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Performance Analsyis of Mixing Chamber of a Ram Jet Engine

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ABSTRACT

A ram jet engine sometimes referred to as a flying stovepipe or an athodyd is a form of airbreathing jet engine. That uses the engines forward motion to compress incoming air without an axial compressor or a centrifugal compressor. Mixing chamber is the place where the oxidizer and fuel is mixed. In the mixing chamber proper oxidizer and fuel ratio is required for efficient combustion. Mixing chamber plays an important role in combustion process. A fuel is a substance that burns when combined with oxygen producing gas for propulsion. An oxidizer is an agent that releases oxygen for combustion process. The ratio of oxidizer to fuel is called the mixture ratio. In this project performance of oxidizer and fuel mixing chamber will be analyzed.

KEYWORDS: Ramjet engine, Oxidizer, mixture chamber, mixture ratio, Combustion.

1. INTRODUCTION

Ram jet was air breathing jet engine that operates with no major moving parts. It relies on the crafts forward motion to draw in air and on a specially shaped intake passage to compress the air for combustion is self-sustaining. As in other engines, forward thrust is obtained as a reaction to the renaward rush of hot exhaust gases. Ram jets work best at speeds of mach2 and higher. Since ramjets develop no static, some means of launching them at high velocity is required. The Brayton cycle is a thermodynamic cycle that describes the working of the gas turbine engine and others. It is named after George Brayton the American engineer who developed it, although it was originally proposed and patented by Englishman john barber in 1791. It is also sometimes known as the joule cycle. A ramjet is designed around itsinlet. An object moving at high speed through air generates a high-pressure region up stream. A ramjet uses this high pressure in front of the engine to force air through the tube, where it is heated by combusting some of it with fuel. It is then passed through a nozzle to accelerate it to the supersonic speeds.

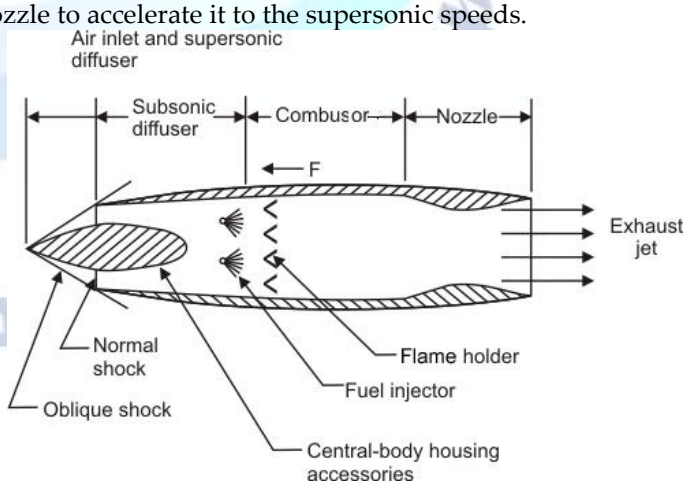

Fig:1. Ramjetengine

This acceleration gives the ramjet forward thrust. constant inlet speed of Mach 0.5 (170 m/s; 610 km/h). In this paper we are doing research on performance analysis of mixing chamber of ram jet enine by the help of air and fuel supply system to mixing chamber.

2. REALATED WORK

Today, we will extend that jet enine coverage to woeking of ramjets and pulsejets, in which the basic cycle understanding that you have acquired for jet engines would be useful. We will also look at the cycles of ramjets and pulsejets which are similar to the cycles that you have done;so that would be quite easy for you to extend your understanding.The ramjets and pulsejets actually histrocially precede those of the turbojet engines.They had actually been used for flying aircraft during the worldwar 2 and as a result of it understanding of hoe ramjets and pulsejets actually work, had been created quite some time back[1].The present scenario is modled towards the high-speed vehicle such as air breathing engines. Ram jet enine is also called as air breathing engine. There are several combinations of engines are performing well nowadays to achieve supersonic and above speed with great performance in preliminary obstacles. Combustion mode transistion of the dual -mode scram jet engine has been explored by R.F. Cao et al. with the help of thermodynamics analysis. Mechanism of controlled combustion in scramjet is challenging is very less.[2] Although ram jet has the advantages of high-speed flying and higher specific impulse, the performance parameters will decline seriously with the increase of flight mach number and flight height. Therefore, the investigation on the thermodynamic performance of ram jet is very crucial for broadening the working rane. In the study a typical ramjet model has been employed toinvestigate the performance characteristics at wide working conditions. [3]. Based on the aforementioned research works, a typical combustion chamber model of the powder fuel ram jet is created. The oxidizer, air, enters the combustion chamber through two separated air inlets mounted on the combustion chamber along the streamwise direction. The air supplied from air inlet 1 and air inlet2. [4]. Jet propulsion is a made of locomotion in which the momentum of expelled matter imparts a reaction force to a body. A jet engine is a reaction engine that generates thrust by discharing a fast-moving jet of fluid in accordance with newtons law of motion.[5]. The numerical simulation of an integrated liquid-fuelledram jet engine comprising supersonic air intake, subsonic combustor and a convergent -divergent nozzle has been carried out and the results are discussed in the paper.[6].

Suspersonic combustion ramjet(scramjet) is a variant of ramjet in which the combustion takes place at supersonic velocity. The flow physics inside the scramjet combustor is quite complex due to the fact that the mixing and completion of the combustion take place in a short time which is of the order of milliseconds. The effect on combustion performance and thereby the energy efficiency on using strut-based falame stabilizer is evakuated at different positions. [7]. When a vehicle flies at a supersonic speed, streamlined forces become a funademntal issue. when the drag force is high, the fuel consumption must be structured kennly tongive a satisfactory air gracefully to engines. This paper presents the design methodology for a mixed compression intake type desing using CFD investigation. The enine was strucures at mach 3 and three ramp anles at high altitude and utilized to give air to solidfuel ramjet. Inlet backpressure effect the overall efficiency of pressure, and the degree of flow distortion was characterized. The engine inlet is of prime significance for all air breathing impetus framework. Its significant capacity is to gather the atmospheric air at free stream mach number, back it of (mostly likely including an altar of course [8].

3. PROPOSED WORK

In ram jet engines mixing chamber generally referred as combustion chamber plays an important role in trust producing. In this paper we are discussing about air and fuel supply system of mixing chamber of a ram jet enine which is different from conventional ram jet engine.

3.1 Fuel supply system to mixing chamber of a ram jet engine

Fuel supply system plays an important role in combustion of mixing chamber. In fuel supply system we are usinn Pressurized fuel pump which are manfactured by bosch company and used in piago autos. The pressurized fuel pump will operate by the working principle of converting rotory motion to reciprocating motion. We are using a cam shaft follower for converting rotory motion to reciprocating motion. An ½ hp electric motor is connected to the cfuel am shaft. While the motor rotates the cam shaft along with knife edge follower attached to the motor will rotates and pressurized fuel pump sitted on knife edge follower. The

knife edge follower pushes the plunger in the pressurized fuel pump.

A fuel tank is placed at a certain height. At bottom of fuel tank, a pipe is attached to it. The fuel is supplied to the inlet of the pressurized fuel pump, the fuel flows with the help of gravity. When the fuel enters into the pressurized fuel pump then the knife edge follower pushes the plunger then the fuel with high pressure comes out from the fuel pump. The outlet of fuel pump is connected to the nozzle and nozzle is attached to the mixing chamber.

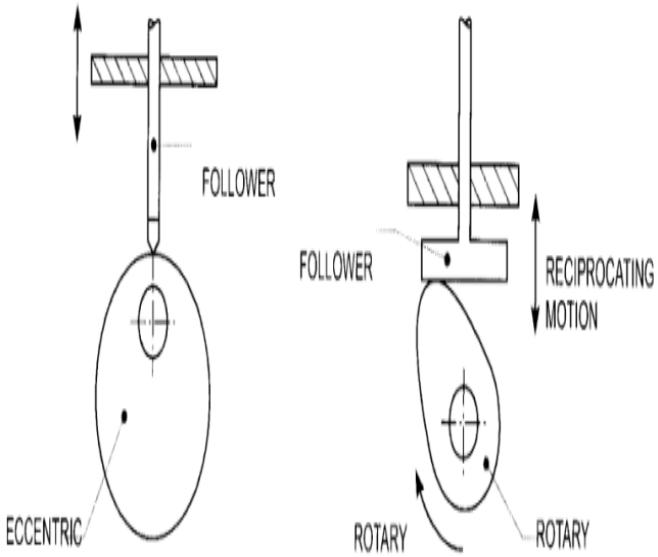

Fig: 2. Conversion of rotory to reciprocating motion.

3.1.1 SPECIFICATIONS OFMOTORS

- Nominal power: -42KW
- Power during 30s: -95KW
- Max speed: - 1480rpm
- Max torque during 30s: -235Nm
- Nominal Voltage: - 370V
- Max Voltage: -440V
- Nominal current: -120A
- Max current: -230A
- Efficiency: - >96% for full load and speed>2000rpm

Fig: 3. ½ hp motor

Fig:4. Cam shaft with knife edge follower

The exit pressure of fuel at the nozzle of our fuel supply system to mixing chamber of a ram jet engine is **140kp/cm2**

3.1.2Specifications of fuel pressure guage

Unit of pressure guage = Kp/cm2 and lb/sqin

Fuel pressure at exit of nozzle = 140kp/cm2

Fig:5.Fuel pressure guage

Fig:6. Fuel supply sysyem to mixing chamber of a ram jer engine

3.2 Air supply system to mixing chamber of a ram jet engine

In this, the air supply system is done with the 5kilograms Mildsteel gas cylinder. For this cylinder we attached an air pressure gauge which shows the pressure of air in the units of $^{kg}/_{cm^2}$ or *PSI.* And then we inserted an air pin to the cylinder to fill air into the cylinder. We attached a regulator at the top of the cylinder, which is used to control the flow of air as per our requirement. We fill the air with a calculated pressure of **2.941Bar**.

Factor of safety for pressure valve = 3.5 to 6

For factor of safety 3.5 the pressure is 4.25 bar

Fig :7 .Thin cylinder

3.3 MIXING CHAMBER

3.3.1 WORKING PRINCIPLE OF COMBUSTION CHAMBER

The combustion process involves the oxidation of constituents in the fuel that are capable of being oxidized, and can therefore be represented by a chemical equation. During a combustion process the mass of each element remains the same. consider the reaction of methane and oxygen 8 This equation states that one mole of methane reacts with two moles of oxygen to from one mole of carbon dioxide and two moles of water. this also that 16g of methane react with 64g of oxygen to from 44g of carbon dioxide and 36g of water. All the initial substances that undergo the combustion process are called the reactants, and the substances that result from the combustion process are called the products. The above combustion reaction is an example of a stoichiometric mixture, that is, there is just enough oxygen present to chemically react with all the fuel. the highest flame temperature is achieved under these conditions however it is often desirable to operate a rocket engine at a "fuel-rich" mixture ratio and this mixture burns in the combustion chamber produces thrust and supply to the nozzle. The mixture ratio is defined as the mass flow of oxidizer.

3.3.2Design calculations of mixing chamber

Inlet dia of throat d1= 20mm

Area of throat = $\frac{\pi}{4}d1^2$

Area of throat (A_t) = 314 mm^2

Area of convergent = 5 times of area of throat

$A_c = 5 \times A_t$

Area of convergent = 5×31

Area of convergent (A_c) = 1570mm^2

Area = $\frac{\pi}{4} d2^2$

1570 = $\frac{\pi}{4} d2^2$

d2 = $\sqrt{\frac{1570 \times 4}{\pi}}$

d2 = $44.7 \cong 45mm$

length of convergent (l_1) = $\sqrt{\frac{Ac}{\pi}} \frac{1}{tan\beta}$

tan β = 35°

length of convergent (l_1) = $\sqrt{\frac{1570}{\pi}} \frac{1}{tan\,35°}$

tan 35° = 0.7002075382

length of convergent (l_1) = 26.72mm

dia of mixing chamber = 45mm

length of miximg chamber = 100mm

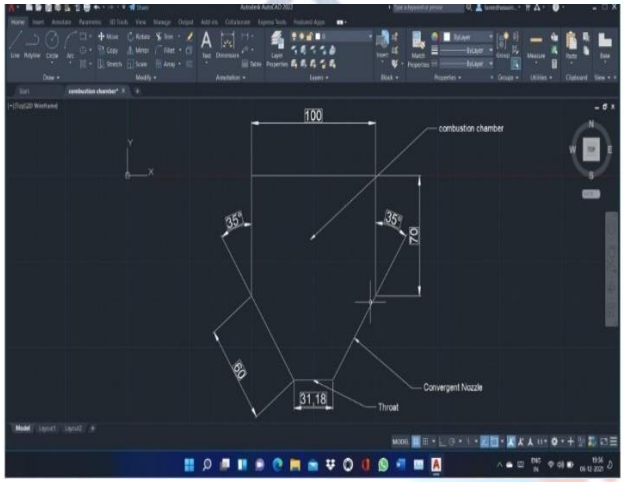

Fig:8. 2d drawign of mixing chamber with convergent nozzle

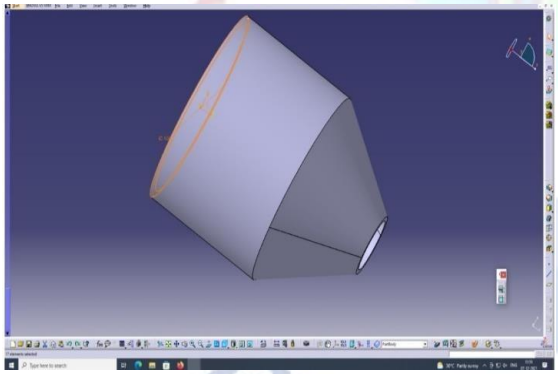

Fig:9.Catia v5 design of mixing chamber with convergent nozzle.

4. RESULT

In this paper we are proposeda air and fuel supply system to a mixing chamber of a ram jet engine. By this fuel system we gain the fuel pressure at exit of the system is 140kp/cm2 and the air inlet pressure to the mixing chamber is 2.941 bar. With the help of this air and fuel supply system we are making mixing chamber of a ram jet engine. The following are the dimesions of the mixing chamber.

- Inlet dia of throat = 20mm
- Outlet dia of throat = 45mm
- Inlet taper angle of throat = 35°
- Length of the mixing chamber = 100mm
- Dia of mixing chamber = 45mm

5. CONCLUSION

Inthispaper,with the help of welding fabricationmethod we are fabricated an air and fuel supply system to a mixing chamber of a ram jet engine which are different from the conventional ram jet engines.With the help of air and fuel supply systems we designed a mixing chamber of a ram jet engine according the exit pressure of fuel supply system and intake pressure of air to mixing chamber.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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