DESIGN AND ANALYSIS OF SURFACE TO SURFACE MISSILE
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Abstract — The main purpose of the project is to propose that the obsolete and old surface to air missiles can be used as surface to surface missiles because old missiles can’t follow complex trajectory of the present highly maneuverable target. Hence they can be used to hit a stationary target which is on ground with sufficient accuracy. This is the best way to use these old missiles than abandoning them. In this project, a 50 Km range surface to surface missile is designed based on old existing surface to air missile. The aerodynamic theory has been adopted to evolve the airframe of missile. The dimensions of surface to surface missile taken from old existing surface to air missile are plotted in CATIA V5R20. We simulate a flow of Mach 4 over the 3D model of missile using the software CFX. We find out the pressure, velocity, density and temperature variations. Finally we plot the trajectory in mat lab and obtain the following graphs: Range vs. Time, Altitude vs. Time and Velocity vs. Time.

Keywords - Air missiles; Surface missiles; Range; CATIA V5R20; CFX.

I. INTRODUCTION

Surface to surface missiles follow ballistic path where they are boosted by rocket engine to certain altitude and then they travel purely under gravity, tracking a nearly parabolic path before reaching earth and hitting the target. There are many surfaces to air missiles used in the past. Old missiles are lengthy. This is because they have to accommodate bulky electronics and payload which increase the weight of the missile. These obsolete missiles can be used as surface to surface missiles. The surface to surface missiles can have small range (e.g.: anti-tank missile) of 4-5 Km or medium range or long range. Long range missiles have a typical value of range greater than 500 Km and cover IRBMs, ICBMs. Intermediate Range Ballistic Missile (IRBM) normally has a range of 5000 Km or more. Inter-Continental Ballistic Missile (ICBM) has a range of 8000 Km or more. The medium range missiles can have a range of up to 500Km.

II. OBJECTIVES OF PROJECT

➢ Proposing the concept of using surface to air missile as surface to surface missile.
➢ Designing the outer structure of surface to surface missile in CATIA V5R20 and obtaining a 3D model.
➢ Meshing the model in ICEM CFD.
➢ Simulating flow of Mach 4 over the missile at angle of attack of 0°, 45° and 60° and plotting pressure variation, velocity variation, density variation and temperature variation. This is done in CFX.
➢ Plotting graphs in Mat lab software.

III. DESIGN METHODOLOGY

3.1 Design specifications of missile:
In any missile design, the normal procedure is to observe the existing missile for similar applications and then come back to the actual design to meet the specifications. The specifications are laid down
by the end uses (military users) to meet their specific requirements. In this project we have assumed the following specifications and have evolved a simple, economical design.

- **Range:** 50 Km
- **Maximum speed:** Mach 4. The speed is also a matter of convection. The missiles have to be fast acting since the operational time is crucial for military operations. Mach 4 in this case is appreciable in this case.
- **Diameter:** The usual practice is to assume a suitable diameter based on existing design and work out the length needed to accommodate the propulsion and other subsystems of the missile. For this range to start with a diameter of 500mm can be assumed. Then after working out the length, \( l/d \) is estimated. If \( l/d \) is greater than 10, the aerodynamic effects will be predominant which would complicate the structural and aerodynamic design. Therefore, in this condition it is preferable to assume a higher diameter to keep \( l/d \) less than 10.
- **Airframe:** Normally for this range of missiles, a tangent ogive nose profile is used to reduce shock wave drag. Airframe can be made of Al alloy 2014 –T6 which is the most common material in the aerospace field. Airframe consists of wings and or fins plus control surface. Cruciform configuration i.e. 4 no’s radially is adopted to keep the flight desperations less and to keep the missile stable.

Detail dimensions of the modeled missile is shown in the figure below.

The diameter of the cylindrical airframe is 0.5 m. Its length is 4.5 m. The nose part of the missile is a tangent ogive shape. Its length is 1.5 m. The model obtained in catia is as shown in figure below.
Figure 1: Symmetrical model.

3.2 Mesh obtained in ICEM CFD:
The mesh obtained is shown in the figure below. They are unstructured mesh with reasonable accuracy.
3.3 Design loads:
There are many types of external and internal loads imposed on the missile structures and components. In general, these loads may be divided into two classes: flight loads and ground loads. In practical design, critical structural-design conditions arise from both classes of load. Hence the designer must consider these loadings with equal care.

3.3.1 Flight Loads:
The flight loads may be subdivided into two categories; free-flight loads and captive-flight loads. Free-flight loads arise primarily from aerodynamic and thermal forces and internal pressure forces such as those present in a rocket motor or propulsion system. Captive-flight loads arise primarily from the aerodynamic loads induced on the missile during its carried condition by the parent aircraft. The missile structure must be adequate to withstand the most critical loadings imposed during flight on each component of the missile.

3.3.2 Ground Loads:
The basic ground loads consist of those which the missile, experiences during transportation and preparation for launching. Many data have been gathered over the past several years on the environmental conditions of all modes of transportation. These environmental loads, which are generally expressed in terms of amplitude and frequency (i.e., 30 g’s at 150 cps), may have detrimental effect on the missile, particularly on its internal electronic components. Hence proper design such as shock mounting must be incorporated to minimize the effects of these environmental loads. In addition, proper design must be incorporated in missile shipping containers to withstand the loads encountered during transportation and ground handling. The ground-handling loads must also be carefully analyzed to assure that the structural design of the missile and the ground-support equipment (i.e., missile launcher, erector, etc.) are satisfactory. The magnitude of these loads can be determined only after the complete concept and details of the ground-support system have been established.

3.4 Material:
The materials in general usage for the construction of missiles are aluminum, steel, magnesium, and titanium. Because of the high temperatures encountered by missiles flying at high supersonic and hypersonic speeds, other types of materials are coming into more common usage. These include molybdenum beryllium, plastic, and graphite compounds.

3.5 Results obtained in CFX:
- At angle of attack of 0°:
Pressure, temperature, density, velocity contours are shown in the following figures. The values of variables on the missile can be seen from the scale to the left.
Figure 2: Density Contour

Figure 3: Pressure contour

Figure 4: Temperature contour
At angle of attack of 30°:
Pressure, temperature, density, velocity contours are shown in the following figures. The values of variables on the missile can be seen from the scale to the left.
Figure 8: Pressure contour

Figure 9: Pressure contour

Figure 10: Temperature contour

Figure 11: Velocity contour
At angle of attack of 45°:
Pressure, temperature, density, velocity contours are shown in the following figures. The values of variables on the missile can be seen from the scale to the left.
At angle of attack of 60°:
Pressure, temperature, density, velocity contours are shown in the following figures. The values of variables on the missile can be seen from the scale to the left.

Figure 16: Density contour

Figure 17: Pressure contour

Figure 18: Temperature contour

Figure 19: Velocity contour
IV. PLOTS OBTAINED IN MATLAB
We have obtained the following plots in matlab by analyzing the trajectory. From the first plot we see that the missile has reached a range of 50 Km in 125 sec.

The maximum velocity of missile is shown in the plot below.
V. CONCLUSION

- We have successfully proposed that we can use old existing surface to air missiles as surface to surface missiles.
- The outer structure of the missile was designed in CATIA and a flow of Mach 4 was simulated over it in ANSYS CFX.
- We have designed a missile which can travel a range of 50 Km within 125 sec.
- We have obtained “Pressure, Temperature, Density, Velocity” parameters over the missile travelling at a Mach number 4 (supersonic).

REFERENCES

1. “Missile Configuration Design” by S.S Chin.
2. “Rocket Propulsion Elements 7e” by George P. Sutton
3. “Gas Turbines” by V Ganesan
4. “Gas Turbines and Jet & Rocket Propulsion” by M.L.Mathur ,R.P.Sharma
5. www.cfd-online.com
6. adl.stanford.edu
7. confluence.cornell.edu