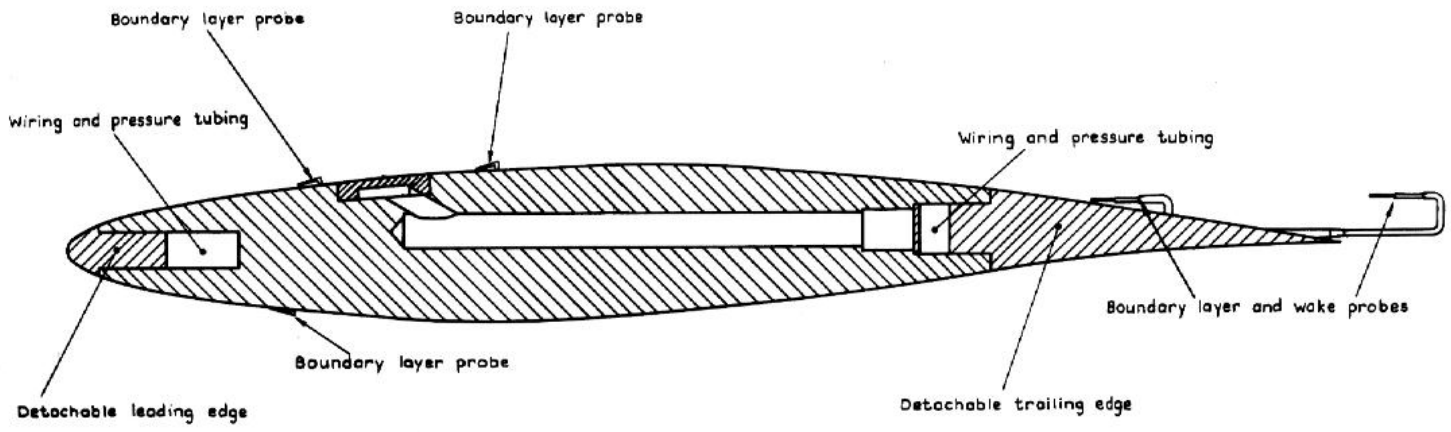
Problem definition

Transonic Flow over an RAE 2822 Airfoil

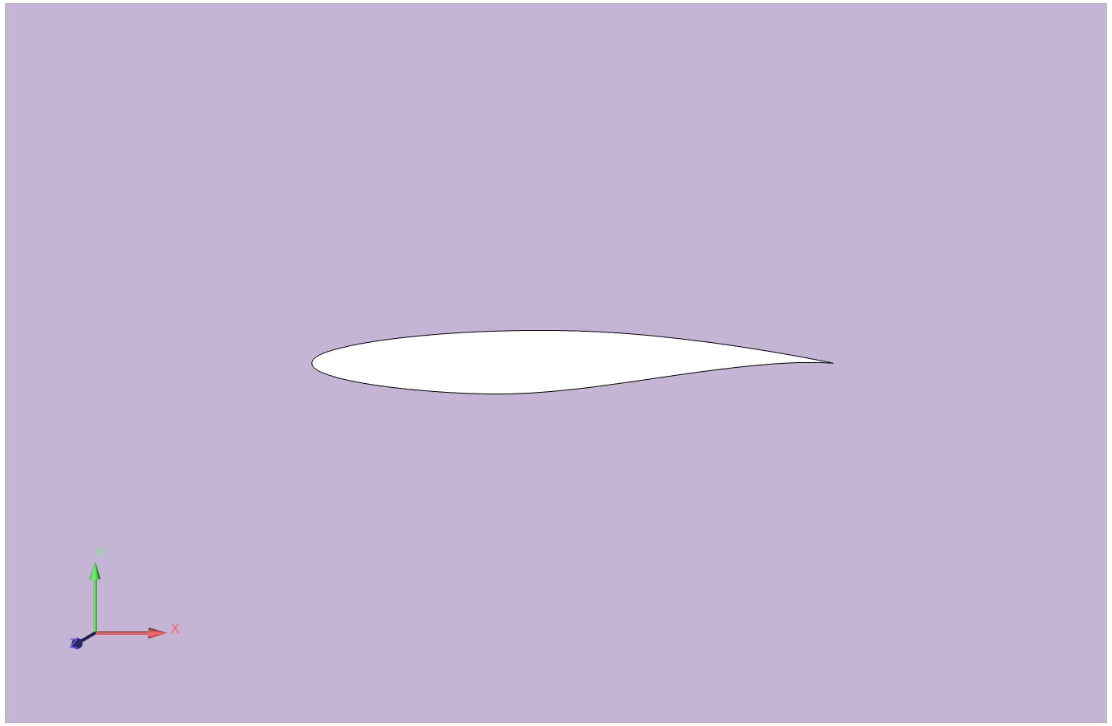


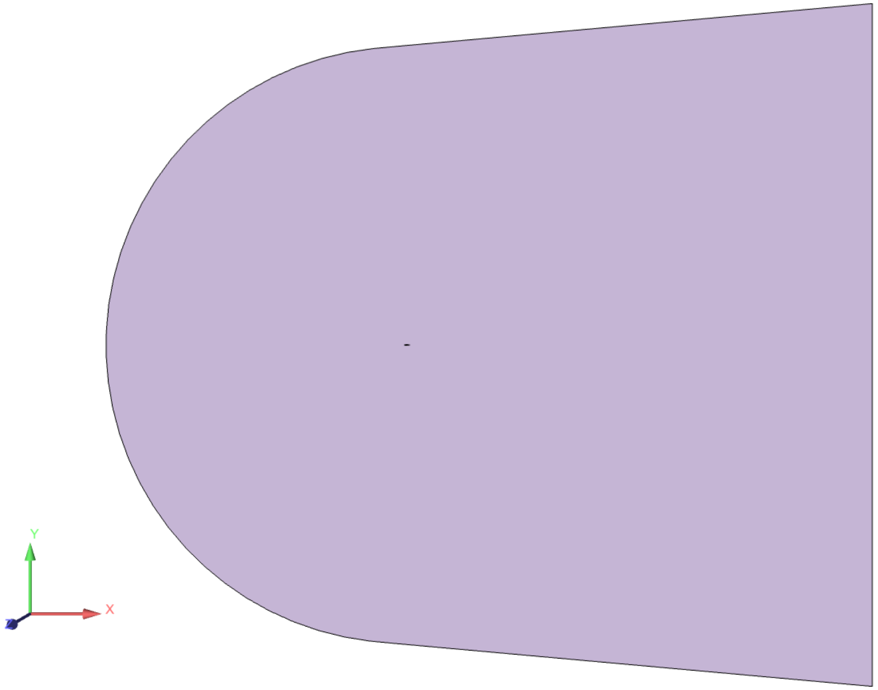
RAE 2822 transonic airfoil (From Ref. 1).

- Flow past airfoils (and wings) are classical validation cases in turbulence modeling.
- This case corresponds to transonic conditions with shock waves.
- **A few references:**
  - http://www.grc.nasa.gov/WWW/wind/valid/raetaf/raetaf.html
  - Cook, P. H., M. A. McDonald, M. C. P. Firmin. Aerofoil RAE 2822 - Pressure Distributions, and Boundary Layer and Wake Measurements. Experimental Data Base for Computer Program Assessment, AGARD Report AR 138, 1979.
  - Kline, S. J., Cantwell, B. J., Lilley, G. M. 1980-81 AFOSR-HTTM-Stanford Conference on Complex Turbulent Flows: Comparison of Computation and Experiment. Stanford University, Stanford, California, 1982.

Problem definition

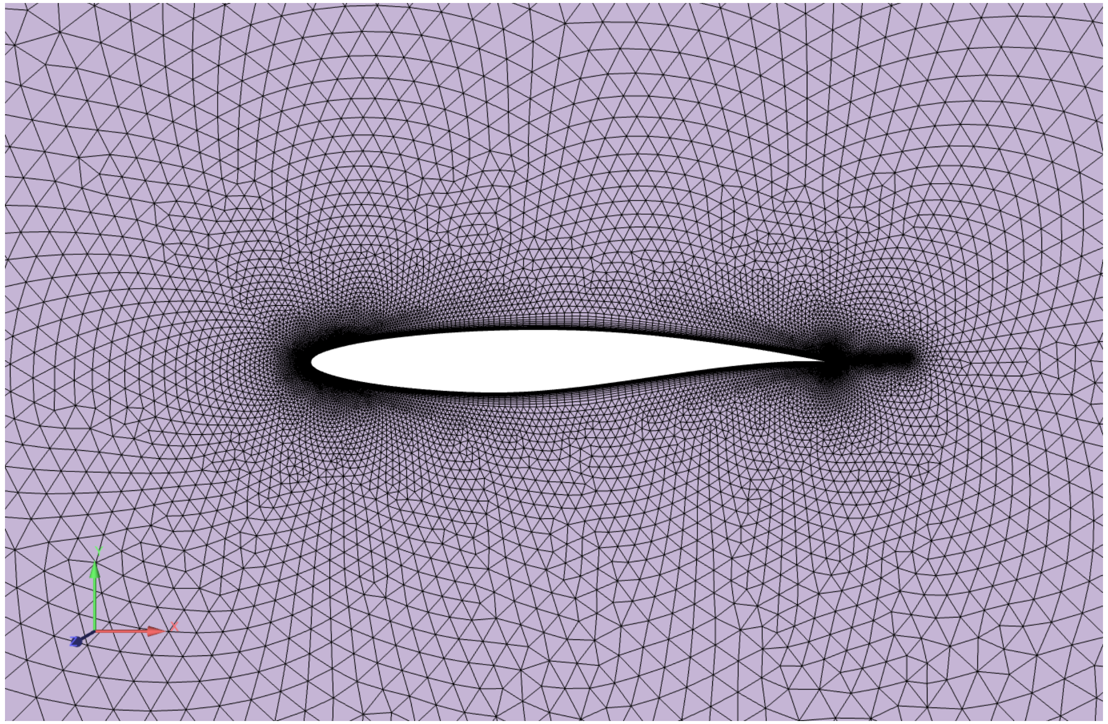
Geometry and mesh

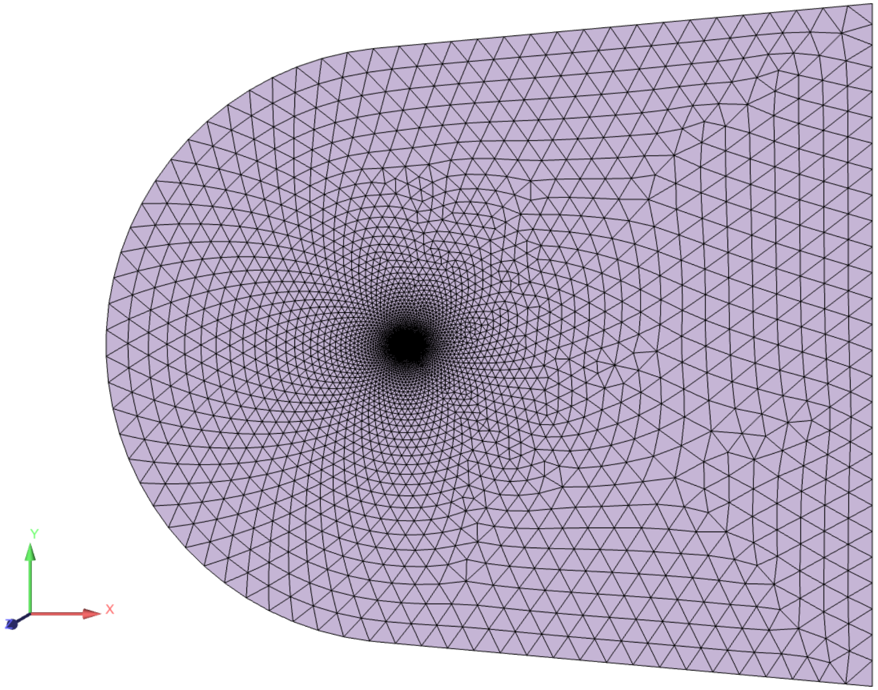




Problem definition

Geometry and mesh

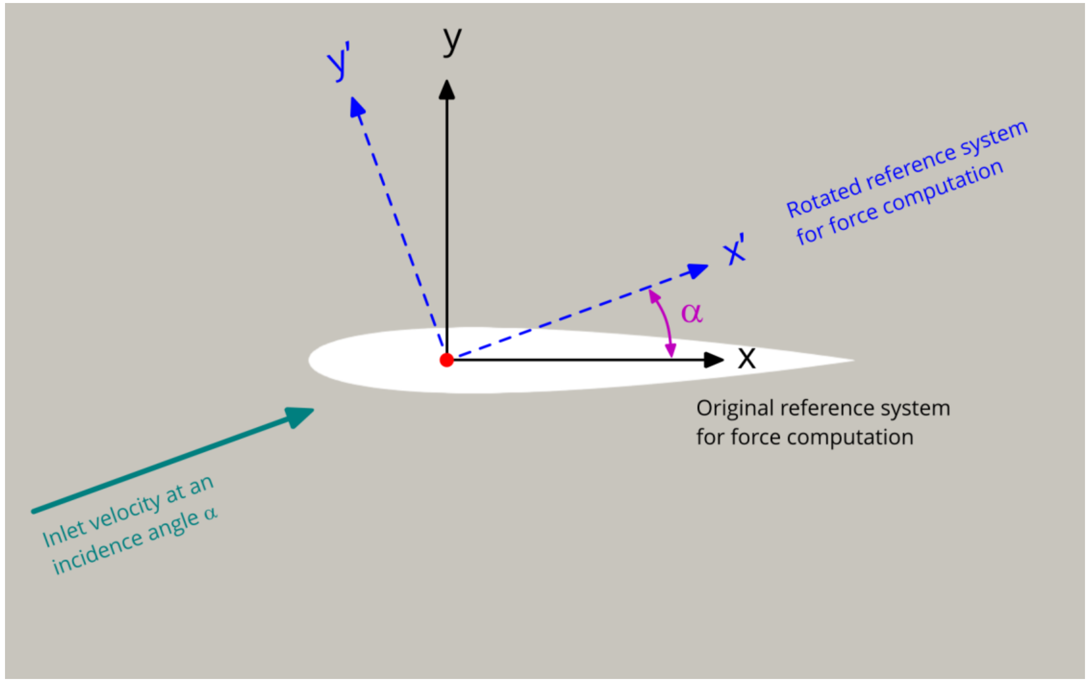




- The mesh illustrated is a structured one.
- It is called a C-type topology.
- This is a wall modeling mesh.

Problem definition

Reference axes to compute the lift and drag coefficients



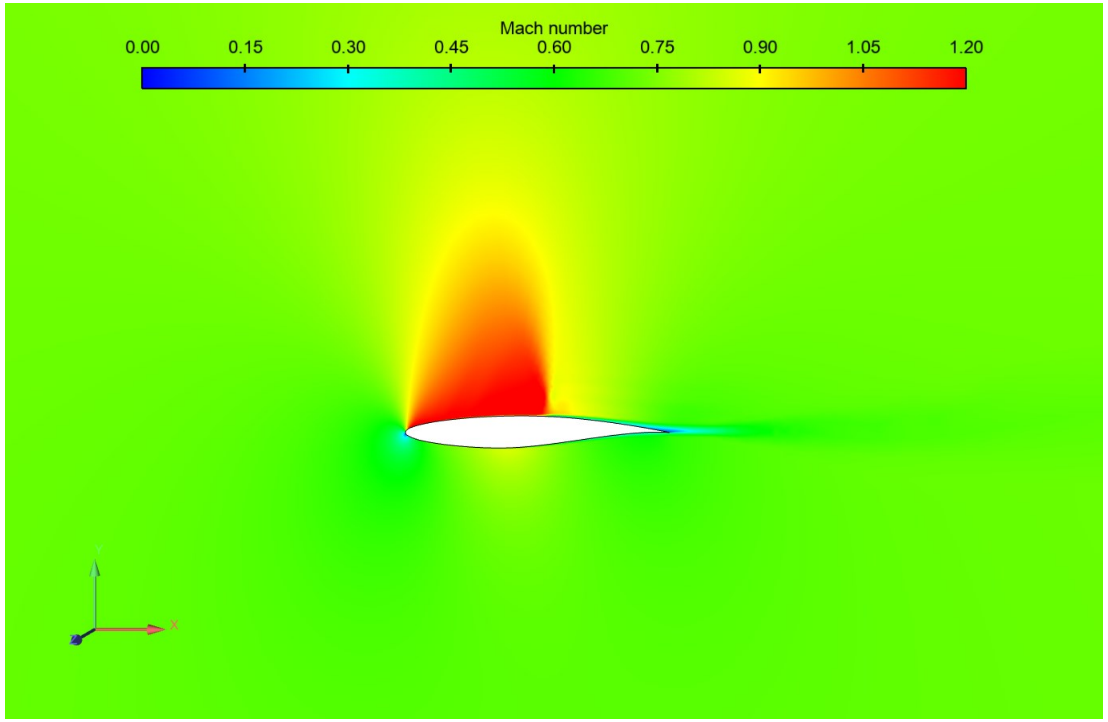
$$\text{liftDir } (\text{-}\sin(\alpha), \cos(\alpha), 0)$$

$$\text{dragDir } (\cos(\alpha), \sin(\alpha), 0)$$

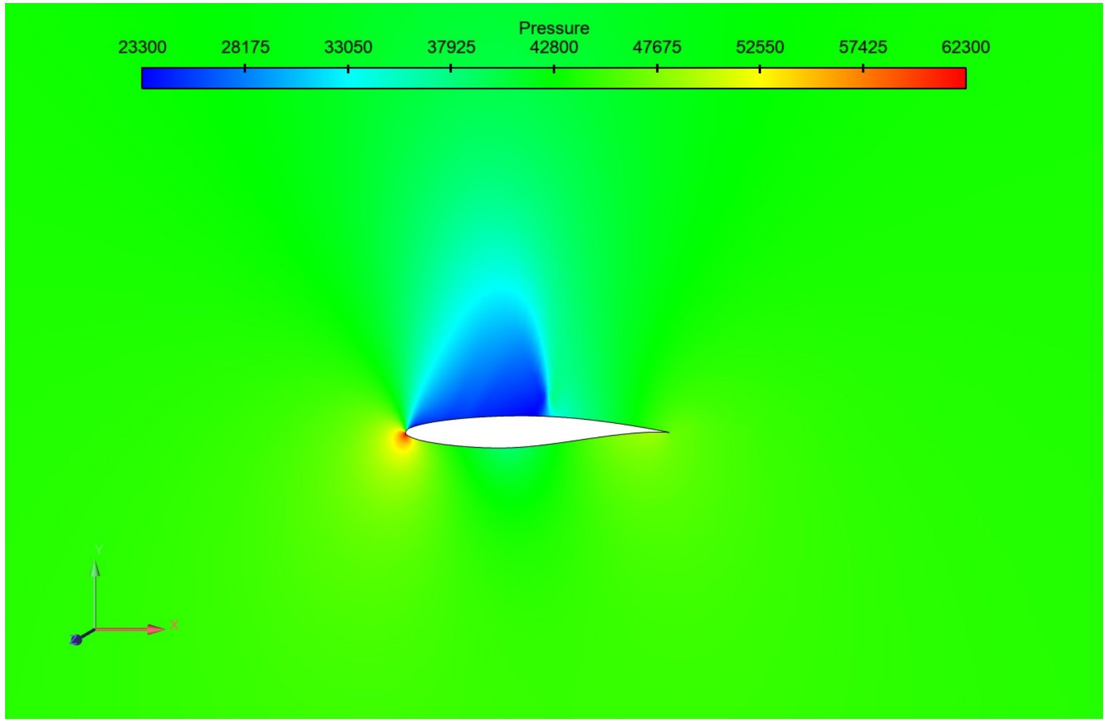
- Remember, lift and drag are perpendicular and parallel to the incoming flow, respectively.
- So, if the inlet velocity is entering at a given angle, you should adjust the vectors **liftDir** and **dragDir** so they are aligned with the incoming flow (rotation matrix).
- Personally speaking, I prefer to rotate the geometry instead of changing the angle of incoming flow.
    - But this requires updating the geometry and mesh.
- **In this case, we will change the angle of the incoming flow, so it is required to adjust the reference axes.**

Qualitative and quantitative results

Transonic Flow over an RAE 2822 Airfoil – Ma = 0.73 – AOA = 2.79°



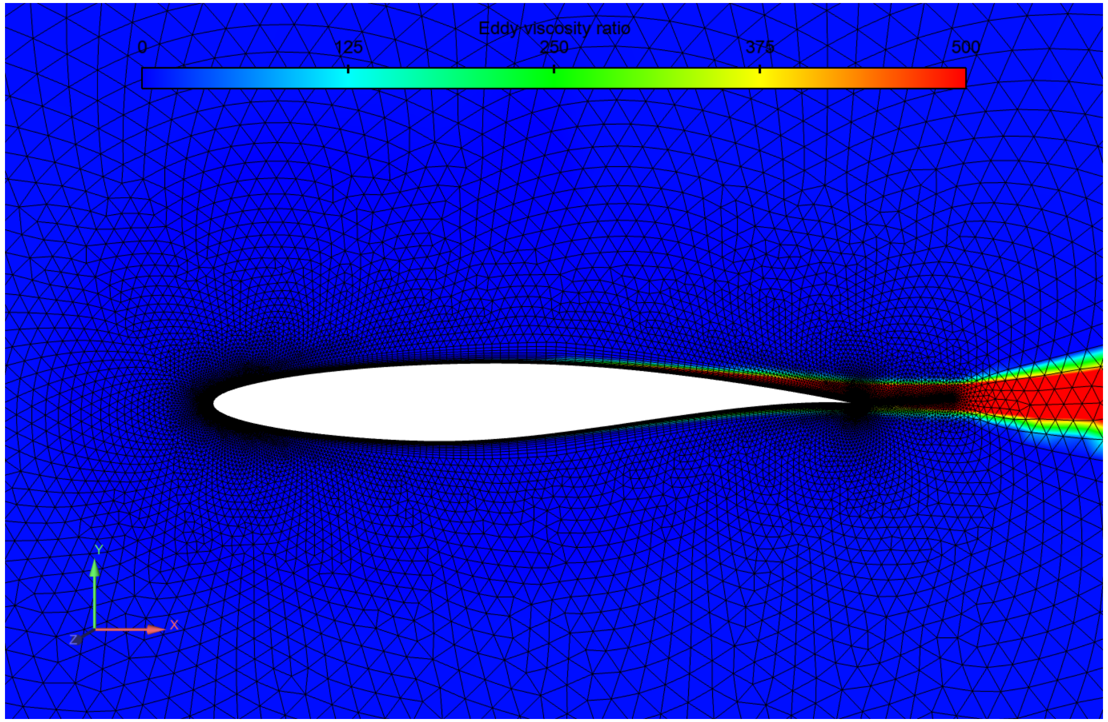
Contours of Mach



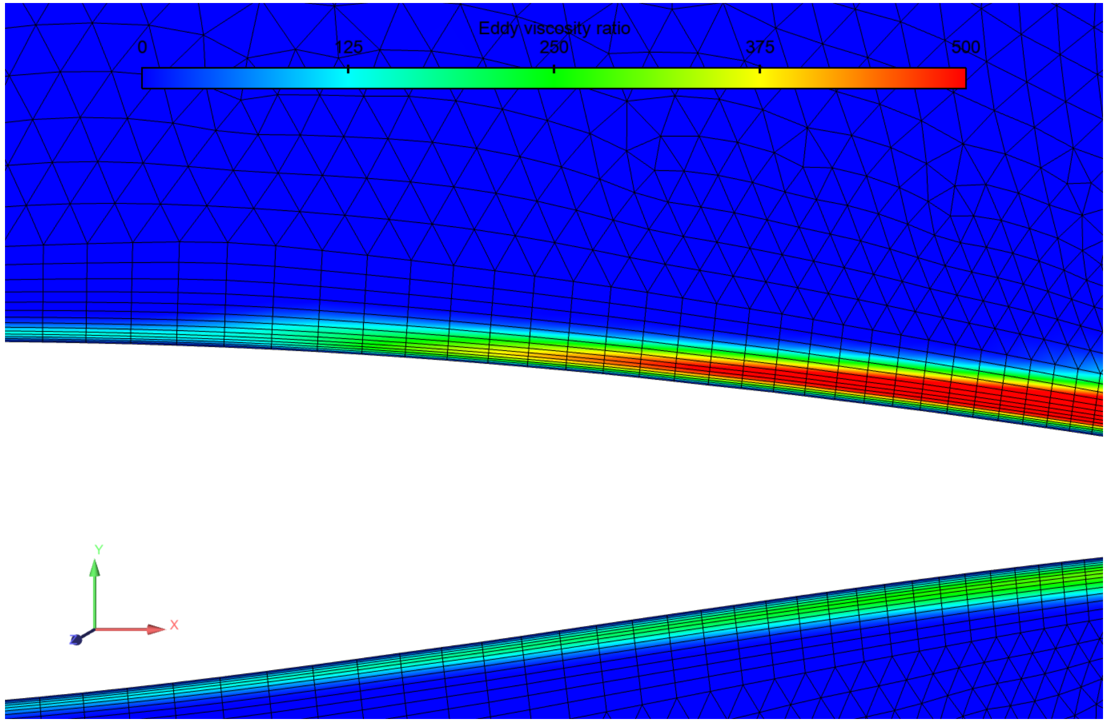
Contours of pressure

Qualitative and quantitative results

Transonic Flow over an RAE 2822 Airfoil – Ma = 0.73 – AOA = 2.79°



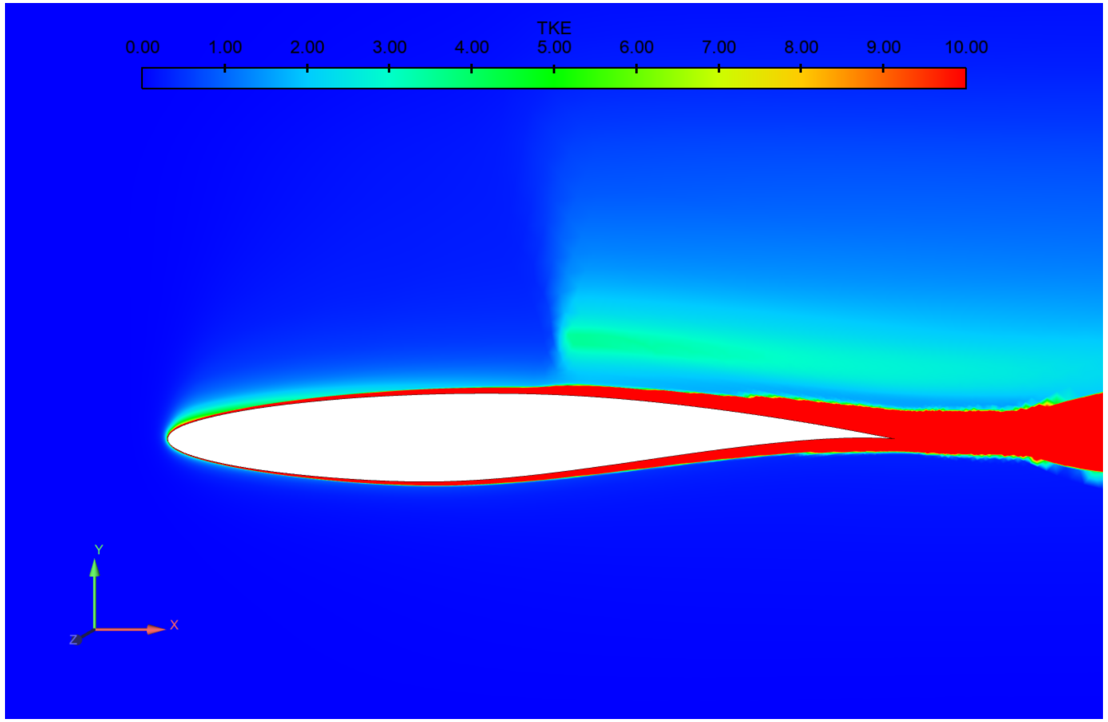
Contours of viscosity ratio



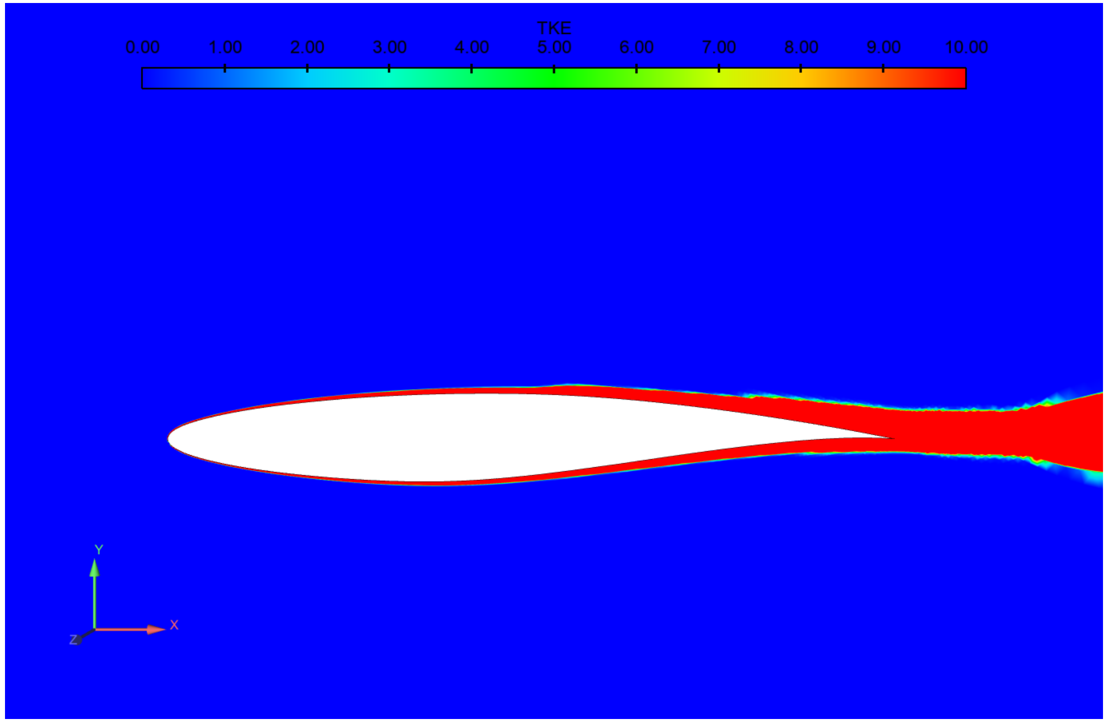
Contours of viscosity ratio

Qualitative and quantitative results

Transonic Flow over an RAE 2822 Airfoil – Ma = 0.73 – AOA = 2.79°



Production limiter disabled

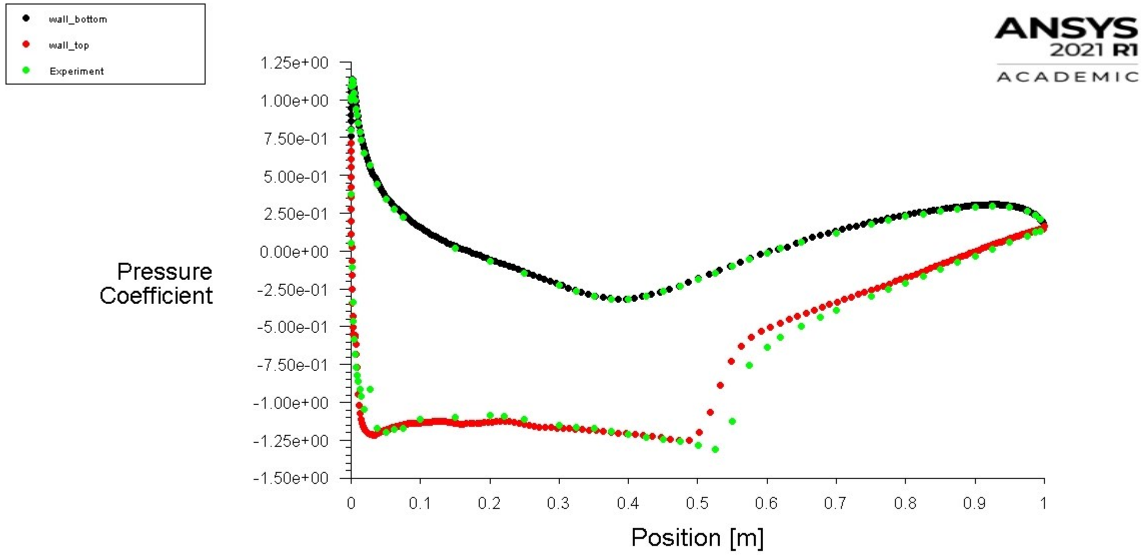


Production limiter enabled

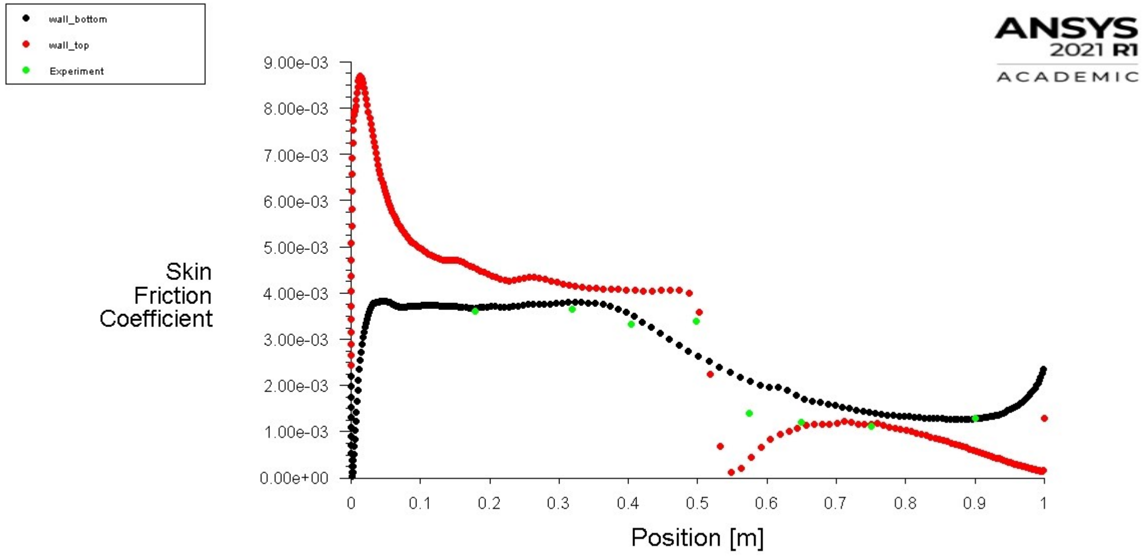
- Production limiters attenuates the excessive generation of turbulent kinetic energy in stagnation points.
- This excessive generation of TKE can have a negative impact on the boundary layer, forces predictions, and heat transfer rate.

Qualitative and quantitative results

Transonic Flow over an RAE 2822 Airfoil – Ma = 0.73 – AOA = 2.79°



Pressure coefficient distribution on the airfoil surface



Skin friction coefficient distribution on the airfoil surface

Qualitative and quantitative results

Transonic Flow over an RAE 2822 Airfoil – Ma = 0.73 – AOA = 2.79°

	AOA	c_d	c_l
Experimental values	2.79°	0.0168	0.803
Numerical values	2.79°	0.01608	0.7817

Experimental data from references [1, 2]. The simulation was conducted using the K-Omega SST turbulence model

- Remember, experiments are not the absolute truth, they are also subject to uncertainty.
- When comparing results, you should be sure to capture definite and clear trends.
- Usually, it is fine to be within a 5% margin of error.
- But this is not a rule, can be more, can be less.

[1] http://www.grc.nasa.gov/WWW/wind/valid/raetaf/raetaf.html

[2] Cook, P.H., M.A. McDonald, M.C.P. Firmin. Aerofoil RAE 2822 - Pressure Distributions, and Boundary Layer and Wake Measurements. Experimental Data Base for Computer Program Assessment, AGARD Report AR 138, 1979.