

# Flow study by Simulation over Drone-Aerofoil blade

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**Abstract:** Flow study with Incompressible flow simulation is done for the drone aerofoil blade with few angle of attack. The blades are similar to NACA types of blades. Pattern of Flow pattern with distribution of surface pressure are studied. The stagnation point is noted. Discretization of the governing equations by control volume is used. Fluent Software is used to get the result.

**Index Terms—** Angle, Control Volume, Drone blade, Fluent, simulation, surface pressure.

## I. INTRODUCTION

Flow simulation method is used to study the flow above the drone blades. Fluent CFD software is adopted. Flow over drone blade section is obtained. Drawing is modeled, meshed, boundary condition is used and pressure distribution are drawn.

In addition to the governing equations, boundary and initial conditions, material properties, and geometrical details in order to completely solve the problem Partial differential equations govern the phenomena are considered.

## 2.GOVERNING EQUATIONS AND NUMERICAL PROCEDURE

### 2.1 Continuity equation

Physical principle: - Law of conservation of mass.

$$\frac{\partial}{\partial t} \iiint_V \rho \, dV + \iint_S \rho \, v \, dS = 0$$

### 2.2 Momentum equation

Physical principle: - Newton's second law (F=ma)

$$\frac{\partial(\rho u)}{\partial t} + \nabla \cdot (\rho u V) = -\frac{\partial p}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + \rho f_x$$

$$\frac{\partial(\rho v)}{\partial t} + \nabla \cdot (\rho v V) = -\frac{\partial p}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + \rho f_y$$

$$\frac{\partial(\rho w)}{\partial t} + \nabla \cdot (\rho w V) = -\frac{\partial p}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + \rho f_z$$

Equations are the momentum equations in x, y and z direction respectively in conservation form.

$$\rho \frac{Du}{Dt} = -\frac{\partial p}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + \rho f_x$$

$$\rho \frac{Dv}{Dt} = -\frac{\partial p}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + \rho f_y$$

$$\rho \frac{Dw}{Dt} = -\frac{\partial p}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + \rho f_z$$

### 2.3 Discretisation methods

The discretisation methods i.e. the numerical methods for solving PDEs include the finite difference methods (FDM), and the finite volume method (FVM) is used.

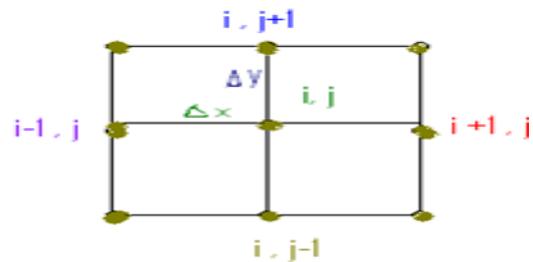


Fig.2.3.1.Mesh Grid

### 2.4 Geometry mesh

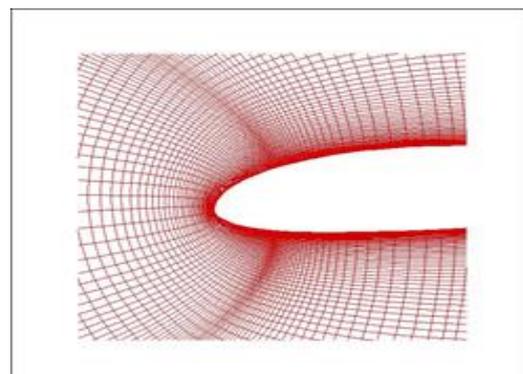


Fig.2.4.1 Mesh Grid used for simulation of flow past Drone blade. [O-topology with 200x100 control volumes divided into 2 blocks]

### 3.RESULT

The Simulation analysis over drone blade are given. Fig. shows the surface pressure type as well as the particle path or streamlines drawn using the Fluent software, based on the computed velocity vectors for the flow on drone 0016 at different angles of attack. Figs. Shows the Chordwise variation of surface pressure for flow past drone016 airfoil. (Chord-based Reynolds number = 2 million)

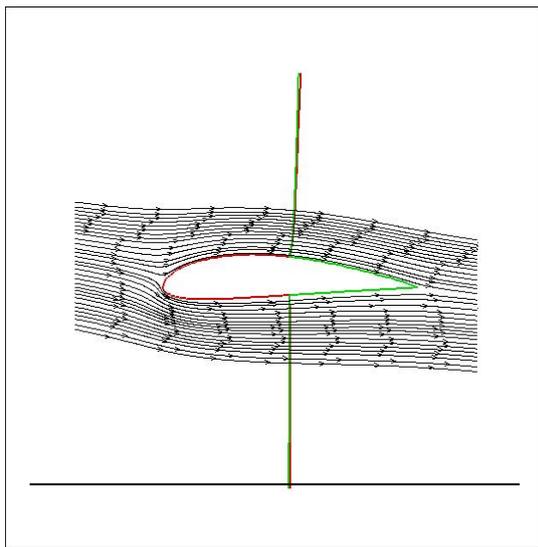


Fig.3.0 Particle path

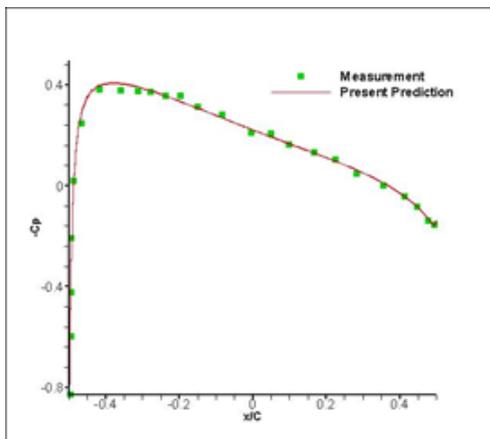


Fig.3.1 ,  $\alpha = 3^\circ$

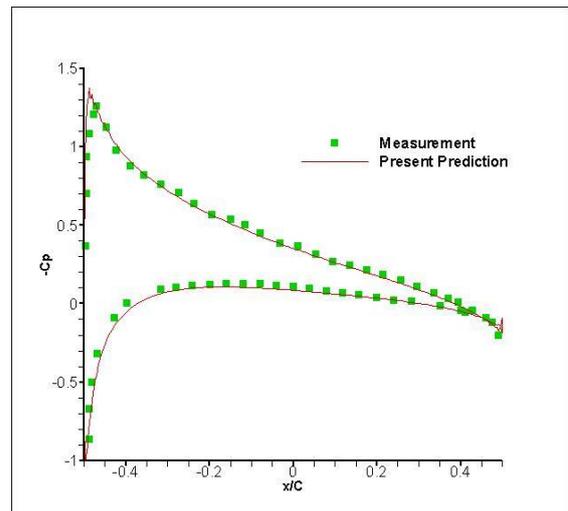


Fig.3.2,  $\alpha = 5^\circ$

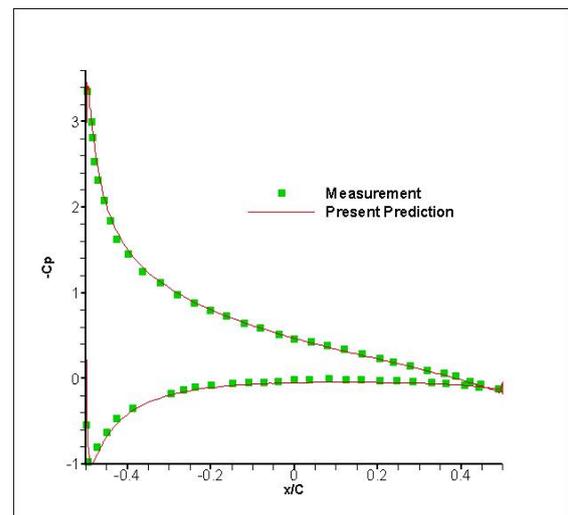


Fig.3.3.  $\alpha = 7^\circ$

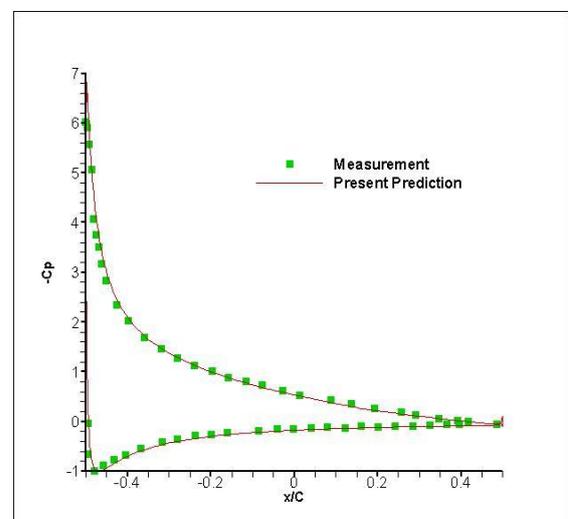


Fig3.4,  $\alpha = 9^\circ$

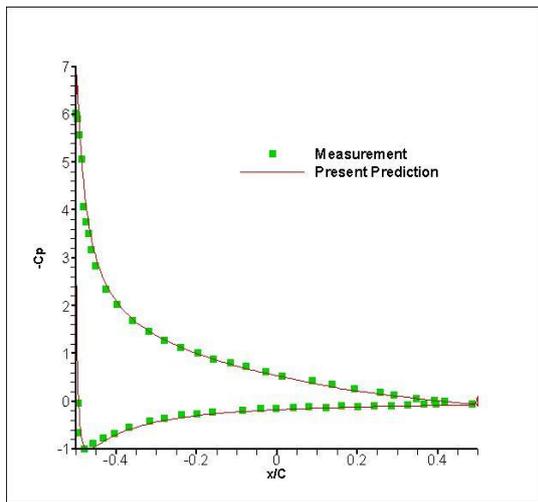


Fig.3.5,  $\alpha = 13^\circ$

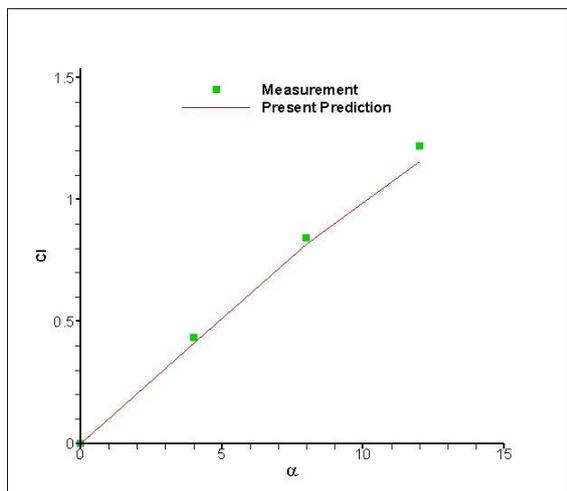


Fig.3.5 Graph of Coefficient of Lift  $t$  and few angle of flow of incidence.

#### 4. CONCLUSION

With few different angle of incidence, the flow is hitting the drone blade ,that point is the stagnation point near the front point and takes shape into two streams – one along the lower and the other along the upper surface of the drone. The flow is remaining attached all over the upper and lower surface of the drone blade for few of the angles of incidence. The coefficient of lift changes with the angle of incidence in a straight manner and show enhancement for positive angles of incidence.

Notations:

P-pressure

$\mu$  - viscosity

$\tau$  - viscous stress

U,V,W-free stream mean velocity

$u',v',w'$  - instantaneous velocity

$\rho$  – density

f- body forces

#### REFERENCES

- [1] Computational Fluid Flow and Heat Transfer by K.Muralidhar and T Sundararajan, IIT Kanpur series of advanced texts
- [2] Schlichting H. (1979), Boundary Layer Theory, Seventh Edition, McGraw Hill
- [3] Emmons H.W. (1951) The Laminar-Turbulent Transition in a Boundary Layer – Part I, Journal of Aerospace Science, vol. 18, no.7, pp. 490-498
- [4] Suzen Y.B., Huang P.G. (2005) Numerical simulation of unsteady wake/blade interactions in low-pressure turbine flows using an intermittency transport equation, Journal of Turbomachinery, ASME vol.127, pp. 431- 444
- [5] Majumdar S., Rodi W., and Zhu J.(1992), Three dimensional finite volume method for incompressible flows with complex boundaries, Journal of Fluids Engineering,, ASME, pp. 496-503.
- [6] Majumdar S., Rajani B.N., Kulkarni D., Mohan S., (2003), RANS computation of low speed turbulent flow in complex configuration, Proceedings, Symposium on State of the Art and Future Trends of CFD at NAL, NAL SP 03 01
- [7] Patankar S. V. and Spalding D. B. (1972), A calculation procedure for heat, mass and momentum transfer in three-dimensional parabolic flows, International Journal of Heat and Mass Transfer, Vol. 15, pp. 1787-1806.
- [8] Patankar S. V. (1980), Numerical Heat Transfer and Fluid flow, McGraw-Hill, New York, N.Y.
- [9] Peric M. (1985), A finite volume method for the prediction of three-dimensional fluid flow in complex ducts, PhD Thesis, Imperial College, London University.
- [10] Kulkarni D.S. Rajani B.N. Majumdar S. (2001), Studies on the temporal and spatial discretization schemes used in a Pressure-Based RANS algorithm for incompressible Flow, Project Document CF 0108, NAL Bangalore.