International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 11 Nov 2021, pp: 869-874 www.ijaem.net ISSN: 2395-5252

Design and Analysis of Scramjet Engine Inlet at Various Conditions

Arunraja.K.K(Assistant Professor),
Sangaralingam.N(Student), Thawood Afif.A.A(Student),
Venkatesh.K(Student), Karthick.M(Student)
Department Of Aeronautical Engineering, Hindusthan Of College Of Engineering And Technology

Submitted: 10-11-2021 Revised: 24-11-2021 Accepted: 27-11-2021

ABSTRACT

Scramjet inlets are an important part of their operation and their design has important implications for overall engine performance. Therefore, the forward-facing position of the engine inlet should be consistent with the body position of the vehicle. These geometric changes have a dramatic effect on the flow of several elements. Air intakes incorporating various ramps that produce oblique shocks followed by cowl shocks are selected to increase the capture of air masses. Disruptive shock may force the boundary layer to separate from the wall, resulting in a total loss of pressure gain and a decrease in the efficiency of the entry. Design an entry point to meet requirements such as lower position pressure, high vertical pressure and gain temperature and flow reduction to the required Mach number. A two dimensional analysis is being done on this project.

I. CHAPTER-1 INTRODUCTION

Despite the wide range of applications that can be done with scramjet technology, the car must first be moved to a Mach number high enough for the scramjet to start. This requires, depending on the target system, one or two additional systems to move the vehicle to accelerate the initial scramjet speed.

The scramjet is made up of three basic components: the converging inlet, in which the incoming air is pressed; combustor, in which gasoline gas is heated with atmospheric oxygen to produce heat; and a diversion pipe, in which the hot air is accelerated to produce a push.

BASIC PRINCIPLE

Scramjets are designed to operate in a hypersonic aircraft government, apart from turbojet engines, and, along with ramjets, close the gap between high efficiency turbojets and highspeed rocket engines. Although the flow from transonic to low supersonic velocity may be reduced in these cases, doing so at high speeds results in a significant increase intemperature and loss of total flow pressure. Scramjet engines operate on the same principles as ramjet, but do not reduce the flow to subsonic velocities. Instead, the scramjet combustor is supersonic: the inlet reduces the flow of the lower Mach number to burn, after which it is accelerated to the higher Mach number by mouth.

DESIGN PRINCIPLE

The scramjet is made up of three basic components: the converging inlet, in which the incoming air is pressed; combustor, in which gasoline gas is heated with atmospheric oxygen to produce heat; and a diversion pipe, in which the hot air is accelerated to produce a push. Therefore, no moving parts are required for scramjet. In comparison, conventional turbojet engines require multiple rotating compressor rotor components, as well as multiple rotating turbine components, all of which add weight, complexity, and a large number of engine failure points.

APPLICATION OF SCRAMJET ENGINES

Unlike rockets, scramjets do not need to be fitted with an oxidizer in the aircraft as it is an air-conditioning engine, which collects oxygen in the atmosphere. This reduces the required weight of the movement system and fuel, resulting in a permissible loading wall or increased width.

There is a range of possible applications for scramjet engines, including missile propulsion, hypersonic cruiser propulsion, and part of the stage space access system. It turns out that in Mach numbers more than 6-7, the only available way to move rockets and scramjets.

SCRAMJET INLET

The main purpose of the air inlet is to compress the supersonic flow into the subsonic flow and to disperse the state so that the correct burns occur. Also provide the amount of air needed in the engine to ensure stable flow and keep the amount of pressure loss is minimal. In hypersonic cases inlets are often called Inlet diffusers

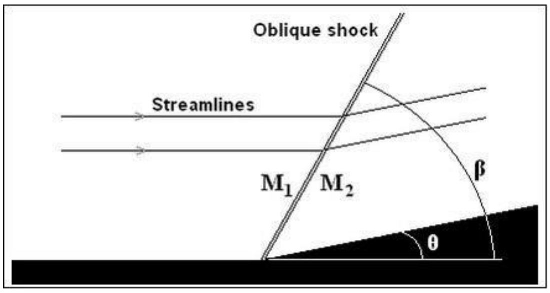
These inlets are usually longer than the external congestion setting, but also the leakage flow when operating under Mach design number. Depending on the amount of internal pressure, however, mixed pressure inlets may require flexible geometry to start.

SHOCK WAVE

Shock not to continue on the fluid flowing too much. Fluid crossing the stationery shock front rises abruptly and is irreversible under pressure and rapidly declines. The common shock of such a plane is easy to analyze. We will not go into details about the common shock as the presence of oblique shocks applies to our project.

OBLIQUE SHOCK

Oblique shock wave, in contrast to normal shock tends to be related to the event of a river flow. It will occur when the supersonic flow meets an angle that effectively converts the flow into its own and compresses. The rising streamlines are similarly diverted after the shock wave.



II. CHAPTER-2 LITERATURE SURVEY

Analysis and Design of a Hypersonic Scramjet Engine with a Transition Mach Number of 4.00,2009, The University of Texas at Arlington, TX 76019.

The paper describes the performance of the scramjet inlet design test free of Mach number 4.00 where the engine starts. Part parameters and price parameters for the design of the scramjet inlet are provided. Design performance therefore investigates acceptable performance values if a reduced Mach number is a desirable target.

Design and Analysis on Scramjet Engine Inlet, 2013, Muffakham Jah College of Engineering and Technology, Hyderabad

This paper outlines the basic presentation of a scramjet engine. Describes performance, current scramjet engine challenges and design limitations. There are four methods outlined to choose the best way to design an inlet with a low value starting Mach with analytical calculations.

A new approach for the design of hypersonic scramjet inlets,2012, Department of Mechanical Engineering, Indian Institute of Technology Hyderabad, Hyderabad, Andhra Pradesh.

This paper describes a new way of designing hypersonic scramjet inlets using flexible gas relationships and a method aimed at obtaining high-quality inlet geometry with a significant pressure return to a fixed Mach free number. They have chosen a shock-on-lip state that guarantees abundance

Performance Analysis of Scramjet Inlet by L.Hariramakrishnan, K.Nehru , T.Sangeetha.

This paper is based on the full functionality of the scramjet model shown and launched and resolving settings are taken. Computer analysis described throughout the paper as a Design tool, matchmaking, troubleshooting method, and background of the scramjet entry model and illustrated with Mach contours and line graph. (K. Nehru, et.al, 2017)

SUMMARY

So far we have had detailed information about scramjet engine, scramjet inlet its classification and usage etc. A brief description of the shocks, types and technical challenges the scramjet engine faces. We have collected Literature papers based on incoming papers and analysis. In a literature review, we obtained a detailed idea of how we can design an entry and analysis site by ANSYS Fluent CFD.

III. CHAPTER-3

METHODOLOGY

Design

The creation of geometry in CATIA is done with the necessary instructions from the toolkit to create geometry. The geometry creation tool pad contains scramjet entry specification with limit, ramps, ramp angle and length, cow rotation and shrinkage rate.

- Three Ramped Inlet model with a rounded front and a sharp deviation.
- Two-way Ramped Inlet model.
- Axisymmetric Inlet model with deviation.

External pressure occurs with a slanted shock from a series of external pressure ramps near the front and internal pressure begins on the cowl lip. The fluid then passes between the cow and the inner person through a series of internal shocks and in this process the flow is continuously reduced and then into the isolator, where the compressed flow is brought into the combustion chamber by supersonic velocities.

As the number of internal ramps increases, the cowboy descent will be approximately the smooth curve provided by Prandtl Meyer's intropic relationship, and the facial contouring concert will have one point.

STEP 1 : The modeling is done in ANSYS Design modeler .

STEP 2 : The inlet is designed using parameters obtained from reference paper.

Leading edge	**Sharp**
No. of ramps	Three
Ramp angles	5.7˚,11˚,14.3˚
Ramp length(mm)	75,69,35
Cowl angle	0˚
Throat area (mm)	35

STEP 3: The design is drawn like 1st model, in place of cowl, the upper body is mirrored to make them axisymmetric.

STEP 4: Create a domainin Rectangular shape and draw lines to split faces.

STEP 5: For adding surfaces, Concept Surface from sketches.

STEP 6: Face split is done as in above model.

STEP 7: Add a material to the surface.

STEP 8: Using Tools Face split option, Domains will be splited into separate faces.

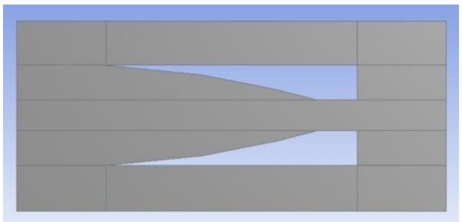


Fig. 3.1.2 Axisymmetric Inlet model with Sharp leading edge

COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to analyze and solve problems involving fluid flow. Computers are used to perform the calculations needed to simulate the free flow of fluids, as well as the interaction of fluids (liquids and gases) with areas defined by boundary conditions.

CFD is used in many research and engineering problems in many fields of study and industry, including aerodynamics and aerospace analysis, climate simulation, natural science and natural engineering, industrial design and analysis, biological engineering, fluid flow and heat transfer and heat transfer.

ROLE OF CFD

CFD is also a method by which basic fluid mechanics can be studied. Through the use of highdensity computing computers, CFD is often used to study how liquid behaves in complex situations, such as boundary transformation, chaos, and sound production, with applications throughout and outside aerospace engineering.

WHY ANSYS?

ANSYS analytics software allows you to solve complex architectural engineering problems and make better, faster design decisions. Ansys analytics software is used in all industries to help engineers improve their product designs and reduce the cost of physical testing.The power of the ANSYS meshing helps to reduce the amount of time and effort spent to get accurate results. Since meshing usually takes up a large portion of the time it takes to get imitation results,

- CFD software known for its advanced physics modeling and renowned for industry leading accuracy.
- Modern user-friendly interface.
- Single window workflow – pre to post-processing.

IV. CHAPTER-4

RESULT AND DISCUSSION

Two flow field simulations will be performed using FLUENT. Statistics are verified by imitating the hypersonic inlet in the Mach number you want. Border conditions and model structures are defined as references.Complete flow forecasts clearly show that the models of turmoil have a significant impact on the flow of high Mach numbers. The k-ε model predicts flow characteristics compared to the k-ε model. The results of the 2D flow statistics were present.

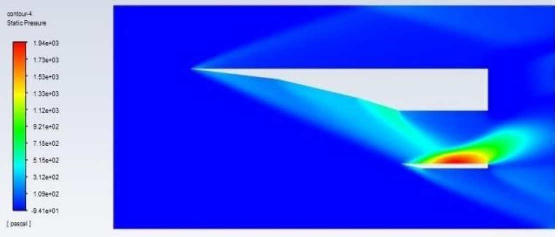
MODEL 1

Parameters	Values
Mach Number	4
Pressure	153.84
Reference temperature	221 K
Turbulent Viscosity	0.01
Turbulent Ratio	10

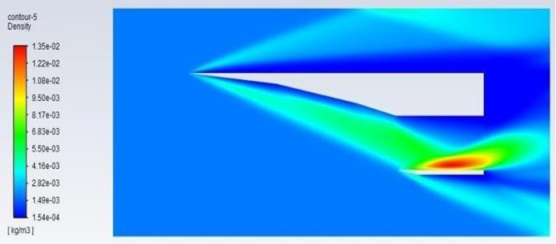
MODEL 2

Parameters	Values
Mach Number	5
Pressure	536.1
Reference temperature	K
Turbulent Viscosity	0.01
Turbulent Ratio	10

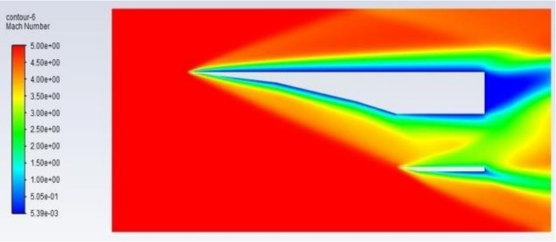
Model 1: Three Ramped Inlet model with Sharp leading edge



PRESSURE CONTOUR

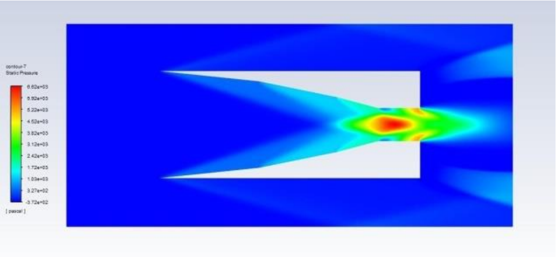


DENSITY CONTOUR

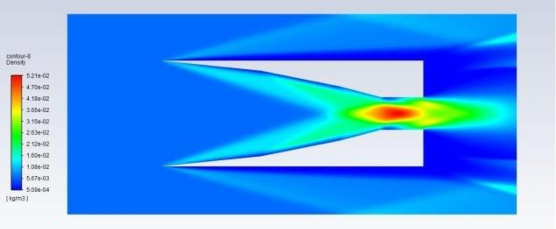


MACH CONTOUR

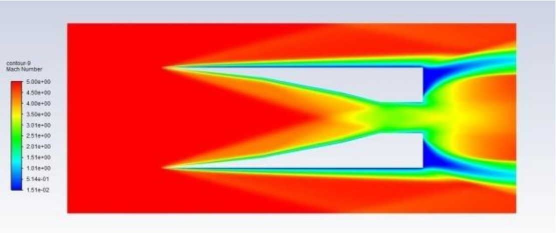
Model 2: Axisymmetric Inlet model with Sharp leading edge



PRESSURE CONTOUR



DENSITY CONTOUR



MACH CONTOUR

Discussion :

The simulation contours obey the flow pattern which is analysed here as plots to compare the performance of the models with respect to these designs. Here, is to compare the standard parameters such as Pressure, Density and Mach number.

Three Ramped Inlet model with Sharp leading edge

MACH NUMBER	PRESSURE CONTOUR	DENSITY CONTOUR	MACH NUMBER CONTOUR
4	0.921 x 103	6.83 x 10-3	2.50

5	1.99 x 103	1.93 x 10-2	2.10

Axisymmetric Inlet model with Sharp leading edge

MACH NUMBER	PRESSURE CONTOUR	DENSITY CONTOUR	MACH NUMBER CONTOUR
4	1.17 x 10^{3}	8.85 x 10^{-3}	2.00
5	3.12 x 10^{3}	2.63 x 10^{-2}	2.51

The formation of Oblique shock results in increase of pressure which reduces the velocity.
Due to the reduction of velocity at inlet throat area, maximum compression is achieved.

V. CONCLUSION

When the flow enters the inlet pressure increases after the flow of the cowl pressure increases again due to the collision. The pressure drops as you exit. Following a stressful situation continues.

The flow enters the entry point at Hypersonic speed due to the increase in pressure and the collision speed begins to decrease within the entry point. After a certain flow the speed increases and the supersonic flow enters the combustor.

Analysis performed with the same ANSYS FLUENT for different design models. Among all the designs, the design with the Axisymmetric model produced better results than other designs. In this activity look at the pressure, congestion and conditions of many different ramp models.

REFERENCES

[1]. M. K. Smart, “Design of three-dimensional hypersonic inlets with rectangular-toelliptical shape transition,” J. Propul. Power 15(3), 408–416 (1999),GoogleScholarCrossref.
[2]. Analysis And Design of A Hypersonic Scramjet Engine With A Starting Mach Number of
[3]. 4.00 By Kristen Nicole Roberts,August 2008.
[4]. Kerrebrock, Jack L. "Some Readily Quantifiable Aspects of Scramjet Engine Performance." Journal of Propulsion and Power, Volume 8, No. 5, September-October 1992.
[5]. 4. Heiser, William H., David T. Pratt, Daniel H. Daley, and Unmeel B. Mehta. Hypersonic Airbreathing Propulsion. Washington, D.C.: American Institute of Aeronautics and Astronautics, 1994.
[6]. N. Om Prakash Raj and K. Venkatasubbaiaha) Department of Mechanical Engineering, Indian Institute of Technology Hyderabad, Hyderabad, Andhra Pradesh 502205, India (Received 24 April 2012; accepted 1 August 2012; published online 30 August 2012).
[7]. COMPUTATIONAL ANALYSIS OF SCRAMJET INLET Murugesan S1, Dilip A Shah2 and Nirmalkumar D3 123Department of Aeronautical Engineering, Hindustan Institute of Technology and Science, Chennai, India, International Journal of Recent Scientific Research Vol. 6, Issue, 4, pp.3391-3403, April, 2015.
[8]. Scramjet Inlets Professor Michael K. Smart Chair of Hypersonic Propulsion Centre for HypersonicsThe University of Queensland Brisbane 4072 AUSTRALIA.