ABHIYAAN-2006

A National Level Paper Presentation

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Paper on

Scram Jet Engine for Hypersonic Flight

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ABSTRACT

With the dawning of the new scenario man wants speed to satisfy his demands, his needs, but this is not possible with the conventional jet engines due to the many constraints regarding the speed of jet engine and this gives birth to the very high speed engine which achieve even the hypersonic speed called as scramjet engine.

In the scramjet engine the design is made in such way that, without any working parts it achieve hypersonic speed.

INTRODUCTION

Since the down of human civilization, it has been man's strong desire to fly like a bird. This dream comes true with the invention of flying machines. The airplane. But still he is not satisfied; one thing which attracts him is speed. He would like to fly higher and faster, so the jet engines are invented. The hunger for the speed and the power goes on increasing. Therefore a passionate beast man is still going for new invention. One of the jewel in his hand is newly designed "scramjet engine".

This paper gives an overview of a 21st century engine "scramjet" which can attend a speed up to mach no 10 (8000 km/hr). Research is being carried out throughout the world by various organizations viz. NASA (National Aeronautics and Space Administration), NAL (National Aerospace Limited), QUEENSLAND University of Australia and also in India by DRDO (Defense Research and Development Organization) and ISRO (Indian Space Research Organization) on the same. All these organizations have their own rules and regulations to keep the information confidential. Scramjet technology depends upon ramjet and turbojet technology, which are the types of jet engine. So first turn towards the first engine.

JET ENGINES

During the Second World War, in 1939 the jet fighter named the Heinkel HE 178 built by Emst Heinkel became the world's first combat jet aircraft. Within two years, it was followed by the Gloster E 28/39 powered by a jet engine designed by WHITTLE.

How the Jet Engine works is based on the Newton's third law of motion- "To every action there is equal and opposite reaction". A gas turbine engine consists of three main parts. At its front is compressor, which is a series of fans that spin at very high speeds (around 16,000 revolutions per minute). These blades pull air in and send it through a channel that gets progressively narrow. As the air in and send it through a channel that gets progressively narrow. As the air moves through this channel, it is compressed until it is anywhere from 10 to 30 times more dense than it was to start with. Alternating with these spinning blades are the stationary fan blades also called stators, they are there to make the flow of compressed air move in a straight line rather than in swirling currents that would make the air burn less efficiently when it reaches the combustion chamber.

The combustion chamber is the second main section of a gas turbine engine. There, fuel- a refined form of kerosene, in the case of jet airplanes- is injected into the pressurized gas. When the engine is first started, igniter plugs are used to get the mixture burning. Once initial ignition is achieved, combustion is continuous, with the gas that is already burning igniting the fuel-and –air mixture that flows into chamber. Temperatures of around 2,500 degrees Fahrenheit are typical inside a gas turbine combustion chamber.

The third section of a jet engine is the turbine. As the hot gasses are expelled-at speeds well above 1,540 km per hour-they provide power in the form of thrust. They also turn a series of fans that are much like the blades found in the compressor portion of the engine. These fans in turn provide the power to turn those compressor blades.

Remember, it is the pressure exerted by the thrust is on the wall of engine itself and not the pressure of gas pushing against the outside air.

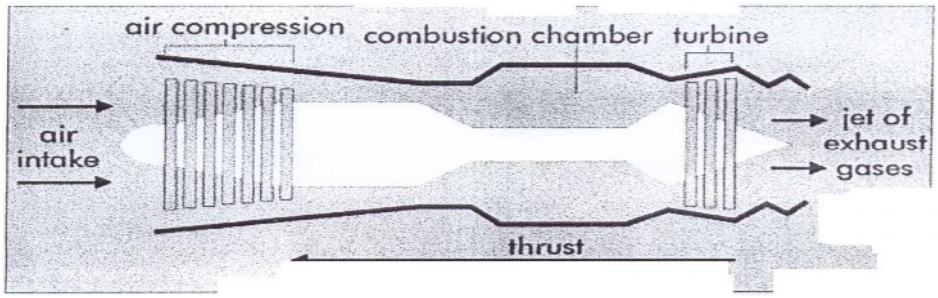

Fig.1 Schematic Diagram of Jet Engine Propulsion

TURBO JET ENGINE

Figure 2 shows the part of the turbo Jet Engine

1. Diffuser
2. The mechanical compressor
3. Combustion chamber
4. Mechanical turbine
5. Exhaust Nozzle

The function of diffuser is to convert kinetic energy of entering air in to a static pressure rise, which is achieved by the ram effect. After this air enters the mechanical compressor. Air compresses in the range of 6-16 pressure ratio.

After the compressor, air enters to the combustion chamber, the fuel nozzle feeds fuel continuously and continuous combustion take place at the constant pressure. The high pressure, high temperature gases then enters the turbine where it expand to provide enough power output from the turbine. A turbine is directly connected to the compressor and compressor and auxiliaries absorb all the power developed by the turbine. The main function of the turbine is to give power to compressor. After that gases leave the turbine they expand further in the exhaust nozzle and are ejected into the atmosphere with the velocity greater than the flight velocity. Thereby producing thrust for propulsion.

ADVANTAGES

1. The power of weight ratio of turbojet is about 4 times that propeller system having reciprocating engine.
2. Required low lubricating oil.

DISAVDVANTAGES

1. Very critical in structure.
2. The fuel economy at low operational speed is extremely poor.

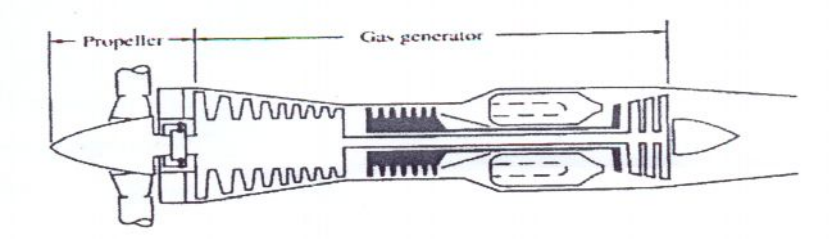

Fig. 2 Schematic Diagram of a Turbojet

RAMJET ENGINE

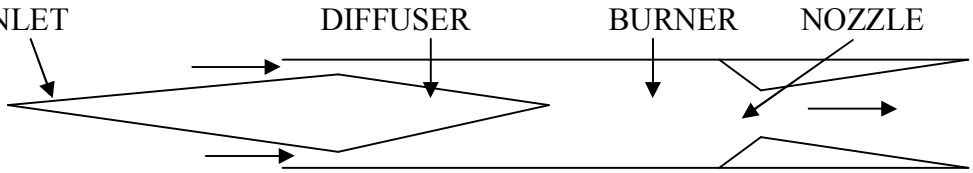

Fig.3. Schematic Diagram of Ramjet

Ramjets are the engines of choice if your goal is supersonic speed. Developed beginning in the 1950s, the ramjet flew for the first time in 1957 in an experimental aircraft developed by the French government. That plane set a speed record in 1959 of 1570.8 km per hour, and eventually hit Mach 2.19 or about 2156 km per hour. The SR71 Blackbird-a sleek, dark, high-flying spy plane-tops out at better than Mach 3. and in theory, at least, ramjets can achieve speeds approaching Mach 6, which translates to a stunning 6160 km per hour.

In the early 1900's some of the original ideas concerning ramjet propulsion were first developed in Europe. Thrust is produced by passing the hot exhaust from the combustion of a fuel through a nozzle. The nozzle accelerates the flow, and the reaction to this acceleration produces thrust. To maintain the flow through the nozzle, the combustion must occur at a pressure that is higher than the pressure at the nozzle exit. In a ramjet, the high pressure is produced by "ramming" external air into the combustor using the forward speed of the vehicle. The external air that is brought into the propulsion system becomes the working fluid, much like a turbojet engine. In a turbojet engine, the high pressure in the combustor is generated by a piece of machinery called a compressor. But there are no compressors in ramjet. Therefore, ramjets are lighter and simpler than a turbojet. Ramjets produce thrust only when the vehicle is already moving; ramjets cannot produce thrust when the engine is stationary or static. Until aerodynamic losses become a dominant factor, the higher the speed, the better a ramjet works. But since a ramjet cannot produce static thrust, some other propulsion system must be used to accelerate the vehicle to a speed where the ramjet begins to produce thrust.

In simplest terms, a ramjet engine is a long tube with a torpedo-shaped object at the front opening, which is called an inlet. Air rushing through the inlet is compressed between the sides of the tube and the torpedo-shaped body, whose nose is pointed at the front. Its

wider part, which sits inside the engine, slows incoming air down to subsonic speeds. Fuel is then sprayed into the air stream, and the mixture is ignited as it flows past a flame inside the combustion chamber. The resulting hot gasses are then ejected out of a nozzle in the back, yielding plenty of thrust according to third law of motion.

ADVANTAGES

1. Simplest type of gas turbine having no moving parts.
2. Cheap and require no maintenance
3. Due to absence of turbine, maximum temperature allowed ramjet is 2000 C as compared to about 900 C in turbojets.
4. Specific fuel consumption is better than other gas turbine at high speed and high altitude.
5. No upper limit of flight speed.

DISADVANTAGES

Since the compression of air is obtained by virtue of its speed relative to the engine, the take-off thrust is zero and it is not possible to start the ramjet without an external launching device.

WHAT IS SCRAMJET ENGINE?

The scramjet is acronym for ramjet with the "s" from supersonic and the "c: from combustion added to the front. This can achieve speed of mach no.10. in scramjets, the engine inlet is designed so it doesn't create as much compression as in a ramjet, allowing the air to zip through the engine at supersonic speeds. This reduces shockwave problem, somewhat. Even so, when fuel is injected into the onrushing air, small shock waves are created, so the combustion chamber must be able to withstand the pressure.

But the truly amazing thing about scramjets is they achieve this feat with no working parts. It turns out that once you reach hypersonic speeds the compressors and turbines essential to conventional jet engines aren't required. Instead, the sheer force of forward movement does most of the work of compressing the incoming air.

Scramjet making platform for the unmanned hypersonic fighter Craft, which seduces the Department of Defense throughout the world. Scramjet engine with rocket engine or turbojet engine may be capable of "single stage to orbit operation" (SSTO) in satellite launching program.

The simplest type of air breathing engine is the scramjet engine and simplified sketch of engine is given in figure.

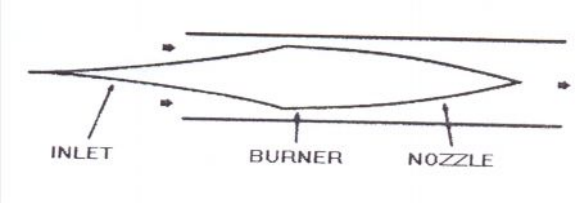

Fig.4. Scramjet Engine

PRINCIPLE OF WOKRING

Scramjet works on the same principle of Ramjet. In simple words, passages are provided for the various functions of engine. All the operations are done by the varying cross section of passages. There are inlet passage, diffuser passage, combustion passage and exhaust passage.

Basically in order to achieve the initial speed, a second engine is integrated in the Scramjet model. It may be rocket or turbojet engine. Scramjet start working above the speed of mach no 5 (3500 km per hour). As these are air breathing engines, air from the atmosphere enters at very high speed in the inlet passage. Since a Scramjet is different from the Ramjet in the sense that in scramjet the diffuser is merged with inlet. Hence the air from the atmosphere enters in the inlet section having very high velocity is reduced in diffuser section; thereby its static pressure increases. According the Gas law, (PV/T=C) temperature of air also increases when passing through the narrow cross section towards combustion chamber. Hot air flows in the combustion chamber and at this moment the propellant i.e. hydrogen (having a very low ignition temperature) are injected by the injector in the combustor. Where it gets self ignited within a millisecond and the combustion process is carried out at the supersonic speed. The fresh air supply to the diffuser builds up a pressure at the diffuser so that these burned gases cannot expand towards the diffuser. Instead, the gases are made expand in combustor towards tail eng. At the tail end there are ventury like structure having the two walls, one is fix and the other is movable shown in the figure. Movable wall is used for getting wide range of speed.

The “lifting body” shape also gives the lift so that it doesn’t need wings. The sharp shape of the nose, scramjet engine, and tail reduces drag so that the aircraft can cut through the atmosphere at such high speeds. Flying at “hypersonic” speeds-faster than Mach 5-can get really hot! Thermal Protection Systems (TPS) will keep the aircraft from burning up in the atmosphere. Some TPS materials will act like Space Shuttle tiles by insulating the vehicle from the intense heat of hypersonic flight. Other TPS will use water with anti-freeze,

hydrogen or other fuel to take away the heat from the hottest surfaces before being burned in the engine or released overboard

ADVANTAGES

1. Launching a scramjet-powered plane into orbit has huge advantages over the standard rocket-powered spacecraft. Today, rockets have to carry their own oxygen with them, which adds a great deal of weight- and expense-to the task of placing objects in space. The space shuttle, for example, carries more than a million pounds of liquid oxygen with it when it lifts off. Because scramjets get their oxygen from the passing air, they could play a major role in helping bring the cost of reaching earth orbit down from thousands of dollars per pound of payload to just hundreds per pound.
2. As the hydrogen is used as a propellant and combustion is carried out at supersonic velocity with the help of oxygen from the atmosphere. As a result of that, steam (H_2O) is being exhaust gas which is echo friendly in nature.
3. The inlet and the nozzle become the part of an air craft based on Scramjet. As a result the engine and the vehicle get combined and work as a single unit as shown in figure no 4.
4. Shape of the aircraft is so designed that the high air pressure develops below the aircraft which provide it additional lift as shown in figure 5.
5. No mechanical compressor and turbine are required.
6. As movable walls are provided in tail end of the combustor so it can be used for varying speed applications.
7. Use for the supersonic speed.

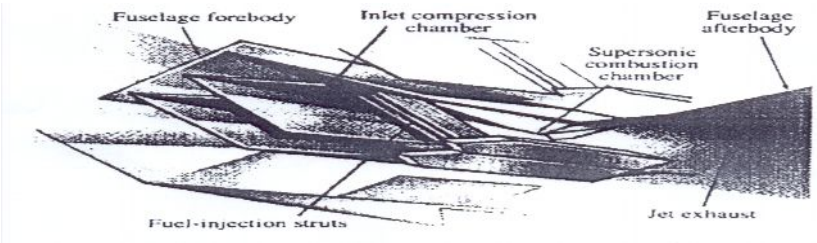

Fig.5. 3D View of Scramjet Engine

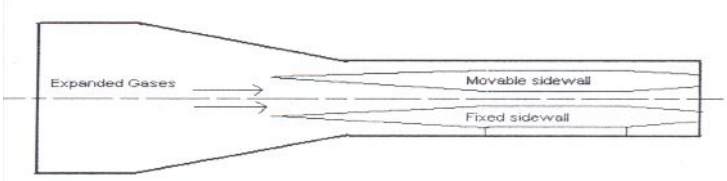

Fig. Top View of Scramjet

RECENT DEVELOPMENTS

1. Hyper-X "Scramjet" Experiment:

A new program, called Hyper-X, was launched by NASA in 1997. The goal is to build working jet airplanes that use a clever combination of ramjet, scramjet, and rocket engines to reach sufficient speeds to achieve orbit around the earth. These planes would use conventional rocket engines to get started and then switch over to ramjet power at Mach 2 or 3, and then scramjet power at about Mach 5. The scramjet engines would accelerate the plane to as fast as Mach 18 (nearly 12,000 miles per hour). The rockets would kick back in to take the vehicle the rest of the way into orbit.

The first Hyper-X plane, called the X-43A, is scheduled for a test flight this month over the Pacific Ocean. About 12 feet long and pilot less, the X-43 will be launched from the wing of a B-52. A rocket engine will boost the X-43 to Mach7, about 4,600 miles per hour. At that point, NASA scientists hope, the scramjet engine will kick in. if all goes ell, test flights planned for next year will see the X-43 reach speeds of Mach 10-a hasty 6,600 miles per hour. After that, NASA will look at the possibility of building a scramjet large enough to take off from a runway with a pilot at the controls.

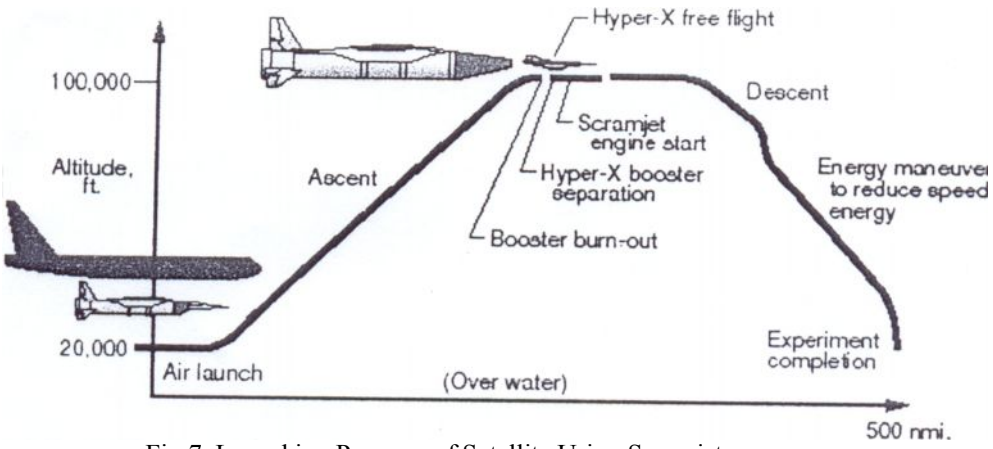

Fig.7. Launching Program of Satellite Using Scramjet.

2. Hyshot "Scramjet" Experiment:

The University of Queenshland in Australian launched a hypersonic "scramjet" on 30th July 2002, claiming a world first with a revolutionary engine that could one day propel airliner at 8000 km/hr or more under the project leader "Allan Paull". It really giant step in world of space research. Members of "Hyshot" project fired the scramjet engine from a launch site in the Australian outback into the upper atmosphere and allowed it to plunge back to earth. The engine was designed to ignite on the way. Researchers expect scramjets will

first be commercially applied to satellite launches. Eventually, scramjets may revolutionize air travel, allowing passenger aircraft to fly to London from Sydney in just two hours, making in flight movies obsolete. The scramjet was fired off in the late morning into a hazy sky over the Australian outback on a Terrier Orion MK70 rocket, which took it into the upper atmosphere.

3. Avtar "Scramjet" Experiment:

It is good news that Indian hose is also in court of race. Recently Air Commodore Raghavan Gopalaswami publicly announced in early July 2002 in the United States, AVTAR is the hyperplane concept that has been developed by India, through financial support from the DRDO (Defense Research and Developed Organization). Its design has been patented in India and applications for registration of the design have also been filed with patent offices in the United States, Germany, China and Russia.

AVTAR stands for "Aerobic Vehicle for Advanced Trans Atmospheric Research". It weighs only 25 tonns-60 percent of which his liquid hydrogen fuel. It can enter into a 100 km orbit in a single stage and launch satellite weighing up to one ton. It can be used as a missile launcher as well. Interestingly, it can be converted into an aircraft for carrying passengers into space. This hyperplane would, however, use a combination of turbojet, ramjet and scramjet to reach an altitude of 100 km. after that a cryogenic rocket engine needs to be employed to provide a final push into space.

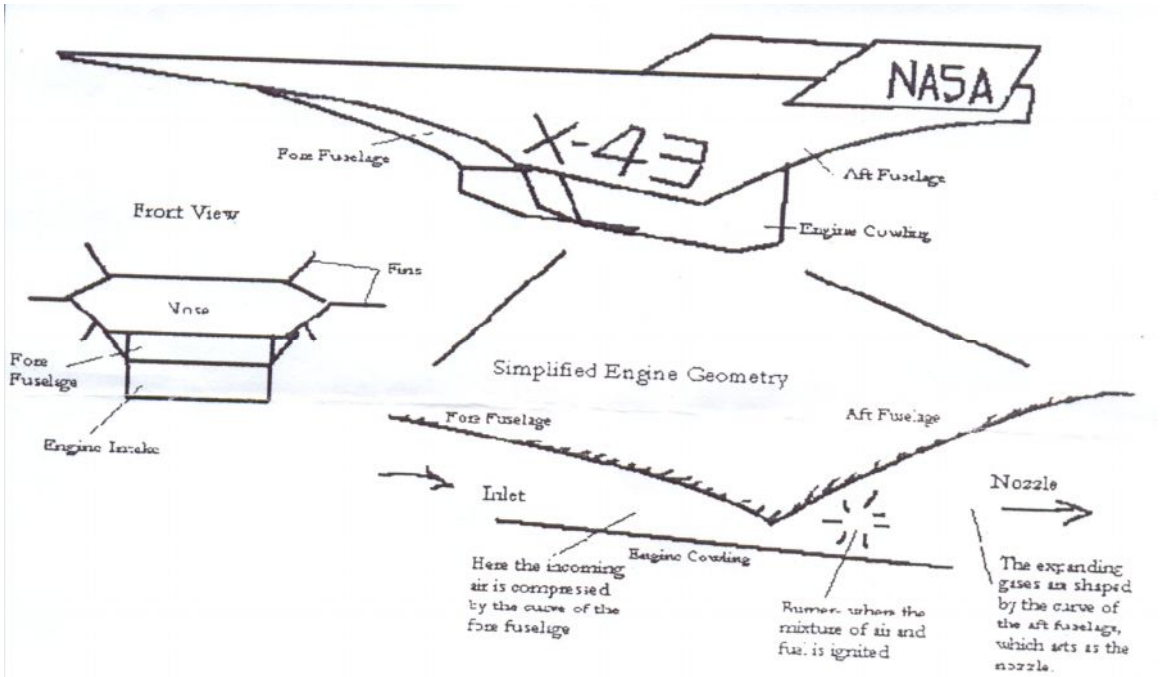

Fig.8 Nasa's X-43

CONCLUSION

Today scramjet is not just a concept, as it has become a reality. Though a scramjet has simple mechanism, it is technically so complex engine. Successful working of this engine is solely depend upon the airflow. This engine requires careful designing and construction with negligible tolerance. Within a decade or so hyper planes and such highly sophisticated aircraft will become a part of your routine life. In the future, scramjets could be used to launch satellites, visit space stations, or travel from New York to Tokyo in under three hours. In other words, the dream of space tourism is likely to come true.

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