Computational Analysis Of Slotted Wing Tips At Low Reynolds Number

A. Saiteja, C. Suresh

ABSTRACT: The aerodynamic characteristics of a simple rectangular wing of NACA0012 airfoil with slotted tips, which is mostly used in MAV's and UAV's at low Reynolds number has been analyzed using FLUENT. UAV's fly at low Re and have smaller dimensions, low AR, and fly in similar environmental conditions as compared to biological fliers of similar weight. In the present study wings with slotted tips are modeled and analyzed with and without slots at different angles of attack for Reynolds number regimes of 300000. It is observed that the drag coefficient has been decreased consistently with small increment in lift to drag ratio. The current analysis is done for 8,10,12,14 and 16 degree of angle of attack and results seems to be good at 8 degree angle of attack

Keywords: slotted wing tip, low Reynolds number, Lift to drag ratio

INTRODUCTION

UAV that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. UAVs are thought to offer two main advantages over manned aircraft: they are arguably cheaper to procure, and they eliminate the risk to a pilot's life. UAVs/MAVs protect the lives of pilots by performing the "3-D" missions - those dull, dirty, or dangerous missions that do not require a pilot in the cockpit. But UAV'S have some drawbacks like Short endurance, Poor flying qualities, Fast landings causes damage of equipment, low Lift to drag ratio of flight. Due to these drawbacks wings with slotted tips are analyzed at different angles of attack at low Reynolds number to enhance more lift and lift to drag ratio for subsonic aerofoil.

Abbreviations and Acronyms

L -Lift
D -Drag
CL -Lift coefficient
CD -Drag coefficient
Re -Reynolds Number
AOA -Angle of Attack
UAV -Unmanned Aerial Vehicle
MAV -Micro Aerial Vehicle

LITERATURE

J.Alexander[1] presented the research extensively carried out based on the static analysis for finding the optimum design of wing structure. Two types of wings (rectangular wings) for Unmanned airplane were chosen and designed at the basis of M=0.21 and M=0.4 respectively.

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The aerodynamics study was achieved by using the vortex lattice method using XFLR-CFD software. M.J.Smith[2] examined the potential of multiwinglets for the reduction of induced drag without increasing the span of aircraft wings. Wind tunnel models were constructed using a NACA0012 airfoil section for the untwisted rectangular wing and flat plates for the winglets and texted for 161,000 to 300,000 Reynolds number and the results shown that certain multi-winglet configurations reduced the wing induced drag and improved L/D by 15-30% compared with the baseline wing. A substantial increase in lift curve slope occurs with dihedral spread of winglets set at zero incidence relative to the wing.

MODEL CONSTRUCTION

Geometric parameters of the wing model are as tabulated.

CHARACTERISTICS	RECTANGULAR WING
Wingspan	3.35
Aspect ratio	7.33
Taper ratio(m)	1
Tip chord (m)	0.45
Root chord (m)	0.45
M.A.C (m)	0.45
Wing tip length (m)	0.41
Slot width (m)	0.129
Slot gap (m)	0.1

The CATIA model of the slotted wing are shown in fig.1.

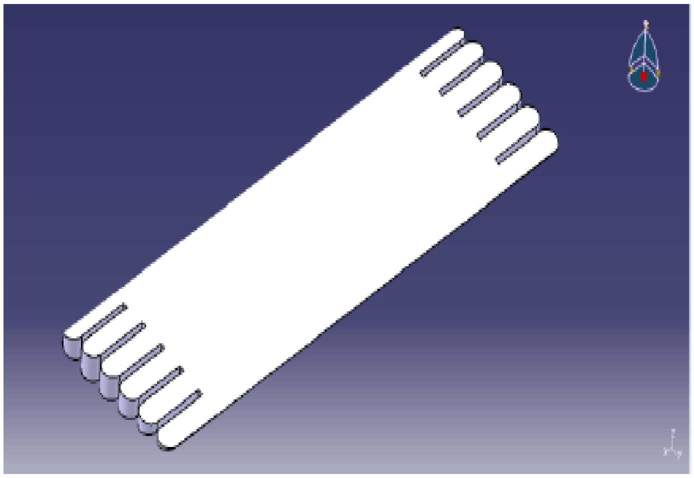

Fig.1 Rectangular wing with slotted wing tips

MESH DETAILS AND BOUNDARY CONDITIONS

Unstructured grids are generated on rectangular wing with 2,24,252 nodes. Unstructured grids are generated due to the presences of wing tip slots. A laminar flow is considered for the analysis at constant Re of 300000 for different AOA.

RESULTS AND DISCUSSIONS

The configuration that has been chosen for numerical analysis is

- Wing with no slotted wing tips
- Wing with 5 slotted wing tips

The Pressure distributions on the wing with tip slots are shown in the following figures for different angle of attacks.

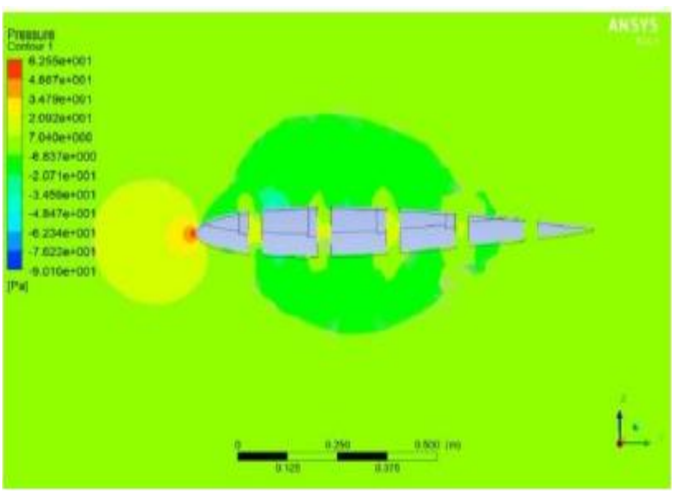

Fig.2. Pressure distribution for 80 AOA

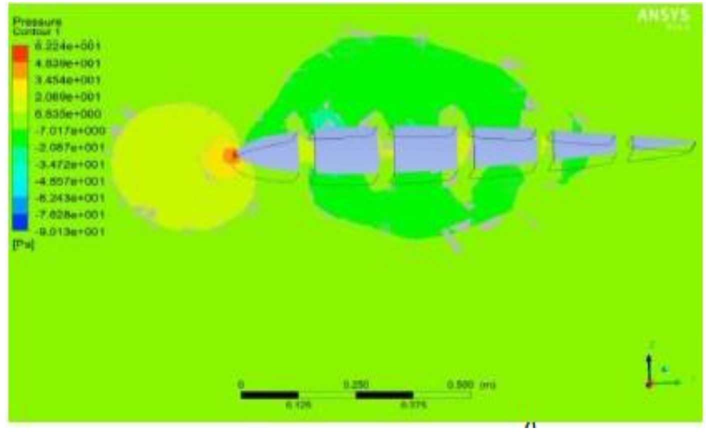

Fig.3. Pressure distribution for 100 AOA

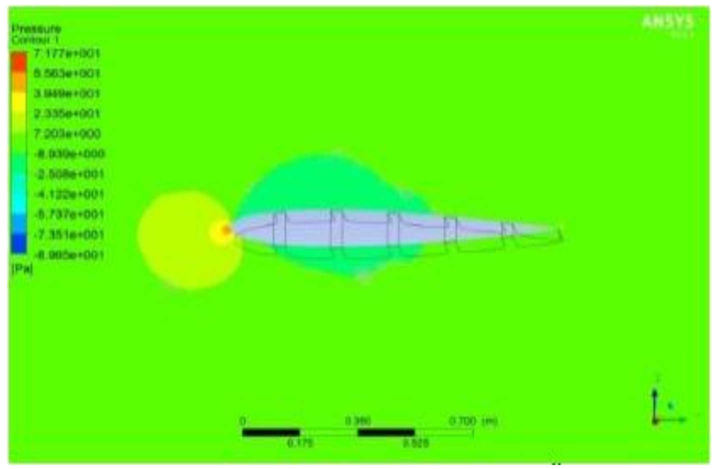

Fig.4. Pressure distribution for 120 AOA

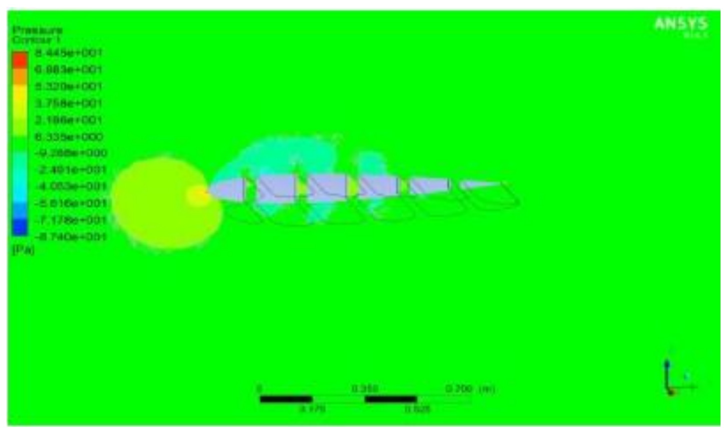

Fig.5. Pressure distribution for 140 AOA

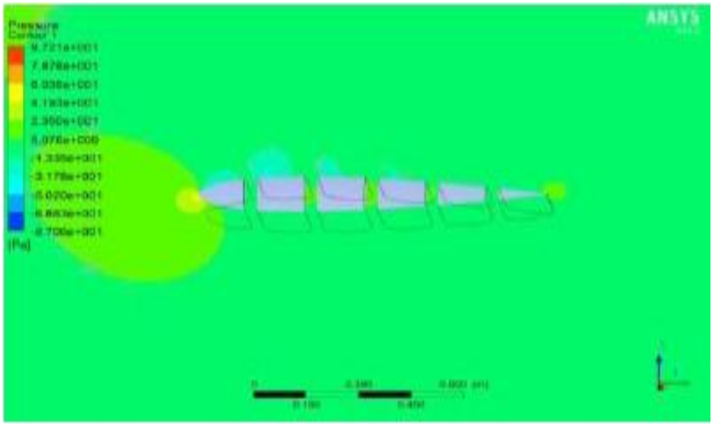

Fig.6. Pressure distribution for 160 AOA

From the pressure contour plots at different angle of attack it is observed that the wing stalls at 14 degree of AOA. From these contours it is observed that maximum lift will be at 10 and 12 degrees of AOA. The pressure distribution at 16 degree of AOA seems to be very much disturbed due to stall. At 14 degree of AOA the wing begins to stall due to flow separation. The lift coefficient and drag coefficient for the wing with tip slots and without tip slots for different angle of attack is tabulated as follows.

Coefficient of Lift					
Wing configuration	8^0 AOA	10^0 AOA	12^0 AOA	14^0 AOA	16^0 AOA
Base wing	0.957	1.135	1.255	1.248	1.140
Slotted wing tip configuration	0.876	0.954	0.964	0.752	0.568

Table.1 Lift coefficient vs AOA

Coefficient of Drag					
Wing configuration	8^0 AOA	10^0 AOA	12^0 AOA	14^0 AOA	16^0 AOA
Base wing	0.11925	0.1596	0.20816	0.27136	0.34458
Slotted wing tip configuration	0.03372	0.04722	0.05974	0.1060	0.12528

Table2 Drag coefficient vs AOA

From Table 1 it is observed that the lift coefficient decreased for the wing with tip slots. It is due to the presence of slots, which disturbs the flow patterns on the wing. But from table 2 it is observed that the drag reduces to consistent amount for the wing with tip slots. The CLvs AOA, CD vs AOA and L/D vs AOA graphs are as follows.

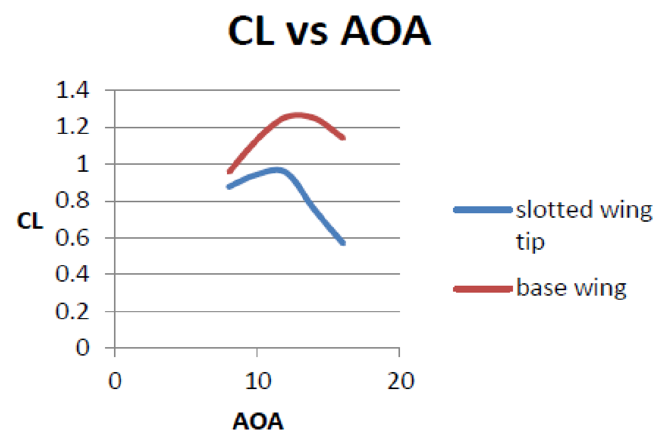

Fig.7. CL vs AOA

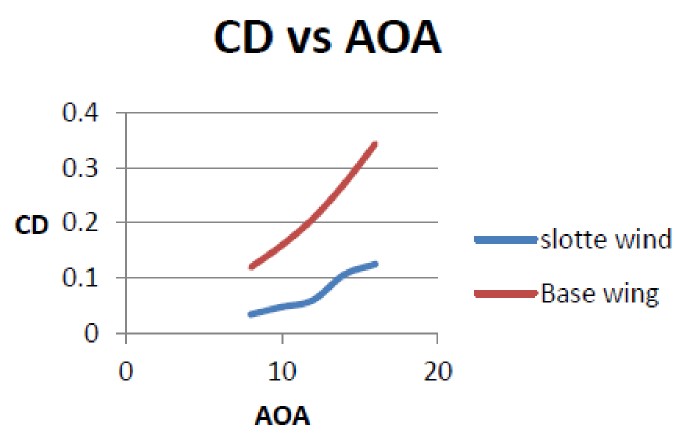

Fig.8. CD vs AOA

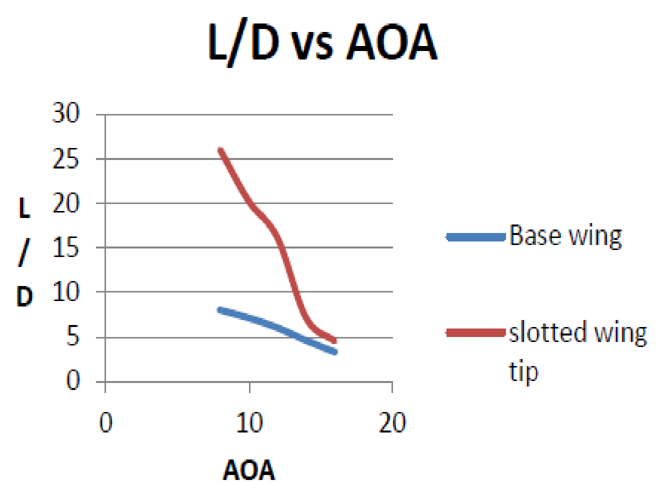

Fig.9. L/D Vs AOA

AOA	Base wing	Slotted wing tip
8^0	8.02170	25.9999
10^0	7.112816	20.2059
12^0	6.028094	16.1324
14^0	4.59981	7.09224
16^0	3.308825	4.5382

Table.3. L/D Vs AOA comparison

From the L/D ratio vs AOA it is observed that for the wing with tip slots, there is a dominant increase at 8 and 10 degree AOA. But at 8 and 10 degrees there is a decrease in lift coefficient. So the tip slots give better results at 12 and 14 degree of AOA.

CONCLUSION

Wings with tip slots can be used at low Reynolds number in UAVs/MAVs for long range and endurance by flying at 12 to 14 degree AOA. The lift coefficient and crag coefficient analysis for different AOA showed that the wing gives best aerodynamic efficiency at 12 to 14 degree AOA. Even though there is a decrease in lift coefficient the overall L/D ratio is increased for the tip slotted wing when compared with base wing without tip slots. The analyses are planned to continue for various Reynolds number and further more analysis in future.

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