

CFD Analysis of Pressure Coefficient for NACA 4412

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Abstract— in this paper NACA 4412 airfoil profile is considered for analysis of wind turbine blade. Geometry of the airfoil is created using GAMBIT 2.4.6. And CFD analysis is carried out using FLUENT 6.3.26 at various angles of attack from 0° to 12° . Variations of pressure coefficient are plotted in form of contour for 1×10^5 Reynolds number.

Keywords— Computational fluid dynamics, Angle of Attack, Airfoil.

I. INTRODUCTION

Realize a 2-D flow it is necessary to extrude an aerofoil into a wing of infinite span. On a real wing the chord and twist changes along the span and the wing starts at a hub and ends in a tip, but for long slender wings, like those on modern gliders and wind turbines, Prandtl has shown that local 2-D data for the forces can be used if the angle of attack is corrected accordingly with the trailing vortices behind the wing. These effects will be dealt with later, but it is now clear that 2-D aerodynamics is of practical interest even though it is difficult to realize. Figure 1 shows the leading edge stagnation point present in the 2-D flow past an aerofoil. The reacting force F from the flow is decomposed into a direction perpendicular to the velocity at infinity V_∞ and to a direction parallel to V_∞ . The former component is known as the lift, L ; the latter is called the drag, D (see Figure 2). [1]

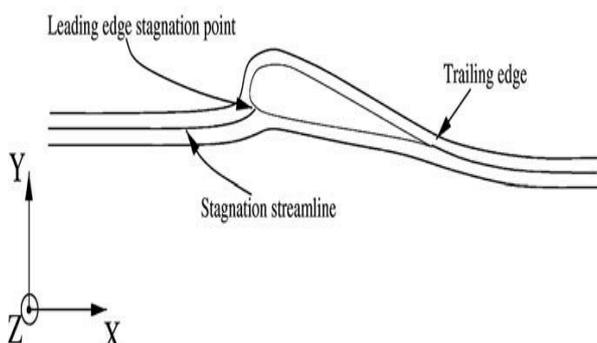


Fig 1 schematic view of streamlines past an airfoil [1]

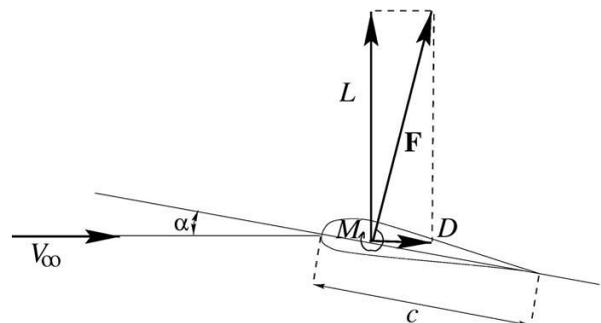


Fig 2 Definition of lift and drag [1]

II. AIRFOIL NOMENCLATURE

- 1) Chord length – length from the LE to the TE of a wing cross section that is parallel to the vertical axis of symmetry
- 2) Mean camber line – line halfway between the upper and lower surfaces
- 3) Camber – maximum distance between the mean camber line and the chord line, measured perpendicular to the chord line
- 4) Thickness – distance between upper surface and lower surface measured perpendicular to the mean camber line

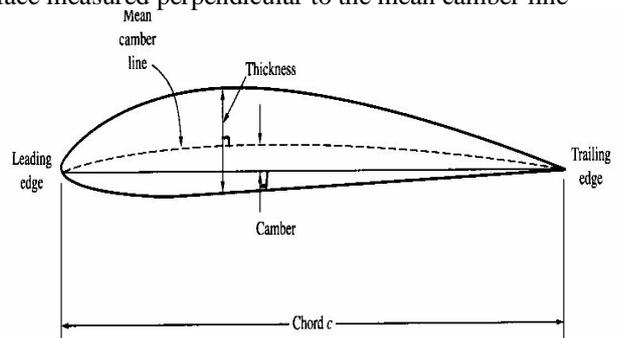


Fig 3 Airfoil nomenclatures [2]

III. CONSTRUCTING THE DOMAIN AND MESHING

For the flow analysis of the wind turbine blade mesh is created in the GAMBIT software. Figure 4 shows the meshing drawing of the airfoil below. [3]

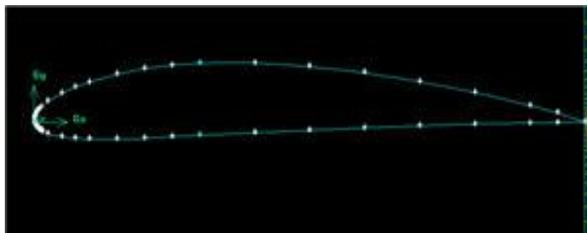


Fig 4 Geometry of Airfoil created in GAMBIT

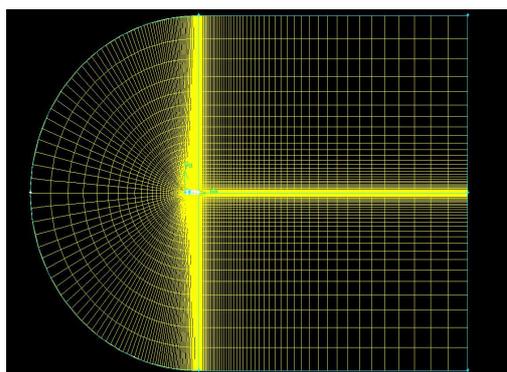


Figure 5 Completed Meshes.

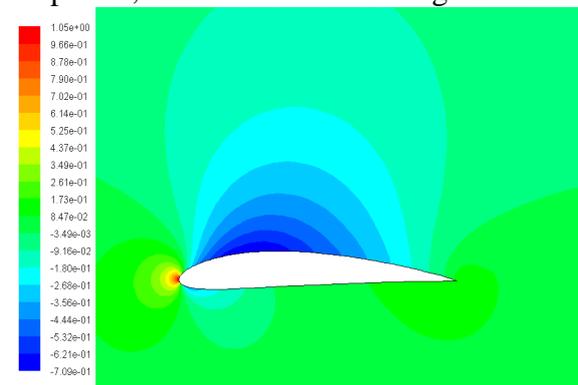
FLUENT input parameters:

Solver	Pressure based steady state
Viscous model	Spalart-allmaras
Density (kg/m ³)	1.225
Viscosity (kg/m-s)	1.7894
Turbulent viscosity ratio	10
Inlet velocity	18 m/s
Chord-length	0.1 m
Momentum	Second order upwind
Pressure velocity coupling	Simple

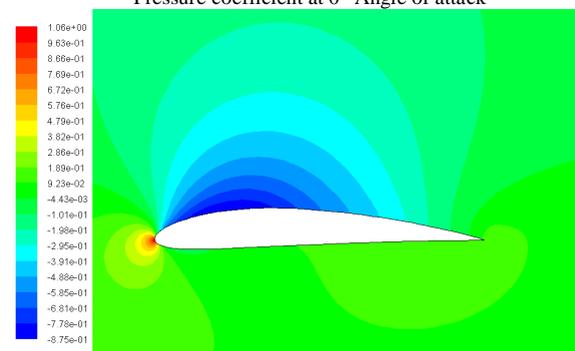
IV. RESULT OF PRESSURE COEFFICIENT

From the contours, we see that there is a region of high pressure at the leading edge (stagnation point) and region of low pressure on the upper surface of airfoil. From Bernoulli equation, we know that whenever there is high velocity, we have low pressure and vice versa. Figure 1 to 6 shows the simulation outcomes of static pressure at angles of attack 0° to 12° with spalart allmaras model. The

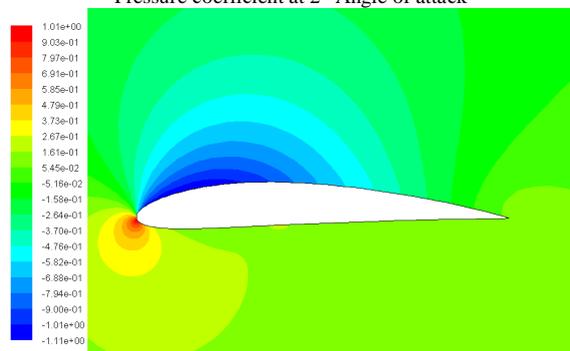
pressure coefficient on the lower surface of the airfoil was greater than that of the incoming flow stream and as a result it effectively “pushed” the airfoil upward, normal to the incoming flow stream.



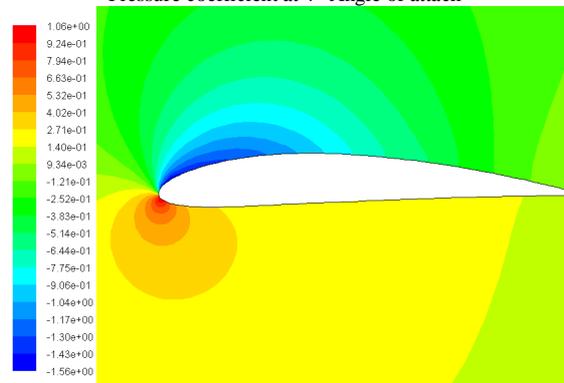
Pressure coefficient at 0° Angle of attack



Pressure coefficient at 2° Angle of attack



Pressure coefficient at 4° Angle of attack



Pressure coefficient at 6° Angle of attack

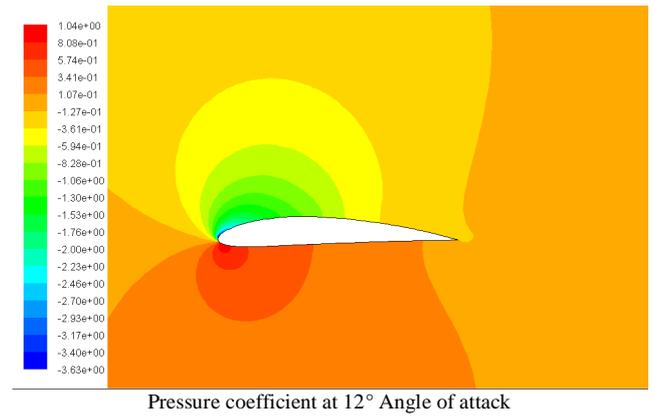
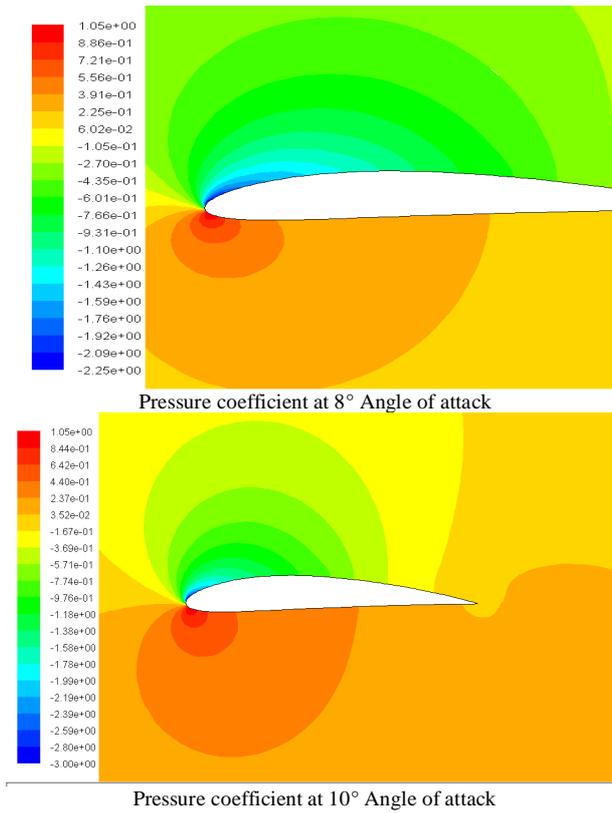


Fig 6 variation of pressure coefficient from 0° to 12°

V. CONCLUSION

From the contours of the CFD analysis of NACA 4412 airfoil conclude that at 0° pressure coefficient of upper surface indicate negative pressure. When increase the angle of attack we can understand the decrease the pressure coefficient on upper surface and increase on lower Surface also became the maximum at 12°.

REFERENCES

- [1] Martin O. L. Hansen, *Aerodynamics of Wind Turbines*, Earthscan, London, sterling, VA, 2008.
- [2] Airfoil nomenclature.pdf
- [3] http://ocw.kfupm.edu.sa/ocw_courses/user061/AE33301/Lecture%20Notes/Flow%20over%20airfoil.pdf