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Testing of a Liquid Rocket Engine with Kerosene and HHO Fuels

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Abstract

The research to develop an alternative to carbon-based fuel is growing day by day. In this paper, we have discussed a way to generate HHO gas (Oxy-Hydrogen gas) from our Hydrogen-Hydrogen-Oxygen generator. The generated HHO gas was sent to the combustion chamber of a liquid rocket engine as a secondary fuel. The primary fuel used was kerosene and the oxidizer was gaseous oxygen. When the combustion chamber was completely filled with HHO gas, the primary fuel was injected at 3 bar pressure. Followed by the fuels, gaseous oxygen was injected at 6 bar pressure and the combustion was initiated. During the combustion, the combustion properties were evaluated and the obtained result was compared with the combustion properties of the liquid engine which uses only Kerosene (at 3 bar injecting pressure) and gaseous oxygen (at 6 bar injecting pressure). This research proved that the HHO gas is increasing the combustion performance on the liquid rocket engine.

Keywords: HHO gas, Liquid rocket engine, Kerosene, HHO generator, Oxy-Hydrogen.

1. Introduction

The increase in fuel consumption, carbon emission, pollution, greenhouse effort is forcing the researchers to seek an alternative solution for this carbon-based fuel. We also don't want much modification to the existing engine. Though there are many ideas and techniques found, one such predominant solution is using Hydrogen as an alternative fuel to enhance the engine performance and produce less pollution [1]. Not only the automobile industry is keen to develop alternatives to the existing carbon-based fuel, but even the aerospace industry is also looking for various other propellants and oxidizer than the regular ones for reducing the cost and complexity of space exploration. Though we have rocket engines that use Liquid Hydrogen as a propellant, the rocket engine using HHO gas for combustion is a bit new. There is a lot of research being done on using HHO gas as secondary fuel in automobile engines and few have succeeded too.

Hydrogen-Hydrogen-Oxygen (HHO) gas got several other names namely, Hydroxy gas, Brown's gas, water gas, green gas and oxyhydrogen. This HHO gas contains oxygen with it so, there is no necessity to provide an extra oxygen for combustion. This HHO gas is highly combustible. The auto-ignition temperature of HHO gas for a stoichiometric mixture at normal atmospheric pressure is 570˚C. The energy of 20 μ J is required to ignite this mixture. When the percentage of hydrogen is between 4% to 95 % of the total volume of HHO the combustion initiates. HHO gas is a highly ignitable source of power that produce very high energy as compared to the ordinary ignition process. During ignition, the mixture release energy of about 241.8 kJ for every mole of HHO burned and then converts to water vapour. The amount of heat generated may vary from engine to engine [2].

To produce HHO, we need to electrolyse water. The efficiency of the electrolysis depends on the quality of the water. The efficiency decreases when the impurity in water increases. So, distilled water is preferred as it does not contain any impurities. Other water like river water, rainwater, groundwater can be also used with sacrifice in efficiency. The cathode and anode in the electrolysis setup separates the Hydrogen and Oxygen in water to form HHO gas which is shown in *Eqn. 1*

Electrolysis: $H_2O \rightarrow H_2 + O$ *(Eqn. 1)*

2. Hho Generator

We have made an HHO generator that can contain 10 Liter of distilled water. The container which carries the water and electrode was completely leak-free. The container was 225 mm x 280 mm x 150 mm. The electrode plates were made with stainless steel. The dimension of the plate was 150 mm x 200 mm x 2 mm. Three holes of 10 mm diameter were drilled in an inverted triangular pattern to insert a rod made using Polypropylene to hold all the electrodes together. Another 3 holes of 2 mm diameter were drilled at the centre of the plate in a linear pattern for water passage. The surface of the plate was made rough to increase efficiency. There were 12 such plates. Plate 1, Plate 6 and Plate 12 were connected to the negative terminal of the power source and Plate 3, Plate 9 were connected to the positive terminal of the power source. The remaining 7 plates were neutral plate. A gasket of 2 mm thickness was placed between all the plates. A very small amount of Potassium Hydroxide (10-15 g) was added to the distilled water to speed up the reaction. The electrode was connected to a 12 Volts and 6 Ampere D.C power source.

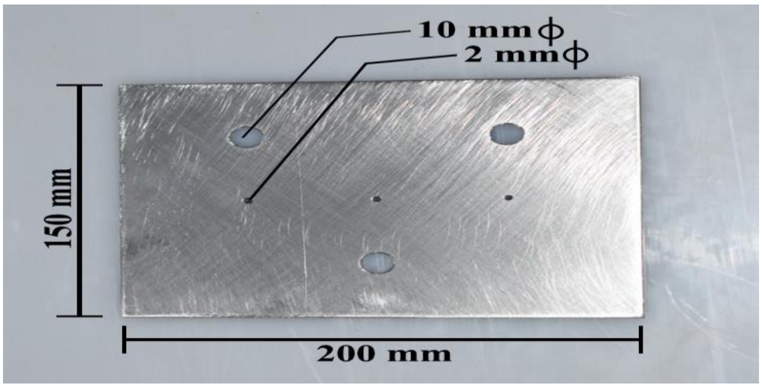

Figure 1 Electrode plate

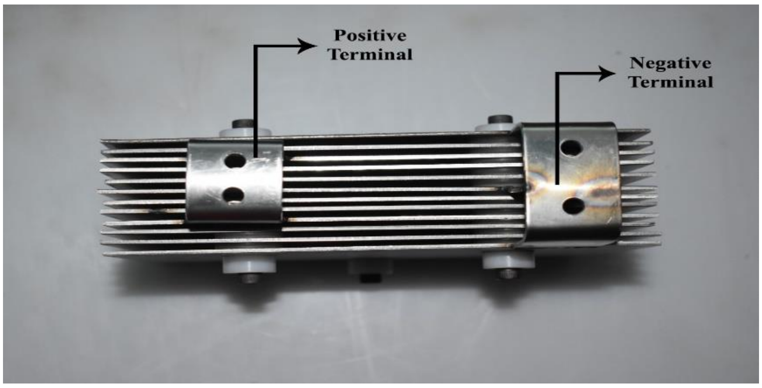

Figure 2 Electrodes

3. Rocket Engine

The generated HHO gas will be given to the combustion chamber of the liquid rocket engine as a secondary fuel to increase the combustion performance. The design parameters of the Liquid rocket engine used for the experiment are given in *Table 1.*

PARAMETERS	VALUE
Diameter of Combustion Chamber (d_c)	$0.026m$
Diameter of Nozzle Throat (d_t)	0.015m
Diameter of Nozzle Exit (d_e)	$0.03m$
Chamber length (L_c)	0.385m

Total Thickness (t)	0.022m
Contraction angle(β)	60°
Divergence angle (α)	15°

Table 1 Engine design parameters

4. Experimental Setup

4.1. Test 1

The O_2 tank contains oxygen at 6 bar chamber pressure. This oxygen tank was connected to the oxygen injector through a solenoidal valve. This solenoidal valve helps us to control the oxidizer supply manually. Tank 2 contains nitrogen at 6 bar chamber pressure. Tank 1 contains kerosene. When tank 1 was filled with kerosene, the solenoidal valve connecting tank 1 and tank 2 was opened so that both the tank's chamber pressure will become 3 bar. Tank 1 was connected to the fuel injector through a solenoidal valve. A high power 22000 Volts igniter coil was also connected to the chamber to ignite the fuel oxidizer mixture. This is the setup of a liquid rocket engine that uses kerosene as fuel. A test was carried out with this setup.

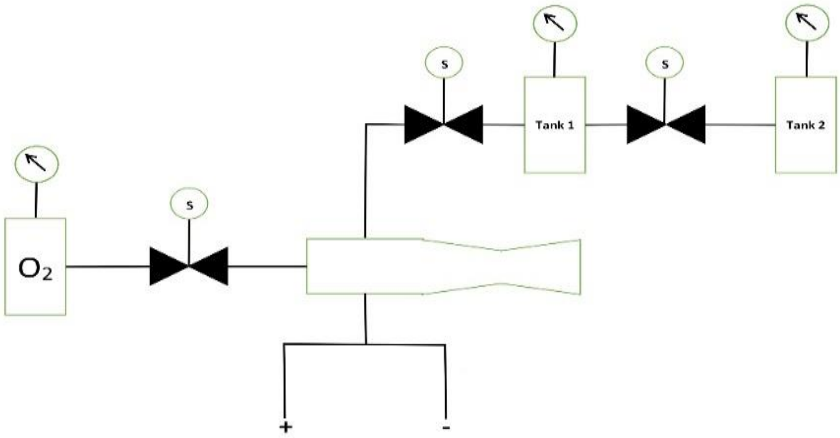

Figure 3 Schematic of the experimental setup for test 1

4.2. Test 2

With the same setup of test 1, an additional secondary fuel injection system was added to perform test 2. The secondary fuel injection system has an HHO generator, Bubbler and water reservoir. HHO generator was connected to a 12 Volts 6 Ampere D.C power supply. As soon as the power supply was given, generation of HHO began and the solenoidal valve connecting the HHO generator and bubbler was opened. The HHO gas produced was collected and sent to the bubbler. The function of the bubbler is to arrest backfire if anything goes wrong and to compress the HHO gas. The ¾ of the bubbler volume was filled with water and was connected to the water reservoir through a solenoidal valve. The generated HHO gas was kept on depositing in the bubbler. After 2 minutes, the power supply to the HHO generator was stopped. The solenoidal valve connecting the water reservoir and bubbler was opened and the water level in the bubbler kept raising. This increase in the water level compressed the HHO gas. When the desired pressure has reached, the reservoir valve was closed and the valve connecting the bubbler to the combustion chamber was opened. All the HHO gas was injected into the combustion chamber. Simultaneously, Primary fuel (kerosene) and oxidizer (gaseous oxygen) were also injected into the combustion chamber and the combustion test was carried out.

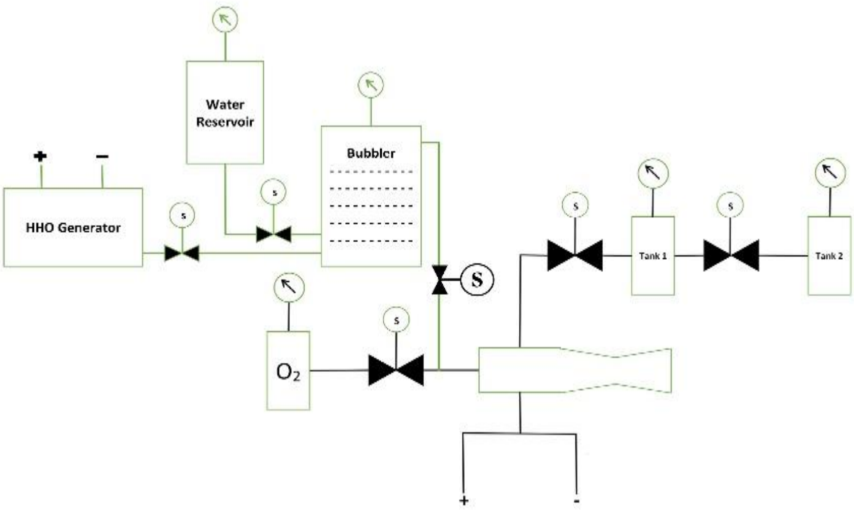

Figure 4 Schematic of the experimental setup for test 2

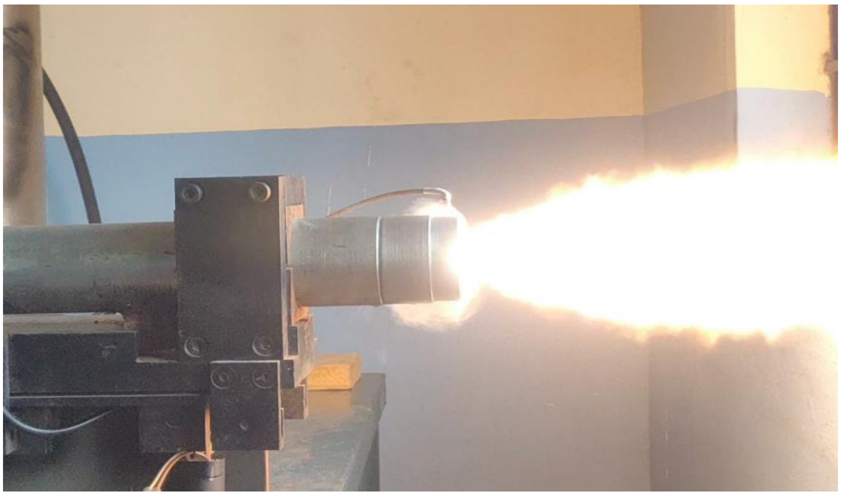

Figure 5 Test image

5. Results And Discussion

TITLE	WITHOUT HHO	WITH HHO
Oxygen feed Pressure	6.0 bar	6.0 bar
Fuel feed Pressure	3.0 bar	3.0 bar
Chamber Pressure	12.42 bar	12.56 bar
Exit Temperature	1841 K	1881 K
C^*	1106 m/s	1117 m/s
Exit Density	0.206 kg/m^3	0.201 kg/m^3
Exit Velocity	1365 m/s	1394 m/s
Exit Mach Number	1.83	1.83
Thrust	271 N	277 N
Isp	139.1 s	142.1 s
C_F	1.234	1.248

Table 2 Experiment result

The results of the experiment are tabulated in Table 2. It is clear from the table that, upon adding HHO there is an increase in the Chamber pressure of about 0.14 bar and also the exit temperature raised by 40˚C. The thrust is increased by 6 Newton.

6. Conculsion And Future Work

From the experiment conducted we can conclude that on adding HHO gas as secondary fuel there is an increment in combustion properties and also the thrust is increasing. But, this increment in the combustion properties and thrust is not very high because the amount of HHO gas generated was very less. The HHO generator was functional only for 2 minutes and then the power supply was turned off. If we could generate more amount of HHO gas and properly feed it to the combustion chamber as secondary fuel continuously as how kerosene was injected then, there will be a very significant increment in the combustion properties as well as the thrust. However, it is the future work of this project.

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