EFFECT OF ALTITUDE ON THE MISSILE DESIGN

Amandeep Singh

Student, Department of Aerospace Engineering,
School of Mechanical Engineering, Lovely Professional University, Punjab, India

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. In this paper, we analyse the aerodynamic flow over a missile body with different altitude and how altitude effect the aerodynamic characteristic coefficient. In standard atmosphere there are two types of layer, first is "Gradient layer" and second is "Isothermal layer". In Isothermal layer, the temperature though out the layer is constant but in Gradient layer, the temperature is varying sometime increase and sometime decrease and in this we also discuss about the standard atmospheric layer. 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 different altitude with their different Mach number. The motivation of such work is caused due to lack of data on missile design analysis with different altitude. In this paper we also discuss about, how the temperature and density effect with increasing the altitude. Now days we are moving towards high speed vehicle. Designing field give the ability to make more efficient body design for aeronautical Industry. By this paper, we develop prototype missile design with accurate aerodynamics and also see change's on aerodynamic flow over the missile body.

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

I. INTRODUCTION

In Today modern military usage missile or a guided missile is a self-propelled guided weapon system. Every nation researching or finding the new technology's in space as well as aeronautical industry, for example Elon Musk found reusable rocket system. The technologies of a guided missile are propulsion, guidance and control which helps in making a missile specific to a target and give stability to the missile. They determine the size, range and state of motion of a missile. Missiles are more accurate on target as compare to other weapons and we can give or control by remote system. In 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 but now days the aerospace industry growing up. 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. Missile use only in war field but when we talk about aeroplane, the aeroplane mostly use's in daily life and aeroplane have capability to transport the heavy weight machine from one nation to other nation. In fact, configurational distinctions between missile and airplane seem to narrow as the operational speed increases, Atmosphere of the earth also effect the aerodynamic coefficient and air flow over a body because of the temperature variation and density variation with the altitude. We know that, high speed object are more stable as compare to low speed object because in high speed object the forces are more negligible, force acting on a body is low. Therefore, much of the missile aerodynamics contained herein will be directly applicable to airplanes.

Note: IN THIS PAPER ALL UNITS IN SI SYSTEM.

II. PROBLEM STATEMENT

The objective of this paper is to show the variation in drag force on entire missile with different altitude (0,6,11) Km and how the aerodynamic coefficient change's at different altitude with different Mach number. In defence system Most of the anticraft missile use up to 11km. To increase overall efficiency, we need to give an optimum shape and altitude to missile design shape which can reduce drag force and provide a streamline structure & flow and increase the efficiencies and we also check the moment coefficient value and compare with condition of longitudinal static stability.

Table1: Temperature values at (0,6,11) Km

Altitude	Density	Temperature	Speed of sound	Viscosity
0	1.225	288.16	340.3	17.89
6	0.660	249.2	316.5	15.95
11	0.365	216.8	295.2	14.22

III. TEMPRATURE EFFECT ON ALTITUDE

We know that our atmosphere is unique as compare to different planet atmosphere. In earth standard atmosphere they are lost of things for study they different types of layer in which every layer have different properties and most important thing , the changing behaviour of temperature with increasing the altitude, in atmosphere there are two types of layer first is Isothermal Layer , in which temperature remains constant and second is gradient layer in which the temperature varying with altitude.in this we discuss about this types of layer and there formula how we can find the temperature, density and pressure. let's discuss about it.

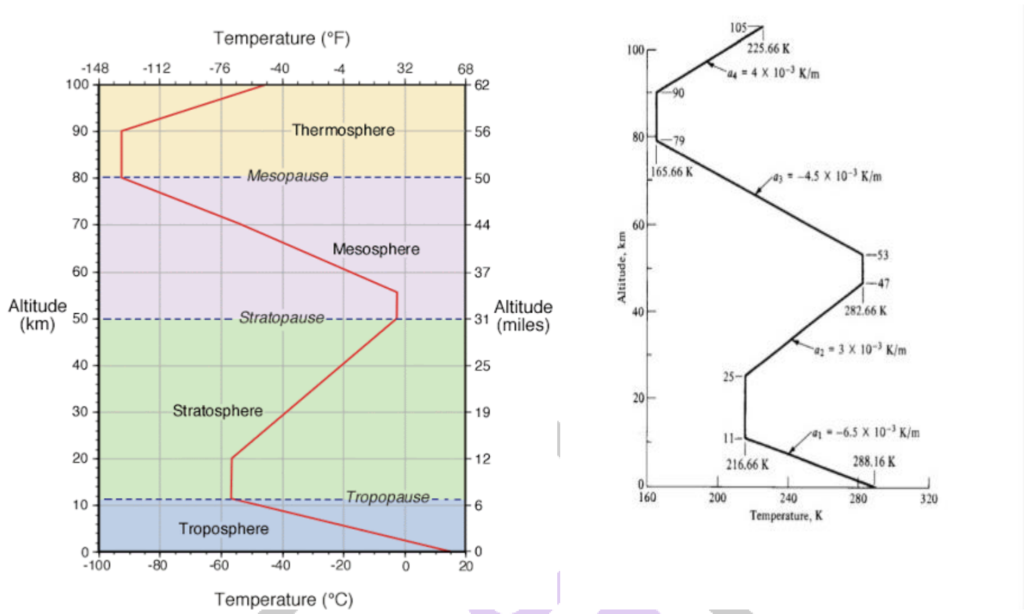
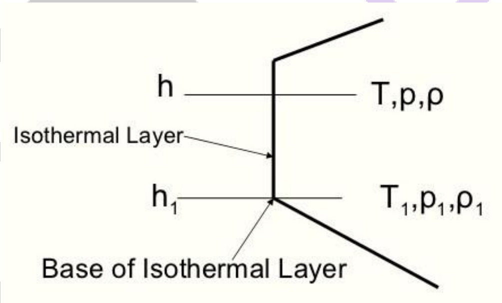


Figure 1&2: showing different types of layer with its temperature value.

Isothermal Layer: A zone with constant temperature in the **atmosphere** is called an **isothermal layer**.



Formula:

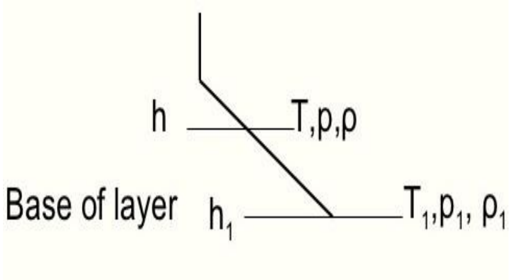
P/P1= e-[g/(RT)] (h-h1)

T=T1 + a (h-h1)

Where:

P= Pressure at some altitude.
P1= pressure at standard sea level.
T=Temperature at some altitude.
T1=Temperature at standard sea level.
a= Lapse rate (ratio of change in temperature with change in altitude)
h= Height at initial point.
h1= height at some final point or final altitude.
R= universal gas constant

Gradient Layer: A zone in which the varying temperature in the **atmosphere** is called **gradient layer**, sometime its increase and decrease with changing the altitude.



Formula:

P/P1= (T/T1) ^ (-g/aR)

T=T1 + a (h-h1)

Where:

P= Pressure at some altitude.
P1= pressure at standard sea level.
T=Temperature at some altitude.
T1=Temperature at standard sea level.
a= Lapse rate (ratio of change in temperature with change in altitude)
h= Height at initial point.
h1= height at some final point or final altitude.
g= 9.8m/sec^2
R= universal gas constant

IV. TYPES OF ATMOSPHERIC LAYER

There are "six" major atmospheric layer are given below.

1). TROPOSHERE

The temperature of the **troposphere** is highest near the surface of the Earth and decreases with altitude. On average, the temperature gradient of the troposphere is 6.5o °C per 1,000 m (3.6o °F per 1,000 ft.).

2). STRATOSPHERE: The **ozone layer** is found within the stratosphere between 15 to 30 km (9 to 19 miles) altitude. The thickness of the ozone layer varies by the season and also by latitude. The ozone layer is extremely important because ozone gas in the stratosphere absorbs most of the Sun's harmful ultraviolet (UV) radiation. Because of this, the ozone layer protects life on Earth. High-energy UV light penetrates cells and damages DNA, leading to cell death (which we know as a bad sunburn). Organisms on Earth are not adapted to heavy UV exposure, which kills or damages them. Without the ozone layer to reflect UVC and UVB radiation, most complex life on Earth would not survive long.

3). MEOSPHERE: Temperatures in the **mesosphere** decrease with altitude. Because there are few gas molecules in the mesosphere to absorb the Sun's radiation, the heat source is the stratosphere below. The mesosphere is extremely cold, especially at its top, about −90 degrees C (−130 degrees F.

4). THERMOPSHER: The density of molecules is so low in the **thermosphere** that one gas molecule can go about 1 km before it collides with another molecule. Since so little energy is transferred, the air feels very cold. Within the thermosphere is the **ionosphere**. The ionosphere gets its name from the solar radiation that ionizes gas molecules to create a positively charged ion and one or more negatively charged electrons. The freed electrons travel within the ionosphere as electric currents. Because of the free ions, the ionosphere has many interesting characteristics. At night, radio waves bounce off the ionosphere and back to Earth. This is why you can often pick up an AM radio station far from its source at night.

5). IONOSPHER: The **ionosphere** is the ionized part of Earth's upper atmosphere, from about 48 km (30 mi) to 965 km (600 mi) altitude, a region that includes the thermosphere and parts of the mesosphere and exosphere. The **ionosphere** is ionized by solar radiation.

6). EXOPSHERE: The exosphere is the outermost layer of our **atmosphere**. "Exo" means outside and is the same prefix used to describe insects like grasshoppers that have a hard shell or "exoskeleton" on the outside of their body. The exosphere is the very edge of our **atmosphere.**

V. 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.

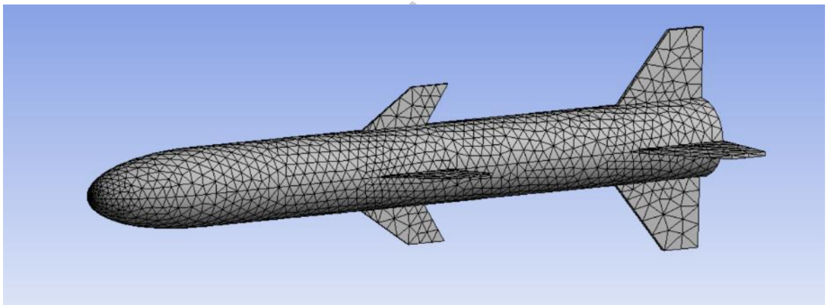


Figure 1 Mesh generation on missile design

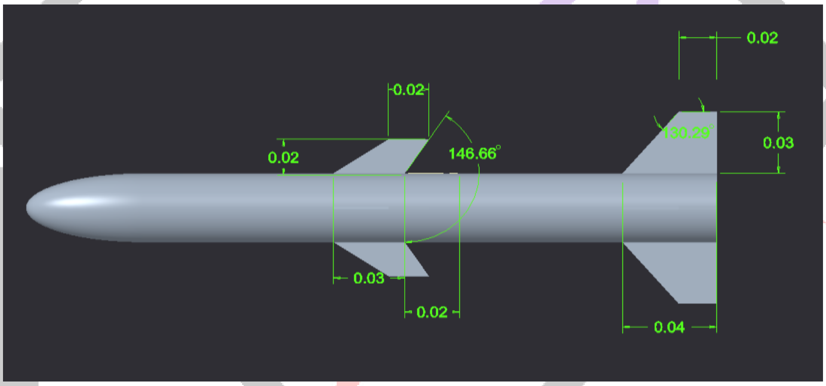


Figure 2 Fins and wing dimension.

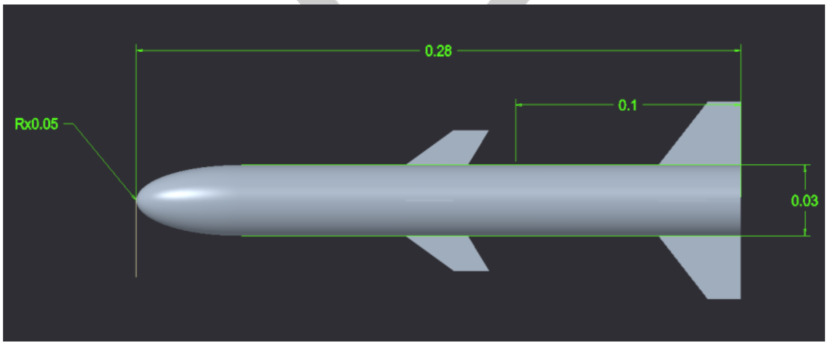


Figure 3 Slender body and nose shape dimension.

NOTE: IN THIS PAPER, ALL DIMENSION IN SI UNIT.

VI. RESULT AND DISCUSSION

The effect of altitude 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 altitude, the drag value decreasing with different Mach number. If We compare the results for 0km, 6km, 11km, we analyse that in 11km the Darg value are less as compared to standard sea level. the missile design is more stable and one more thing we analyse that, the dynamic pressure and static Pressure is decreasing with altitude which make more stability and reduce structural vibration.

TABLE 2: AT STANDARD SEA LEVEL

Mach Number	Drag	Drag coefficient	Moment	Moment Coefficient
0.3	2.4	4.0	-0.015	-0.025
0.6	9.6	15.7	-0.038	-0.062
0.8	16.9	27.7	-0.082	-0.134
1.0	26.7	43.6	-0.13	-0.21

TABLE 3: AT ALTITUDE 6 Km

Mach Number	Drag	Drag coefficient	Moment	Moment Coefficient
0.3	1.7	2.9	-0.0014	-0.0023
0.6	6.4	10.5	-0.00636	-0.010
0.8	11.0	18.0	-0.014	-0.023
1.0	17.16	28.0	-0.034	-0.055

TABLE 4: AT ALTITUDE 11Km

Mach Number	Drag	Drag coefficient	Moment	Moment Coefficient
0.3	1.0	1.7	-0.0024	-0.0039
0.6	3.8	6.2	-0.0017	-0.0028
0.8	6.4	10.6	-0.0051	-0.0083
1.0	10.0	16.3	-0.0093	-0.015

AT STANDARD SEA LEVEL

DYNAMIC PRESSURE DISTRIBUTION

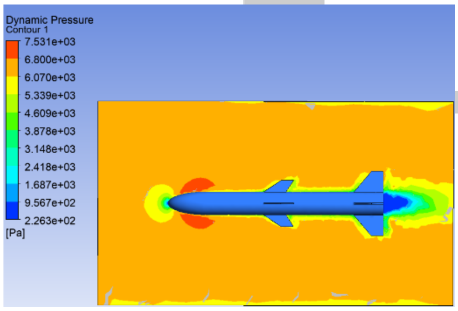


Figure 5: At Mach0.3

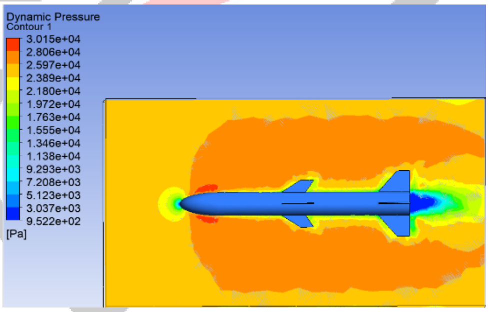


Figure6: At Mach0.6

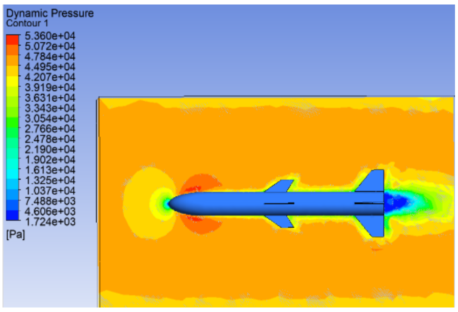


Figure 7: At Mach0.8

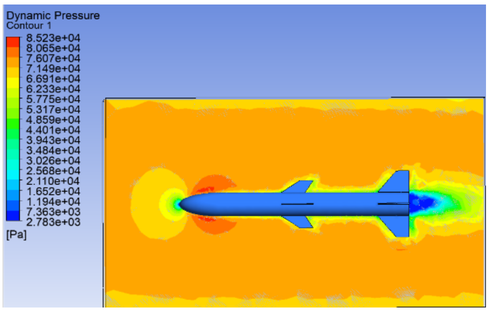


Figure 8: At Mach 1.0

PRESSURE DISTRIBUTION

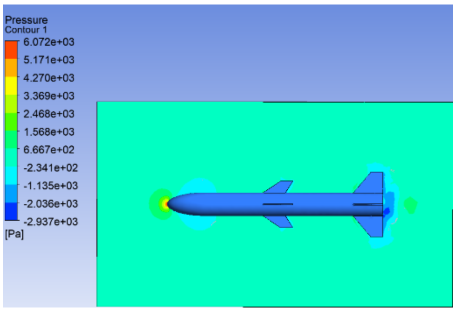


Figure9: At Mach 0.3

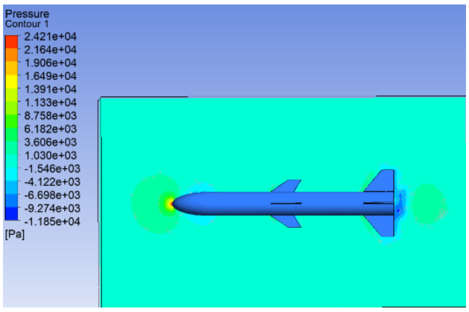


Figure10: At Mach 0.6

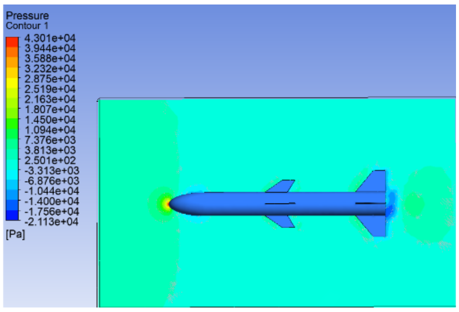


Figure11: At Mach0.8

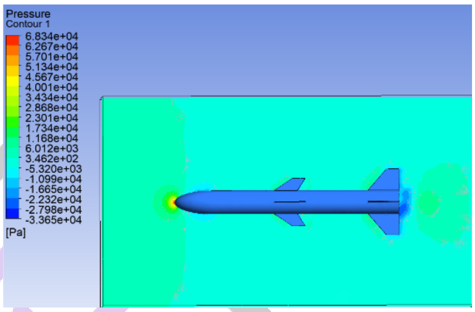


Figure12: At Mach 1.0

AT ALTITUDE: 6Km

DYNAMIC PRESSURE DISTRIBUTION

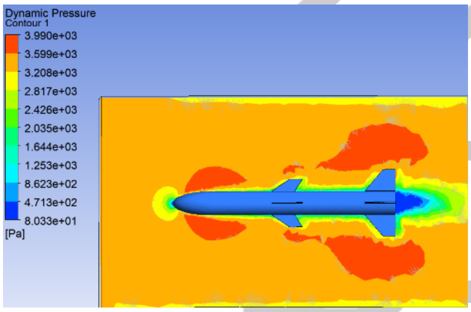


Figure13: At Mach 0.3

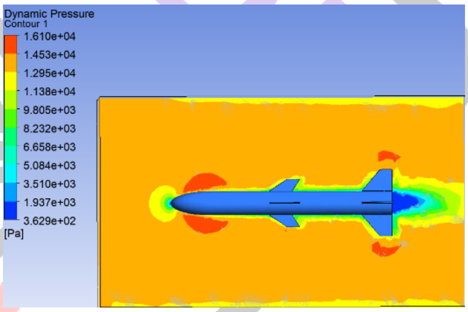


Figure14: At Mach0.6

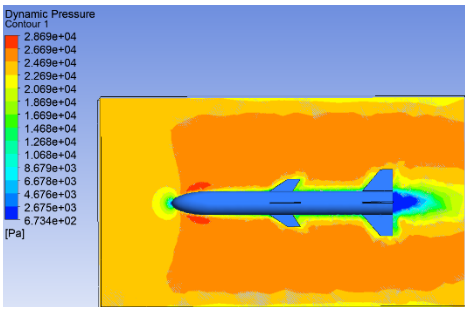


Figure15: At Mach 0.8

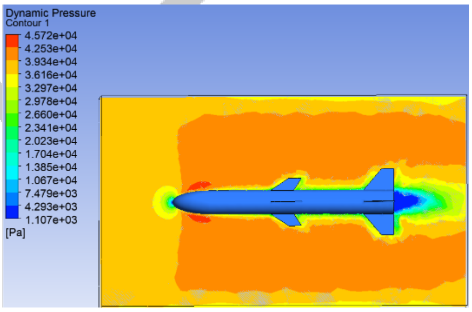


Figure16: At Mach 1.0

PRESSURE DISTRIBUTION

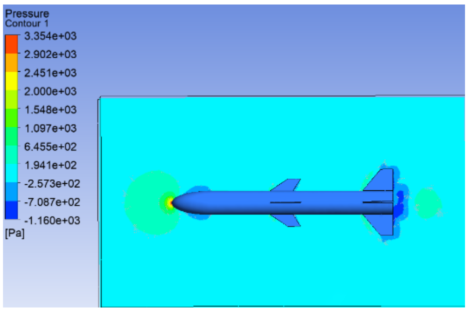


Figure17: At Mach 0.3

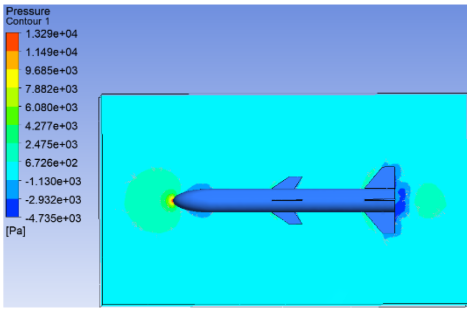


Figure18: At Mach0.6

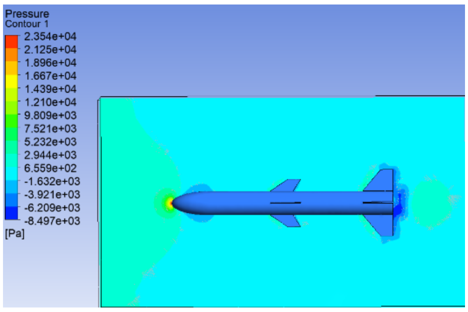


Figure19: At Mach 0.8

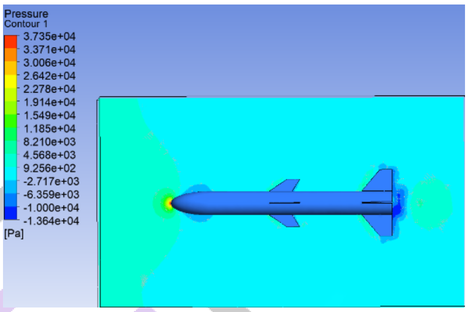


Figure20: At Mach 1.0

AT ALTITUDE: 11Km

DYNAMIC PRESSURE DISTRIBUTION

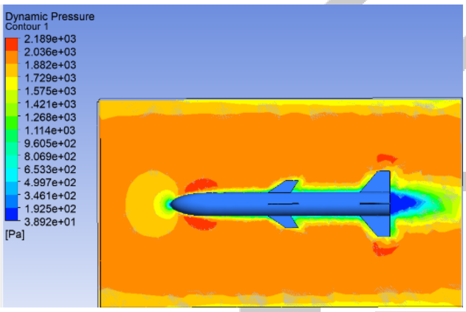


Figure21: At Mach 0.3

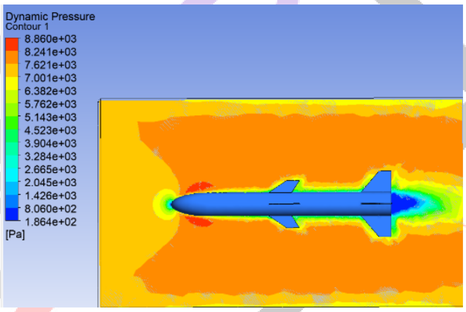


Figure22: At Mach0.6

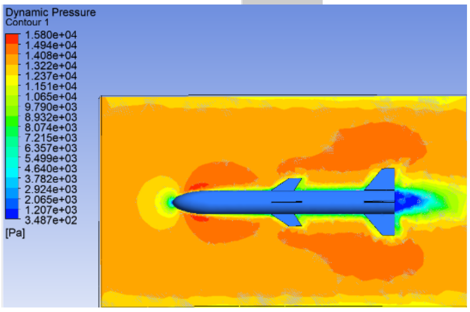


Figure23: At Mach 0.8

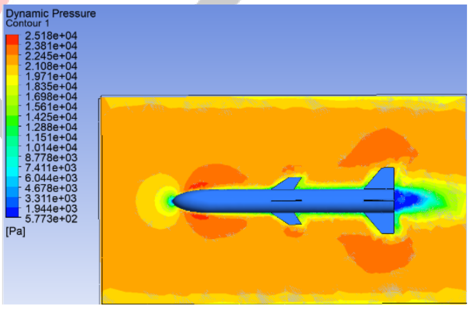


Figure24: At Mach 1.0

PRESSURE DISTRIBUTION

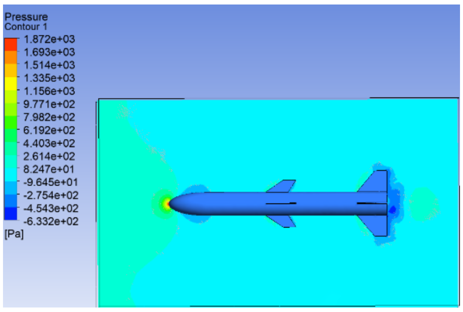


Figure25: At Mach 0.3

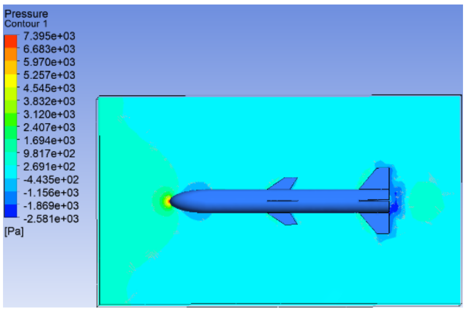


Figure26: At Mach0.6

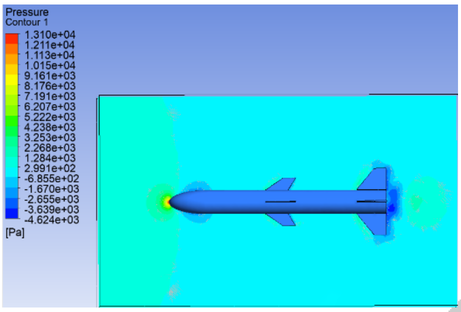


Figure27: At Mach 0.8

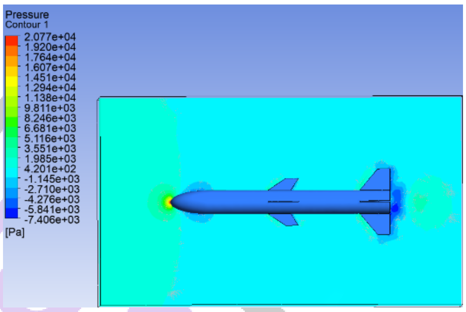


Figure28: At Mach 1.0

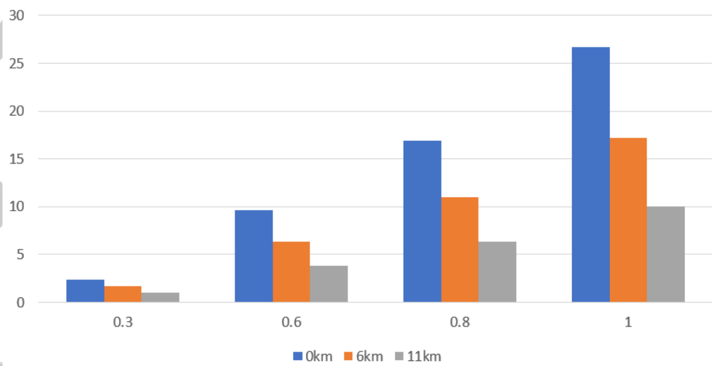


Figure29: Drag vs altitude (Mach Number on X-axis, drag on Y-axis)

VII.CONCLUSION

The overall presentation of this paper concludes about the variation of flow over a missile body with changing altitude and with different Mach number. From results, we conclude that, the Drag values are decreasing with increasing the altitude which results in formation of less induced drag over the body surface. and we also see that, the minimum drag at 11km and we analyse one more thing in this paper, the moment coefficient value in all altitude are coming negative and decreasing with altitude, which satisfy the condition of longitudinal static stability as well as stability condition, which said that the moment coefficient of missile design should be negative for stable missile design .By this we conclude that this type of design is good for 11km altitude and the missile design is stable , for more stability we use thrust vector method's , flight computer.

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