2-D CFD Analysis of Ring Airfoil UAV

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Abstract

In this paper examined the aerodynamic behaviour of ring airfoil UAV. The ring airfoil is non-planar wing like disk shape and its cross-section like mirrored airfoil with respect to the vertical axis. Ring airfoil increase UAV VTOL performance. In numerical analysis of ring airfoil cross-section to find lift, drag and L/D ratio with respect to the different angle of attack and various velocities. k-ε turbulent model is use numerical analysis in fluent.

Keywords: UAV, Ring Airfoil, L/D Ratio, Fan, Stall Angle

I. INTRODUCTION

An UAV commonly known as Remotely Piloted Aircraft by the International Civil Aviation Organization. UAVs are used in modern warfare and surveillance. In planar wing (straight wing) UAV required more length for rolling and yaw but circular platform wing UAV does not required any length to rolling and yaw it is seen now days coanda saucer UAV so circular wing UAV is most compactable and high manoeuvrability UAV. The ring airfoil is circular platform wing and it is act streamlined body and bluff body based on flow direction if flow blown into radial direction it is act streamline body or flow blown in axial direction it bluffs body. the ring foil is use to increase VTOL performance of UAV. Aerodynamic behaviours addressed by lift, drag and L/D ratio.

II. NUMERICAL ANALYSIS

A. Pre-processing of model

The cross section of ring airfoil UAV created in preprocesing software gambit. The airfoil chord length is 0.4m and diameter of ring airfoil is 1m. Propeller with flow duct fixed in between 0.2m hollow spacing in ring airfoil middle. Guide plates direct the propeller axial flow in to radial direction of the ring airfoil. In design the propeller diameter is 0.1m.

Fig. 1: Isometric view of Ring foils UAV

Fig. 2: Isometric view of Ring foils UAV
B. Mesh

Gambit software were used to mesh generation and boundary condition specification on control volume. The control volume dimensions are 12c x 6c (c- chord length). It is specified based on airfoil chord length. The four node quad element is used to mesh the control volume structurally. In meshing the control volume mapped and specifies the interval count with ratio to increase element density at required place.

![Fig. 3: (a) Fine meshed control volume (b) ring airfoil cross section and flow duct shown](image)

Computational analysis were run on CFD code fluent V15.0. The UAV is propeller powered so fan boundary condition is used to give the required velocity. In fan boundary condition static pressure jump specified for corresponding velocity that pressure jump calculated based on actuator disk theory.

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<td><strong>Boundary conditions</strong></td>
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III. RESULTS AND DISCUSSION

C. Force Measurement

The coefficients of lift and coefficient of drag and L/D ratio curves from the CFD of ring airfoil cross-section as shown in figure 4, 5, 6 respectively. For the velocity 3ms⁻¹ to 12ms⁻¹ and an angle of attack 0° to 15°. The ring airfoil cross-section numerical analysis done by four angles of attack and each angle of attack analysed by four velocities. In numerical analysis k-ε turbulence viscous model used to calculate the forces. The ring airfoil cross-section is misaligned airfoil so lift and drag force of both airfoils averaged and plot as a function of angle of attack. The lift force are same upward direction but drag force of two airfoil is opposite to each other so averaged values of drag for is lower than single airfoil drag.

From these c_D value the ring airfoil tangential direction drag forces are approximately negligible because forces are opposite to each other but ring airfoil UAV take off vertically so upward force is important. From this various angle of attack and various velocity numerical analysis values to find which condition the lift value is high comparably low drag. It is find out with help of L/D ratio plotted as a function of angle of attack from the L/D ratio plot highest L/D ratio reach at the 15° angle of attack in 6ms⁻¹. In this design condition the ring foil UAV vertical lift force is high comparably tangential drag. From these results the ring airfoil UAV takes off vertically with low propulsive force.
D. Streamline Pattern

The streamline patterns of 150 angle of attack ring airfoil UAV at 6ms-1 as shown in figure 7. The fan sucks the air from the atmosphere and blown in the ring airfoil the guide plates are direct the flow axial to radial direction of ring airfoil. Flow losses
may occur at guide plate. In first condition of numerical analysis the vortex shedding occurred further flow developed and vortex shedding were vanished.

![Streamline pattern of ring airfoil cross section](image)

**Fig. 4:** Streamline pattern of ring airfoil cross section, (a) vortex shedding form behind the ring airfoil, (b) vortex shedding was disappeared by flow development.

### IV. CONCLUSION

The flow phenomenon around the ring airfoil UAV was done by numerical analysis. In numerical analysis the ring airfoil instigated various angles of attack with various velocities. The averaged drag value indicates ring airfoil tangential drag is negligible because each airfoil drag forces is opposite to each other. Highest L/D ratio value occurred at 150 and 6m\(\text{s}^{-1}\) it is indicate ring airfoil has high lift with respect to low drag. So ring airfoil UAV design at this condition to take off long distance with low propulsive power. Further investigation required for UAV construction.

### REFERENCE