ISSN: 2278-0181
NCRTET-2015 Conference Proceedings

Stability Analysis of Low Renolds Number UAV Using XFLR5

J. Jensin Joshua, N. Ganesh Kumar, A. A. Aswini
Department of Aeronautical Engineering,
Adhiyamaan College of Engineering,
Hosur.

Abstract **--The Unmanned Aerial Vehicle (UAV) having no pilots have proven their values in many areas. In this research we have made an attempt design and analyze an indigenous UAV with good stability knowing the mass of the entire system. Stability analysis of the UAV has been carried out at different conditions and the values are noted. The paper will also discuss the step by step procedure of design and analysis of the complete UAV. The design of the vehicle has been done in catia V5 and the analysis has been carried out in XFLR software. The software structure of the UAV has been designed in such a manner to give good lift even at very low speed. this UAV has got the special ability to operate even at low Reynolds number. The results of this analysis could be utilized to further improve the aerodynamics of the existing design and enhance the stability and performance characteristics of the UAV.**

Keywords : ***Unmanned Aerial Vehicle (UAV),stability, solid works, XFLR.***

I. INTRODUCTION

The term UAV is an abbreviated of unmanned aerial vehicle which mean aerial vehicle which operate without a human pilot. UAVs are commonly used in boththe military and police forces in situations where the risk of sending a human piloted aircraft is unacceptable or the situation making using an unmanned aircraft impractical. The small unmanned aircraft are designed to support individuals, companies and national regularity authorities who wish to embrace the requirement set out the by the civil aviation authority (ICAO) for remotely piloted aircraft systems (RPAS). Flight crew competence, airmanship, legal and regularity awareness are key components of training

II. AIRFOIL SELECTION

The importance of selecting an appropriate wing airfoil with good CL versus alpha characteristics at low Reynolds numbers cannot be overemphasized. It is a well-known fact that airfoil lift characteristics can degrade significantly under low Reynolds number operation. In this research paper Eppler 325 airfoil is selected. The of the Eppler 325 airfoil is 1.55 at Reynolds number of 3,000,000 falls off significantly to 0.83 (reduction to 54%) at Reynolds number of 170,000.

III. DESIGN

CATIA V5 is the software used for designing the model

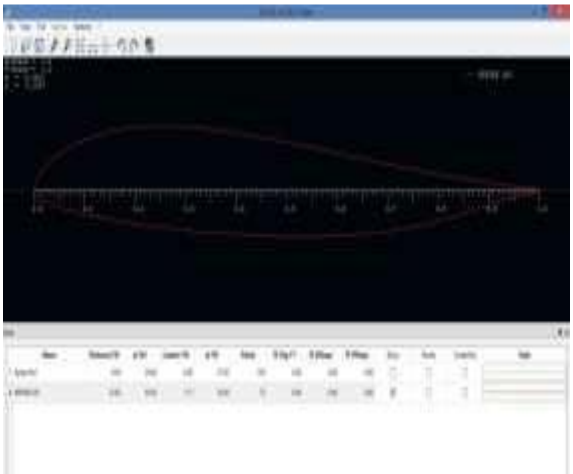


Fig 1 : Eppler 325 AirfoiL

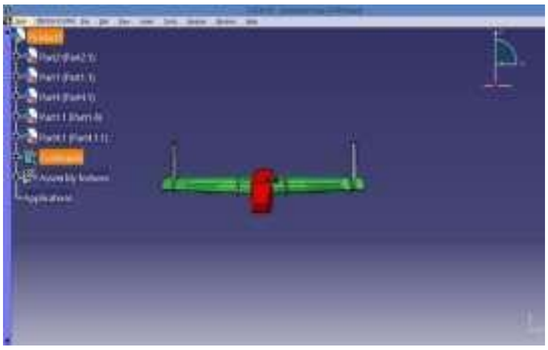


Fig 2 : Front View

The two dimensional view of the UAV is drawn in the software called CATIA the above diagram shows the isometric view, top view, right view & front view.

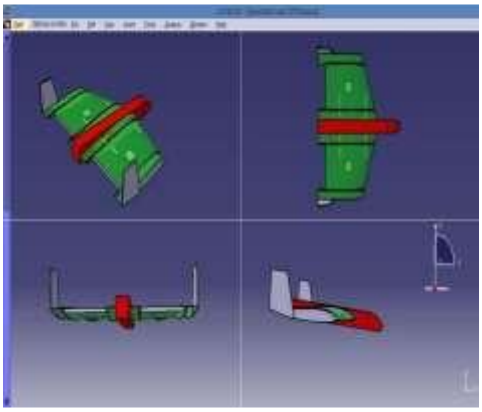


Fig3 : Four views of MAV

The three dimensional view of the unmanned aerial vehicle (UAV) is drawn in the CATIA (the designing software). The UAV has the twin tail fin and the airfoil used in this uav is eppler 325.
The vertical stabilizer which is placed in in the rear gives the vehicle the good lateral The vehicle has got a elevator at the rear side of wing and serves as the horizontal stabilizer providing the longitudinal stability.

IV. COMPUTATIONAL FLUID DYNAMICS ANSYS CFX

Computational Fluid Dynamics (CFD) was performed using Ansys CFX. Flow simulation was used to determine the global goals and surface goals, namely the total lift of the MAV, lift generated by the wing, drag of the MAV as well as the moment characteristics of the MAV. Refinement of mesh was done on the wing to ensure that the curvature and partial cells are properly meshed and laminar and turbulent flow was selected to ensure flow.

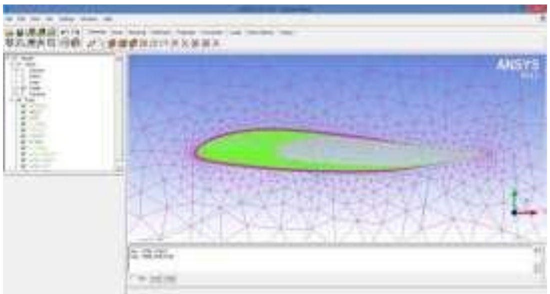
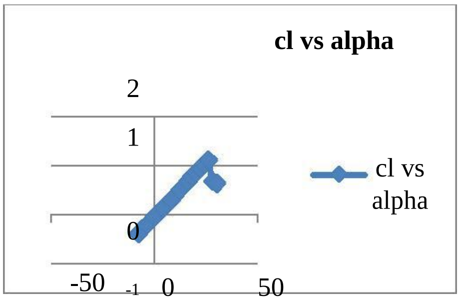


Fig 4 : Mesh generated for MAV wing using ICEM CFD

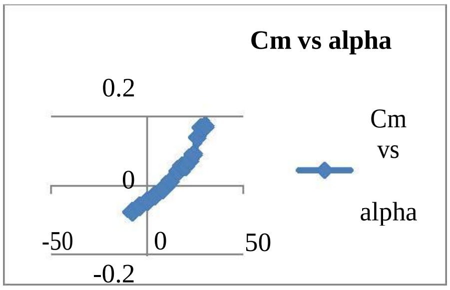
Flow simulation done in CFX was as close to the real life situation as possible. An animation of flow over the MAV was also performed to analyze the flow patterns as it passes the MAV. CFD model from flow simulation is based on time dependent Navier-Stokes equations for reiterative calculations to generate the required data. Due to time constraint and the level of refinement of the cells, CFD was performed on the ICEM CFD mesh shown in figure 4 of the MAV and used to determine the lift data at different angles of attack.

CFD results shown in graphs indicate that at an AOA of 2 degrees, the coefficient of lift is about 0.2. The stalling angle of the MAV is about 25 degrees since the airfoil used is reflex cambered.
The design of the MAV is capable of achieving sufficient lift at a speed of 15m/s, a 30% margin before stalling occurs at 25 degrees



CL Vs. α curve

CFD results in the below graph shows the moment variation with the gradual increase in the AOA. Since the MAV is tail less moment varies in small intervals at high AOA.



Cm vs.α curve

V. STABILITY ANALYSIS

A. Longitudinal Stability

Static longitudinal stability of an aircraft is crucial as it determines the ability of the aircraft to return to its original position when displaced by a gust of wind or there is a sudden change in the AOA. Stability analysis for the MAV is carried out using XFLR5 software.

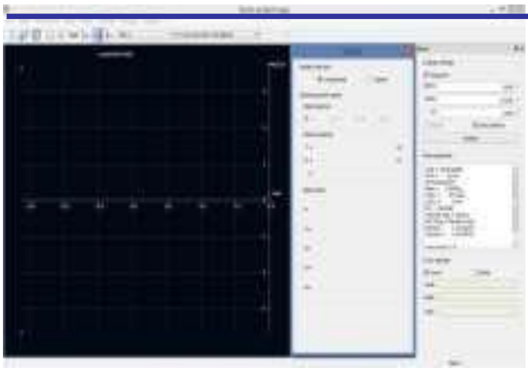


Fig 5 : Longitudinal stability graph of the MAV

The above figure 5 shows all the co-ordinates lies in the negative region at Different AOA and so as to ensure the MAV is longitudinally stable. Each point on the graph represents the location of the stability points as per the numerical formulas. By the graph Moments vs. AOA graph, the position of the Centre of Gravity of the MAV can be determined to ensure trim conditions.

B. Lateral Stability

Dihedral effect on the MAV was due to the wing position. The wings of the MAV are positioned at the top of the fuselage, i.e. high wings. The high wings enable greater stability as it guides the position of cross flow around the fuselage in a sideslip, changing the angle of attacks at the wing root and wing tip, resulting in a net lift component which brings the MAV back to stability.

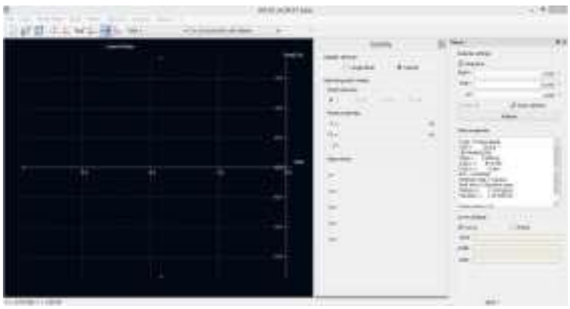


Fig 6 : Lateral Stability graph of the MAV

Since the MAV is tail less ensuring the lateral stability is a tough job, in order to do that airfoil is selected in such a way, to bring back to its original flight conditions. This creates an opposite reaction force to make the MAV stable during flight conditions.

VI CONCLUSION

Thus the model that could fly at low Reynolds number has been designed and the stability analysis has been studied clearly. The longitudinal and the lateral stability conditions has been successfully inferred from the software results. The model is found to be stable for the low angle of attacks.

REFERENCES

[1] Grasmeyer, Joel M. and Keennon Matthew T.(2001)" Development of the Black Widow Micro Air Vehicle".
[2] Mueller, Thomas J.(1997) "Aerodynamic Measurements at Low Reynolds Numbers for Fixed Wing Micro- Air Vehicles".
[3] Morris, Stephen J.(1995) "Design and Flight Test Results for Micro-Sized Fixed- Wing and VTOL Aircraft".
[4] Torres, Gabriel and Mueller, Thomas J.(2002) "Micro Aerial Vehicle Development: Design, Components, Fabrication, and Flight-Testing".
[5] Bastedo, Jr., William G. and Mueller, Thomas J.(1996) "Performance of Finite Wings at Low Reynolds Numbers".
[6] McMichael, J. M., Francis, M. S. (1997) "Micro Air Vehicles – Towards a New Dimension in Flight".
[7] Tousley. B., (2005) "Micro Air Vehicle (MAV) Advanced Concept TechnologyDemonstration (ACTD)".
[8] Thom, A., Swart, P. "The Forces on an Airfoil at Very Low Speeds", Journal of the Royal Aeronautical Society
[9] Kunz, P. J., Kroo, I. (2001) "Analysis and Design of Airfoils for Use at Ultra- Low Reynolds Numbers".
[10]Fixed and Flapping Wing Aerodynamics for Micro Air Vehicle Applications, AIAA Progress in Astronautics and Aeronautics Series, Vol. 195, (2001). 45