RAE6-9CK Airfoil simulation using Spalart Allmaras model

By Computational Domain

Introduction

- Simulation of a supercritical airfoil RAE6-9CK is performed using Spalart Allmaras in openFOAM
- Spalart Allmaras turbulence model:
  - Uses one transport equation

$$\nu_t = \tilde{\nu} f_{v1}, \quad f_{v1} = \frac{\chi^3}{\chi^3 + C_{v1}^3}, \quad \chi := \frac{\tilde{\nu}}{\nu}$$

Conditions

- Standard Sea-level conditions:
  - Temperature: 298.15 K
  - Pressure: 101 325 Pa
  - Density: 1.225 kg/m^3
  - Reynold's numer: 6.5e6
  - Mach numer: 0.7
  - Angle of attack: 5º

Sutherland's viscous law

$$\mu = \mu_0 \left(\frac{T}{T_0}\right)^{\frac{3}{2}} \frac{T_0 + T_s}{T + T_s}$$

$$\mu = \Lambda_s \frac{T^{\frac{3}{2}}}{T + T_s}$$

$$\Lambda_s = \mu_0 \frac{(T_0 + T_s)}{T_0^{\frac{3}{2}}}, \qquad \frac{T_s}{T_0} = \frac{110.4}{273.15}$$

Sutherland's viscous law

$$\mu_0 = \frac{\rho \cdot M\sqrt{\gamma RT} \cdot c}{Re} = \frac{1.225 \cdot 0.7\sqrt{1.4 \cdot 287 \cdot 298.15}}{6.5 \cdot 10^6} = 4.56607 \cdot 10^{-5}[Pa \cdot s]$$

$$T_s = \frac{110.4}{273.15} \cdot 298.15 = 120.5043383[K]$$

$$A_s = 4.56607 \cdot 10^{-5} \cdot \frac{298.15 + 120.5043383}{298.15^{\frac{3}{2}}} = 3.71318 \cdot 10^{-6}$$

Equation of State

- Molar mass of air: M = 28.97 g/mol
- Number of moles: n = 1

$$p = \frac{\rho RT}{M}$$

Initial turbulent viscousity

- Initial turbulent viscousity: $\mu_t = 3\text{-}5\mu$
- Source: https://www.iccfd.org/iccfd7/assets/pdf/papers/ICCFD7-1902_paper.pdf