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Cryogenic Engine

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***Abstract*: Cryogenics originated from two Greek words "kayos" which means "cold or freezing" and "genes" which means "born or produced". Cryogenics is the study of very low temperatures. CRYOGENIC ENGINE means study of engine working on liquid fuels which are freezed like liquid nitrogen and oxygen. The significance of critical temperature is also apparent. In the vapour compression cycle shows all the processes occur below the critical temperature, as it typical for such cycles, and therefore condensation of the working fluid is possible simply by rejecting heat to a sink at lower temperature. As per the Newton's third law of mechanics, the thrust produced in rocket engine is outwards whereas that produced in jet engine is inwards. A cryogenic engine is typical rocket engine designed to escape from Earth's gravity (or) to lift satellites into orbit. These engines use liquid fuels that are cooled to very low temperatures and which would be in gaseous state at normal atmospheric pressure and temperature, such as hydrogen and oxygen.**

Keywords: Cryogenic Engine

I. Introduction

During World War II, when powerful rocket engines were first considered by the German, American and Soviet engineers independently, all discovered that rocket engines need high mass flow rate of both oxidizer and fuel to generate a sufficient thrust. Therefore, to get the required mass flow rate, the only option was to cool the propellants down to cryogenic temperatures (below −150 °C, −238 °F), converting them to liquid form. Hence Cryogenic Technology which mainly deals with temperatures below -150 C is the main working principle behind the cryogenic engines. When elements cooled at these temperatures they change their properties. Same is the case with one used in rocket engines when oxygen is cooled below -183 degree centigrade it changes it's state to liquid & it's properties, similarly when hydrogen is cooled below -253 degree centigrade.

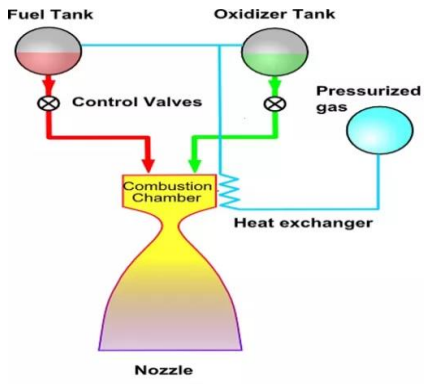

Fig. 1. Lay out of cryogenic engine

This concept of a cryogenic engine is designed in order of developing non-polluting automobiles. Payload capacity of the space vehicle can be increased with the propulsion system having higher specific impulse, in general liquid propellant engines result in longer burning time than conventional solid rocket engine which result in higher specific impulse. All the current rockets run on Liquid propellants. The first operational cryogenic rocket engine was the 1961 NASA design, RL-10 LOX LH2 rocket engine which was used in Saturn 1 rocket employed in the early stages of the Apollo moon landing program.

Components of cryogenic engines:

1. Combustion chamber (thrust chamber)
2. Pyrotechnic initiator
3. Fuel injector
4. Fuel cryo pumps
5. Oxidizer cryo pumps
6. Gas turbine
7. Cryo valves
8. Regulators
9. Fuel tanks
10. Rocket engine nozzle

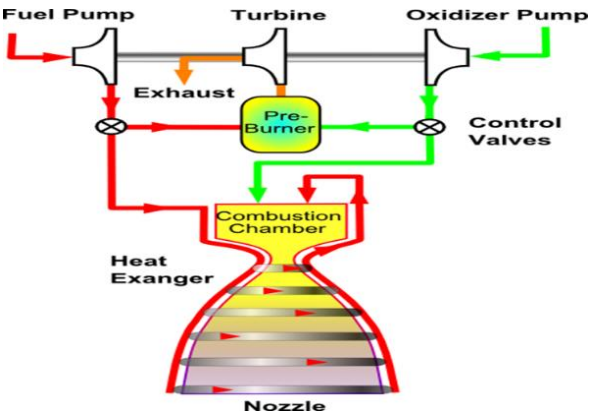

Fig. 2. Components of cryogenic engine

II. Working Principle of Cryogenic Engine

1) The chemical energy stored in the fuel is converted into kinetic energy by burning it in the thrust chamber and subsequent expansion in the nozzle.
2) The liquid fuel and oxidizer are fed from the storage tank to an expansion chamber. Then it is injected into the combustion chamber.
3) In this chamber, they are mixed and ignited by a flame or spark.
4) The fuel expands as it burns and the hot exhaust gases are directed out of the nozzle to provide thrust.

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5) The thrust comes from the rapid expansion from liquid to gas with the gas emerging from the motor at very high speed.
6) The energy needed to heat the fuels comes from burning them, once they are gasses.

$$F = \text{mue} + (Pe - P\infty)\, Ae \quad (1)$$

Where,
Ue is exhaust gas value at exist area.
Ae and Pe is respective pressure and area
P∞ is ambient pressure

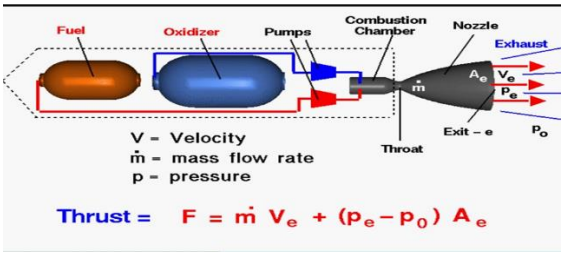

Fig. 3. Working principle of cryogenic engine

Advantages:

1) High Energy per unit mass: Propellants like oxygen and hydrogen in liquid form give very high amounts of energy per unit mass due to which the amount of fuel to be carried aboard the rockets decreases.
2) Fuel density: More fuel can be stored in the tank due to more density of liquid fuel stored at low temperature.
3) Cooling: The fuel can be used to cool the engine. So, no additional cooling circuits is required to cool the engine.
4) Clean Fuels: Hydrogen and oxygen are extremely clean fuels. When they combine, they give out only water.
5) Economical: Use of oxygen and hydrogen as fuels is very economical, as liquid oxygen costs less than gasoline.
6) Power density: Due to higher density, the energy per unit volume of fuel is higher. So, the power generated per unit volume is h.

Dis-advantages:

1) One disadvantage is that the fuel tanks tend to be bulky and require heavy insulation to store the propellant.
2) High cost as Cryogenic storage tanks must be able to withstand high pressure.
3) A low temperature needs to be maintained to keep the fuel in liquid form.
4) Cryogenic propellants make the problem more complex due to stratification issues.

III. Conclusion

It can be concluded as cryogenics can be applied to almost everywhere in every field. It finds its application in military, tooling industry, agricultural industry, aerospace, medical, recycling, household, and automobile industry. Cryogenics is found to improve the grain structure of everything treated be it metal or plastic or coils or engines. This field could be put to many other applications in various fields. Its reaches in the mentioned industries hold a good chance of extension. Hence Cryogenics proves to be very promising for the future in this world of materials.

References

[1] https://www.quora.com/How-does-cryogenic-engine-work
[2] https://en.wikipedia.org/wiki/Cryogenic_rocket_engine
[3] Cryogenic Technology Development for Exploration Missions by David J. Chato.
[4] Richard Cohn, Developments in Liquid Rocket Engine Technology, Air Force Research Laboratory, 2012.
[5] https://www.google.co.in/images/ cryogenic rocket engine