Design and Analysis of Corrugated Wing Section

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Abstract

This paper The effectiveness of corrugated Aerofoils is to be used in the wing section. The bioinspired model of corrugated aerofoil section based on the dragonfly wing surface cross section has a unique high lift to drag ratio predominant at low Reynolds number at the region of transition flow. A rectangular lofted structure based on the dragonfly wing cross section is lagged by the structural strength due to its geometric properties. Hence the further improvement can be illustrated by the design of a wing section is to be made with the reference of the rectangular lofted dragonfly wing based aerofoil section with the aid of modeling tools like Solid works or Catia and the analysis of flow over the surface is done with the aid of fluent in ANSYS. The result obtained will show up with greater structural strength in comparison with rectangular lofted aerofoil section by Khan MA, Padhy C, Nandish M and Rita K with an increase in flow properties along the surface of the aerofoil section.

Keywords— *Corrugated aerofoil, high lift devices, glider wing, powerless flight wing , wing, high L/D ratio, corrugated wing ….*

I. INTRODUCTION

Any structure that can produce lift with the interference of stationary or moving fluid can be denoted as an airfoil.

While considering the design of aerofoil the following factors are to be considered

- Lift required
- Lift to drag ratio
- Lift coefficient
- Drag coefficient
- Angle of attack
- Thickness
- Chord length
- Thickness to chord ratio
- Camber of aerofoil
- Reynolds number
- Angle of attack
- Velocity

Aerofoils are something that related with the cross section of the wing surface and something related to National Advisory Committee of Aeronautics(formerly known as NACA). They provided some regulations and data related to aerofoil sections . the standardization is provided by them

Beyond some standardization and rules of NACA. A new type of aerofoil section are under development based on the inspiration of the nature . The design criterion involves the analysis of flight motion of some flying organisms based on the geometry and the flow over the surface and the efficiency provided

As a result of such an analysis dragonfly wing are found with high efficient gliding performance. Micro aerial vehicles travels at a speed nearly equal to that of insects. The flow over the wing surfaces leads to produces lift.

According to Khan [1], a bioinspired corrugated aerofoil will produce high lift to drag ratio. He also proves the vortices generated in corrugated aerofoil will induces lift.

As per Okamoto[2], the dragonfly wing section and the body of the dragonfly causes flow to move and stagnate at specific locations along the chord. According to Zhao H X and Yin Y J[6], the flow across the hind wing and fore wing of the dragonfly, The forewing is highly cambered to circulate the flow in the bottom surface of the wing .

The stagnant flow along the fore wing provides a greater gliding efficiency and it also guides the flow along the hind wing which accelerates the flow. Some images of aerofoils in existence is shown in the figure.

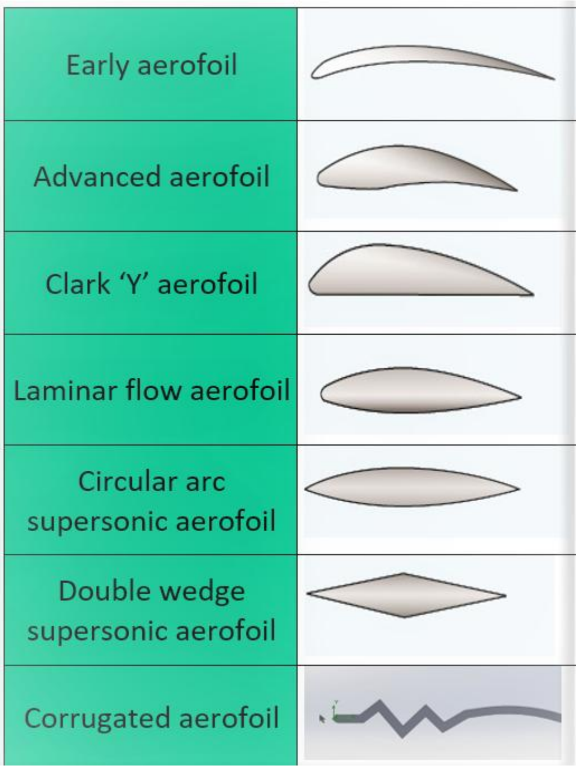


Fig 1: Types of aerofoils

II. DESIGN OF AIRFOIL

A. Methodology

The corrugated aerofoil are designed based on the cross section of wings of insects and birds

A typical dragonfly aerofoil Wing section is producing efficient flow pattern over the surface of the geometry

The vortices generated in the upper section of the aerofoil in a dragonfly aerofoil reduces the efficiency of the system.

B. Numerical methods

The calculation of flow properties over the involves the Reynolds number, coefficient of lift and drag forces

The following equations are considered in calculation of flow properties

$$Re = Ul \,/\, V_\infty ,$$

$$C_L = L \div (0.5\rho U^2 S),$$

$$C_D = D \div (0.5\rho U^2 S),$$

Where,
L= lift force generated
D= drag force generated
U=velocity of the fluid
l=length of the object
S= area of the object
C_D=coefficient of drag
C_L=coefficient of lift
Re= Reynolds number
ρ= density of fluid

C. Design

The geometry of the aerofoil section the types

i) Symmetrical aerofoil
ii) Unsymmetrical aerofoil
iii) Cambered aerofoil
iv) Corrugated aerofoil

The chord length of the aerofoil is 100mm. The design of geometries used in analysis are flat plate , standard symmetrical aerofoil NACA0015 and modified corrugated wing section

The models are designed using Solidworks

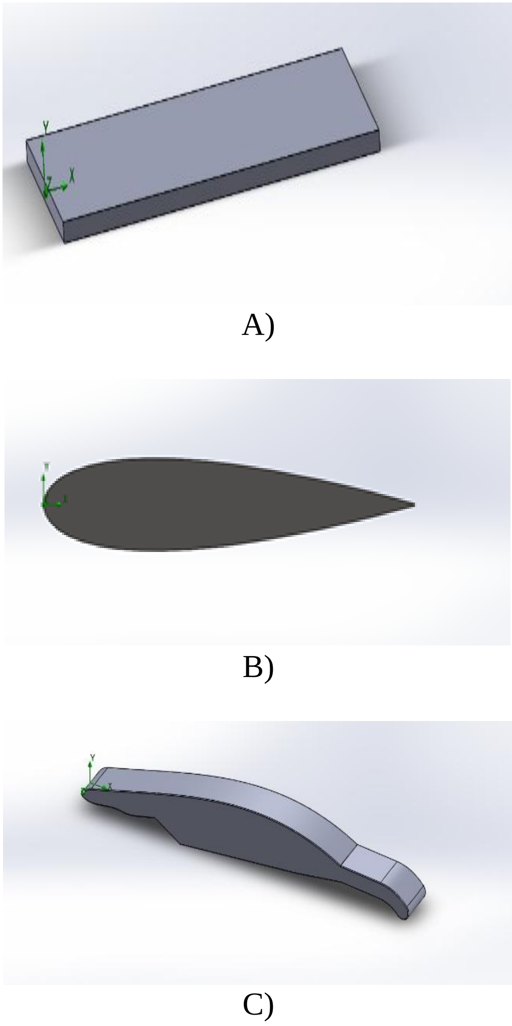


Fig 2:A) 3D view of flat plate
B) 2 Dimensional view of NACA0015
C) Three Dimensional view of modified corrugated wing section

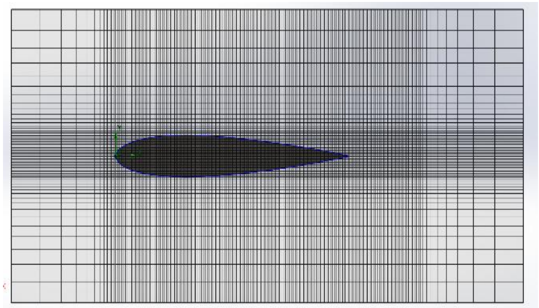
D. Computation domain

After modelling the wing in solid works. The wing is analysed using flow simulation-addon in solid works. The domain is limited to 2D. The performance analysis corrugated aerofoil is done in a two dimensional computational domain. The grid points are generated using the number of divisions. The grid are refined with a fine scale of mesh.

As the analysis of flow is done with the aid of Solidworks flow simulation Add-in .The structured grid is generated with number of division in x and y axis of computation domain. The x axis of the computation domain is divided into 150 division and y axis is divided into 80 division.

The cells are refined between themselves at the boundary layer and at the regions nearing the fluid solid interface. The refinement of mesh makes the nodes very close. The dimension of the each cell is of 3.495 e-04 x 3.715 e-04 m.

The boundary condition is limited with inlet conditions of inlet velocity 25m/s and the angle of attack is zero degree.



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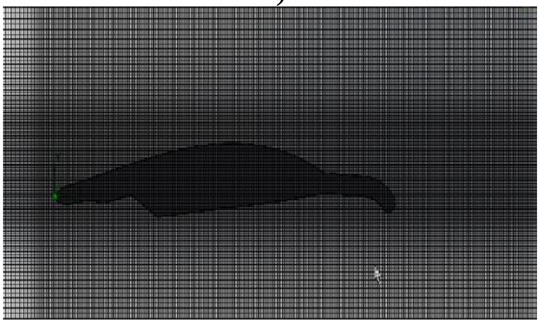


B)

Fig 3.A) Cross section view of mesh of NACA 0015 B) Cross section view of mesh of top profiled corrugated aerofoil with refinement view

III.ANALYSIS AND RESULTS

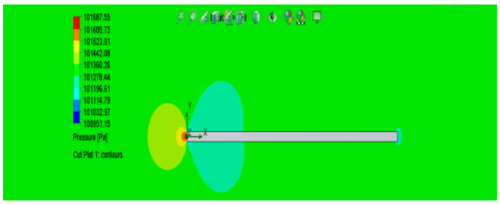
A) Units

All the reading and values mentioned in the paper follows MMGS(millimetre, grams, second) unit system. Forces are mentioned in Newtons N.

B) Analysis and Plots

The analysis of the geometries of the airfoil sections using Solidworks flow simulation's. The solver is set to stop on the convergence of the goals. The plots obtained are shown below

On the analysis of the plots of flat plate. The flat plate produces a negligible lift. Due to the vortices developed and uniformly distributed airflow over the top and bottom surfaces of the airfoil. The flow travels nearly at the same velocities across the top and bottom surfaces of the plate due to the uniformity of the surface and flow over the surface



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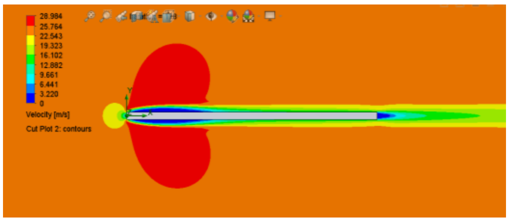

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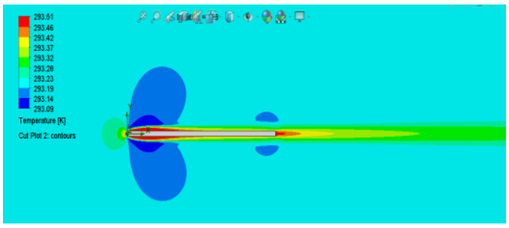

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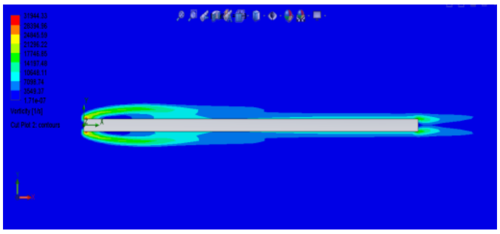
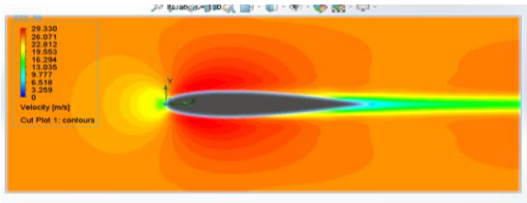


D)

Fig 4: A)Pressure plot of flat plate, B)Velocity plot of flat plate, C)Temperature plot of flat plate, D)Vorticity plot of flat plate

In comparison with the flat plate NACA 0015 produces a reasonable lift. But it's too not meeting the force requirements needed for lift the aircraft. Some plots obtained as a results of calculations are given below



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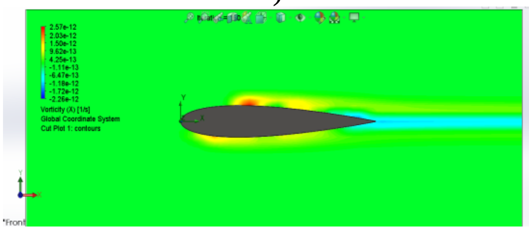

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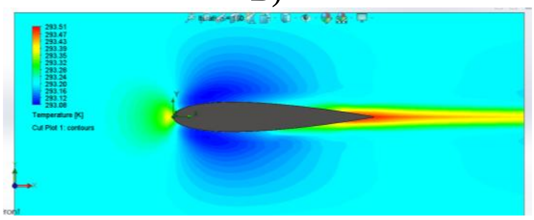

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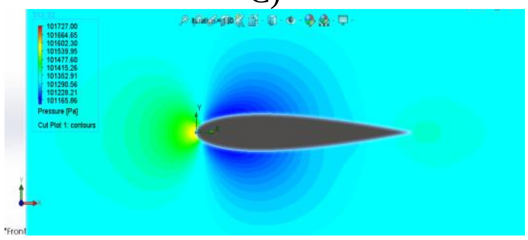

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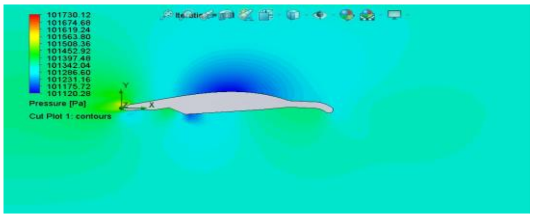
Fig 5:A) Velocity plot of NACA 0015,
B) Vorticity plot of NACA 0015,
C) Temperature plot of NACA 0015,
D) Pressure plot of NACA 0015

The above plots gives the pressure distribution over the surface of the airfoil. The interpretation shows that the flow pattern over the flat plate and NACA 0015 are quite similar to each other. The effectiveness of the airfoil to as similar as flat plate at zero degree angle of attack. In accordance with the flow pattern along flat plate , NACA 0015 airfoil and corrugated airfoil sections.

The velocity of the flow along the top and bottom surfaces of the airfoil are same . Hence the flow over the airfoil does not produce any upward force. As the pressure difference between the top and bottom surface is the key factor for generation of lift by the airfoil.

C) Analysis of enhanced top profiled aerofoil

The top profiled airfoil is design based on the series of interpretation of flow over the airfoils, flat plate and corrugated airfoils . The geometry is created based on set of rules and criterions . The newly created geometry is analyzed through flow simulation solver of Solidworks 19.0. The plots obtained as a result of the calculations are given below



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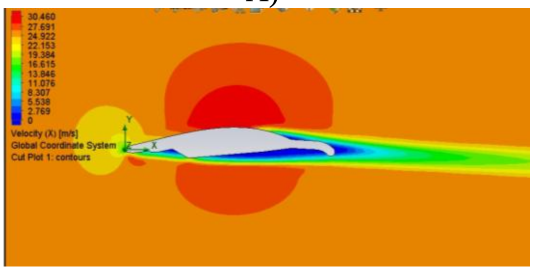

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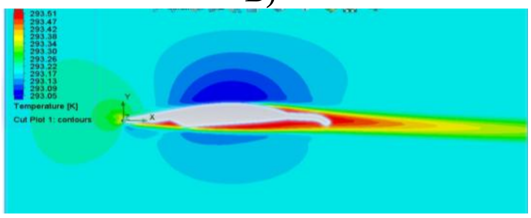

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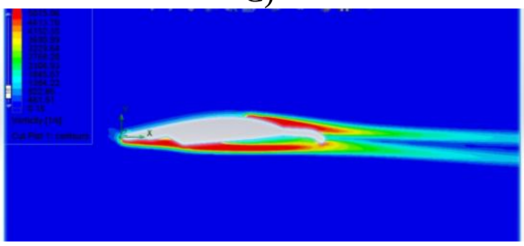

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Fig 6: A)Pressure plot of enhanced top profiled corrugated aerofoil,
B)Velocity plot of enhanced top profiled corrugated aerofoil,
C)Temperature plot of enhanced top profiled corrugated aerofoil,
D)Vorticity plot of enhanced top profiled corrugated aerofoil

The plots obtained shows the flow over the surface. The pressure over the upper surface of the airfoil must as low as possible for efficient lift generation. enhanced top profiled airfoil at zero degree angle of attack. The plots shows that flow is well efficient over the surface of the airfoil

IV. CONCLUSIONS

The results obtained as a result of analysis shows that the newly generated profile of aerofoil is efficient than the current sections in study.

The values obtained are tabulated below

S.No	*Geometry*	*L/D Ratio*
1	Flat plate	□*0*□
2	NACA 0015	0.2435
3	Enhanced Top-profiled corrugated airfoil	3.975

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