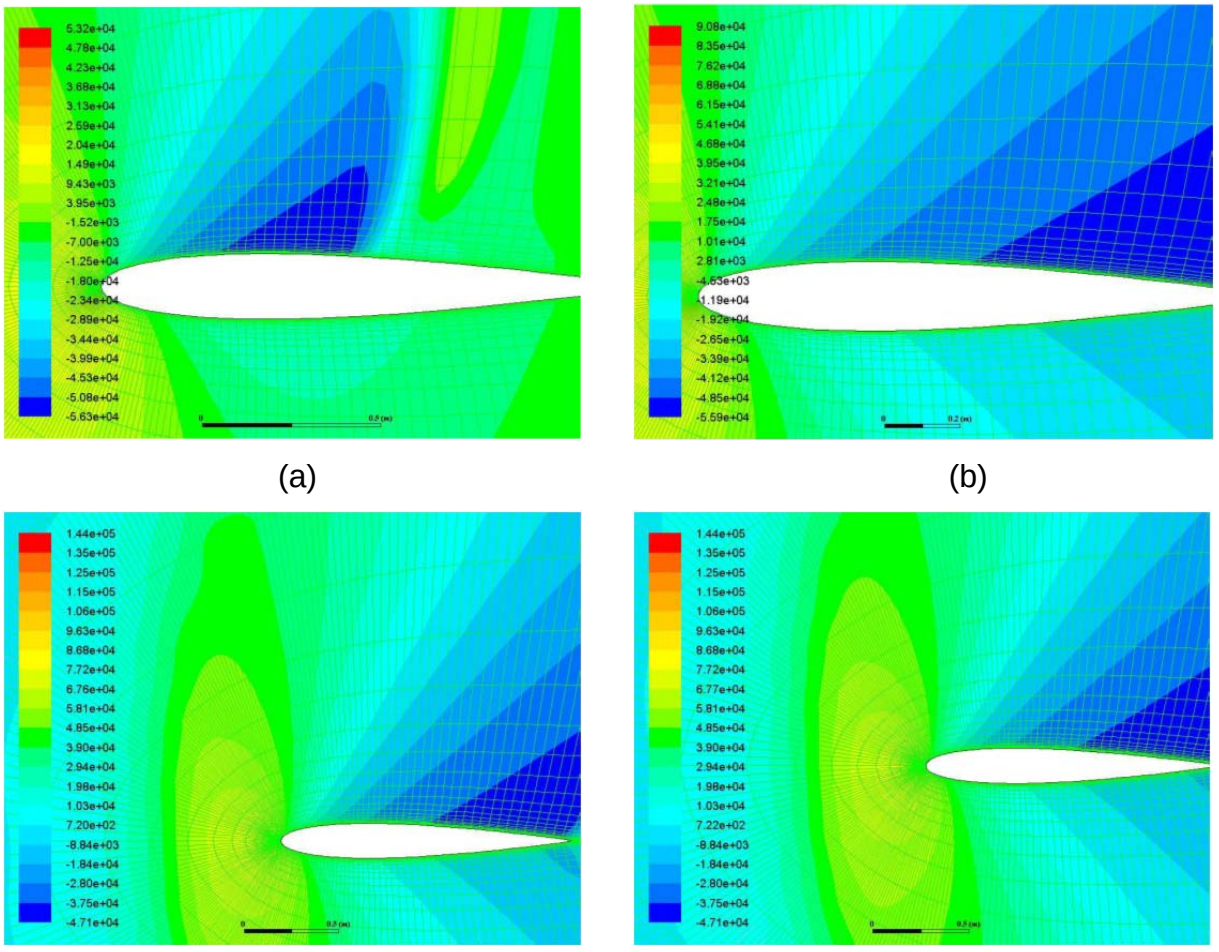
  Simulation 1. Mach Number: 0.8; Turbulent Viscosity Ratio: 10
  Simulation 2: Mach Number: 1.0; Turbulent Viscosity Ratio: 10
  Simulation 3: Mach Number: 1.2; Turbulent Viscosity Ratio: 10
  Simulation 4: Mach Number: 1.2; Turbulent Viscosity Ratio: 30

  - Comparative studies for the above simulations are performed by reproducing the below indicated results:

    1. Pressure Contours
    2. Velocity Magnitude History
    3. Drag Coefficient Convergence History
    4. Lift Coefficient Convergence History
    5. Moment Coefficient Convergence History
    6. XY Plot of y+ Distribution
    7. Contour Plot of Mach Number
    8. XY Plot of Pressure
    9. XY Plot of x Wall Shear Stress
    10. Contour Plot of x Component of Velocity
    11. Plot of Velocity Vectors

- **Comparisons:**

1 - Pressure contours:




(a) (b)

(c) (d)

Figure 1. Pressure contours a) Simulation 1; b) Simulation 2; c) Simulation 3; d) Simulation 4

2 - Velocity magnitudes

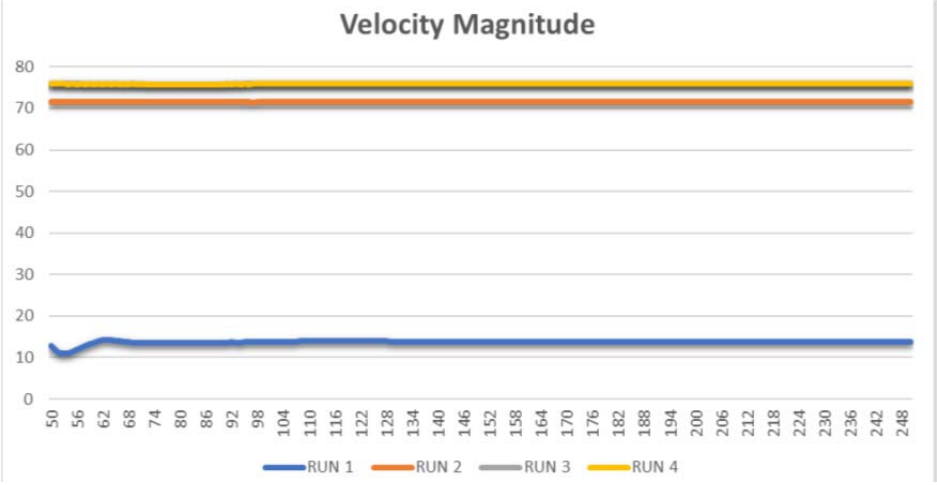



Figure 2. The velocity magnitude obtained for each simulation

3 - Drag history

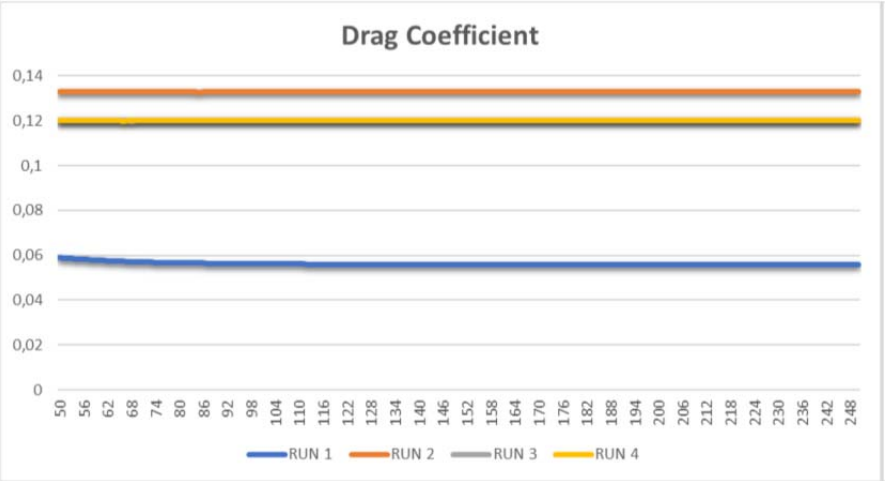



Figure 3. The drag history obtained for each simulation

4 - Lift history

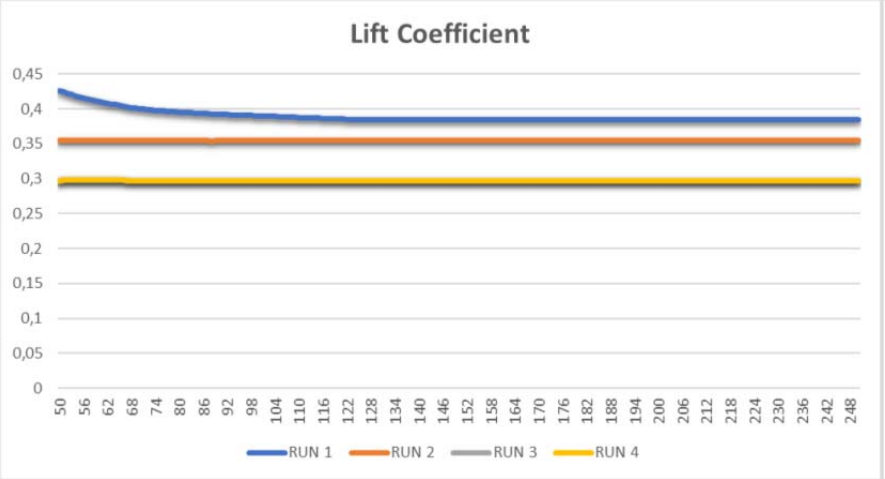



Figure 4. The lift history obtained for each simulation

5 - Moment coefficient

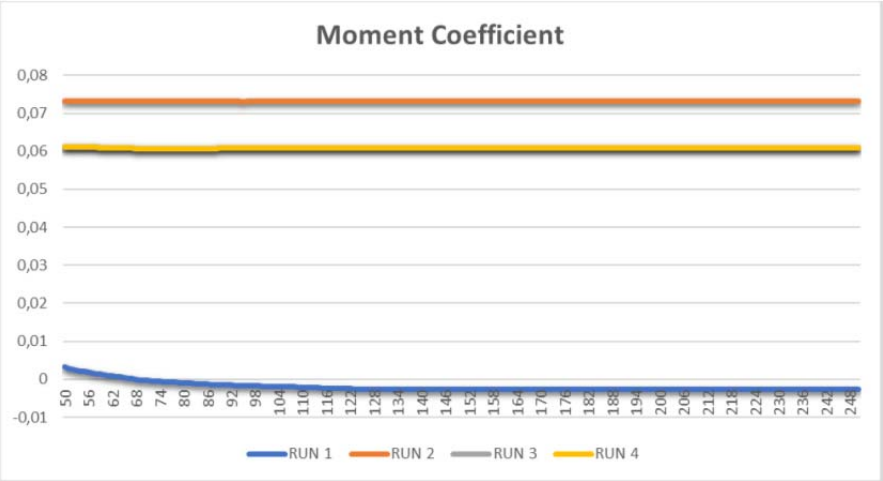



Figure 5. The lift history obtained for each simulation

**References**

1. Jameson A., Iterative solution of transonic flows over airfoils and wings, including flows at mach 1, Communications on Pure and Applied Mathematics, Volume 27, Issue 3, Pages 283–405, May 1974.

2. Melnik R.E., Chow R., Mead H.R., Theory of viscous transonic flow over airfoils at high Reynolds number, 10th Fluid and Plasmadynamics Conference, Albuquerque,NM,U.S.A., 1977.

3. Harris C.D., “Two-Dimensional Aerodynamic Characteristics of the NACA 0012 Airfoil in the Langley 8-foot Transonic Pressure Tunnel,” NASA Ames Research Center, NASA TM 81927, 1981.

4. Coakley T.J., “Numerical Simulation of Viscous Transonic Airfoil Flows,” NASA Ames Research Center, AIAA-87-0416, 1987.

5. Hall K.C., Thomas J.P., Dowell E.H., Proper Orthogonal Decomposition Technique for Transonic Unsteady Aerodynamic Flows, AIAA JOURNAL, Vol. 38, No. 10, October 2000.