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Comparative Study on Nose Cones with respect to Angle of Attack using CFD

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Abstract. A nose cone is the conically shaped forward most section of a rocket, guided missile or aircraft, designed to modulate oncoming airflow behaviours and minimize drag. In this paper, the authors analysed by means of a computational procedure the influence of varying the angle of attack for shapes of rocket nose cones in each of them, with this analysed and calculated the values of the, coefficient of lift and the coefficient of drag generated by our nose cones having as a working parameter in subsonic medium ranging from a Mach 0.03 to approximately 0.50, considering standard conditions for temperature and pressure. Drag and Lift both are aerodynamic forces which need to be calculated for cones. Objects with every kind of shapes experience a significant magnitude of Cl and Cd from airflow with the use of the ANSYS platform based on the CFD Fluent method it was possible to measure behaviour in the 3 shapes of cones and thus analyse the different contours. We showed the variation of pressure and velocity with their graphs. The scope of this paper is to simulate the different nose cones with different angle of attack for taking out the best result and comparing which one cone is best for which angle of attack.
Keywords: Angle of attack, Nose Cone, CFD, K-epsilon SST.

1. Introduction

For high speed aerodynamic vehicles such as missiles, rockets, space shuttles etc. different nose shapes are used for reducing the aerodynamic drag and increasing lift as well as not allowing flow separation which are adverse effects on efficiency of an aircraft. In present, we examined the different nose cones on various different angle of attacks by using Solid works 2022 for designing and we have done simulation in ANSYS using concepts of CFD (computational fluid dynamics) (1). For this purpose, two different types of ammunition with different nose cone profiles were designed: conic nose cone and ogive nose cone. With different parameters on aerodynamic characteristics, in order to determine the nose cone with best angle of attack giving us the best output for Cl and Cd. Geometry and parameters which provide minimum aerodynamic drag as well as maximum lift, since the drag is highly essential for the better performance of the vehicles. A steady axis symmetric simulation is carried out with an implicit Pressure-based solver. The model has been seen to provide good results with reduced computational time for problems involving wall bounded flows as well as boundary layers subjected to adverse pressure gradients (2). We have used Mach number 1.5. This will give the greatest critical Mach number and the least adverse pressure gradient over the cylindrical afterbody. Although vortices cannot be avoided, they can be mitigated by updating and using the best nose cone shape. We have firstly examined ogive nose at different Angle of attack (3) and then conical nose cone further then elliptical nose cone. In this paper we have used different angle of attacks (i.e. 0, 3, 6, 9 and 12).As we know the pressure drag for all kinds of the nose cone is zero and the main resistance factor is the friction drag. So to reduce the drag forces and increase the performance of the design of nose cones the most appropriate nose cone type should be chosen. Conic, spherically blunted conic, bi-conic, tangent ogive, spherically blunted tangent ogive. (6)

2. Methodology

In this paper nose cones are designed using ANSYS software. The first step is to create different nose cones geometry in solid works 22 after that import that geometries of your nose cones in ANSYS in IGES file extension then start all the desired operation on your nose cones by opening the space claim in ANSYS. We will do sectioning encloses, meshing, number of iteration , velocity and pressure variations ,sectioning and contours etc on our designs for desired output. After that we will alter the values in solution methods (Pressure velocity coupling) and change iterations and scales. We used k- epsilon equation model with mach number 1.5. We further calculate cl and cd value at different AOA of different nose cones (ogive, elliptical and conical).

3. Structure and Design

Here are the 3d structures of our Ogive, Conical and Elliptical nose cone.

FIGURE 1. Conical nose cone

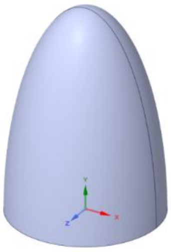

FIGURE 2. Ogive nose cone

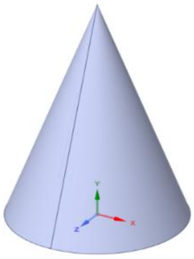

FIGURE3. Elliptical nose cone

4. Meshing

The nose cone coordinates were obtained from the nose cone database and imported onto design modeller of ANSYS. The domain was created and split into different domains for meshing. The model is as shown in the figure. The block pictures of these are inserted below indicating figure and it consists of 12023 nodes, 96396 elements of tetrahedral shape.

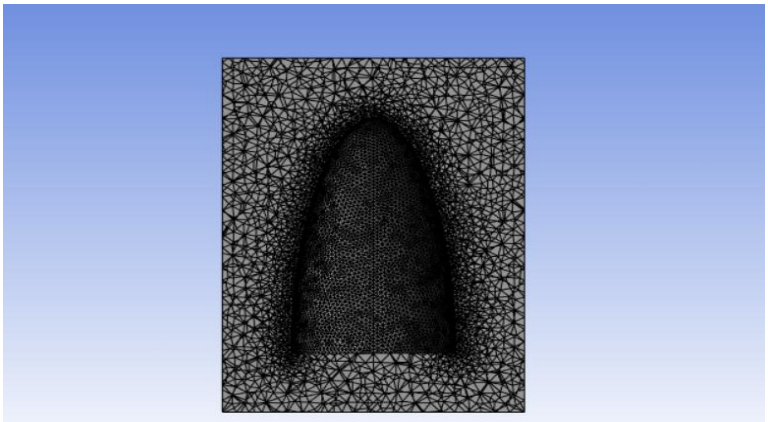

FIGURE4. Meshing of ogive nose cone

The mesh quality was found to be optimal for our nose cones. The meshes were imported into the fluent solver where the boundary conditions, turbulence model etc were selected and applied.

5. Process on Fluent and Selection of Pressure Models

Pressure model is constructed with the help of Ansys software to predict different total and dynamic pressure variation on Nose cones at different angles. K- ε model is a two-equation turbulence model which is used for RANS equations. It uses two variables, k which is the kinetic energy and the second transported variable is the rate of dissipation of turbulent kinetic energy (ε). This model is combined with SST model which is Shear Stress Transport which is also widely used.

The input parameters along with specific conditions in FLUENT as indicated in the table shown below

TABLE 1

Solver	Pressure based stead
Viscous Model	K- ε model
Density (kg/m^3)	1.2257
Inlet velocity (m/sec)	1.5m/s
Nose cone material	Aluminium
Turbulence intensity	5%
momentum	Second order upwind
Pressure velocity coupling	Coupled

6. Result And Analysis

Dynamic pressure contours:

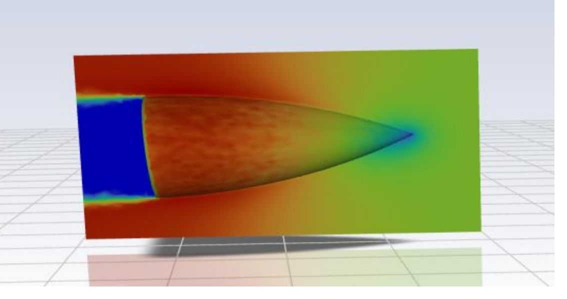

FIGURE5. Ogive nose cone at 3 degree AOA

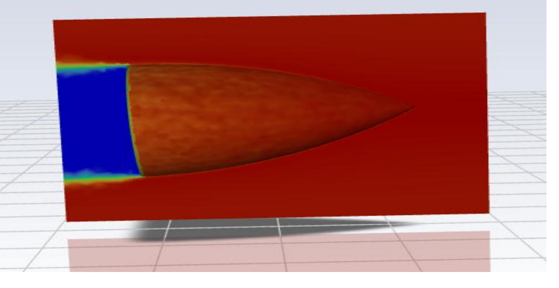

FIGURE 6. Conical nose cone at 3 degree AOA

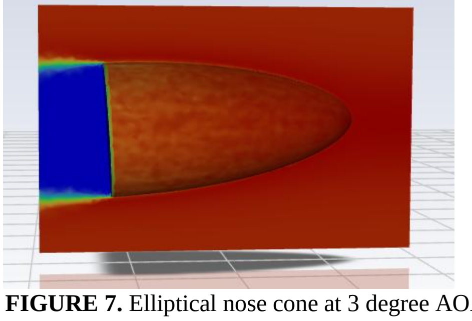

FIGURE 7. Elliptical nose cone at 3 degree AOA

Velocity contours:

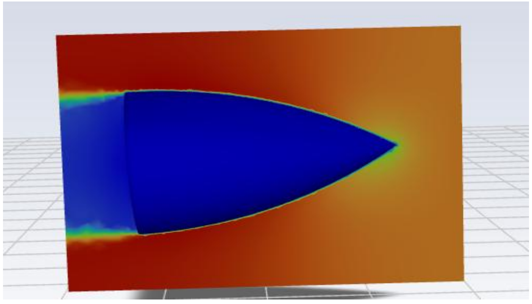

FIGURE 8. Ogive nose cone at 3-degree A

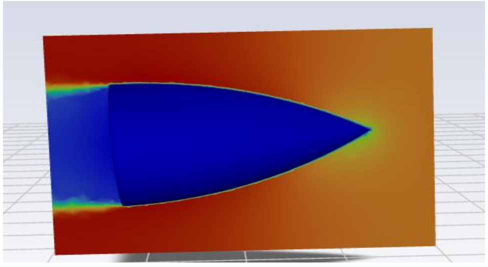

FIGURE 9. Conical nose cone at 3 degree AOA

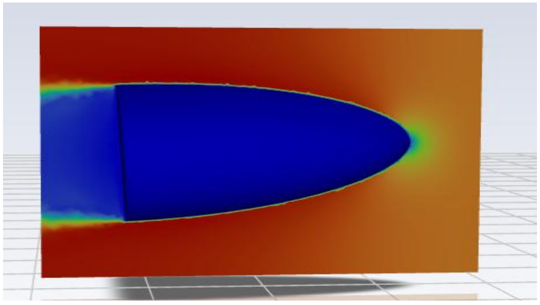

FIGURE10. Elliptical nose cone at 3 degree

Total pressure contours:

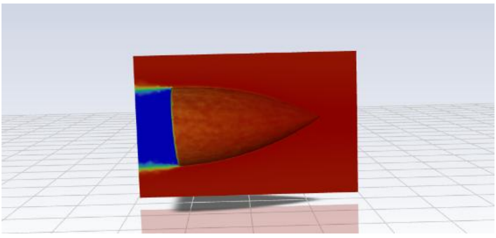

FIGURE 11. Ogive nose cone at 3 degree AOA

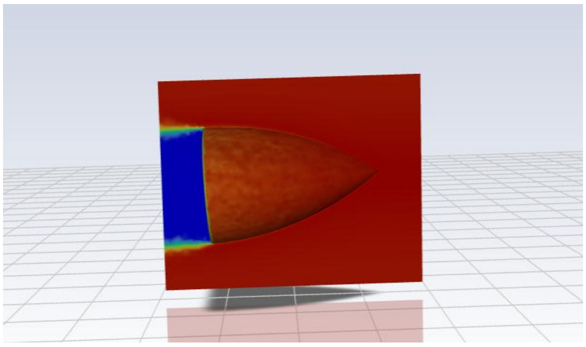

FIGURE 12. Conical nose cone at 3 degree AOA

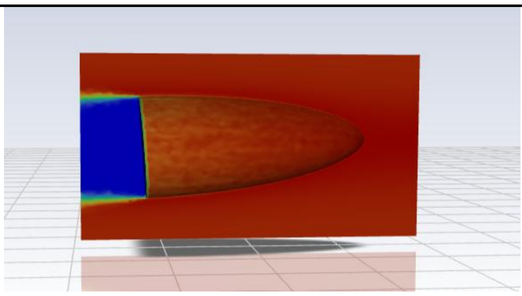

FIGURE 13. Elliptical nose cone at 3 degree AOA

7. Plots OF Aerodynamic Force and Their Coefficients of Different Nose Cone with Different Angle of Attacks

The plots of Coefficient of Lift (Cl) vs Angle of Attack (α) and Coefficient of Drag (Cd) vs. Angle of Attack (α) for both the aerofoils are given below. The variation of coefficients of lift and drag with respect to Angle of Attack can be observed. The Angle of Attack at which the maximum value of Coefficient of Lift (Cl_{max}) is obtained for a given aerofoil is the stall angle for that aerofoil.

TABLE 2

Angle of Attack (ogive)	Cd	Cl
0	0.0519	0.0899
3	0.0360	0.0898
6	0.0212	0.0903
9	0.008	0.0933
12	0.003	0.0976

TABLE 3

Angle of Attack (cone)	Cd	Cl
12	0.091	0.220
9	0.100	0.221
6	0.109	0.221
3	0.119	0.223
0	0.131	0.228

TABLE 4

Angle of Attack(Elliptical)	Cd	Cl
0	0.067	0.116
3	0.042	0.115
6	0.020	0.116
9	0.001	0.120
12	0.017	0.127

8. Conclusion

As we have done simulation of our nose cones at different angle of attack, we can clearly examine that Cd value of all nose cones ate decreasing with increase in AOA. Also, values of Cl for elliptical and conical nose cone are decreasing but Ogive nose cone Cl is increasing. The values are slightly varying.

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