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DESIGN AND ANALYSIS OF SPHERICALLY BLUNTED CONIC AND SPHERICALLY BLUNTED TANGENT OGIVE NOSE SECTION OF THE AIRCRAFTS USING CFD

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ABSTRACT— Transonic flow is a Mach number around 0.8 to 1.2 regime used to distinguish flow fields, phenomena and problems appearing at flight speed equal to the speed of sound. The nose cone should be built with an outer surface

which should be able to withstand high temperature generated by aerodynamic heating and the shape of the nose cone must also be chosen for minimum drag. In this project an attempt is made to Mach number 1 calculates the flow parameters around the nose cone of aerial vehicle. The effect of pressure, velocity and various other parameters are analyzed using ANSYS FLUENT software which is custom made to analyze this parameters. The analysis will be carried out for three model of nose cone namely Sharp, Ogive and Blunt nose cone for transonic flow of Mach number 1.The selection of material for the nose cone as the aerodynamic heating has be to less. Optimization is done for

the best suited shape of nose cones for best suited transonic aerial flight.

1.INTRODUCTION

In aeronautics, transonic refers to the condition of flight in which a range of velocities of airflow exist surrounding and flowing past an air vehicle or an airfoil that are concurrently below, at, and above the speed of sound in the range of

Mach 0.8 to 1.2, i.e. 600–920 mph at sea level. This condition depends not only on the travel speed of the craft, but also on the temperature of the airflow in the vehicle's local environment. It is formally defined as the range of speeds between the critical Mach number, when some parts of the airflow over an air vehicle or airfoil are supersonic, and a higher speed, typically near Mach 1.2, when the vast majority of the airflow is supersonic. For aircraft speeds

which are very near the speed of sound, the aircraft is said to be transonic. Typical speeds for transonic aircraft are greater than 250 mph but less than 760 mph, and the Mach number M is nearly equal to one, M = 1. While the aircraft itself

may be travelling less than the speed of sound, the air going around the aircraft exceeds the speed of sound at some locations on the aircraft. In the regions where the local airspeed is near or greater than the speed of sound, we encounter compressibility effects and the air density may vary because of local shock waves, expansions, or flow choking. vehicle. 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. Due to the extreme temperatures involved, nose cones for high-speed applications have to be made of refractory materials. Pyrolytic carbon is one choice, reinforced carbon-carbon composite or HRSI ceramics are other popular choices. Another design strategy is using ablative heat shields, which get consumed during operation, disposing of excess heat that way.

2.LITERATIURE SURVEY:

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

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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. 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. 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. 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

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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. 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 halfangle 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 , it is shown thatCmq+ Cma starts to deteriorate when C decreases below the value of one and reaches a minimum value at C = 0. 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

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about conical nose shape only. Still research has to be done in various shapes because conical nose is not fit for every aircraft. 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.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. 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 reentry 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. Athira et.al., The optimized nose cone panels, bulkheads and longerons are satisfying the requirements for stability

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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. 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 (HfB2) and zirconium diboride (ZrB2) 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.

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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. COMPUTATIONAL STUDY

There are many types of nose cones. The design adopted and the material depends upon the application. We have modelled three most commonly used types of nose cones.

They are:

A. Sharp Nose Cone

A very common nose cone shape is a simple cone. This shape is often chosen for its ease of manufacture, and is also often chosen for its drag characteristics. Table.1 gives the geometry setup of sharp nose cone and Table.2 gives the mesh formation of sharp nose cone with symmetry walls.

B. Ogive Nose Cone

The profile of this shape is formed by a segment of a circle such that the rocket body is tangent to the curve of the nose cone at its base; and the base is on the radius of the circle. Table.3. gives the geometry setup of ogive nose cone

and Table.4. gives the mesh formation of ogive nose cone with symmetry walls.

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Name of Parameter	Values (mm)
Major axis	120
Minor axis	60
Base	120

Table 3: Dimensions of ogive nose cone

No. Of Elements	188340
No. Of Nodes	33562

Table 4: Mesh formation of ogive nose cone with symmetr walls

C. **Blunt Nose Cone**

In practical applications, a conical nose is often blunted by capping it with a segment of a sphere. Table.5. gives the geometry setup of blunt nose cone and Table.6.gives the mesh formation of blunt nose cone with symmetry walls.

6.RESULTS AND DISCUSSION

The analysis of three type of nose cone of Aerial vehicle for transonic flow of Mach number 1 has been carried out with initials and boundary condition.

A. Sharp Nose Cone

The analyses of sharp nose cone for transonic flow with M=1 are as following.

1) Velocity Contour

Sharp nose cone with M=1, the minimum value of velocity is 0 ms-1 and maximum value is 306 ms-1. The flow speed is maximum near the free stream conditions. The attached shock reduces the flow velocity to subsonic speeds about 100 m/s.

2) **Streamline Contour**

Sharp nose cone with M=1, the minimum value of streamline is 0 ms-1 and maximum value is 318 ms-1.In the front of the nose cone blue colour sonic velocity occurs but side of the nose cone transonic velocity as red colour.

3) **Pressure Contour**

pressure contour of sharp nose cone with M=1 In this Fig.9 Sharp nose cone with M=1, the minimum value of pressure is -21459.5pa and maximum value is 90088.7pa. The maximum pressure occurs at behind the shock wave

where the attach shock reduces the flow velocity to subsonic conditions.

B. Ogive Nose Cone

The analyses of ogive nose cone for transonic flow with M=1 are as following.

1) Velocity contour

In this Fig.10 Ogive nose cone with M=1, the minimum value of velocity is 0 ms-1 and maximum value is 306.9 ms-1. The speed reduction due to the bow shock and the aerodynamic shape of the tangent ogive structure is more gradual when compared to other types of nose cones. The flow speed still remains near transonic range in many regions around the nose cone. As the reduction in flow speed is very less, the aerodynamic heating is reduced.

7.CONCLUSIONS

The analysis of three types of nose cones showed the variation in the pressure, velocity, mach number around the nose cone of an aerial vehicle. Each nose cone shape results in a certain amount of aerodynamic heating. If the aerodynamic heating is less then the need for thermal protection systems will be reduced. Following are the conclusions drawn from the analysis carried out,

– The Sharp nose cone experiance minimum pressure occurs at behind the shock wave where the attach shock reduces the flow velocity to subsonic conditions.

– From pressure countor it is observed that blunt nose cone expreiance more pressure where as sharp nose cone experience minimum pressure in flow pattern.

– Drag coefficient of Ogive nose cone is less compared to other models. So drag force is less for Ogive nose cone.

– As aerodynamic heating directly proportional to drag force on surface of nose cone so Ogive nose cone can be considered for less aerodynamic heating design.

– In Ogive nose cone, the pressure variation at the apex shows that the reduction in velocity and the aerodynamic heating is maximum at that point when compared to other edges of nose cones and the aerodynamic shape of the tangent ogive structure is more gradual when compared to other types of nose cones. The flow speed still remains near transonic range in many regions around the nose cone.

– In Blunt nose cone, the flow separation is the major cause for the reduction in flow speeds to subsonic values behind the nose cone. From the above conclusions it can be considered that Ogive nose cone is suited for transonic and near vacuum conditions when compared to sharp and blunted nose

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cones. The Tangent ogive nose cone is easy to manufacture, has good aerodynamic characteristics and experiences the least amount of aerodynamic heating. It also provides flexibility in the selection of material for the nose cone as theaerodynamic heating is less.

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