Innovation in Cryogenic Engine for Rapid Transit by NOS Propulsion

M.TAMILSELVAN [1], R.VENKATARAMANAN [2],K. HARIPRRASAD[3]
Third Year Mechanical Engineering,
M.Kumarasamy College of Engineering, Karur, Tamil Nadu-639 113, India
[1]tamilmmech@gmail.com , [2] rvenkataramananr@gmail.com , harithestunner90@gmail.com

ABSTRACT

This paper deals with the Cryogenic Engine, Alternative fuel is used in this engine to increases the efficiency. Nowadays, Liquid Hydrogen is used as an fuel for cryogenic engine due to some drawbacks. Liquid Nitrogen is used as an fuel and Liquid Oxygen is used as an Oxidizer. Liquid Nitrogen have more merits than Liquid Hydrogen are high density, high boiling point, Easily produce, 78% of Nitrogen are available in atmosphere. The NOS Propulsion cryogenic engine are used in Rapid Transit. In LRT(Light Rapid Transit) the cryogenic engine are fit in the mid off the Metro Train due to avoid some effect.

Key Words: Cryogenic Engine, NOS Propulsion, Light Rapid Transit.

1. INTRODUCTION

CRYOGENIC ENGINE:

Kryo means Very cold (frost), Genics means to produce. The engine which performs the process of cryogenics. Cryogenics is the science and technology associated with generation of low temperature below 123 K. A rocket engine is a engine that uses a cryogenic fuel or oxidizer, its fuel or oxidizer (or both) are gases liquefied and stored at very low temperatures. Notably, these engine were one of the main factors of NASA's success in reaching the Moon by the Saturn V rocket.

PROPULSION

In cryogenic engine we are using two propulsion, liquid oxygen is used as a oxidizer and liquid nitrogen is used.

NITROGEN

Liquid nitrogen is a nitrogen in a liquid state at an extremely low temperature. Liquid nitrogen can easily be converted to a solid by placing it in a vacuum chamber pumped by a rotary vacuum pump. Liquid nitrogen freezes at 63 K (−210 °C; −346 °F). . Liquid nitrogen is a colourless clear liquid with density of 0.807 g/ml at its boiling point and a dielectric constant of 1.43. The development of pressurised super-insulated vacuum vessels has enabled liquefied nitrogen to be stored and transported over longer time periods with losses reduced to 2% per day or less

OXYGEN:

Oxygen is used as an oxidizer in cryogenic engine, which supports the fuel. Liquid Oxygen is used as an oxidizer in cryogenic engine, which supports the fuel. Liquid oxygen has a density of 1.141 g/cm^3 (1.141 kg/L or 1141 kg/m^3) and is cryogenic with a freezing point of 54.36 K (−361.82 °F, −218.79 °C) and a boiling point of 90.19 K (−297.33 °F, −182.96 °C) at 101.325 kPa (760 mmHg).

PROPERTIES	LIQUID HYDROGEN {fuel}	LIQUID NITROGEN {fuel}
Symbol	LH2	LN2
Density (Kg/m³)	70.8	809
Molecular weight	2.02	28.013
Electron configuration	$1s^1$	$1s^2 2s^2 2p^3$
Melting Point(K)	13.81	63
Boiling point (K)	20.28	77.36
Electronegativity	2.2	3.04
Pressure(psi)	5000	1200
Enthalpy of vaporisation@ 0°C, 1.013 bar	294(KJ/kg)	199(KJ/kg)
Surface Tension	(N/m)	8.9(N/m)
Specific heat(Cp) @ 0°C, 1.013 bar	9.78 (kJ/kg K)	1.040(kJ/kg K)

RAPID TRANSIT:

Rapid transit also known as metro, subway or underground is a type of high-capacity public transport generally found in urban areas. There are two types of rapid transit are LRT and BRT. Light rail transit is urban public transport using rolling stock similar to a tramway, but operating at a higher capacity, and often on an exclusive right-of-way.

CONSTRUCTION:

The major components of a cryogenic rocket engine are the combustion chamber (thrust chamber), pyrotechnic initiator, fuel injector, fuel cryopumps, oxidizer cryopumps, gas turbine, cryo valves, regulators, the fuel tanks, and rocket engine nozzle. In terms of feeding propellants to the combustion chamber, cryogenic rocket engines (or, generally, all liquid-propellant engines) are either pressure-fed or pump-fed, and pump-fed engines work in either a gas-generator cycle, a staged-combustion cycle, or an expander cycle.

The cryo pumps are always turbo pumps powered by a flow of fuel through gas turbines. Looking at this aspect, engines can be differentiated into a main flow or a bypass flow configuration. In the main flow design, all the pumped fuel is fed through the gas turbines, and in the end injected, the fuel flow is split; the main part goes directly to the combustion chamber to generate thrust, while only a small amount of the fuel goes to the turbine.

WORKING:

GAS GENERATOR

The gas generator is used in order to drive the turbo by a gas flow. The gas generated produces this energy by pre burning some amount of liq. Fuel. Use of Gas generator aligned with Turbo pump increases the efficiency of this engine to a great Extent

TURBO PUMPS:

The working of this engine is very easy to understand as it does not involve any complicated cycles or any reciprocating mechanism. The fuel from tanks is firstly passed through the turbo pumps which rotates at a speed of about 14000 rpm by which the mass flow rate of fuel increases to about 2.4 tons before reaching the combustion chamber.

INJECTOR:

Injector plays the most important role in the rocket engine it is like heart of the engine that pumps out the appropriate amount of fuel from the turbo pump to the combustion chamber as per requirement. Injector ensures the stability of the combustion chamber therefore deigning of injector is the most challenging part of the designs department of cryogenic engine even today. The frequency of the combustion chamber is to be maintained between 100-500 cycles per second. If this rate is affected even slightly shifted above or below leads to the failure of engine which has been seen in tragedy of 'Discovery Spacecraft'. But if injector is so designed so as to increase the specific impulse more than 700 Space crafts can travel much long distances in the universe. Injector is the only component of this engine which is still under construction.

COMBUSTION CHAMBER:

Finally when this finely distributed fuel droplets enter into the thrust chamber at such high velocities & at their cryogenic temperatures they colloid to each other in the trust chamber, this reaction at such specific conditions increases the pressure of chamber to about 250 bar with a release of huge amount of thrust which is more than 15000 lb. This high amount of trust is then manipulated by a narrow opening towards the nozzle. The opening is kept narrow so as to follow law of rate of discharge which states that 'velocity is inversely proportional to area'. By this technique we get the desirable amount of thrust which helps a space craft to achieve it's escape velocity. Due this reaction in continues period of time the temperature of Combustion Chamber as well as nozzle raises up to 3000-4000°C. To withstand such a high temperature for long period of time without any deformation a cooling Jacket is required.

COOLING JACKET:

Cooling Jacket is the necessity of this engine but this facility is provided by the fuel of the engine itself so no external energy is to be used. The mechanism usually used in cooling jackets is active cooling.[6] In this Technique the cooling jacket is made such that a flow if liq. Proponents is passed through the tubes provided from between the jackets. The liquid propellant passed are already at their cryogenic temperature so provide a very effective cooling. Use of this technology throughout it's journey without any deformation in Combustion chamber or Nozzle. When all these components work in their perfect algorithm ,only then we can achieve our goal a successful launch of a space vehicle for it's space mission.

DEMERITS OF LH_2:

- The cooling and compressing process requires energy, resulting in a net loss of about 30% of the energy that the liquid hydrogen is storing.
- LH2 daily leaks 1%.

ESTIMATION COST OF LN_2:

- 384,071 gallons of liquid hydrogen in the external tank of the shuttle, for a cost of 25436012.61 INR.
- 141,750 gallons of liquid oxygen for a cost of 6418141.83INR.
- 192035.5 gallons of liquid nitrogen in the external tank of the shuttle, for a cost of 7269334.4INR.
- 1gallon=3.78541liter
- 1liter LN2 =10.81INR

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