KEB-45250 Numerical Techniques for Process Modeling
Exercise 3 - CFD case planing
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Introduction

Today we will plan a wing study but calculate it. Todays exercise will likely be the least computer intensive on the whole course. The setup in this courses CFD assignment will probably be very similar to this wing exercise. Of course, in the assignment you have to run the calculation and write a report.

Our story is about a landing airplane but airplane wings are remarkably similar to other wings. The same kind of simulation would apply to wind turbine, steam turbine, or water pump.

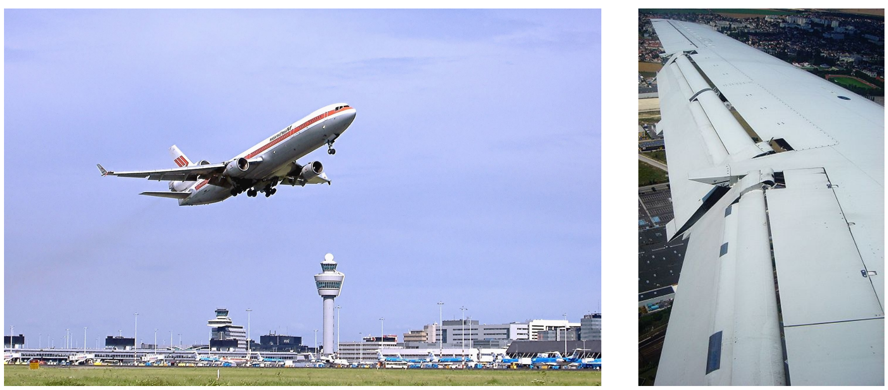

Figure 1: Airplane during landing [Wikipedia]

Wing drag, lift, and stall speed

You have been given an assignment to calculate the lift and drag coefficients of airplane wing during landing, see Fig. 1. You are also tasked with predicting the stall speed. Angle of attach, air speed, and geometry are given. Plan the study. See Fig. 3 for angle of attack and stall.

Start the study with a more simple validation case with available experimental data. Looking up scientific papers on the subject would also be a good idea but we will not do that this time. Wing are a much studied subject and established methods would be relatively easy to find.

Plan a steady state 2D simulation using NACA 2412 wing profile at angles of attacks $\alpha = 6°$ and $\alpha = 12°$. Horizontal air speed $V_x = 270 km/h$.

Plan an unsteady simulation with the real geometry for landing, see Fig. 2.

Plan a full 3D simulation of an airplane during landing.

Things to consider:

- Pre-processing
  - wing CAD model, calculation domain, 2D/3D, details
  - Meshing strategy
- Solver
  - Equations
  - Material properties
  - steady/unsteady
  - compressible/incompressible
  - turbulence model
  - wall treatment
  - boundary conditions
  - convergence
- Post-processing
  - what to save
  - validation
- Mesh independency
- How to report the results

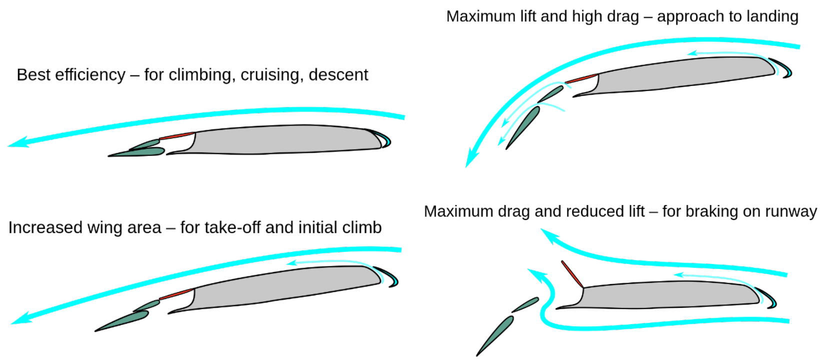

Figure 2: Flap alignment and angle of attack [Wikipedia]

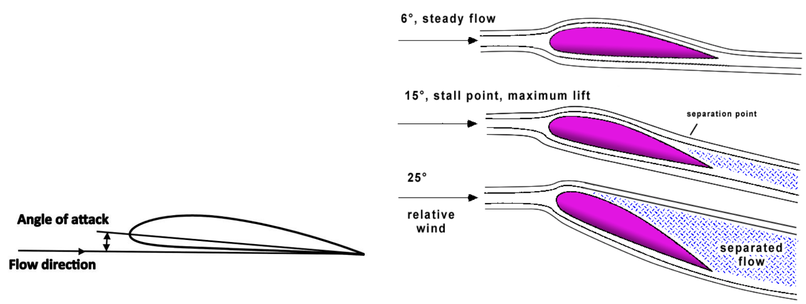

Figure 3: Angle of attack and stall [Wikipedia]

Equations

Drag coefficient

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 A} \quad (1)$$

where D is lift force, ρ is density, V is air speed, and A is wing area. Similarly, the lift coefficient is

$$C_L = \frac{L}{\frac{1}{2}\rho V^2 A} \quad (2)$$

where L is lift force.