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Design and Analysis of Lambda Missile

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Abstract **-- Missile becomes the very strategic weapon for all countries. Missile itself is developing day by day and this research paper is one among them. Here the conventional missile structure is fitted with delta shaped wing then the missile looks like the symbol lambda [λ] and thus named so. The addition of wing will produce lift to the flying missile. Consequently, the drag will be reduced and specific fuel consumption is reduced. Thus the missile can carry huge warhead for a long range at high speed. It will create the huge scale destruction upon the target. This missile can be launched from ground as it can produce required take off lift and able to climb up high altitude as aircrafts. Hence the special launcher is not required.**

***Keywords:** Advanced missile, Heavy Warhead Missile, Hybrid Missiles, Low fuel Missile, Winged Missile.*

I. INTRODUCTION

The missiles are generally wingless but the research is going on around the world to create a missile with wings. The wings in the missile will simply create lift force to the missile as it is doing in the aircrafts. The addition of wing enables the lambda missile to climb high by its own and decent from this high altitude will make the missile to hit the target at high speed. The lift production makes the missile to carry the huge warhead which will destruct the huge mass. The lift production will reduce the overall drag of missile which results in low specific fuel consumption and covers the long range.

II. DESIGN

The comparative study with various existing winged missiles provides the basic design data for lambda missile. The dimension of every missile components is defined after various calculations through trial and error method. The assumed values from comparative studies are used for theoretical calculations and analyzed the results. Again the assumed value is changed according to the result obtained. Finally, the most appropriate dimension for each component is arrived as the overall length of missile is 5.2 m and its diameter is 0.6 m.

Generally the fast flying aircrafts are fitted with delta shaped wing which will be aerodynamically advantageous. The same delta wing is used in the missile with the height of 2.94 m and width of 2.25m. The wing is attached at the angle of attack of 4°.Two vertical fins are attached to keep the missile stable during flight. The nozzle to be used is convergent nozzle. The nose cone where explosives are stored has the diameter of 0.6 m and height of 0.67 m. Missile is designed to fly in high speed subsonic speed at 230 m/s to avoid the shock wave formations during flight. It is designed to cruise at 10000 m altitude. The each component of the missile is designed through the design software CATIA and assembled together as shown in the next figure.

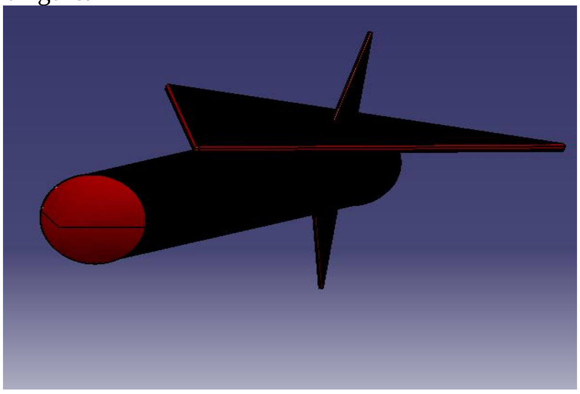

Fig. 1. Lambda Missile Design.

III. WING FALL MECHANISM

Generally the missiles have no wing because the wing will produce drag while decent. This drag produced reduces the velocity of missile and the missile will not hit the target hard. This phenomenon will also affect the lambda missile. Hence the wing in missile should be taken off from the missile once it gets ready for decent. Here the wing and missile structure is locked together by the electronic locks. At the time, the missile is getting ready for decent, the electronic pulse will command the flight system to unlock the wing from missile. Hence the lambda missile will decent without wing which has minimum drag and hit the target with high speed.

IV. MATERIAL SELECTION AND WEIGHT ESTIMATION

The structure of lambda missile is made up of steel and the bulkhead is made up of light weight iron. The nozzle is made up of titanium material to withstand high temperature at the exit. The missile skin is made up of aluminum since it is more reliable with shear stress and light weight. However the nose section of missile is exposed to high temperature due to upstream aerodynamic heating. Hence the skin over nose cone is coated with ceramic layer. The weight of missile consists of weight of structure, warhead, combustor, solid fuel, communication and flight systems and guidance systems. The overall weight of lambda missile is estimated to be 700 kg.

V. THEORETICAL CALCULATION

From various theories, the performance of lambda missile during flight is calculated. Keeping the velocity and weight of missile is constant; the key performance factors of lambda missile such as lift, drag, thrust, power, specific fuel consumption and range are calculated and tabulated as below.

A. Co efficient of Lift

$$cL = 2\pi\alpha \quad (1)$$
$$= 0.22.$$

B. Lift

$$L = ½*\rho v^2 A*cL \quad (2)$$
$$= 18111.6\ N.$$

C. Co Efficient of Drag

$$cD = cL*\alpha \quad (3)$$
$$= 0.0076.\ (Wing)$$

Co Efficient of Drag due to other parts of the missile is 0.1538 hence the overall Co Efficient of Drag is 0.1614.

D. Drag

$$D = ½*\rho v^2 A*cD \quad (4)$$
$$= 13287.4\ N.$$

E. Thrust

$$T = m\, v_e + (p_e - p_o)*A_e \quad (5)$$
$$= 6823\ N.$$

F. Power

$$P = T*v \quad (6)$$
$$= 17.8*10^5\ W.$$

G. Specific Impulse

$$I_{sp} = T/(m*g_o) \quad (7)$$
$$= 26.7\ s.$$

H. Specific Fuel Consumption

$$SFC = M/T \quad (8)$$
$$= 3.9*10^{-3}\ kg.$$

I. Range

$$R = [(V/g)*(1/SFC)*(L/D)*\ln(W_i/W_f)] \quad (9)$$
$$= 3647\ km.$$

TABLE I. THEORETICAL RESULTS.

Co Efficient of Lift	0.22.
Co Efficient of Drag	0.13.
Lift	18111.2 N
Drag	13287.4 N
Thrust	6823 N
Specific Impulse	26.7 s
Specific Fuel Consumption	$3.9*10^{-3}$ kg
Mass Flow Rate	26.1615 kg/ m^3
Power	$17.8*10^5$ W
Range	3647 km

VI. ANALYSIS

A. Fluent

The lambda missile design is computationally analyzed in ANSYS Fluent to get more accurate results. The design is imported and covered with the fluid domain of 2 m distance from the missile as shown in the next figure.

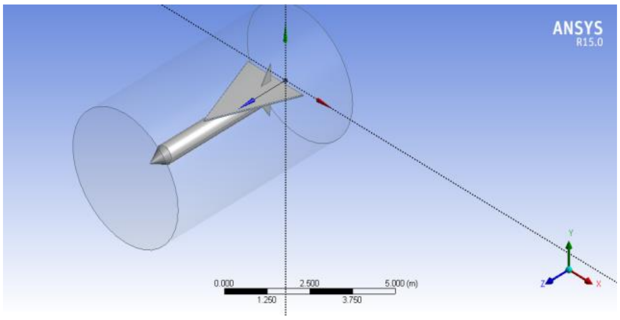

Fig. 2. Missile with Fluid Domain

Then the whole part is finely meshed with tetrahedral formula to get more reliable results. Here K-Ɛ RNG Model is used as the fluid domain is compressible. The boundary conditions given to the second order upwind scheme are v = 230 m/s, P = 101.6 KPa, ρ = 0.9375 kg/m^3 and T = 270 K. The solution for this model is converged at 472th iteration. The result is shown as velocity, pressure, temperature contours and cL plot as shown below.

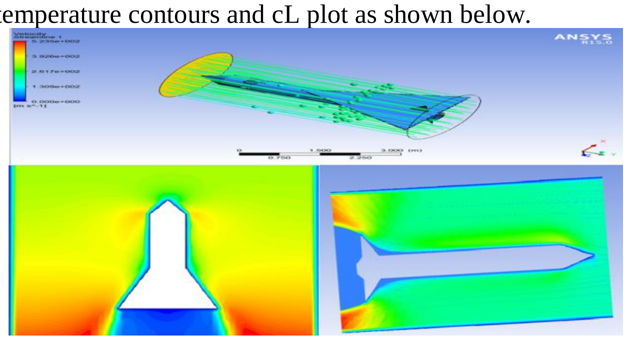

Fig. 3. Velocity Contour.

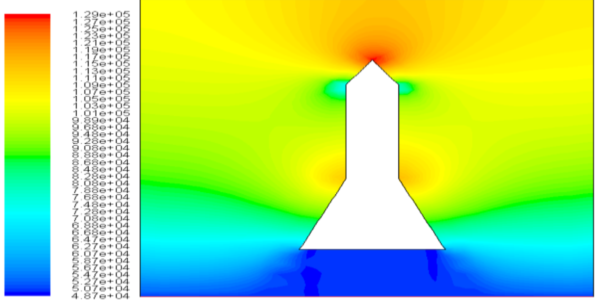
Fig. 4. Pressure Contour.

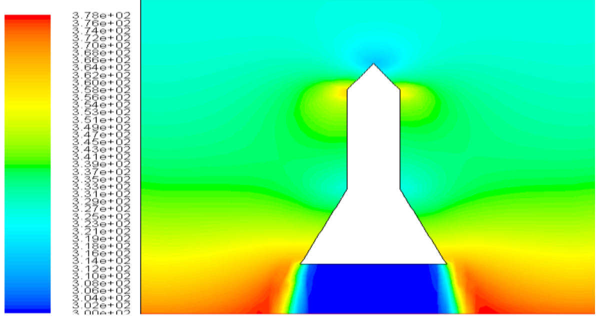
Fig. 5. Temperature Contour.

From the above contours, at the converging points pressure and temperature increases and decreases at the diverging points. The velocity is inversely proportional to the pressure in fluid domain. The velocity range in fluid domain is 523-139 m/s, pressure range is 1.29-0.4 bar and temperature range is 300-378 K. All the above parameters obtained are within the bearable range for a common flight.

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As it is the high speed subsonic missile, there is no shock waves are recorded. The below cL plot from fluent shows the cL value is 0.2 and its corresponding lift is 16465.5 N. Here the lift value is lower than lift calculated by theoretical calculations. However the lift produced is far higher than the drag produced and weight acting on the lambda missile. Hence the flight condition is easily attained.

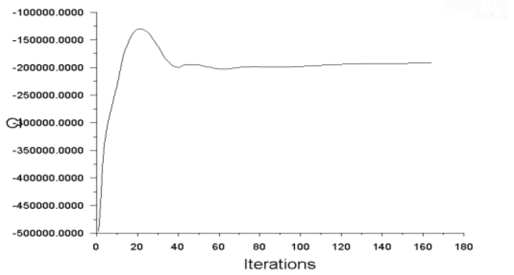

Fig. 6. cL Plot.

B. *Structural Analysis*

There are four forces such as lift, drag, thrust and weight are acting in the missile during flight. The structure is analyzed with this four forces acting on it in corresponding coordinates. The total deformation produced in structure is just 3 mm which is completely negligible. The structural analysis gives maximum stress produced in the missile body is 98.5 MPa whereas the structure strength is 250 MPa. Hence the structure is genuine for flight. **AUTHORS**

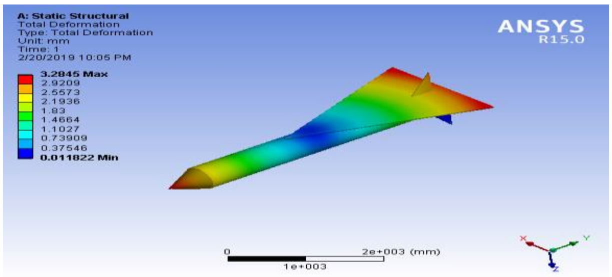

Fig. 7. Total Deformation.

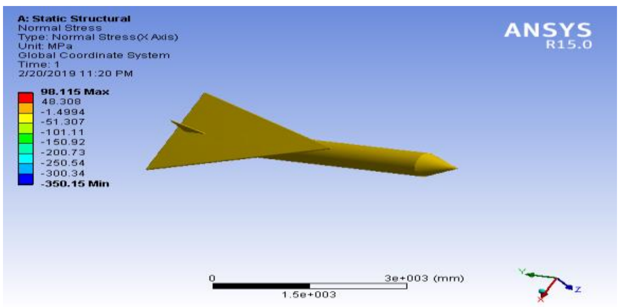

Fig. 8. Stress in Structure.

VII. CONCLUSION

The lambda missile with delta wing is designed with appropriate dimensions and tested with all flying conditions. Both the theoretical and software result shows the missile has good flight condition and the structure is genuine throughout the mission. This lambda missile enables us to handle huge warhead for long range and carryout the large scale destruction. Lift production reduces the fuel consumption and makes the missile to climb high as ballistic missiles do. The wing fall mechanism in missile upon decent reduces the drag and enables to hit the target harder. Due to the lift, the lambda missile can climb up high. Thus it can be used as the ballistic missile. As the lambda missile can act as aircraft, for any operation to be carried out need of fighter aircraft is avoided. Further the missile model is created with this scaled down design and will be tested with wing tunnels to obtain the real time results.

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