EN222: FLUID MECHANICS AND HEAT TRANSFER

Wind Angle and Velocity Effects on a 2D Airfoil

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Objective

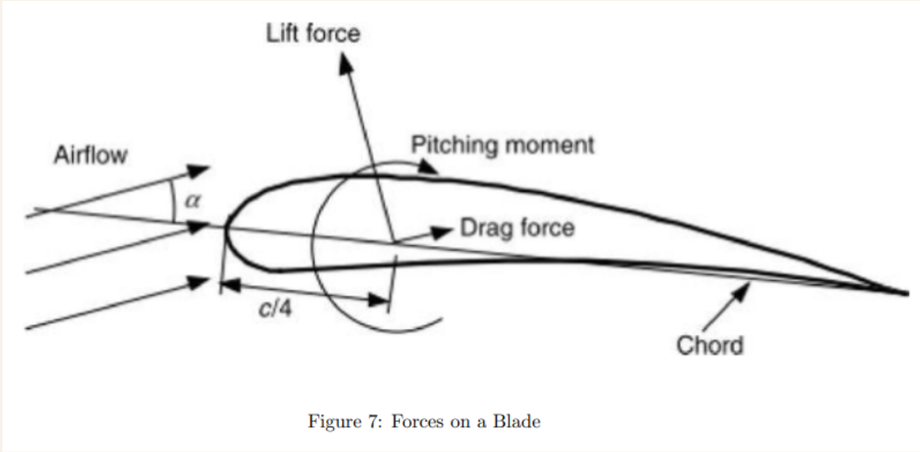


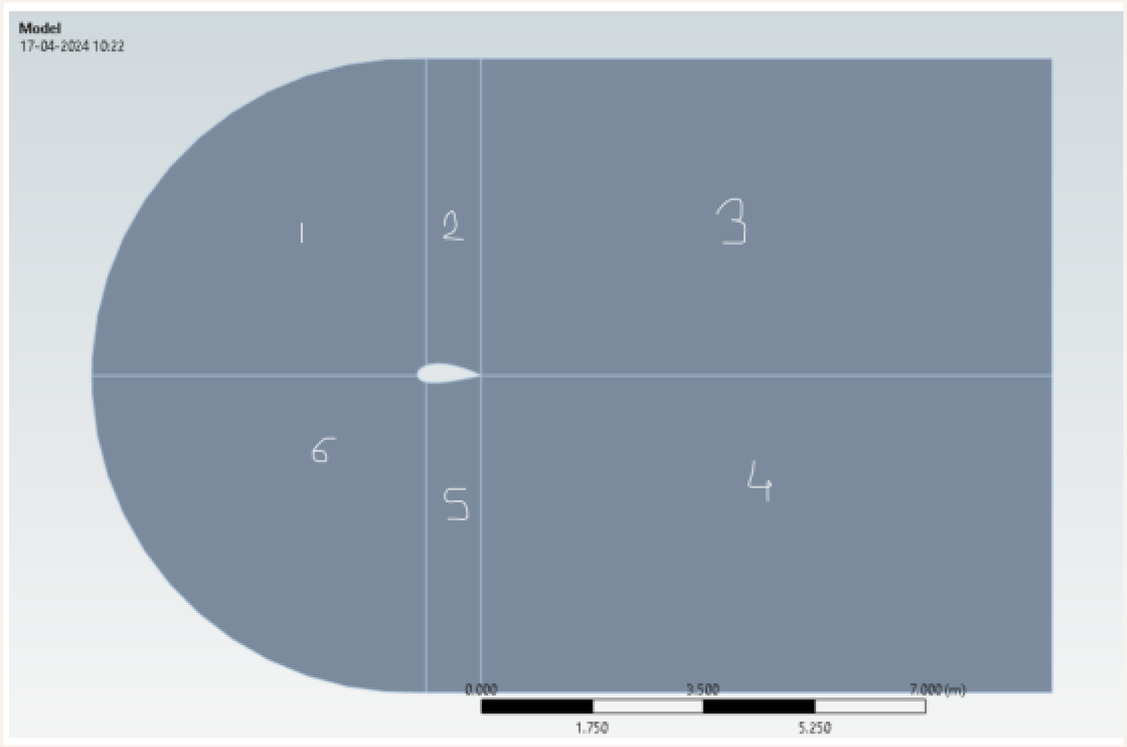
Figure 7: Forces on a Blade

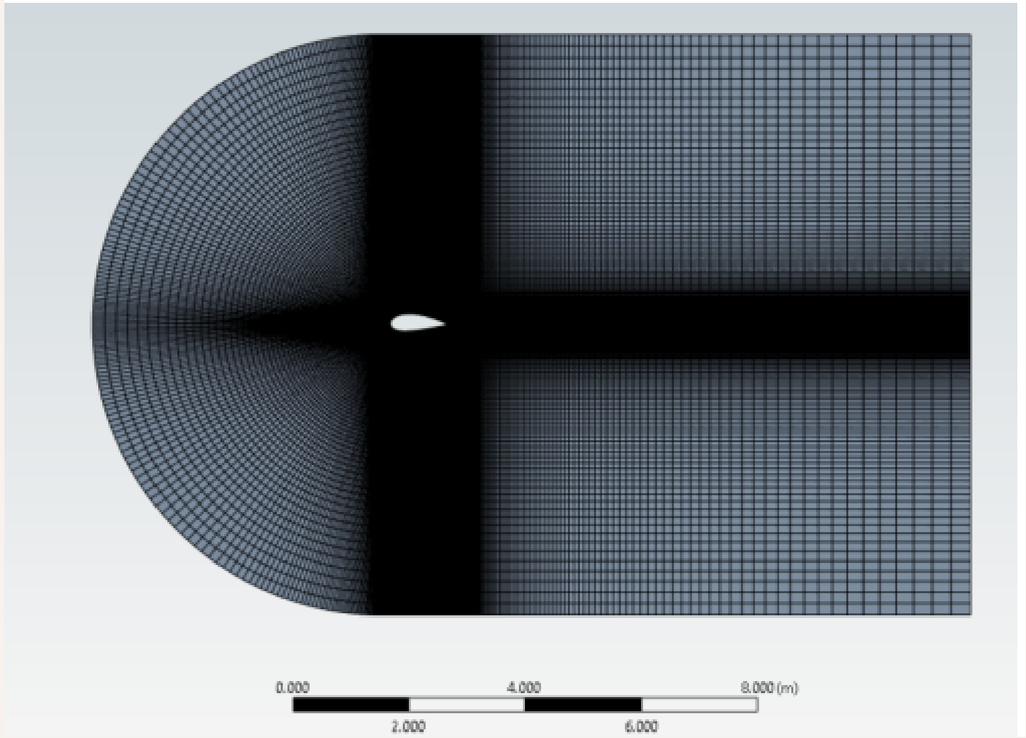
To analyze how different angles of attack and wind velocities affect:

- drag coefficient
- lift coefficient
- moment coefficient

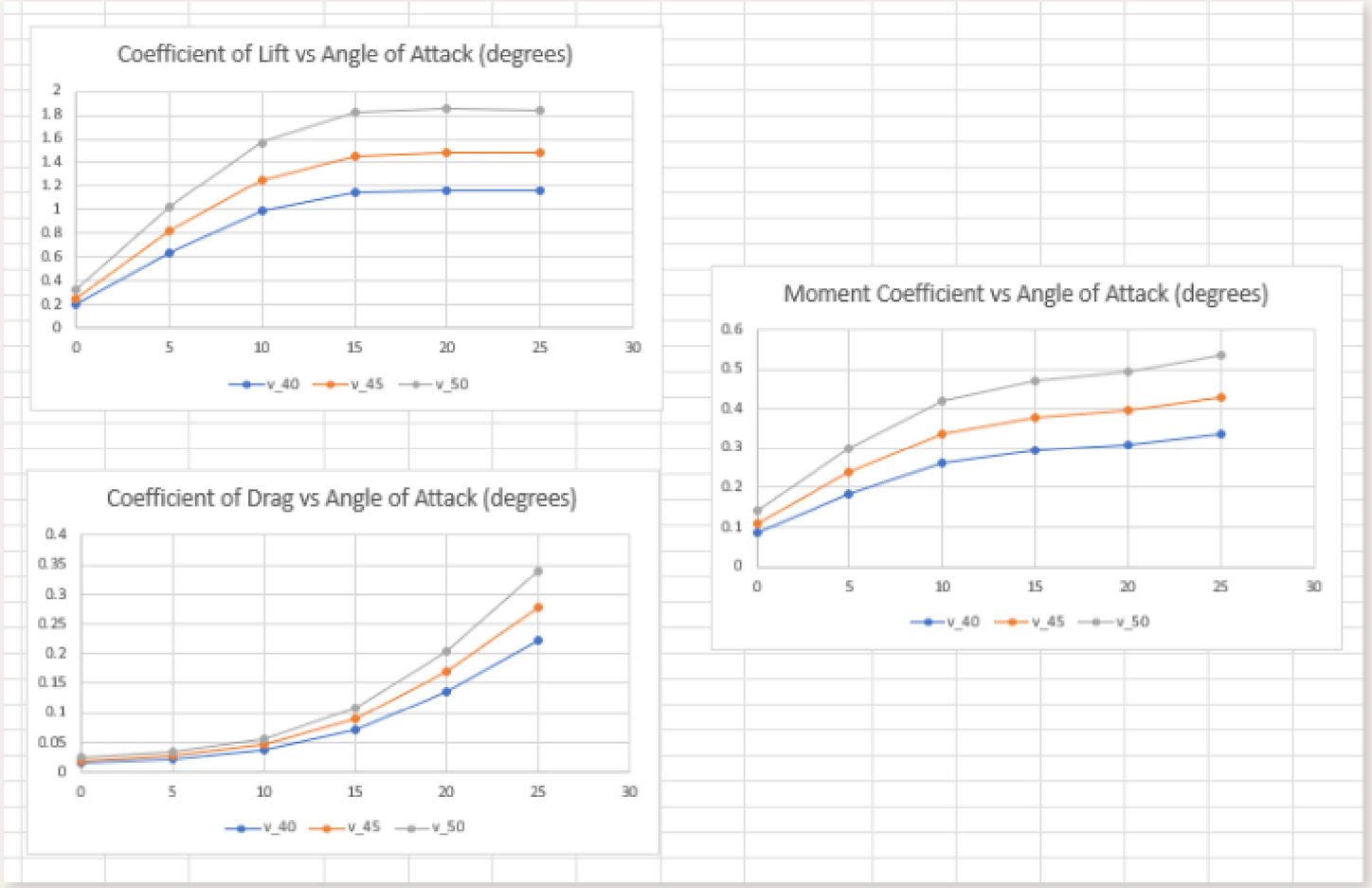
of a windmill blade using a 2D model of **NACA 4430** airfoil

Mesh

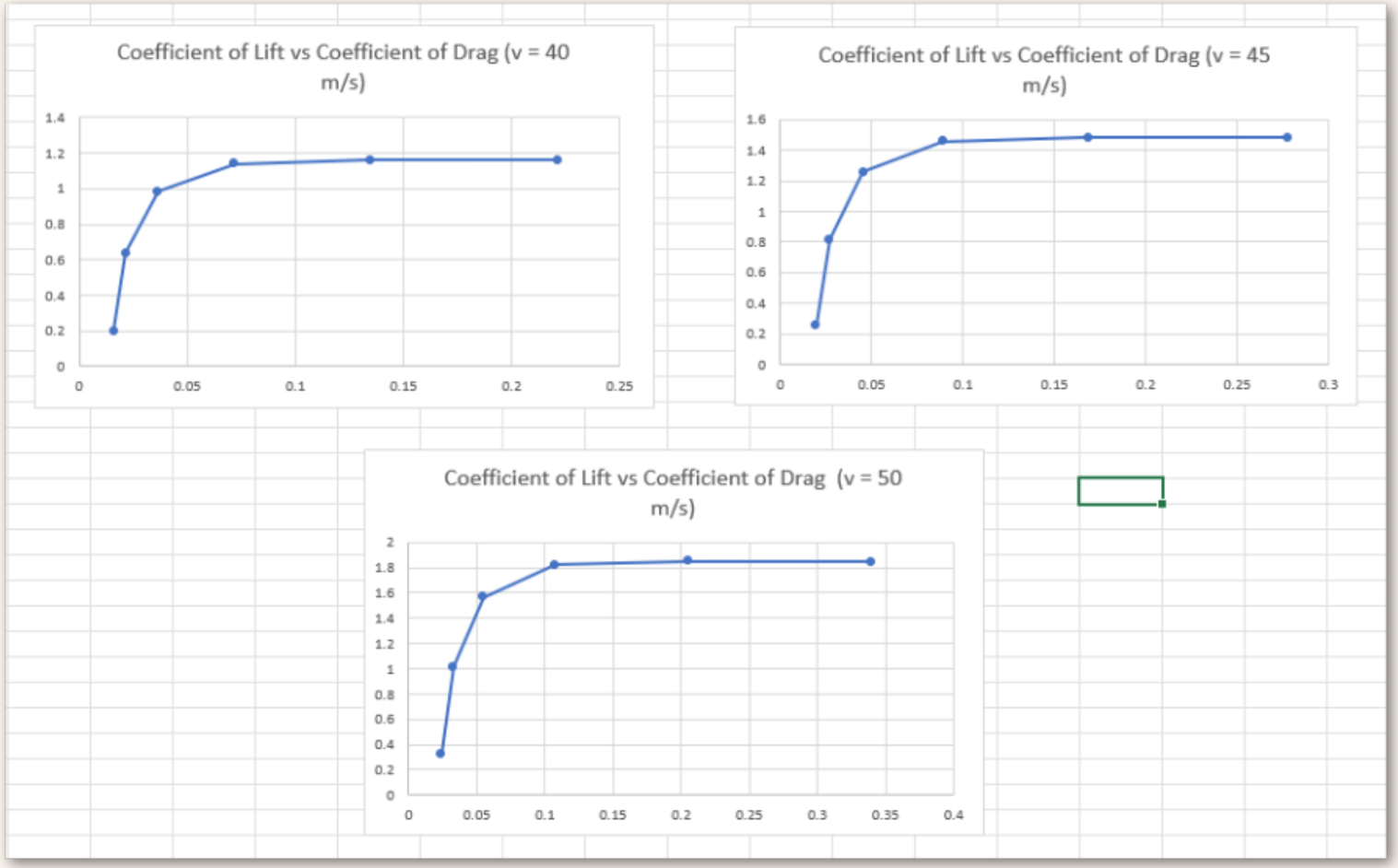

Model
17-04-2024 10:22
1
2
3
4
5
6
0.000
3.500
7.000 (m)
1.750
5.250


0.000
4.000
8.000 (m)
2.000
6.000

Results


Coefficient of Lift vs Angle of Attack (degrees)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
v_40
v_45
v_50
Coefficient of Drag vs Angle of Attack (degrees)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
v_40
v_45
v_50
Moment Coefficient vs Angle of Attack (degrees)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
v_40
v_45
v_50

Results


Coefficient of Lift vs Coefficient of Drag (v = 40 m/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
Coefficient of Lift vs Coefficient of Drag (v = 45 m/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Coefficient of Lift vs Coefficient of Drag (v = 50 m/s)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

Analysis

- Lift Coefficient increases rapidly till a particular angle of attack (around 15 degrees) after which it starts to saturate
- Drag Coefficient increases slowly initially and rapidly afterwards, as the angle of attack increases
- Moment coefficient first increases rapidly with angle of attack, then somewhat saturates (near 15 degrees) and then again starts increasing rapidly (beyond 20 degrees)
- Hence, after plotting lift coefficient vs drag coefficient, we can see that lift saturates beyond a certain value of drag
- The values of lift, drag and moment coefficients increase with increase in wind velocity

Some Thoughts

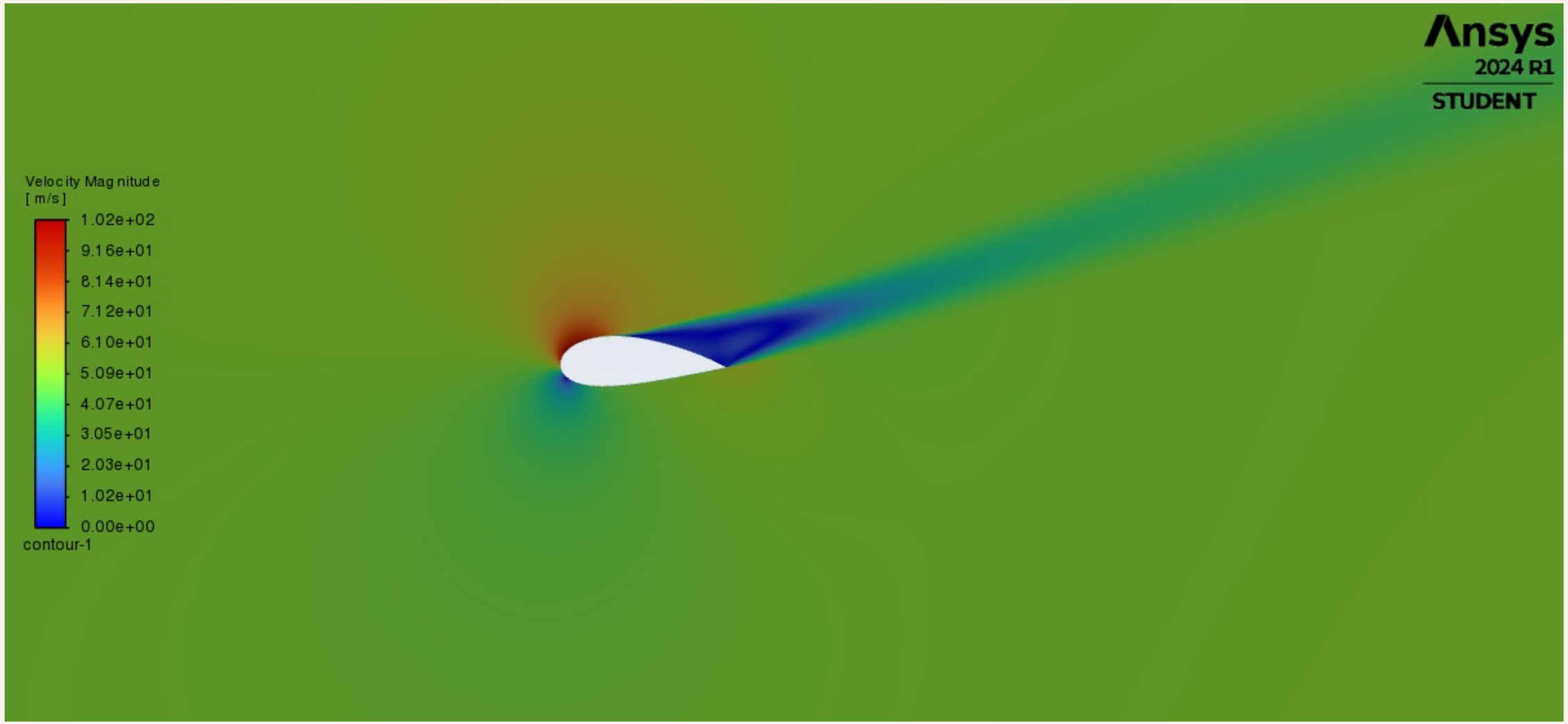
- The force that rotates the turbine depends on tangential coefficient which is given by

$$C_t = C_l sin\phi - C_d cos\phi$$

- Phi depends on twist angle of blade as well as angle of attack
- The force on the axis depends on axial coefficient given by

$$C_a = C_l cos\phi + C_l sin\phi$$

- It is desirable to maximise Ct and minimise Ca
- Hence, we can use Ct as an objective function to be maximised with a constraint on Ca (depending on axial force which the axis can bear), and apply optimisation


Ansys
2024 R1
STUDENT
Velocity Magnitude
[m/s]
1.02e+02
9.16e+01
8.14e+01
7.12e+01
6.10e+01
5.09e+01
4.07e+01
3.05e+01
2.03e+01
1.02e+01
0.00e+00
contour-1

TEAM

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THANK YOU!