ISEC Lisboa

Licenciatura em Ciências Aeronáuticas e do Espaço

Computational Fluid Dynamics

ESCOLA DE GESTÃO, ENGENHARIA E AERONÁUTICA

CFD Project

During the detailed design phase of a drone, we need to analyze the behavior of the main wing.

Mass	m	$25\,\mathrm{kg}$
Airfoil	-	*[to be provided]*
Wing area	S	$0.4\,\mathrm{m}^2$
Mean chord	c	$0.2\,\mathrm{m}$
Air density	ρ	*[to be provided]*
Dynamic viscosity	μ	*[to be provided]*
Efficiency factor	e	*[to be provided]*

For the purposes of this project, assume that all of the aircraft's lift is produced by the main wing. **This is a simplification of the real problem. The effects of the fuselage, empennage, propulsion, ground effect, landing gear, and other components will not be considered.**

1 Angle of attack for cruise

The intention is to perform cruise at approximately $200\,\mathrm{km\,h^{-1}}$. What angle of attack is required for the aircraft to produce sufficient lift for level flight?

In order to obtain the three-dimensional lift coefficient,

$$C_L = C_{L0} + a_{3D}\alpha.$$

a finite-wing correction should be used to estimate the slope of the lift curve

$$\boxed{a_{3D} = \frac{a_{2D}}{1 + \dfrac{a_{2D}}{\pi e AR}}}$$

and determine the angle of attack that satisfies the takeoff condition. **For the purposes of the analysis, we can assume that the value of C_{L0} is equal to C_{l0}.**

2 Maximum aerodynamic efficiency

For a given phase of the mission, the intention is to perform a cruise that maximizes range. For a propeller-driven aircraft, assuming constant propeller efficiency and specific fuel consumption, maximum range occurs at the point of

$$\max \frac{L}{D}.$$

If the cruise is performed at $150\,\mathrm{km\,h^{-1}}$, determine the wing angle of attack that maximizes range.

Minimum CFD requirements

To answer the three questions, the work must include:

1. definition and justification of the computational domain;
2. generation and description of the geometry;
3. generation and description of the mesh;
4. mesh quality analysis;
5. mesh independence study;
6. definition and justification of the boundary conditions;
7. solver setup;
8. demonstration of simulation convergence;
9. presentation of the aerodynamic coefficients;
10. discussion of the physical results;
11. discussion of the main limitations of the model.

Note

The objective of the project is not merely to obtain numerical values, but to demonstrate the ability to use CFD to answer an engineering question.

The results must be accompanied by a physical discussion, clearly identifying the assumptions, approximations, limitations, and uncertainties associated with the analysis.