International Journal of Latest Trends in Engineering and Technology
Vol.(10)Issue(3), pp.190-193
DOI: http://dx.doi.org/10.21172/1.103.33
e-ISSN:2278-621X

FLOW INVESTIGATION STUDIES OVER AN AXIS SYMMETRIC SPIKE INLET

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Abstract- In this project the performance of the intake at various cone angle and various angle of attack is investigated. The design of the axis symmetric spike inlet of miniature ramjet engine is designed by using of conic shock tables, Isentropic flow table and GASTURB code and it's also used for aerodynamic performance prediction. The flow field through the proposed geometry was computed using the over flow code, and small modification are made in inlet cone geometry. The model of inlet at various cone angle are built using CATIA software and surface flow visualization for different angle of attack are obtained from ICEM – CFD software.
Keywords – Axis symmetric spike inlet, isentropic flow, CATIA, ICEM – CFD

1. INTRODUCTION

1.1 Inlet–

The inlet functions to capture and decelerate air prior to entry into the compressor As air flows around the inner body it is squeezed into the narrow opening(INLET)around it. This reduces the speed of the entering air, converting high velocity to higher pressure. While the inlet is often optimized for cruising conditions, it must provide adequate mass flow during all other engine operating conditions. At higher supersonic speeds, due to the nature of shock waves, the best inlet must have a variable geometry. These often produce one or several oblique shocks, as well as a normal shock, to reduce the flow to subsonic speed. They also have the ability to aid in compression, and in the case of a ramjet do all the compression.

1.2 Inlet Cone –

The main purpose of an inlet cone is to slow the flow of air from supersonic flight speed to a subsonic speed before it enters the engine. At supersonic flight speed a conical shock wave, sloping rearwards, and forms at the apex of the cone. Air passing through the conical shock wave (and subsequent reflections) slows to a low supersonic speed. The following two parameters are used to analyze the intake performance of a propulsion system.
a) Total Pressure Recovery Ratio b) Distortion

1.3 Ramjet –

A ramjet needs a constant air supply for best operation. In practice this turned out to be hard to achieve. Air intake design was critical for the design of the Ramjet. The simple air inlet was not prone to oscillations when heat release from ignition or the presence of a booster blocking the nozzle reduces air flow in the engine. Thrust is related to volume of airflow, so maximum flow is desirable. However, it is difficult to achieve reliable ignition with a high airflow. As the airflow increases in speed it becomes more difficult to keep the flame in the desired position in the burner - it tends to blow farther back in the burner and eventually blows out the nozzle, extinguishing the engine. High air speeds also reduce the time for fuel burning causing incomplete combustion in the engine. Stabilize airflow needed to reduce the speed of the air passing through the engine without reducing the volume of air passing through.
Sudden changes in airflow can blow out the flame or cause an over rich mixture and reduced thrust. Engines could not maintain efficient combustion for long periods at high altitudes or high airspeed. A better air inlet design was needed.
Ramjet air inlet reduced air speed to velocities suitable for the combustion system and produced the highest practical pressure .At supersonic speeds air velocity is first reduced by passing through conical shock waves from the tip of the compressor cone. Then the air is compressed near the intake lip in a normal shock wave (a shock wave perpendicular to the surfaces of the diffuser) to produce subsonic flow. The third stage is the subsonic diffusion behind the compressor body to give high pressure at the combustion chamber.

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2. COMPATIBILITY ASPECTS OF RAMJET INTAKE DESIGN

2.1 Inlet total pressure recovery ratio –

Total pressure recovery defined as the measure for the efficiency of the Ram compression of an intake and is the mean value of the total pressure at the engine entry plane (or an agreed-upon interface plane AIP) divided by the total pressure of the free stream flow.

2.2 Distortion –

Distortion exhibits exceedingly high values both at both low and high intake mass flows, indicating unstable intake flows and propulsion performance. Usable working range is limited to the intake mass flows between these two boundaries.

Relationship among the pressure recovery ratio (η), distortion (ϴ), intake mass flow rate. –

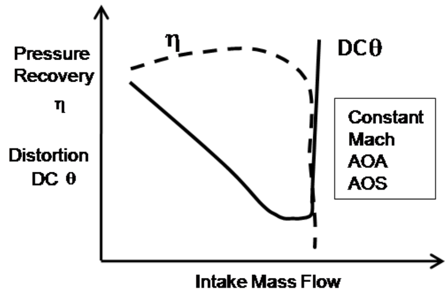

Figure 1 .Relationship among η,ϴ,Mass flow rate.

3. OBJECTIVES AND SCOPE OF THE PROJECT

While analyzing and designing the ramjet the intake part very important why because it is the part which will does the compression process without out any rotary mechanism. The performance (compression) in the Intake is directly related to the total pressure recovery ratio and distortion .in this project the various intake performances described in terms of pressure recovery ratio by changing the inlet cone angle with different angle of attack.

From basics the pressure in direct proportional to the area .so by changing the area the intake will change the pressure of the intake. the change in intake area is done by changing the inlet cone angle .the increase in inlet cone angle increase the cone cross sectional area at the same time it reduce the area of the intake .so the pressure get increased that is the kinetic energy of the fast moving air is converted into pressure entry, the velocity of the air decreased due to this transformation.

4. MODELLING PROCESS

Inlet geometry –

Combustion Mach number = 0.15

Cone angle= 10 degree

Combustion chamber Area = 6.0988× 10^{-4}

Inlet exit area = 7.8× 10^{-4}

Inlet entry area = 3.1571× 10^{-4}

Inlet boundary condition –

Inlet temperature=1588.7k

Inlet pressure= 171.072pa

Altitude= 59000ft

Inlet Mach number= 2.069365

Inlet mass flow rate= 0.3089kg/s

5. MODEL GENERATION (At cone 12.5°)

5.1 CATIA model –

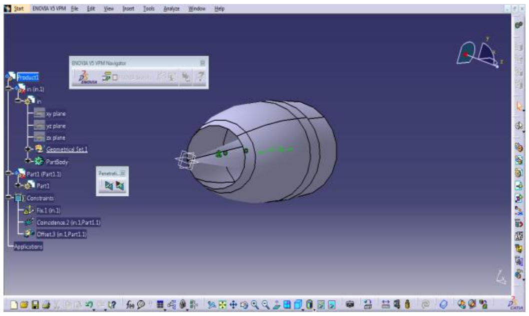

Figure 2 .Inlet CATIA model at 12.5°

5.2 Pressure contour –

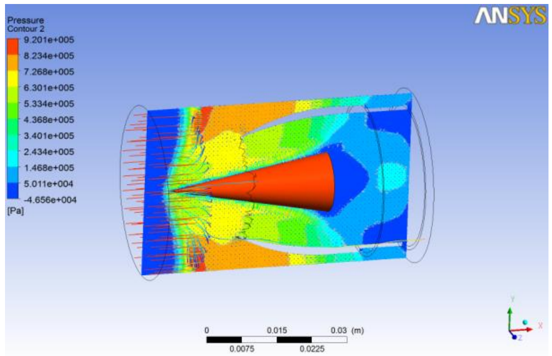

Figure 3. Pressure contour at 12.5°

5.3 Velocity contour –

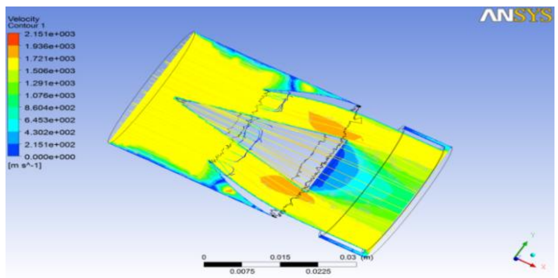

Figure 4. Velocity contour at 12.5°

5.4 Mach Number contour –

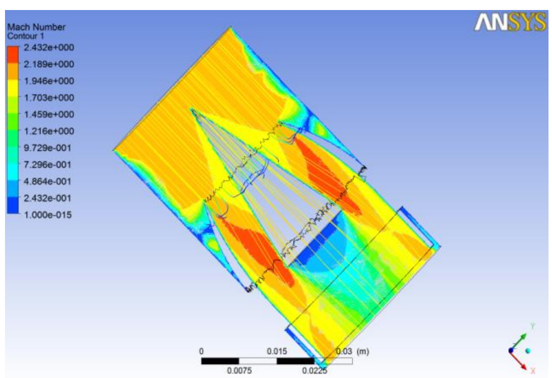

Figure 5. Mach Number contour at 12.5°

Description

=171.073pa

=158.379pa

=2.06627

=1.69253

= 1652.38m/s

=1441.58m/s

=1441.58m/s

Pressure recovery ratio = 0.9257

4. TABLE OF COMPARISION

4.1 Performance Of Spike Inlet At Different Cone Angle

SPIKE INLET CONE ANGLE	AT ENTRY CONDITION			AT ENTRY CONDITION			PRESSURE RECOVERY RATIO (P2/P1)
	P1(Pa)	M1	VI(m/s)	P2(pa)	M2	V2(m/s)	
10°	171.070	2.05866	1648.95	142.81	1.72918	1458.77	0.8345
10.5°	171.068	2.06518	1651.77	148.81	1.83885	1523.02	0.8699
11°	171.054	2.06626	1652.24	153.46	1.70425	1451.26	0.8971
11.5°	171.071	2.06636	1652.28	154.807	1.71139	1454.45	0.9007
12°	171.069	2.06647	1652.33	156.441	1.73479	1466.71	0.9145
12.5°	171.073	2.06627	1652.32	158.379	1.69253	1441.58	0.9257

The above table shows the performance of ramjet intake at various cone angles at zero degree angle of attack. At angle of attack, cone angle of gives the increasing in pressure recovery ratio comparing to the other five angles. The spike inlet analyzed at various angle of attack of both positive and negative angle of attacks. The results are slightly varied from angle of attack

5. RESULT AND CONCLUTION.

A method for preliminary design of a three dimensional spike inlet has been proposed and implemented in this paper, with the objectives of maximizing the total pressure recovery and matching the engine mass flow demand. The result of total pressure recovery for on-design condition is considered acceptable according to the comparisons with experimental data and CFD simulation. A method to estimate the total pressure recovery for off design conditions was also proposed and implemented in this paper. The results for off-design conditions show this method is acceptable.

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