Aerodynamic Design Optimization:
Drag Minimization of the RAE 2822 in Transonic Viscous Flow.

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Problem Statement

Minimize the drag coefficient of the RAE 2822 case 9 at a freestream Mach number of 0.734 and lift coefficient of 0.824 (This approximately corresponds to the wind tunnel corrected angle of attack of 2.79°), and Reynolds number of 6.5×10^6 with respect to a parameterization of your choice subject to an area and pitching moment constraint. In summary, the optimization problem is

$$\begin{aligned} \text{minimize} \quad & c_d \\ \text{subject to:} \quad & c_l = 0.824 \\ & c_m \geq -0.092 \\ & \text{Area} \geq \text{Area}_{initial} \end{aligned}$$

Geometry

Please see, UIUC Airfoil Coordinates Database for the coordinates of the RAE 2822 at the following website http://www.ae.illinois.edu/m-selig/ads/coord_database.html.

Governing Equations, Mesh Requirements, and Flow and Boundary Conditions

The governing equation is the 2D Reynolds-averaged Navier-Stokes equations with a constant ratio of specific heats of 1.4 and Prandtl number of 0.71. Employ subsonic inflow and outflow for the far field boundary, while adiabatic no slip wall for the airfoil surface. The free stream Mach number is 0.734 and Reynolds number of 6.5×10^6. Participants must show that the grid is sufficiently accurate to resolve the lift and drag coefficients within 0.1 count.

Design Variables and Constraints

The participant has the choice on how the shape should be parameterized; however, the lift coefficient must be constrained to 0.824, pitching moment (evaluated at the quarter-chord) constrained to $c_m \geq -0.092$, and area must be greater than equal to the initial airfoil area during the optimization process.

Suggested Results

- Demonstrate that the optimization has converged, through reporting on the convergence of the KKT conditions for gradient based methods and method specific approaches for non-gradient based. Report on all optimization parameters as well as stopping criterions.

- Provide a grid study for both the initial and final airfoil shapes and a table listing the values of drag coefficients.

- (optional) Provide the final surface grid point and any pertain information based on the type of parameterization.
- (optional) Provide pressure distributions as well as contours for the final shape.
- (optional) For your chosen parameterization, investigate the impact of dimensionality.