

CFD ANALYSIS OF AEROFOIL IN TANDEM CONFIGURATION

Shivam Bharara

Department of Aerospace Engineering
University Of Petroleum and Energy Studies
Dehradun, Uttarakhand, India
bharara99@gmail.com

Vinayak Nair

Department of Aerospace Engineering
University of Petroleum and Energy Studies
Dehradun, Uttarakhand, India
vinayaksreenath@gmail.com

ABSTRACT

In this paper, NACA 0018 in Tandem Configuration is examined. Various Aerodynamics characteristics like lift and drag are to be examined. Symmetrical wing of NACA 0018 is created in CATIA V5 and its analysis is done in Ansys Fluent.

General Terms

CATIA V5, CFD, ANSYS, FLUENT, TANDEM WING

Keywords

Symmetrical airfoil, Lift, Drag, Chord length, pressure, temperature, tandem configuration, NACA.

1. INTRODUCTION

The Aerofoil used in the analysis is of the NACA 4-Digit symmetrical aerofoil series and is NACA 0018. The NACA airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee for Aeronautics (NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA". The parameters in the numerical code can be entered into equations to precisely generate the cross-section of the airfoil and calculate its properties.

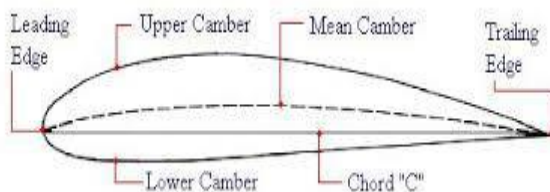


Fig 1. Basic Nomenclature of an Aerofoil.

The analysis is performed on the aerofoil NACA 0018 which is placed in a tandem configuration to observe the effects of pressure and velocity variations on the aerofoil. The lift on an airfoil is primarily the result of its angle of attack and shape. When oriented at a suitable angle, the airfoil deflects the oncoming air (for fixed-wing aircraft, a downward force), resulting in a force on the airfoil in the direction opposite to the deflection. [1]

2. EXPERIMENTAL PROCEDURE

The model for the analysis was designed in Catia V5 by importing the co-ordinate data of NACA 0018 with 25 data points being defined on each of the aerofoil surfaces (upper and lower) using the spline command. The two aero foils are placed 500mm (50cm) apart from each other. The co-ordinates of the points used are as described in Table 1. The co-ordinates were obtained by following the equation defined by NACA for a symmetrical airfoil from the NACA 4-Digit series as expressed in equation 1.

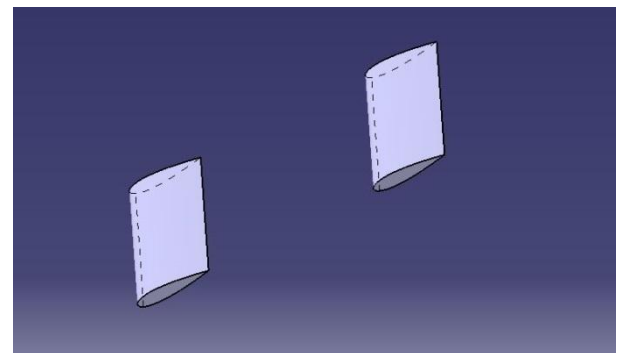


Fig 2. NACA 0018 in Tandem Configuration from CatiaV5.

The CFD Analysis was then done on the model with the following boundary conditions

1. Inlet Velocity	–	100	m/s
2. Temperature	–	300	K
3. Outlet Gauge Pressure	–	0Pa	

The Outer Gauge Pressure is set to 0 to simulate atmospheric pressure.

As seen above the analysis was done in subsonic conditions with the velocity to be Mach 0.288 to obtain the lift and drag. The Analysis also shows the stagnation point in the configuration.

3. RESULTS AND DISCUSSIONS

The analysis was done with 100 iterations and lift and drag obtained is as follows

For the leading wing in tandem configuration

$$\begin{aligned}\text{Lift} &= 8.07298 \text{ N} \\ \text{Drag} &= 5.49483 \text{ N}\end{aligned}$$

For the trailing edge in tandem configuration

$$\begin{aligned}\text{Lift} &= 4.88023 \text{ N} \\ \text{Drag} &= 4.98515 \text{ N}\end{aligned}$$

Thus change in lift, $\Delta L = 3.19275$ and percentage decrease in lift is 39.55%. The Lift and Drag are calculated using the following equations [2]:

$$\begin{aligned}\text{Lift} &= \frac{1}{2} \rho (V^2) S (C_L) \\ \text{Drag} &= \frac{1}{2} \rho (V^2) S (C_D)\end{aligned}$$

The Contours and Streamlines as observed during the analysis are as follows:

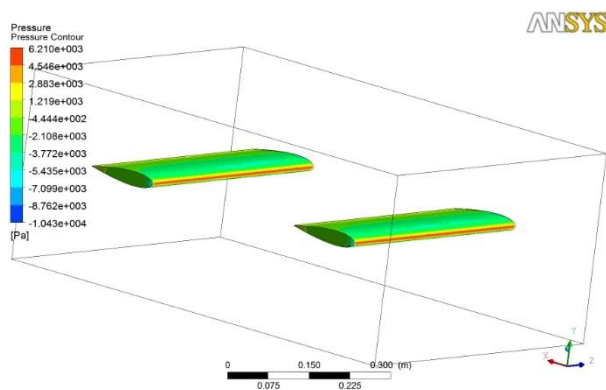


Fig 3. Pressure Contours Depicting location of Maximum Pressure Experienced by Wing.

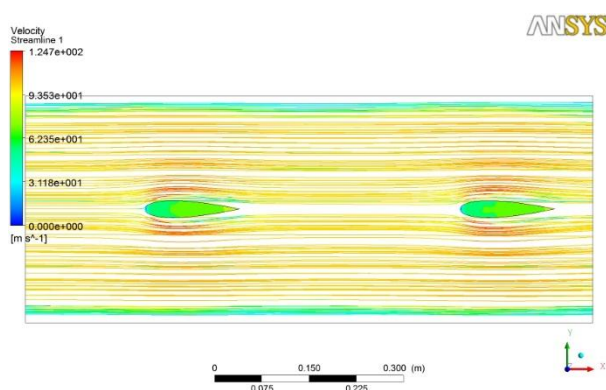


Fig 4. Velocity Streamlines depicting flow over the Aerofoils in Tandem Configuration.

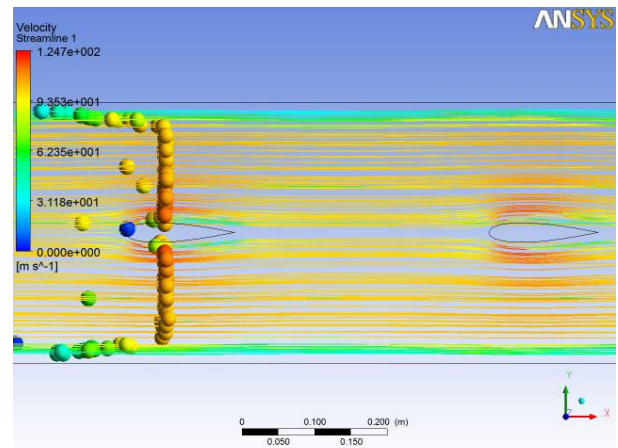


Fig 5. Blue Dot depicts Stagnation Point in Tandem Configuration.

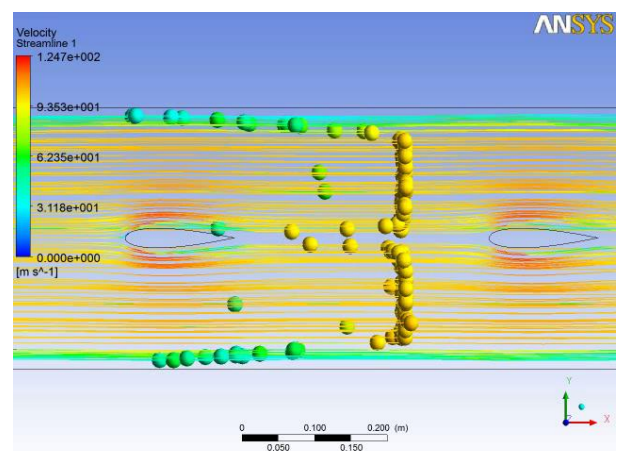


Fig 6. Depiction of Change in Velocity just after Leading Wing And just before Trailing Wing.

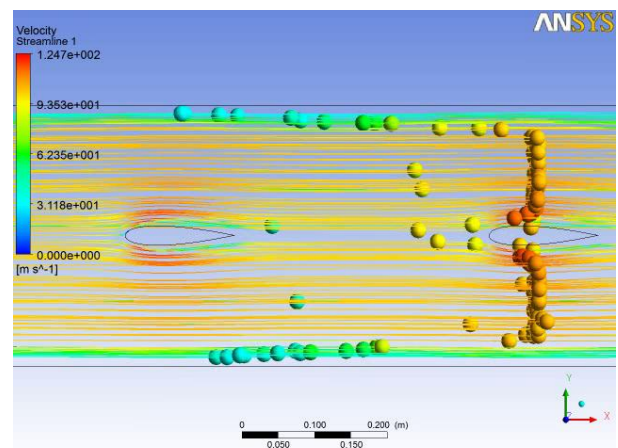


Fig 7. Depiction of change in velocity after flow reaches Trailing Wing.

4. CONCLUSION

In the above analysis it is found that for NACA 0018 aerofoil at Mach 0.288 ($V = 100$ m/s; $T = 300$ K) the lift drops by a percentage of 39.55%. This is mainly due to the downwash of front wing on the rear wing.

5. TABLES AND EQUATIONS

Equation 1. Relation between x and y co-ordinates, thickness of aerofoil and chord length of aerofoil for a symmetric aerofoil as per NACA 4- Digit Series [3].

$$y = 5tc \left[0.2969 \sqrt{x/c} + (-0.1260)(x/c) + (-0.3516)(x/c)^2 + 0.2843(x/c)^3 + (-0.1015)(x/c)^4 \right]$$

Table 1. Co-Ordinates of NACA 0018.

	X	y(t)	y(c)	x(U)	y(U)	x(L)	y(L)
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00214	0.01212	0.00000	0.00214	0.01212	0.00214	-0.01212
3	0.00856	0.02372	0.00000	0.00856	0.02372	0.00856	-0.02372
4	0.01921	0.03475	0.00000	0.01921	0.03475	0.01921	-0.03475
5	0.03407	0.04510	0.00000	0.03407	0.04510	0.03407	-0.04510
6	0.05307	0.05469	0.00000	0.05307	0.05469	0.05307	-0.05469
7	0.07612	0.06337	0.00000	0.07612	0.06337	0.07612	-0.06337
8	0.10313	0.07102	0.00000	0.10313	0.07102	0.10313	-0.07102
9	0.13397	0.07752	0.00000	0.13397	0.07752	0.13397	-0.07752
10	0.16853	0.08275	0.00000	0.16853	0.08275	0.16853	-0.08275
11	0.20665	0.08661	0.00000	0.20665	0.08661	0.20665	-0.08661
12	0.24816	0.08905	0.00000	0.24816	0.08905	0.24816	-0.08905
13	0.29289	0.09001	0.00000	0.29289	0.09001	0.29289	-0.09001
14	0.34065	0.08949	0.00000	0.34065	0.08949	0.34065	-0.08949
15	0.39124	0.08752	0.00000	0.39124	0.08752	0.39124	-0.08752
16	0.44443	0.08413	0.00000	0.44443	0.08413	0.44443	-0.08413
17	0.50000	0.07941	0.00000	0.50000	0.07941	0.50000	-0.07941
18	0.55771	0.07343	0.00000	0.55771	0.07343	0.55771	-0.07343
19	0.61732	0.06628	0.00000	0.61732	0.06628	0.61732	-0.06628
20	0.67856	0.05804	0.00000	0.67856	0.05804	0.67856	-0.05804
21	0.74118	0.04877	0.00000	0.74118	0.04877	0.74118	-0.04877
22	0.80491	0.03853	0.00000	0.80491	0.03853	0.80491	-0.03853
23	0.86947	0.02732	0.00000	0.86947	0.02732	0.86947	-0.02732
24	0.93460	0.01512	0.00000	0.93460	0.01512	0.93460	-0.01512
25	1.00000	0.00189	0.00000	1.00000	0.00189	1.00000	-0.00189



6. LIST OF SYMBOLS AND ABBREVIATIONS USED

1. NACA - National Advisory Committee for Aeronautics
2. ρ -Density of Fluid (in this case Air)
3. V -Velocity experienced by Wing
4. S -Surface Area of Wing
5. C_L -Co-efficient of Lift
6. C_D -Co-efficient of Drag
7. t -Thickness of Aerofoil or Airfoil
8. c -Chord length of Aerofoil or Airfoil
9. x, y -Cartesian Co-Ordinates

7. REFERENCES

- [1] Halliday, David; Resnick, Robert, *Fundamentals of Physics 3rd Edition*, John Wiley & Sons.
- [2] Clancy, LJ, *Aerodynamics Indian Edition 2006*, Sterling Book House.
- [3] <http://www.fges.demon.co.uk/cfd/naca.html#07>
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