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CRYOGENIC ENGINE

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Abstract

The concept of cryogenics was introduced by James Dewar in 1892. The major principle of this invention was to condense the fuel in their lowest possible liquid temperature to compressed and store huge amount of fuel in less volume. Such technological advancement was further used in the application were enormous amount of thrust is required. One such application is space rocket where very high thrust in needed to lift up the whole setup of rocket and satellite attached to it at a very high speed against the gravity pull. A Cryogenic rocket stage is more efficient and provides more thrust for every kilogram of propellant it burns compared to solid and earth-storable liquid propellant rocket stages. Basically these space rockets are divided in three stages. And the cryogenic engine is mounted at the upper most position of the rocket. After the successful completion of first two stages cryogenic engine comes to life when the rocket is nearly out of the earth's gravitational field. A very complicated design has implemented where all the process of maintaining cryogenic fuel and providing required thrust is been carried out. ISRO (Indian Space and Research Organisation) has also successfully completed their space mission by putting a GSVL (Geosynchronous Satellite Vehicle Launch) in space with the help of such indigenous cryogenic engine in their space rocket on which Indian scientist where working on over 3 decades.

Index Terms: *Cryogenic, Propellant, Geosynchronous, Indigenous, Thrust etc.*

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1. PRINCIPLE

The cryogenic is a Greek word which means cold temperature. In physics cryogenic is the production and behaviour of material at very low temperature and those people who works in such field are known as cryogenicist. One of the major applications of particular principle is cryogenic engine. These engines are equipped in space rocket where huge amount of thrust is required for the whole setup to lift up against the gravity of the earth towards the space. Cryogenic temperature is not defined in any refrigeration temperature scale. But standard temperature values have been assumed for a substance to be a cryogenic which is below -180^0 C.

Likewise a cryogenic engine is a rocket engine which uses a cryogenic fuel and oxidiser where the fuel and oxidiser are maintained at very low temperature or that in cryogenic state. There are many fuel and oxidiser combination available out there but the combination of liquid hydrogen and liquid oxygen is one of the most widely used combinations. Both the components are easily available in nature and release very high enthalpy when burned. Combustion of these fuel and oxidiser mixture can produce specific impulses up to 450 s and an effect exhaust velocity of 4.4 km/s

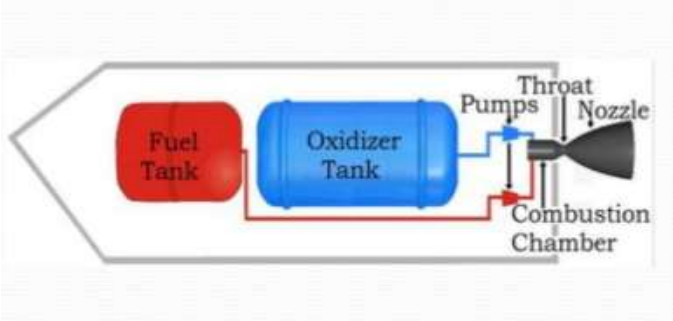
2. CONSTRUCTION

The main component of cryogenic engine are given as follows:

- Combustion chamber :
  Combustion chamber is that part of internal combustion engine or reaction engine in which the fuel / air mix is burned .The combustion process increases the internal energy of gas which translates into an increases the temperature, pressure and volume.
- Pyrothenic igniter:
  It is also known as pyrogenetic initiator. It is a device containing a pyrogenatic composition used primarily to ignite other, more difficult- to- ignite materials.
  E.g. - gas generator, solid fuel rocket, termites etc.
- Nozzle :
  Pumps generates high pressure a few hundred atmosphere. The nozzle turns the static high pressure, high temperature gas into rapidly moving gas at near ambient temperature. The nozzle converts the subsonic flow into supersonic flow.
- Injector:
  The fuel injection is the introduction of fuel in an combustion engine, most commonly in automobile engine by the means of injector
- Storage tank :
  In the cryogenic engine two kind of tank are used. One of which consist of hydrogen in liquid form as a fuel and another of oxygen which is also in liquid from as oxidiser. Oxidiser container is also known as oxidiser tank. In hydrogen fuel chamber the liquid hydrogen is kept at -253^0 C and similarly in oxygen chamber liquid oxygen is kept at -183^0 C. Near about 13 tones is the capacity of fuel tank in different ratios.

3. WORKING

There are two tanks one is fuel tank and another one is oxidiser tank. The fuel tank contains liquid hydrogen as fuel and liquid oxygen as oxidiser. The temperature of liquid hydrogen is -253^0C and temperature of liquid oxygen is taken to be -183^0 C. The liquid is condensing at low temperature since it stores more volume of gas. The fuel and oxidiser then pass through fuel injector in proper composition to control combustion. After proper composition mixture of fuel and oxidiser goes in combustion chamber and ignited by using pyrotechnic igniters. The combustion chamber is present within nozzle. Nozzle helps in converting low pressure gases to high pressure gases from which we get required thrust.



4. ADVANTAGES & LIMITAIONS

- Fuel and Power Density-

More fuel can be store in the tank due to more density of liquid fuel stored at low temperature. High energy per suit mass, propellant like O_2 & H in liquid form give very amount of fuel to be carried out aboard the rocket decreases.

- Cooling

The fuel can be used to cool the engine. So additional cooling circuits required to cool the engine. (Passing cryogenic through outside of the chamber in order to cool it is called as regenerative cooling).

- Clean Fuels

Hydrogen and oxygen are extremely clean fuels when they combine they give out only water. This water is thrown out of converging and divergent type of nozzle in a form of very hot vapour. Thus the rocket is nothing but high burning steam engine

CONCLUSION

From this presentation it can be concluded that cryogenic engine is a much efficient engine for space travel and can be also able to carry Hugh amount of fuel in less amount of volume which is crucial for space exploration. It will be also beneficial for the field where higher thrusts are required.

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Fig : working of cryogenic engine