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COMPUTATIONAL FLUID DYNAMICS OF REFLEX AIRFOIL

VIKAS KUMAR
B.TECH (AERONAUTICAL ENGG.)
PUNJAB TECHNICAL UNIVERSITY, JALANDHAR
Kumar16vikas@gmail.com

JAG SAHIL SAINI
B.TECH (AERONAUTICAL ENGG.)
PUNJAB TECHNICAL UNIVERSITY, JALANDHAR
jagsahil@gmail.com

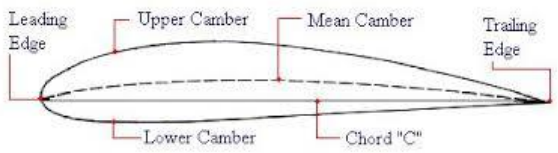
RAJKAMAL SINGH
B.TECH (AERONAUTICAL ENGG.)
PUNJAB TECHNICAL UNIVERSITY, JALANDHAR
Rajkamalsingh278@gmail.com

ABSTRACT
In this paper a NACA airfoil series which is used for making a cross section of a wing, empennage etc. of an aircraft is examined. Aerodynamics effect of an airfoil generating lift and drag is taken into consideration. Aim is to determine lift and drag over a reflex airfoil. In reflex airfoil is designed in a way that camber position of trailing edge is upward. In such airfoil nose up pitching moment coefficient (C_m) is still positive.Reflex airfoil geometry is created in CATIA V5. Terms for lift and drag coefficient of reflex airfoil using ANSYS software are generated.

General Terms
CATIA V5, ANSYS, CFD, FLUENT

Keywords
Reflex airfoil,reflex, upward camber CFD, lift, airfoil analysis, drag, pressure, camber, NACA Series, chord, wind tunnel

1. INTRODUCTION
NACA airfoil series has been major contributor in aerospace industry. NATIONAL ADVISORY COMMITTEE OF AERONAUTICS developed a different airfoils shape of aircraft wing. Airfoil geometry can be characterized by upper and lower surfaceof the coordinates. A few factors such as camber position, maximum camber position, position of maximum thickness, leading edge, trailing edge.



NACA 4-DIGIT SERIES

2	4	1	2
Max. Camber in % chord	Position of max. camber in 1/10 of chord	Max. thickness in % chord	

NACA 5-DIGIT SERIES

2	3	0	1	2
Max. Camber in % of chord	Position of max. camber in 2/100 of chord		Max. Thickness in %of chord	

In the case of reflex airfoil the trailing edge of the airfoil is in upward position which is also called engineering term as positive moment coefficient. It is basically used in tailless aircraft because moment about aerodynamic center of airfoil of wing is zero. The trailing edge portion is bent up so camber is still positive. Normally it behaves a neutrally stable regarding its load. The angle of attack should remain positive so that lift remains upwards and stable. For symmetrical airfoil there is no camber so moment coefficient is zero and non-symmetrical airfoil camber causes generation of moment coefficient. A moment coefficient is far behind from the trailing edge so it is quite effect on aerodynamic pitching moment. It gives less amount of lift to change the value of C_m.

Therefore a nose pitching moment would be back to its original position called as a neutral position. Angle between chord and free stream is called as an angle of deflection (δ_e).It moves upward at 5˚ or 10˚.Main influence of reflex airfoil is that desired value of C_m near the trailing edge of airfoil is achieved.

2. METHODOLOGY
These days analysis is done with help of CAD, FEM and simulation runs. With help of these methods more interactive and efficient response comes out. Software like ANSYS, NASTRAN-PATRAN, etc are used in aerospace industry because effectiveness. We examine results by using a computational fluid dynamics in ANSYS software.

2.1 CATIA V5
CATIA V5 (Computer aided three- dimensional interactive application) is a pre dominant solver which makes a conceptual design or a prototype at less time consuming rate. It is mainly used in automotive, aerospace, shipping and other industries. There are many workbenches are available to construct a geometry in CATIA V5 such as product, part, sheet metal, surfaces etc. It supports different types of stages in computers:-

- CAD (computer aided design or conceptually)
- CAE (computer aided engineering)
- CAM (computer aided manufacture)

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It saves a time relevance and low cost during conceptual and simulation.

2.2 ANSYS

ANSYS simulation software is usedto solve the most challenging engineering problems. It is very user friendly and easily understandable. Several industries are able to determine static structural analysis, linear and non-linear analysis, buckling analysis, explicit dynamics, computational fluid dynamics, electromagnetic, hydrodynamics etc. ANSYS CFD is used for testing data by simulating fluid flow.

3. DESIGN AND DETAILS

Firstly NACA 23012 airfoil coordinates are chosen to import and made into an airfoil in CATIA V5. To construct a reflex airfoil trailing edge portion upwards at 10°.

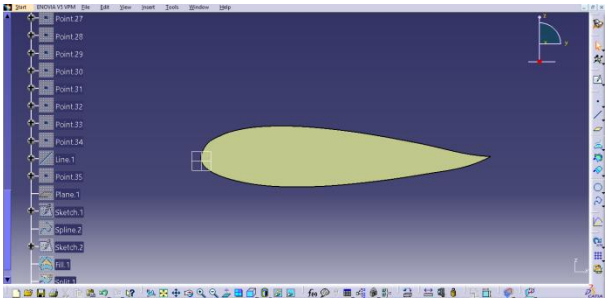

Fig.1. CATIA V5model of a reflex airfoil 23012

Now 2-d reflex airfoil has created in case of wind tunnel. Show in fig.2

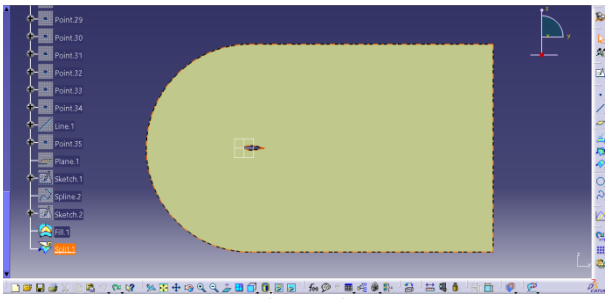

Fig.2. Reflex airfoil 23012

Once model is done design is simulated by computational fluid dynamics. We have used ANSYS for this project work.

4. COMPUTATIONAL FLUID DYNAMICS

CFDmodel is generated by importing from CATIAV5 in ANSYS FLUENT. Now mesh on model is applied.

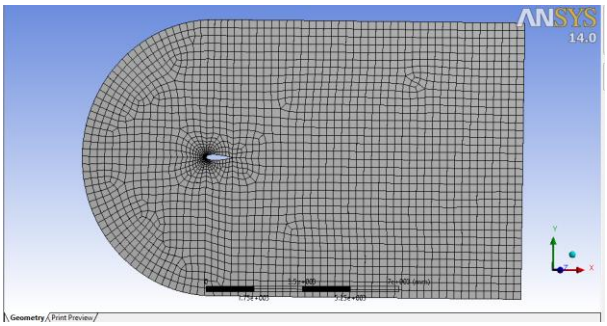

Fig.3. Meshing

In Next step a boundary condition based on the working principles is applied in ANSYS 14.0.and also name selection where the fluid is moving throughout the section is mentioned.

Zone/Region	Type
inlet	Air intake/velocity inlet
wall	stationary
Airfoil wall	Tested data
outlet	Pressure outlet

Table.1

Consider velocity of the fluid particles to be 133m/s. In order to represent parameters such as static pressure, velocity vector and path lines which could be introduced when process occurs.

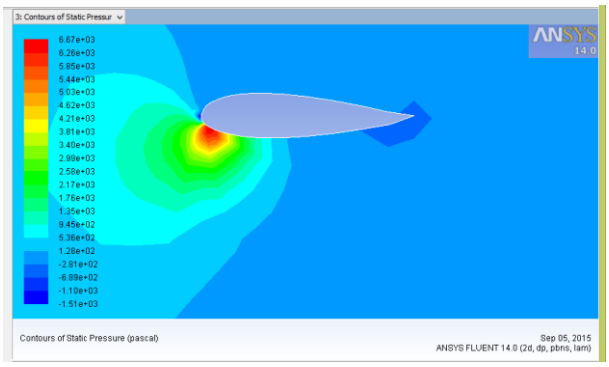

Fig.4. Static pressure

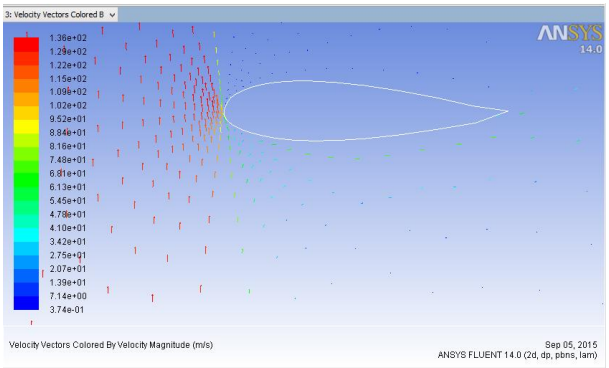

Fig.5. Velocity vector

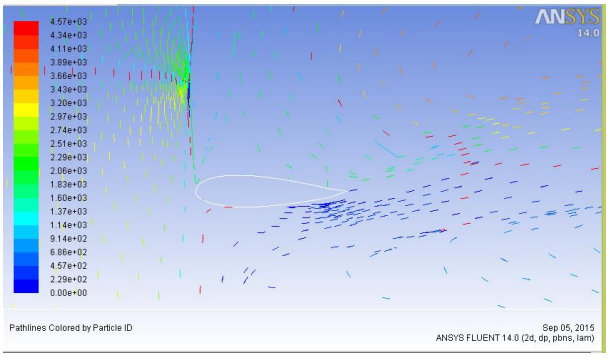

Fig.6. Path lines

5. RESULTS

Simulation runs automatically when input is given to the solver. We study a reflex airfoil 23012 and examine results

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during process. It comes out to be lift is 1991.43(N) and drag is 227.31(N). Lift is much more value as compared to the drag. And also to find out the results of different NACA airfoil series which can be seen in table.2.

NACA SERIES	LIFT	DRAG
23012	1991.43(N)	227.31(N)
23021	849.755(N)	409.957(N)
23112	2911.32(N)	111.253(N)
24112	1585.84(N)	134.741(N)

Table 2

6. CONCLUSIONS

We have chosen different types of NACA airfoil series and then made a reflex airfoil. Each airfoil has different values of parameters such as lift and drag. Our aim is to choose a reflex airfoil whose lift is more as comparison to other. After all the comparisons it is concluded that 23112 has the highest lift to drag ratio which favorable result for aircraft wing design.

7. FUTURE SCOPE

We took an overview of reflex airfoil which determined the result by performed analysis.These results confirm the conclusion that the reflex airfoil has improved all the characteristics of well-known and commonly used airfoils.Major contribution role of reflex airfoil will be used in aerospace industry for different purposes. Wing designing according to the given reflex airfoil and its effects can further be studied by adding more parameters and factors like wing tip vortexes and 3D wing analysis can be done. Wings designs using reflex airfoils are used in tailless planes so it can be studied how these wings compensate for horizontal stabilizer.

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