AE 244: Assignment 3

Weightage: 15% of the total grades

Deadline: 14th April 2024 (Sunday) 11:59 PM
(Submissions after this deadline will attract 5% penalty for each 30 minutes delay. For example, 15% will be deducted from the assignment grades if the submission happens at 1:30 AM)

A note on plagiarism:

This is an individual assignment. While discussion is encouraged, simply copying someone else's work will attract zero marks for all involved.

Background

You are a part of a recreational vehicle design division in a startup. You have been asked to design a glider that can seat one person weighing up to 100 kgf. The glider is completely unpowered. It will be towed behind another aircraft before getting released at an altitude of 4000 meters.

Goal:

Now that we have a fair idea about the aerodynamic forces and flows around airfoil and tools used in predicting the same, we can proceed with the task of designing the complete glider comprising of wings, fuselage, and stabilizers.

The requirements from the glider to be designed are:

1. Should sit one person up to 6 feet tall, weighing up to 80 kg,
2. Should be able to glide at least 30 km distance when starting from 1000 m altitude.

Tasks

1. Learn OpenVSP for aerodynamic simulations
2. Create a tool (MS Excel or computer program) to estimate approximate overall weight of the glider based on the dimensions of the glider's parts and material used.
3. Wing design and analysis
    a. Design the wing
    b. Analyse the performance of the wings (lift, drag) at a range of angles of attack using lifting line theory for lift and induced drag estimates.
    c. Use the empirical method to estimate the parasite drag.
    d. Compare the final results with those obtained through OpenVSP.
    e. Plot and compare airfoil and wing lift coefficient curves.
4. Fuselage design and analysis:
    a. Create a CAD model of the fuselage that meets requirements.
    b. Estimate lift and drag of the fuselage using OpenVSP.
    c. Compare the fuselage drag found through OpenVSP with that from the empirical method to estimate parasite drag.
    d. Comment on the observations.
5. Stabilizer design and analysis:

a. Design horizontal and vertical stabilizers for the glider
b. Analyse performance of the stabilizers using OpenVSP for various angles of attack.

6. Overall glider design and aerodynamic analysis
   a. "Assemble" the glider components into a complete glider.
   b. Estimate performance of the entire glider using Open VSP (C_L & C_D vs α)
7. Validate requirements
   a. Check if the designed glider meets the original operational requirements. Mention the flight conditions (speed, glide angle, descent rate, etc.) at which the requirements are met.
   b. Comment on the outcome of the design process.

Report Structure

1. Wing Design

1.1. Full description of wing designed (airfoil, taper, angle of attack, twist, sweep, dihedral, other devices and attachments if any) [6]

1.2. C_L vs α curves of the wing for α = -2^0 to 10^0 in increments of 2^0 computed using the lifting line theory and OpenVSP (in the same plot). [12]

1.3. C_D vs α curves of the wing for α = -2^0 to 10^0 in increments of 2^0 computed using the classical method (induced drag + empirical parasitic drag) and OpenVSP (in the same plot) [12]

1.4. C_L vs α of the wing and C_l vs α of the constituent airfoil for α = -2^0 to 10^0 in increments of 2^0 as computed using OpenVSP on the same plot [3]

1.5. Main observations and interpretations from sections 1.2, 1.3, and 1.4. [3]

2. Fuselage Design

2.1. CAD of the fuselage [5]

2.2. Lift and drag estimates from OpenVSP at α = -2^0 to 10^0 in increments of 2^0 [6]

2.3. Parasitic drag estimates based on empirical method [5]

2.4. Comparison of drag results from 2.2 and 2.3, and comments [3]

3. Stabilizer Design

3.1. Horizontal and Vertical stabilizer designs (dimensions, airfoil, sketch/CAD) [5]

3.2. C_L vs α curves for both stabilizers for α = -3^0 to 3^0 in 1^0 increments using OpenVSP [5]

3.3. C_D vs α curves for both stabilizers for α = -3^0 to 3^0 in 1^0 increments using OpenVSP [5]

3.4. Comments on findings from 3.2, 3,3. [3]

4. Overall glider design

4.1. Overall glider design (placement of wing, stabilizers, fuselage, pilot) and CAD [8]

4.2. Performance of the entire glider using Open VSP (C_L & C_D vs α) [5]

4.3. Glider component weight estimates (using CAD) and total weight [4]

5. Design Validation

5.1. Optimal speed, glide angle, range, descent rate for the designed glider [6]

5.2. Comment on glider performance w.r.t original requirement and possible scope for improvements [4]

6. Acknowledgement

Mandatory to acknowledge people you discussed with or took help for any part of the assignment.

7. References

List all references (books, paper, websites, etc.) used while doing the assignment