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NOSE CONE DESIGN AND ANALYSIS OF AN AVION

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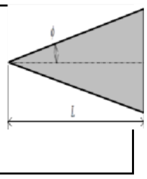
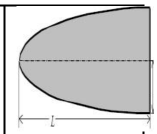
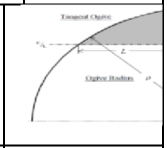
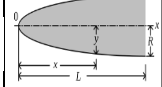
ABSTRACT: — The objects moving at high speeds encounter forces which tend to decelerate the objects. This resistance in the medium is termed as drag which is one of the major concerns while designing high speed aircrafts. Another key factor which influences the design is the air drag. The main challenge faced by aerospace industries is to design the shape nose of the flying object that travels at high speeds with optimum values of air drag. This study deals with computational analysis various nose cone profiles of a commercial aircraft. The effect of nose shape on the drag is studied at subsonic flow considering various shapes. The paper objective was to identify the types of nose profiles and its specific aerodynamic characteristics with minimum drag at particular Mach number. The scope of this paper is to develop some prototype profiles with outstanding aerodynamic qualities and low cost for use in construction projects for aircrafts increasing their efficiency and effect on target. The motivation for such a work is caused by a lack of data on aerodynamics for profiles of some nose cones and especially improved aerodynamic qualities that can be used in designing aircrafts. The present problem is analyzed using CFD software. Flow phenomena observed in numerical simulations for different Mach for different nose cone profiles are highlighted, critical design aspects and performance characteristics of the selected nose cone are presented.

KEYWORDS: Mach number, subsonic flows, nose profiles, solid works, CFD.

1. INTRODUCTION:

In many countries aerospace projects involve designing, building, and launching experimental sounding rockets or research rockets and missiles carrying payloads that perform scientific experiments in a sub-orbital trajectory that reach apogees up to 3 to 4 km. but when comes to aircraft in my view they are not more concentrating on nose as much as they concern about rockets. But in sub sonic conditions also nose cone shape plays an important role reducing drag force on entire body and not allowing flow separation which are adverse effects on efficiency of an aircraft. And I strongly believe that efficiency of an air craft can be increased by producing least drag on air craft. Providing optimum shape to nose is not a difficult when compared to other designs but little care has to be done which I am going to discuss in my paper and this paper is to show at different Mach numbers various shapes experiences different values of drag by which we can select optimum shape of nose cone. The mostly used nose profiles now a day are majorly used are conical, parabolic ogive and elliptical as per commercial purpose. Designing of these four models is done using solid works and analyzed using computational fluid dynamics for different Mach numbers under sub sonic conditions by comparison of results we can select the optimum shape for particular aircraft. This work totally based on CFD analysis but used in real world which brings a difference in efficiency of air craft and not only this flow separation also plays an important role in aircrafts which can be controlled by usage of optimum nose cone.

Table 1 Various nose profiles

1	Cone	$y = \frac{xR}{L}$	
2	Parabola	$y = R\left(\frac{x}{L}\right)^n$ n=0.5	
3	Ogive	$\rho = \frac{R^2 + L^2}{2R}$	
4	elliptical	$y = R\sqrt{1 - \frac{x^2}{L^2}}$	

2. LITERATIURE SURVEY:

[1] A Sanjay Varma, et.al. : Comparison of various nose profiles is to be carried out to know performance over existing conventional nose profiles is discussed in this paper. The paper objective was to identify the types of nose profiles and its specific aerodynamic characteristics with minimum pressure coefficient and critical Mach number. The scope of this paper is to develop some prototype profiles with outstanding aerodynamic qualities and low cost for use in construction projects for missile increasing their range and effect on target. The motivation for such a work is caused by a lack of data on aerodynamics for profiles of some nose cones and especially improved aerodynamic qualities that can be used in designing missiles/ rockets. The present problem is analyzed using ANSYS software. Flow phenomena observed in numerical simulations during Mach 0.8 for different nose cone profiles are highlighted, critical design aspects and performance characteristics of the selected nose cone are presented. INFERENCE: The purpose of this paper is to propose a solution for performance improvement using various missiles nose profiles. von Karman ogive nose profile give higher critical Mach number and minimum pressure coefficient which is desirable for the subsonic flows as stated in problem

definition. [2] Levi .C wade: The Sonobuoy Precision Aerial Drop (SPAD) vehicle developed by Kazak Composites, launched from an aircraft will pilot a sensor package to the ocean surface. This project evaluates a spring-loaded, an inflatable, a rubber, and a foam nose-cone concept for SPAD. Results from aerodynamic analysis of the nose cone are used in structural analysis performed with ANSYS. Fabrication and experimentation with selected concepts supports the analysis. INFERENCE: The purpose of this paper is to develop a nose cone using composites as mentioned above. After analysis of selected nose cones, the rubber nose concept conforms with the requirements for structural integrity, weight, functionality, and cost. [3] Wizzum. D. et.al., A wind-tunnel investigation was conducted on large-angle cones at a Mach number of 3.0 and at Reynolds numbers, based on maximum body diameter, of approximately 1.1 X 106 and 3.0 X 106 to determine the effects on static aerodynamic characteristics of cone angle, base flare angle, and base corner radius. INFERENCE: The author concluded 9 results regarding his survey in this paper. Among those results the best are regarding cone angle, base flare angle and base corner radius. [4] Hemateja et.al., The objects moving at high speeds encounter forces which tend to decelerate the objects. This resistance in the medium is termed as drag which is one of the major concerns while designing high speed aircrafts. Another key factor which influences the design is the heat transfer. The main challenge faced by aerospace industries is to design the shape of the flying object that travels at high speeds with optimum values of heat generation and drag. This study deals with computational analysis of sharp and blunt cones with varying cone angles and nose radii. The effect of nose radius on the drag is studied at supersonic and hypersonic flows and at various angles of attack. It is observed that as the nose radius is increased, the heat transfer reduces & the drag increases and vice-versa. INFERENCE: This paper mainly focusses on reducing drag force and heat generation on nose cone while a craft moving at high speeds and how both are co related to each but this paper fails in giving best results and still research has to be done. [5] James t clay, et.al. "A theoretical and experimental study to evaluate the influence of spherical nose bluntness, of cone angle, c. g. location and Mach number on the stability characteristics in pitch of blunt slender cones has been conducted.at the USAF Aerospace Research Laboratories. A 101' half angle cone with nose bluntness ratios from .025 to. 30 was investigated.in the ARL 20" Hypersonic Wind Tunnel at M = 14. The small amplitude free oscillation technique was used to extract the static and dynamic 3tabiliLy derivatives from the time history of a planar oscillatory motion about zero trim angle of attack. The observe effect of the nose bluntness on the stability, derivatives were quite similar to earlier results with a 5. 6 half-angle cones. INFERENCE: Wind tunnel tests with air at Mach 14 and three different types of analyses agree in describing the high Mach number effect of nose blunting on the static and dynamic stability derivatives in pitch for spherically blunted slender cones at zero trim angle of attack. Using the cone angle-bluntness ratio correlation parameter $\overline{\theta_c(1-\xi)/2\xi}$, it is shown that$Cm_q$+ Cm_a starts to deteriorate when C decreases below the value of one and reaches a minimum value at C = 0. 6. [6] Q. Saw et.al. In designing a projectile, there are various configurations and designs that can be considered. Normally, the shape and design of the projectile are selected on the basis of the combined considerations of aerodynamic, guidance and structure. One of the main design factors that affect projectile configuration is the nose drag. In this study four widely known nose shapes are considered, pointed and blunted cone; pointed and blunt ogive. The drag of the configurations is considered with respect to the Mach number. As fineness ratio and Mach number increases the overall drag decreases. Each drag component behaves differently depending on the Mach number and fineness ratio. The drag is compared based on the 3 main drag components; skin friction drag, wave drag and base drag. For this paper only, the conical nose shape is presented. INFERENCE: By increasing the fineness ratio of the nose, it is possible to reduce the overall drag of the projectile.as mentioned above this paper discuss only about conical nose shape only. Still research has to be done in various shapes because conical nose is not fit for every aircraft. [7] M. Srinivasula et.al. new nose cone concept that promises a gain in performance over existing conventional nose cones is discussed in this paper the term nose cone is used to refer to the forward most section of a rocket, guided missile or aircraft. The cone is shaped to offer minimum aerodynamic resistance. Titanium Ti-6Al-6V-2SN Titanium grade 1 the remainder titanium. These are significantly stronger than commercially pure titanium. While having the same stiffness and thermal properties a structural-loaded, a pressure sudden impact loads and a foam nose-cone concept Results from analysis of the nose cone are used in structural analysis performed with ANSYS.INFERENCE: The author discussed about an aircraft made up of special material to reduce the drag force and heat reduce due to convection at nose cone.[8] B. tyler brooker et.al., : A new nose shape that was determined using the penetration mechanics to have the least penetration drag has been tested in the supersonic wind tunnel of The University of Alabama to determine the aerodynamic characteristics of this nose shape. The aerodynamic drag measured on the new nose shape and on four additional nose shapes are compared to each other. The results show that the new nose shape has the least aerodynamic drag. [9] T J Prasanna Kumar et.al. The term nose cone is used to refer to the forward most section of a rocket, guided missile or aircraft. The cone is shaped to offer minimum aerodynamic resistance. Nose cones are also designed for travel in and under water and in high speed land vehicles. On a rocket vehicle it consists of a chamber or chambers in which a satellite, instruments, animals, plants, or auxiliary equipment may be carried, and an outer surface built to withstand high temperatures generated by aerodynamic heating. Much of the fundamental research related to hypersonic flight was done towards creating viable nose cone designs for the atmospheric re-entry of spacecraft and ICBM re-entry vehicles. INFERENCE: This paper completely discus about temperature distribution over a nose cone due to conduction and convection. various materials are used for design and analysis purpose. [10] Athira et.al., The optimized nose cone panels, bulkheads and longerons are satisfying the requirements for stability under design loads. An integrally stiffened panel of 2 mm thickness with stringers of 2.5 x 25 mm, optimized bulkheads and longerons are sufficient to prevent the buckling and failure stress. A mass computation is carried to check the minimum weight concept of integrally stiffened panel construction. The analysis results show that there is an 8.5% reduction of mass compared to the metallic nose cone structure of similar geometric configuration by a combination of stiffened skin with bulkheads and is grid type of construction. [11] Sagar Krishna: Aerodynamic heating and drag plays crucial role in the thermal stability of reentry vehicle. The design of nose cone structure demands an effective Thermal Protection System (TPS). The most difficult task in TPS design is the defining the thermo-mechanical properties of the heat-shielding material of reentry vehicles at the reentry in the atmosphere. The Conventional reentry vehicles use liners and foam materials as insulating materials in the design of TPS. The main objective of this work is to present a Coupled Field Analysis of Nose Cone of a Reentry vehicle using ultra high temperature composite materials like Hafnium diboride (HfB_2) and zirconium diboride (ZrB_2) as insulating materials through Finite Element Analysis approach. INFERENCE: In this work a special attention is devoted to the modelling of composite material lay-ups and greater numerical efficiency. This work encompasses; To study the effect of Thermal loads on the structure and to observe how the structure reacts because of the thermal loads.

3. PROBLEM STATEMENT

The objective of this paper is to show minimum drag force on entire body can be achieved by the shape of the nose of aircraft. For a space vehicle like an aircraft the shape of the nose cone has a significant effect on the drag of the vehicle. So, to increase overall efficiency we need to give an optimum shape to nose cone which can reduce drag force and provide a stream line structure to an aircraft. Now a days the main problem faced by commercial aircrafts are not having optimum shape or geometry that chooses the air craft. So, in my paper, I am going to discuss about basic nose cone structures used now days and how can we improve efficiency of an aircraft by providing optimum geometry to the nose cone.

4. METHODOLOGY:

In this paper 4 nose cone shapes are designed using solid works software for future work. The first step is to create a 2D model as per the equations mentioned above and convert into a 3D model for CFD testing. The commonly used tools to create a model in solid works are Extrude, extrude cut, Revolve, revolve cut Sweep, Swept cut, Fillet, Chamfer, Mirror. CFD Analysis is carried out in three steps i.e. (i) preprocessing, geometry, – Designing, meshing, boundary conditions and numerical method, (ii) Processing – Solving fluid flow governing equations by numerical method till the convergence is reached and (iii) Post processing – extracting results in terms of graphs, contours which explains the physics of flow and required results. The above three steps are carried out in ANSYS using fluid fluent CFD for designing and meshing with Hybrid grid that is prismatic layer around nose and unstructured grid with tetrahedral cells around 0.4 million elements are used. Simulations are carried out using ANSYS CFX a finite volume solver at with inlet conditions Mach 0.4,106,0.8 for each nose by using fluid fluent model with convergence criteria of 10-4.

5.RESULTS AND DISCUSSIONS:

The results are extracted from CFD POST after the analysis from CFX solver as shown in below figures. These results give the coefficient of drag and velocity distribution over the aircraft for various nose shapes. Coefficient [5] drag given by following equation

$$C_d = \frac{D}{\frac{V^2}{2}\rho A}$$

Conical:

Velocity distribution-

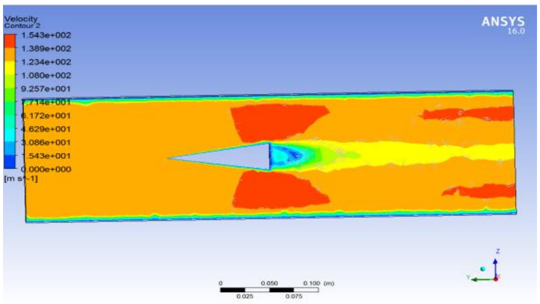


Fig 1 Mach number 0.4

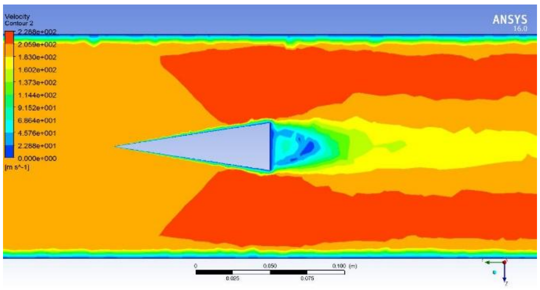


Fig 2 Mach number 0.6

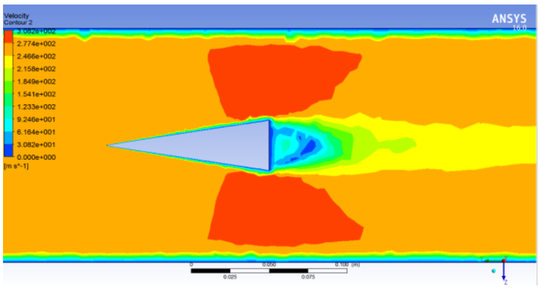


Fig3 Mach number 0.8

Parabolic:

Velocity distribution:

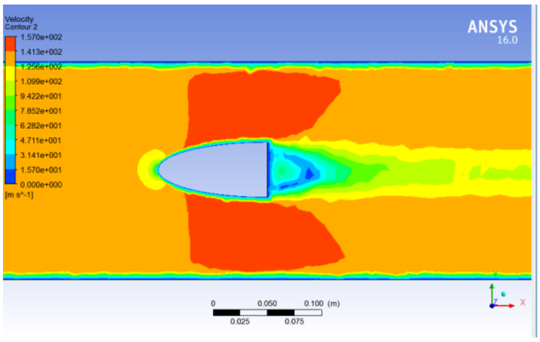


Fig 4 Mach number 0.4

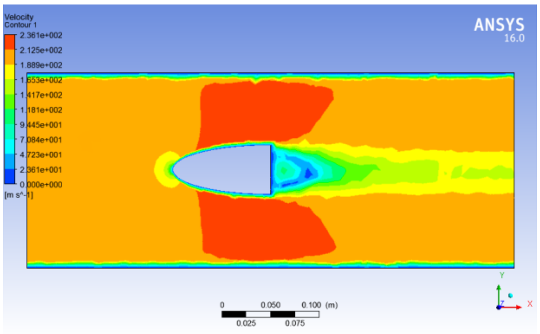


Fig 5 Mach number 0.6

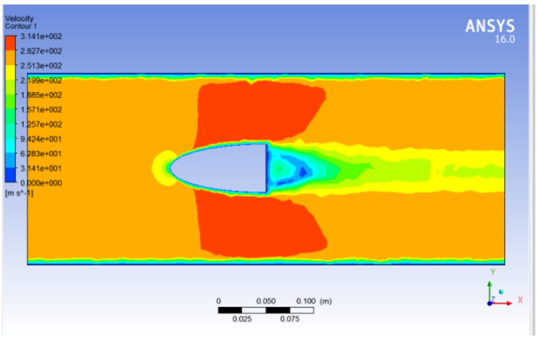


Fig6 Mach number 0.8

Ogive:

Velocity distribution:

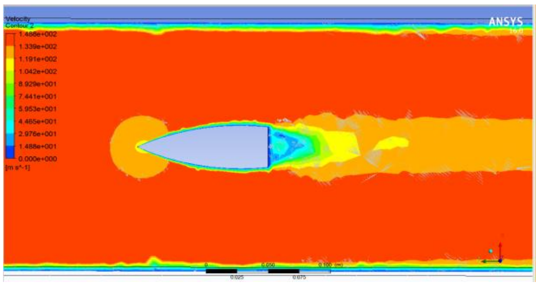


Fig 7 Mach number0.4

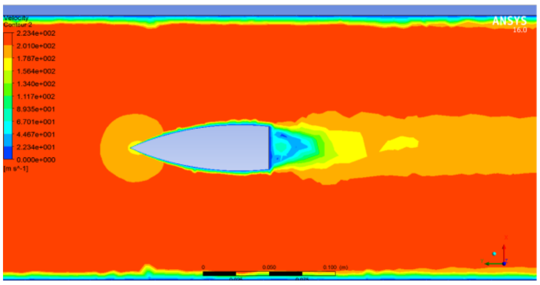


Fig 8 Mach number 0.6

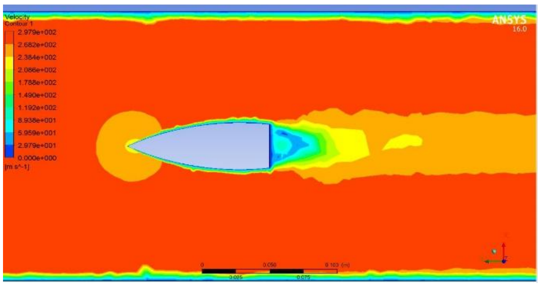


Fig9 Mach number 0.8

Elliptical:

Velocity distribution:

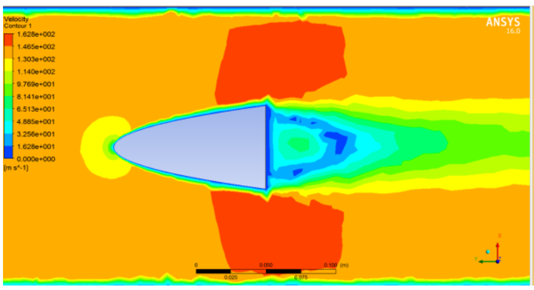


Fig 5.10 Mach number0.4

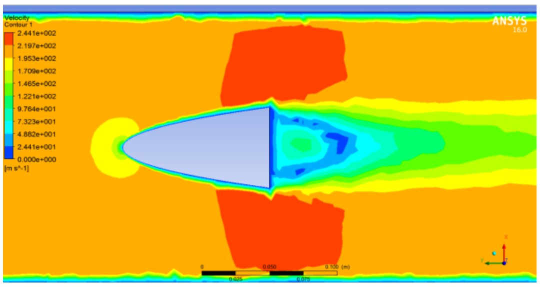


Fig 11 Mach number 0.6

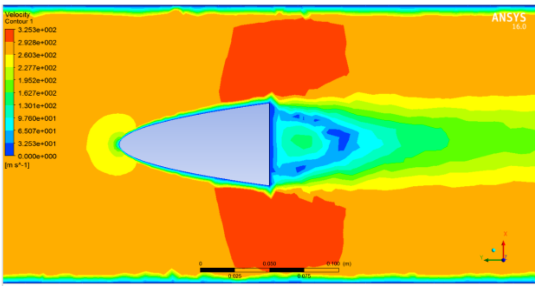


Fig12 Mach number 0.8

VARIATIONS OF Cd FOR VARIOUS NOSE PROFILES AT MACH NUMBER 0.4

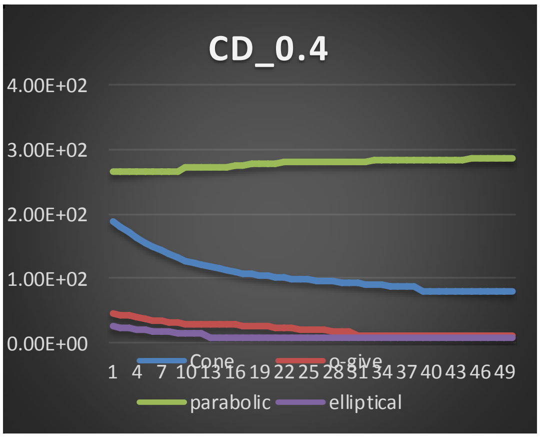


Fig 13

VARIATIONS OF Cd FOR VARIOUS NOSE PROFILES AT MACH 0.6

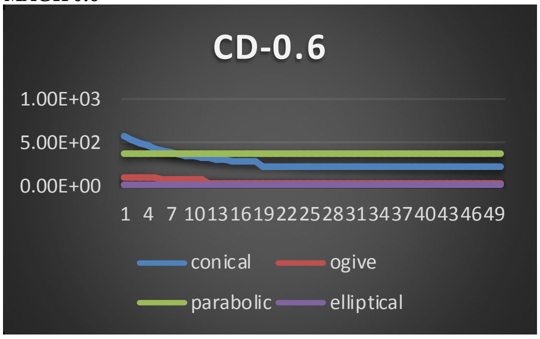


Fig 14

VARIATIONS OF Cd FOR VARIOUS NOSE PROFILES AT MACH 0.8

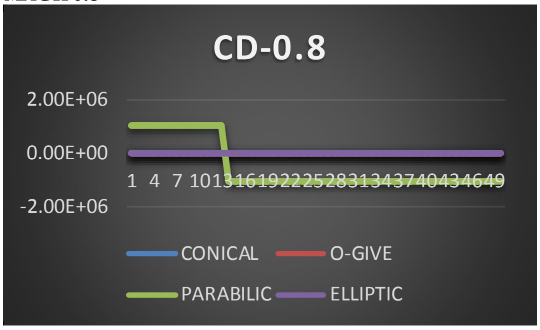


Fig 15

CONCLUSIONS

The purpose of this paper is to propose a solution for performance improvement using various Avion nose profiles. By referring to above results elliptical nose profile give minimum drag coefficient at 0.4,0.6,0.8mach number which is desirable for the subsonic flows to improve efficiency of vehicle by reducing drag as stated in problem definition.

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