AERODYNAMIC ANALYSIS ON MISSILE DESIGN

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***Abstract*: In this proposed paper the aerodynamic characteristics of an anti-aircraft missile were computed using Computational fluid dynamics by ANYS2020R1 software which is analysis software. Generally predicting the aerodynamic characteristics is mandatory in case of performance analysis. Aerodynamic characteristics are important role in missile aerodynamic because on the basis of results we conclude that missile design is stable or not and how they behave when missile is in cruise stage. Aerodynamic coefficient are Drag, Drag coefficient, moment, moment coefficient characterization is carried out at subsonic & supersonic speed with their Mach number's at standard sea level. The motivation of such work is caused due to lack of data on missile aerodynamic at supersonic level .The object moving at high speed induced the drag which decrease the velocity and affect the efficiencies of object. Now days we are moving towards high speed vehicle. By high speed vehicle, we save our time and more accurate on target like in defence system we use the different ballistic missile for targeting the object. Designing field give the ability to make more efficient body design for Aerospace Industry. By this paper, we develop prototype missile design with accurate aerodynamics.**

Keywords: **Missile, Drag, Drag Coefficient, moment, moment coefficient, AOA (Angle of Attack)**

I. INTRODUCTION

In Today modern military usage missile or a guided missile is a self-propelled guided weapon system. The technologies of a guided missile are propulsion, guidance and control which helps in making a missile specific to a target, i.e., they determine the size, range and state of motion of a missile. Missiles are more accurate on target. Ancient time we use the bow which same like as a missile body design but only the difference is that they don't have any propulsion engine and any control system. One distinction between a missile and an airplane is that, unlike an airplane a missile is usually expandable in the accomplishment of its mission. From the configurational point of view, the distinction is frequently made that a missile is more slender than an airplane and tends to possess smaller wings & fins in proportion to its body. These distinctions are, however, subject to many exceptions. In fact configurational distinctions between missile and airplane seem to narrow as the operational speeds increases. Therefore much of the missile aerodynamics contained herein will be directly applicable to airplanes. Now days we are moving towards hypersonic missile design which are more stable than subsonic and supersonic design because on the fast moving object the force acting on a body are negligible only the aerodynamic forces are acing on it. Fins are used for the stabilization and wings control the yaw, roll, pitch moment.

II. LITERATURE REVIEW

Guided missiles can be broadly classified based on their features such as type of target, range, mode of launching, system adopted for control, propulsion, guidance, aerodynamics, etc. Among these classifications general and most popular is based on method of launching surface to surface (SSM), surface to air (SAM), air to air (AAM), air to surface (ASM), air to underwater (AUM) and underwater to underwater (UUM).

A.) On the basis of guidance system

There are various types of Command guidance, Beam-riding guidance, homing guidance, and inertial navigation guidance .In a command system the missile and the target air continuously tracked from one or more vantage points and the necessary path for the missile to intercept target is computed and relayed to missile by some means such as ratio. A beam-riding missile contains a guidance system to constrain it to a beam. The beam is usually a radar illuminating the target so that, if the missile stays in the beam, it will move towards the target. A homing missile has a seeker, which sees the target and gives the necessary direction to the missile to intercept the target. The homing missile can be sub divided into classes having active, semi active, and passive guidance systems. In the active class the missile illuminates the target and receives the reflected signals. In the semi active class the missile receives reflected signals from a target illuminated by means of external to the missile. The passive type of guidance system depends on the receiver in the missile sensitive to the radiation of the target itself.

B). On the basis of trajectory

They are of three types Ballistic missiles, Glide missiles, and Skip missiles. Ballistic missile follows the usual ballistics trajectory of a hurled object. By definition a ballistic missile is the one which covers a major part of its range outside the atmosphere where the only external force acting on the missile is the gravitational force of the earth, while the cruise missile is the one which travels its entire range in the atmosphere at a nearly constant height and speed. However, a missile could have a combination of the two also where a missile could cover part of the flight in ballistics mode and later a terminal portion in cruising mode. A glide missile is launched at a steep angle to an altitude depending on the range, and then glides down on the target. A skip missile is launched to an altitude where the atmosphere is very rare, and then skips along on the atmospheric shell.

C). On the basis of range

- Short range missiles – 50 to 100 km;
- Medium range ballistic missiles (MRBM) – 100 to 1500 km;

- Intermediate range ballistic missiles (IRBM) – up to 5000 km;
- Intercontinental or long range ballistic missile

(ICBM) – 12000 km;

D). On the basis of target

There are various types of Anti-tank/anti-armour, Antipersonnel, Anti-aircraft/helicopter, Anti-ship/anti-submarine, Anti-satellite, or Anti-missiles.

E). On the basis of launch platform

Land/mobile (wheeled vehicle or tracked vehicle), Aircraft/helicopter-borne, Ship/submarine-launched, Silo-based, or Space-based.

F). On the basis of aerodynamic control

Wing controlled, Tail controlled or Canard controlled.

G). Based on propulsion system

In propulsion system, They are of three types Solid propulsion, Liquid propulsion, and Hybrid propulsion.

III. DESIGN CONSIDERATION OF GENERAL *AERODYNAMICS*

The design of missile configurations is one of the most interesting and challenging fields and perhaps the most complex for the aeronautical design engineers since it requires a broad knowledge of the fundamentals of many technical specialties such as aerodynamics, thermodynamics, kinematics, propulsion, structural design, etc.

A. Sections of a missile

The body of a missile may be divided into three major sections

1) The forebody or the nose

2) The mid-section

3) The boat-tail section.

1) The forebody or the nose section

Forebodies may have many varieties of shapes, most common of which are conical, ogival, power series or hemispherical. These shapes are used primarily on the missiles of supersonic speeds and are generally selected on the basis of combined aerodynamic, guidance and structural considerations. Since the pressure or wave drag may be several times that due to friction at supersonic speeds, careful selection of the nose shape needs attention to assure satisfactory performance of the overall system.

2) Mid-section

The mid-section in most missile configurations is cylindrical in shape. This shape is advantageous from the stand point of drag, ease of manufacturing and load carrying capability. It is known that the total reaction of the missile at any instant has two components, the lift and drag. These may be positive or negative. It becomes desirable to have a greater lift than the drag and this can be done by using a curved surface. Angle of attack is the direction of the reaction force with respect to the free stream direction. Even at zero angle of attack, some lift can be obtained by using airfoil section's .The effect of mid-section or after body extension on the aerodynamic characteristics of the conical and ogival nose bodies have been investigated and it is seen that the effect of after body extension is to increase the lift coefficient and move the centre of pressure toward aft end as a result of body carry over and viscous cross-flow effects.

3) Boat-tail section

Boat-tail is the tapered portion of the aft section of a body. The purpose of the boat-tail is to decrease the drag of a body which has a „squared off" base. By „boat-tailing" the rear portion of the body, the base area is reduced and thus a decrease in base drag may be partially nullified by the boattail.

III. PROBLEM STATEMENT

The objective of this paper is to show the variation in drag force on entire missile and how the aerodynamic coefficient change with Mach number. To increase overall efficiency, we need to give an optimum shape to missile design shape which can reduce drag force and provide a streamline structure & flow.

IV.METHODOLOGY

In this paper missile is designed using PTC Creo parametric 4.0 software. The first step is to create a 2D
Slender body shape with nose shape and revolve with respect to central axis, for convert into a 3D model for CFD testing. The commonly used tools to create a model in Creo 4.0 parametric are- Extrude, extrude cut, Revolve, revolve cut Sweep, Swept cut, Fillet, Chamfer, Mirror. CFD Analysis is carried out in three steps i.e.

(i) Pre-processing, geometry, – Designing, meshing, boundary conditions and numerical method.

(ii) Processing – Solving fluid flow governing equations by numerical method till the convergence is reached.

(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 missile design and unstructured grid. Simulations are carried out using ANSYS fluent a finite volume solver at with inlet conditions. In this analysis we use the automatic mesh generation method because of the complexity of structure.

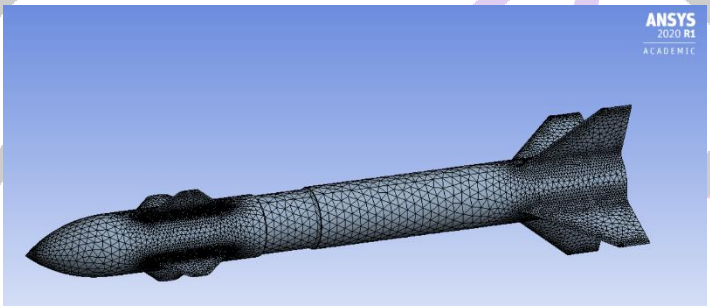

Figure 1 Mesh generation on missile design

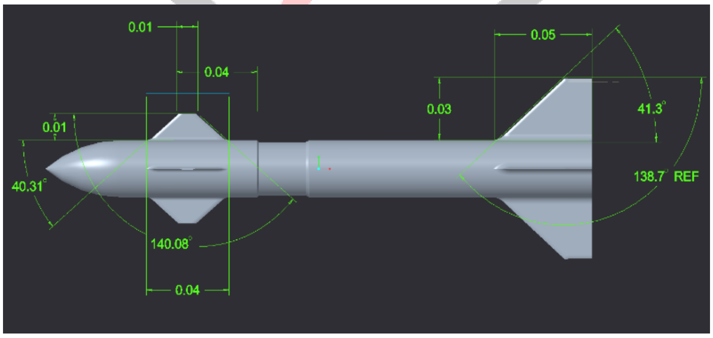

Figure 2 Fins and wing dimension.

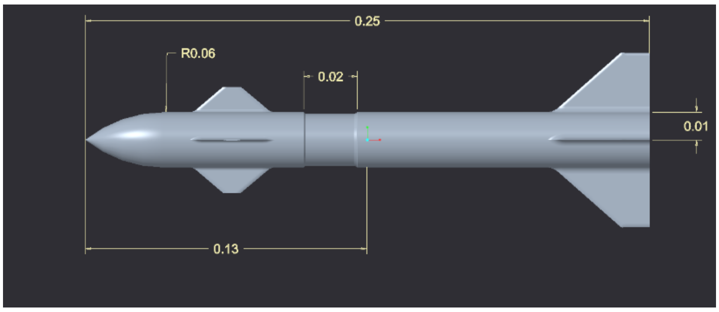

Figure 3 Slender body and nose shape dimension.

NOTE: ALL DIMENSION IN SI UNIT.

V. INLET CONDITION AND BOUNDARY CONDITION

Table 1:Inlet and boundary condition

SL.NO	Parameter	Value
1	Flow Medium	Air
2	Mach Number	0.2,0.4,0.6,0.8,1,2.0
3	Density	1.225Kg/m^3
4	Length	0.25m
5	Turbulent Model	Spalart-Allmaras
6	Kinematic Viscosity	1.7894e-05kgs/m^2
7	Altitude condition	Standard sea level

VI. RESULT AND DISCUSSION

The effect of Mach Number on the drag & aerodynamic coefficient has been found by the analysis of design for various conditions of Mach number and it is tabulated as follows. Some of the tabulated results are shown hereunder. We can see that with increase in the Mach number, the drag and the moment increase. when this two factor increase than it reduced the efficiency of design and create structural vibration in the missile design. If We compare the results for both condition subsonic & supersonic, we analyse that in subsonic speed, the missile is more stable as compare to supersonic.

Table 2: Aerodynamic characteristic at subsonic level

SL.NO	Mach Number	Drag Coefficient	Drag	Moment	Moment Coefficient
1	0.2	1.3	0.84	-0.0013	-0.0021
2	0.4	5.2	3.2	-0.0063	-0.010
3	0.6	11.4	6.9	-0.015	-0.023
4	0.8	19.9	12.1	-0.028	-0.046
5	1	31.1	19.1	-0.046	-0.076

PRESSURE DISTRI BUTION

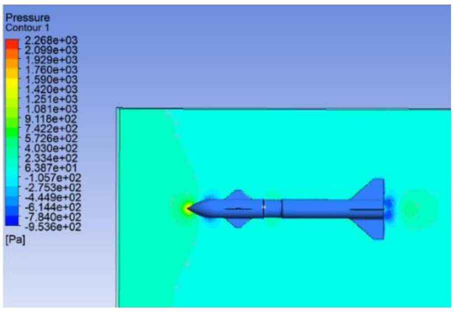

Figure 4: At Mach 0.2

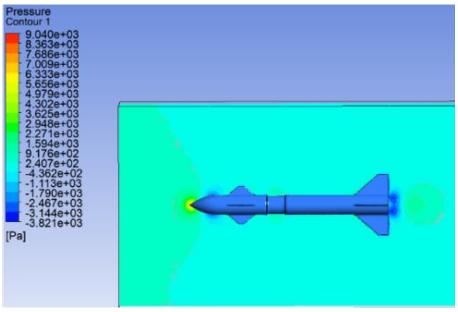

Figure 5: At Mach 0.4

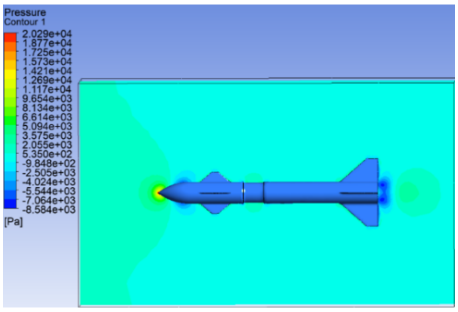

Figure 6: At Mach 0.6

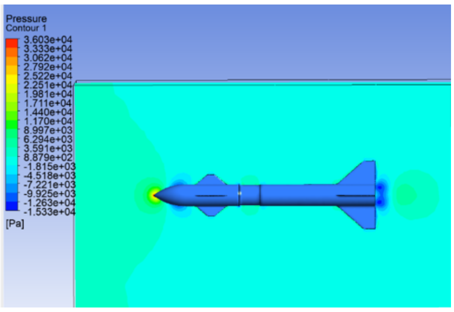

Figure 7: At Mach 0.8

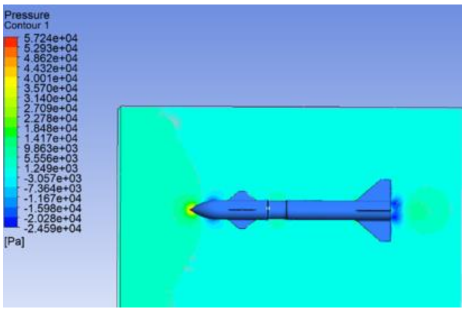

Figure 8: At Mach 1.0

DYNAMIC PRESSUSE DISTRIBUTION

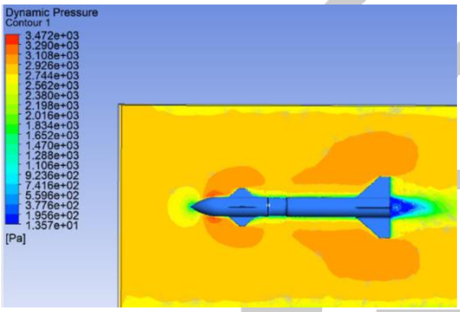

Figure 9: At Mach 0.2

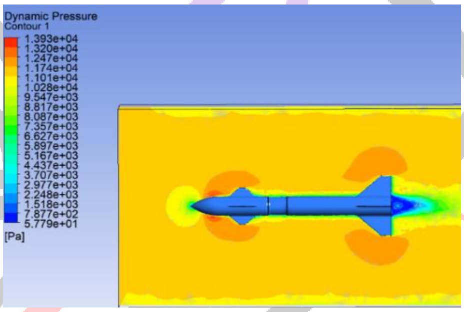

Figure 10: At Mach 0.4

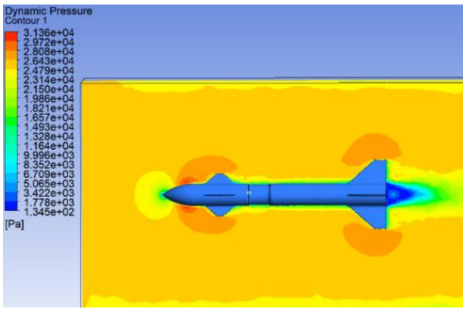

Figure 11: At Mach 0.6

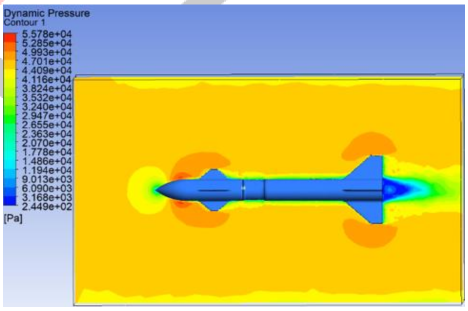

Figure 12: At Mach 0.8

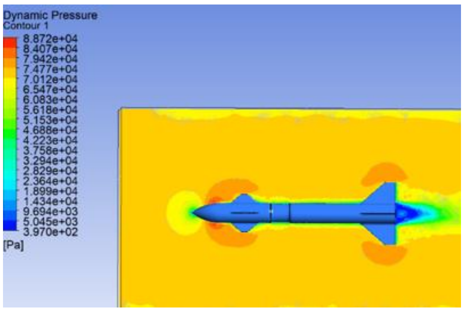

Figure 13: At Mach 1.0

VELOCITY VARIATION

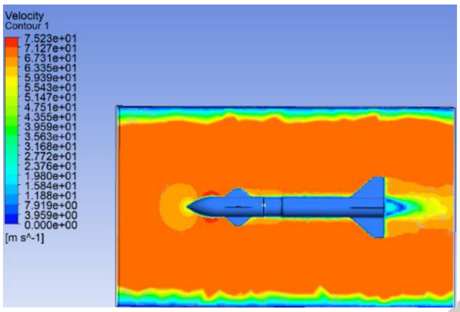

Figure 14: At Mach 0.2

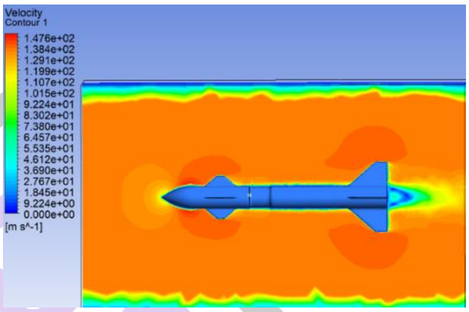

Figure 15: At Mach 0.4

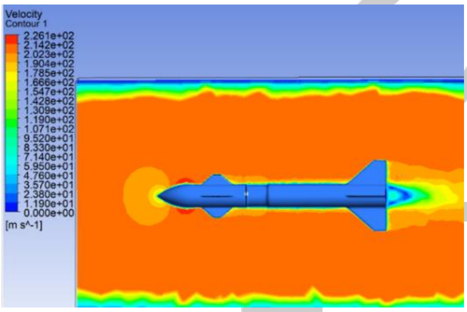

Figure16: At Mach 0.6

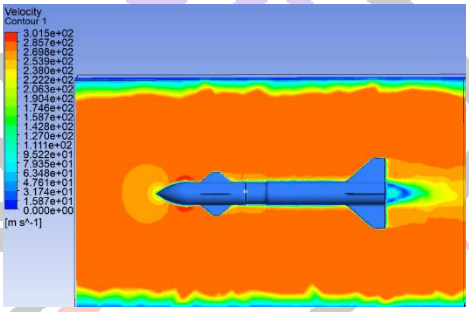

Figure17: At Mach 0.8

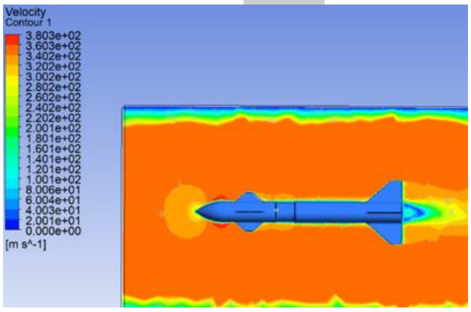

Figure 18: At Mach 1.0

TABLE 3: Aerodynamic characteristic at supersonic level

SL.NO	Mach Number	Drag Coefficient	Drag	Moment	Moment Coefficient
1	2.0	118.	72.3	-0.19	-0.313

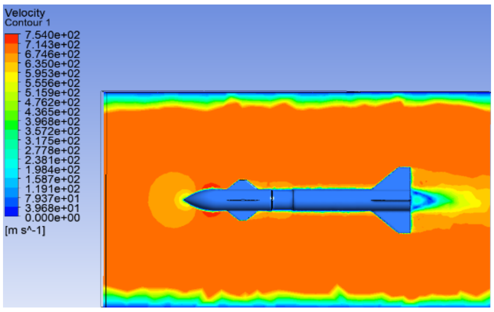

Figure 19: velocity distribution at Mach2.0

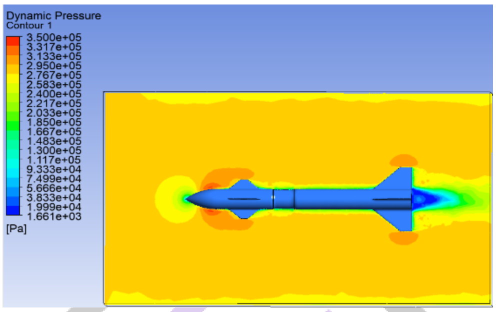

Figure 20: Dynamic pressure distribution at Mach2.0

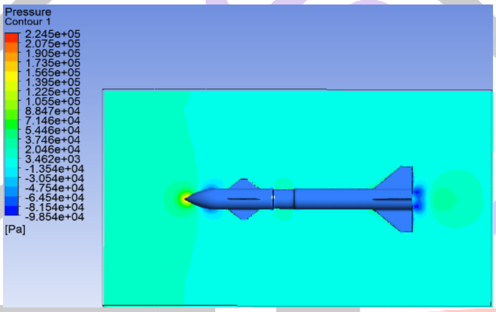

Figure 21: pressure distribution at Mach2.0

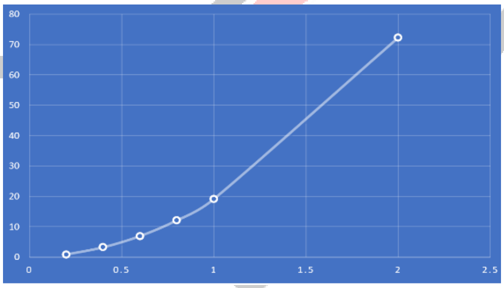

Figure22: Drag(y-Axis) variation with Mach number(x-axis)

VII.CONCLUSION

The overall presentation of this paper concludes about the variation of flow over a missile body. From results, we conclude that the Drag values are increasing with Mach Number which results in formation of induced drag over the body surface which increases as well. and we also see that, the minimum darg and moment induced at Mach number 0.2& 0.4 by this we conclude that this type of design is good for medium range subsonic missile design.

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