Aerodynamic Behaviour Of Reusable Launch Vehicle With Different Fuselage Structures

J.Jayashree, A.Reeneshwari, B.Roopavathi, 
Department of Aeronautical Engineering, 
Arunai Engineering College. 
reeneshwari2013@gmail.com

Pon Maa kishan.A, 
Department of Mechanical Engineering, 
Tirunelveli, India. 
ponmaakishan@gmail.com.

Abstract—Space transportation system is one of the most important infrastructures for space activities. Low cost, improvement of reliability and safety are required for the development of RLV (Reusable Launch Vehicle). To achieve high aerodynamic performance in the whole flight speed region is one of the most important issues in the development of RLV. An experimental and computational study on examining aerodynamic characteristics of fuselage cross sections for RLVs (Reusable Launch Vehicles) have to be conducted at Mach number 0.3, 0.9 and 2.0 in the wind tunnel. Three different bodies, having the same dimensions of projected area and length, with and without a set of fins will be tested. The cross sections of RLV fuselages are a circle, a square and a triangle with rounded corners. The fuselage cross sections of RLVs had large effects on aerodynamic characteristics in subsonic and transonic flow. Investigating a favorable fuselage configuration of the RLVs is important to enhance the aerodynamic performances.

Keywords—RLV; Aerodynamic coefficient; Supersonic wind tunnel; fuselage structure.

I. INTRODUCTION

Space technology has changed the nation of India into the world of high technology. ISRO is growing day by day by developing efficient space technology. For any space mission the cost of building the rocket is the most expensive part. So for expandable launch testing were used which can only launch vehicle with no recovery. The launching of rockets can be recovered and can be used many times which is known as Reusable launch vehicle (RLV) fig 1.0 which can reduce the launching cost upto 80% of the total mission.

Recent trends of developing India is completely based on the space exploration activities. To deliver payload at a certain altitude with required orbital velocity either into earth atmosphere or into space launch vehicles were used and recovered by re-entry. In this paper investigation of favourable fuselage profile configuration is made. Study of fuselage profile configuration of RLV is more important to enhance aerodynamic performance of RLV.

II. METHADOLOGY

Selection of fuselage structure

Fuselage is the main part of launch vehicle which serves to position control, stabilization and maneuverability. For selection of fuselage structure is very important to understand the basic geometric shape. From earlier the shape of fuselage is circular, so triangle and rectangle are the basic shape obtained from circle. We have decided to do our project on these.

Selection of aerofoil (or airfoil) model

An Airfoil is the cross section of wing. It is designed to minimise the drag (air resistance) and to provide control & stability. So that we decided to use NACA 0008 airfoil which is biconvex and symmetrical to the axis to produce greater aerodynamic lift. Then the airfoils are fixed with RLV wings. Wings are attached to fuselage section with preferring right angles.

![Diagram of METHADOLOGY](image-url)
The meshing of the biconvex airfoil with RLV rectangular fuselage structure was done by using point wise software. Boundary condition for analyzing also initiated for the flow analysis. The tetrahedral type mesh fig 2.0 is used for 3D objects.

**III. Meshing**

In an external flow that is a flow over an RLV it is very essential to define the boundary condition. And also mesh will be done between the enclouser region and the fuselage structure and the field boundary. It will be the very correct choice for field boundary assumed should be ambient condition. The meshed square fuselage structure was imported into ansys Fluent and then simulated. The mesh over the fuselage was checked for errors. Then the solver used is steady state pressure based solver. Energy equation was also used for the flow simulation. This is needed since the flow is compressible and also uses ideal gas equation. The one-equation Spalart-Allmaras (SA) model is a best model. SA model have a relatively simple turbulence model which has been shown to give accurate results for boundary layers will be subjected to various pressure gradients, particularly when there is no or mild separation. Setting zero operating pressure which means that all pressures set in fluent will be absolute pressure. The pressure – field boundary type is also applicable only when the density is calculated using the ideal-gas constant law. It is important to place the field boundary enough from the object of interest in this case it is fuselage structure. The pressure, angle of attack and the temperature are given as inlet setup conditions corresponding to the Mach number.

**IV. Solution and result**

The input values are initialized and the flow stimulation will be carried out various mach number. The section will be compared with various velocities fig 3.0.

**Fig 3.0 shows the variation of velocity**

The flow through the domain having the square shaped fuselage structure fig 4.0 with pressure contours for given specified input datas.

**Fig 4.0 shows pressure contours**

**Fig 5.0 shows velocity contour**
The flow through the domain having the square shaped fuselage structure fig 5.0 with velocity contours for given specified input data.

**Estimation of coefficient of lift and coefficient of drag**

The estimation of coefficient of drag with respect to initialized field boundary as shown in below fig no.6

![Fig. 6.0](image)

**Fig 6.0 shows coefficient of drag**

**V. FABRICATION OF REUSABLE LAUNCH VEHICLE USING WOOD MATERIAL**

From the analysis, the coefficient of drag will be reduced by using square fuselage profile. Then we focused on future compare the triangular, square and circular fuselage profiles.

Let we focused on fabrication of these three fuselage models which are tested in wind tunnel by using wood material and compare the result with those three models.

![Fig 7.0](image)

**Fig 7.0 fabrication in wood**

From the results, by using square fuselage we obtained the velocity and pressure contours. Future work is focused on to obtain the experimental data and need to compared with computational results by using wind tunnel testing and software analyzing. Focused on future, compare the result with triangular and circular fuselage structures by numerically and analyzed by using software. It is a need to study effect of Mach at transonic region for different fuselage structures changes with it.

**VI. Conclusion**

**VII. References**

7. N. Gregory and C. L. O'Reilly, Low-Speed Aerodynamic Characteristics of Naca 0012 Aerofoil Section, including the Effects of Upper-Surface Roughness Simulating Hoar Frost,