Computational Study on wake velocity distribution over Parabolic series nose cone

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ABSTRACT

The main objective of this paper is to study surface pressure distribution of parabolic series nose cone. Knowledge of surface pressure distribution over the surface and base is useful for determining the drag coefficient of an object. Variation of velocity profile along the wake axis flow is also determine, which is useful for determining the separation point behind the object. For the present study four parabolic nose cone with 1/4 parabola, 1/2 parabola, ¾ parabola & full parabola was modelled and mesh is generated in ANSYS ICEM CFD. The simulation was carried using shear stress transport turbulence modelling. Flow domain was created with 5349604 tetrahedron elements. ANSYS CFX 15.0 commercially available software was used for preprocessing and post processing of the model.

KEY WORDS: Nose cone; surface pressure distribution; igniter; base pressure.

1. INTRODUCTION

The Nose cone is forward most section of a rocket, guided missile or aircraft. For aerodynamic design of cone it required to determine the optimum geometrical shape that offers minimal resistance for the body to move through fluid medium, which consist of elastic particle. Resistance offered to the body by fluid is depending on the surface pressure distribution over a body. Surface pressure distribution varies as shape of the body is varied. There are different many different nose cone shapes out these very common nose cone shape is cone. It is often used because of ease of manufacture. Conical profile has straight line profile on sides of the cone hence at base the attached is not tangent to the base. The parabolic series nose cone is having sharp nose and the shape is tangent to the body at its base and base is on the axis of the parabola. Study on surface pressure distribution and over parabolic series cone is discussed in this paper. Study was carried computationally using commercial available ANSYS ICEM CFD.

Computation:

Geometry and mesh: Data point for the four parabolic series nose cone generated using the following equation

$$Y = R\left(\frac{\left(2x/L\right) - K\left(\frac{x}{L}\right)^2}{2-K}\right)$$

K = 0.25 for a ¼ parabola
K=0.5 for a ½ parabola
K = 0.75 for ¾ parabola
K = 1 for a parabola

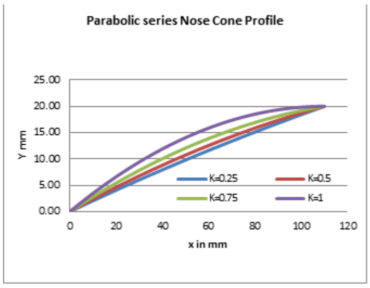

Figure.1. Parabolic series nose cone data points

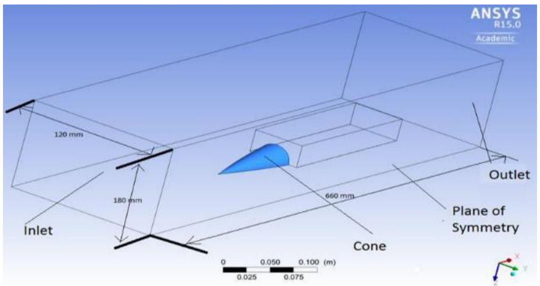

Figure.2. Computational Domain

Since the geometry is symmetrical is about vertical plane only of half of geometry is generated using the above data points, in order to reduce the computational load and time. The fineness ratio (L/D) for all profile is taken as 2.75. The total number of nodes and tetra elements of the generated mesh is 933231 and 5349604 respectively. The domain used for computation is shown in the figure.2.

Boundary condition: Inlet condition for the domain is given as velocity inlet with flow velocity of 80 m/s and output condition is taken as pressure outlet and bottom of domain is taken as symmetric and remaining side of the domain is taken as wall with no slip condition and adiabatic as shown in figure 2. Reference pressure for all computation is taken as 101210 Pa.

Solver: A finite volume coupled flow solver ANSYS – CFX 15 was used for the computation. The computational grid generated from ANSYS- ICEM CFD 15.0 was used for solving the flow equation. Three conservation equation such as continuity equation, energy equation, momentum equations in three direction (U-mom, v-Mom, w-mom) and turbulence equation for kinetic energy and eddy frequency were solved by the solver. Shear stress transport turbulence model is used for this study. Residual target of 1 x 10-4 was used as convergent criteria.

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2. RESULT & DISCUSSION

Surface pressure coefficient: Comparison of computational results for four parabolic series nose cone, full parabolic series nose have better surface distribution compared to other profile shape. This because the in full parabolic shape is tangent to base surface hence flow leaves at base smooth and parallel to the inlet velocity direction. But in other profile the flow always leaves at certain angle to initial flow direction. Hence the pressure coefficient near the base is function of slope of the curve at base. Variation of parabolic nose is shown in fig.3.

Wake axis velocity: Velocity along the wake axis of the shown in fig 4, from the it seen that velocity is goes to zero at x/d=5 where x is the distance measured along the wake axis from the base and d is radius of the base. Velocity reversal is maximum of 0.55 Uinf for ¼ parabolic profile and it minimum for full parabolic profile which is 0.5 Uinf. Velocity reversal occurs at point of 3d from the base.

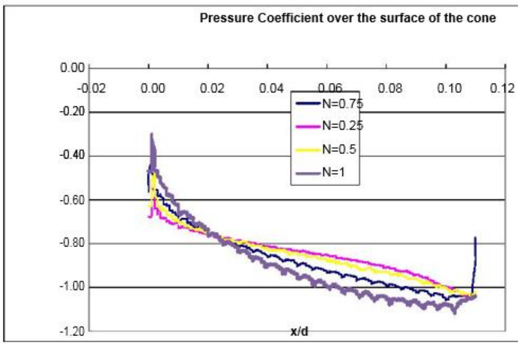

Figure.3. Surface pressure coefficient

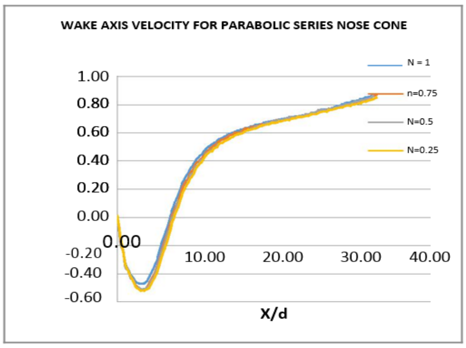

Figure.4. Velocity profile along the wake axis

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