: Assignment 3 :

AE461 - Aircraft Design

Instructor - Prof. Mangal Kothari

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Questions

1.1 Assume CL between 1 and 1.5, find out the Wing loading of your aircraft ?

Ans: For calculating wing loading of our aircraft we choose $C_L = 1.3$. From previous calculation we got $V_{E_{max}} = 98.889$ m/sec

$$C_L = \frac{W/S}{1/2\rho v^2} \tag{1a}$$

$$\implies W/S = C_L(1/2\rho v^2) \tag{1b}$$

$$\implies S = W/(C_L(1/2\rho v^2)) \tag{1c}$$

- In Eq.(1a) where $C_L \rightarrow$ Lift Coefficient,W $\rightarrow$Weight,S $\rightarrow$Wing Area[W/S $\rightarrow$ Wing loading], v $\rightarrow$ Velocity and $\rho \rightarrow$ Density of the medium(in our case air)

- **We will consider** $C_L = 1.3$**;** $1 < C_L < 1.5$

- The Airplane would be at a height of $\approx$ 12000 feet (in cruise and loiter) and their $\rho_{air} = 0.849 Kg/m^3$.

- From Weight estimation calculation (by method1) we got: *(refer Assignment2 part1)*

$V_{E_{max}}$	$98.889 m/s$
W_{TO}	$8430 kg$
W_e	$4816 kg$
W_f	$2879 kg$
W_P	$735 kg$

  Wing Loading, $W/S = (1.3 * 0.5 * 0.849 * 98.889^2)$ [using Eq. (1b)]
  $\implies W/S = 5396.560 N/m^2$

- From Weight estimation calculation (by method2) we got: *(refer Assignment2 part2)*

$V_{E_{max}}$	$98.889 m/s$
W_{TO}	$4158 kg$
W_e	$2522 kg$
W_f	$901 kg$
W_P	$735 kg$

  Wing Loading, $W/S = (1.3 * 0.5 * 0.849 * 98.889^2)$ [using Eq. (1b)]
  $\implies W/S = 5396.560 N/m^2$

1.2 Compare the wing loading with the existing aircraft. If your number is different, find out the reason ?

Ans: We have chosen DA62 aircraft [1] as our reference which has a wing loading of $1318.129 N/m^2 \equiv 134.503 kg/m^2 (1318.129/9.8)$ Our calculated wing loading is different from the reference value, primarily because of the following reasons:

1. W_{TO}(for DA62 aircraft) $= 2300 Kg$ but W_{TO} in our case $> 4100 Kg$

2. ρ and C_L will vary continuously en route and therefore the wing loading calculation (from (1b)) will have different value at different point . We should Consider an average value of the wing loading .

   - The Structural integrity of the conceptual aircraft will have to be compromised (as Wing loading increases Structural integrity decreases).

1.3 For the given wing loading, find the area of the wing.

<u>**Ans:**</u>

- From Weight estimation calculation (by method1) we got: *(refer Assignment2 part1)*

$V_{E_{max}}$	$98.889 m/s$
W_{TO}	$8430 kg$

Wing Area, $S = \frac{8430*9.8}{1.3*1/2*0.849*98.889^2} = 15.309 m^2$ [using eq.(1c)]

- From Weight estimation calculation (by method2) we got: *(refer Assignment2 part2)*

$V_{E_{max}}$	$98.889 m/s$
W_{TO}	$4158 kg$

Wing Area, $S = \frac{4158*9.8}{1.3*1/2*0.849*98.889^2} = 7.551 m^2$ [using eq.(1c)]

1.4 Choose 5 airfoils that can satisfy your requirement, you may to consider appropriate aspect ratio to compute 3D lift from the 2D data.

<u>**Ans:**</u>

We are choosing airfoils which has $C_{l_{max}} = 1.3$

NACA0010	NACA0015	NACA1410	NACA2408	NACA2415

Ignore the Chord Length shown (in Figure 1 to 5). It was just for reference.

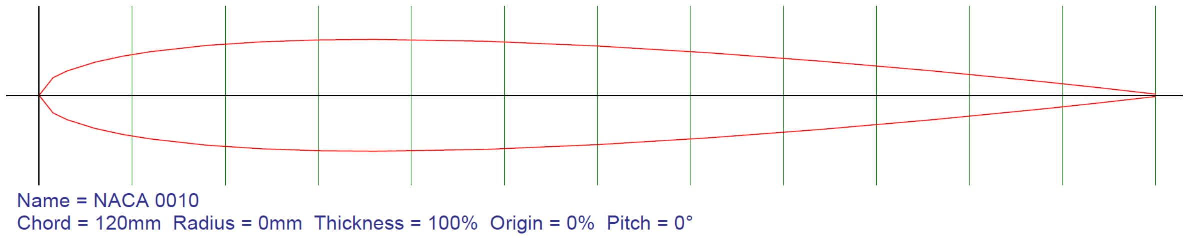

Figure 1: NACA0010 airfoil[2]

- For calculating 3d lift from 2d (airfoil) data

$$C_L = \frac{C_l}{1 + \frac{Cl}{e\mathit{AR}}} \tag{2}$$

Where C_L →3D Lift Coefficient, C_l →2D Lift Coefficient, AR →Aspect Ratio and e →Span Efficiency

- **We will consider** $e = 1$ **and will vary** $\mathit{AR}(= 5, 6, 7, 8,$ **and** $9)$

The 2D lift coefficient, C_l data are obtained from [2]

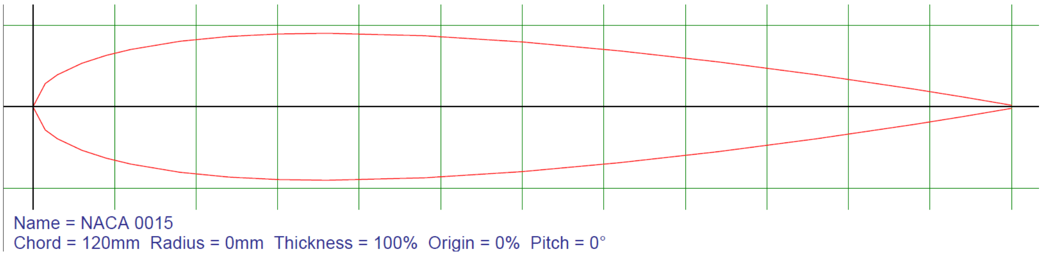

Figure 2: NACA0015 airfoil[2]

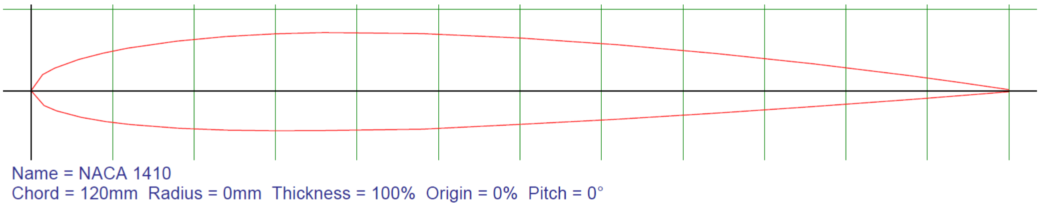

Figure 3: NACA1410 airfoil[2]

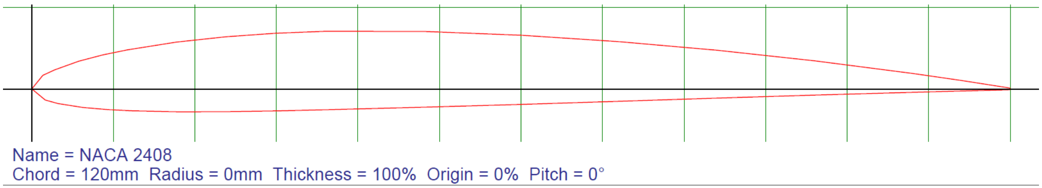

Figure 4: NACA2408 airfoil[2]

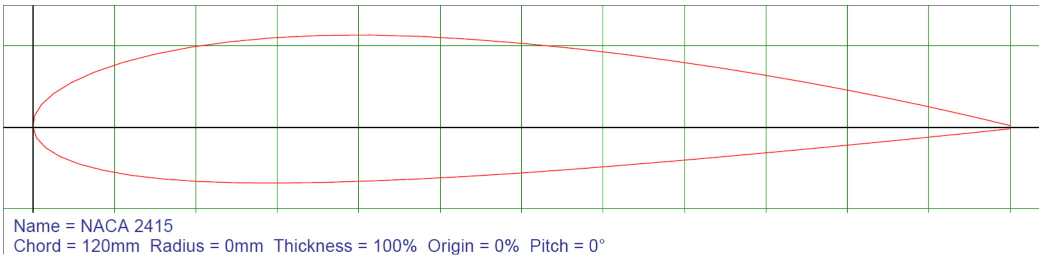

Figure 5: NACA2415 airfoil[2]

1.5 Plot C_L vs C_D and compare it for different Aspect Ratio and airfoils.

Ans:

NOTE: Consider the "AE" in the legends of the following plots to be "Æ", Aspect Ratio

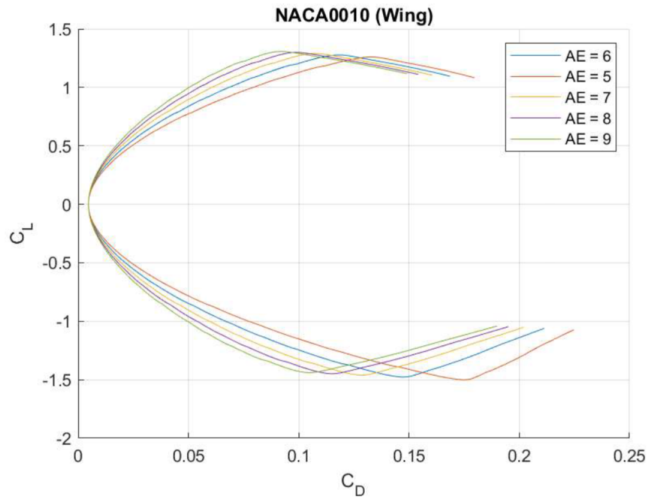

Figure 6: NACA0010 airfoil

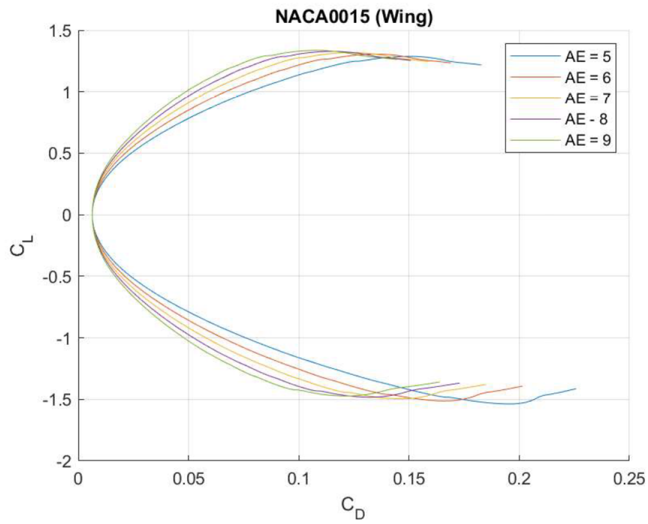

Figure 7: NACA0015 airfoil

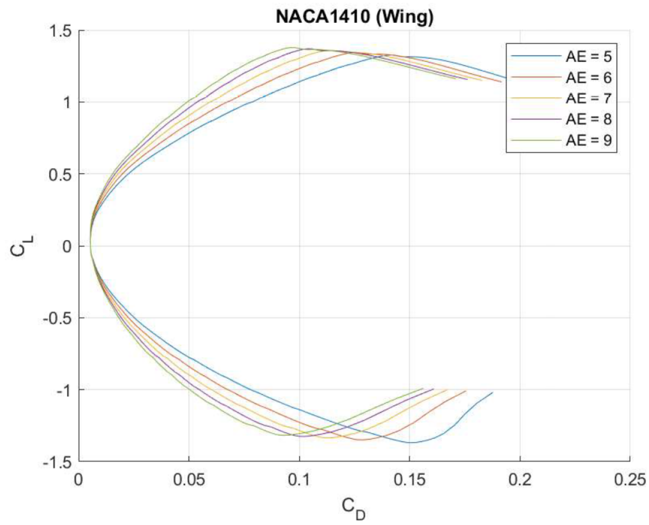

Figure 8: NACA1410 airfoil

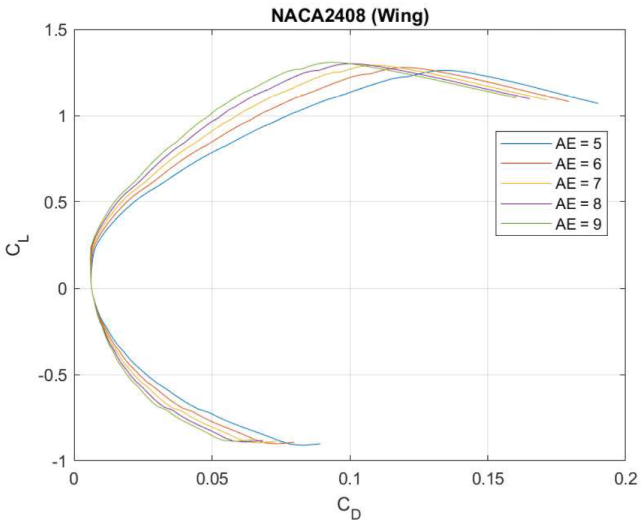

Figure 9: NACA2408 airfoil

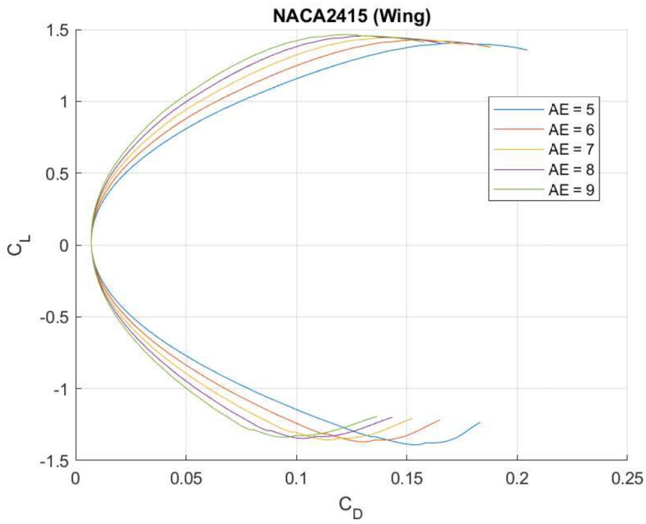

Figure 10: NACA2415 airfoil

References

[1] https://www.diamondaircraft.com/en/private-owners/aircraft/da62/overview/.

[2] http://airfoiltools.com/plotter/index.