Performance and emission testing of hydrogen oxygen mixture with gasoline fuel in 4-stroke single cylinder SI engine for various compression ratio

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***Abstract* - All countries of world have been devoting increased efforts to opening up new energy sources due to international oil crisis and air pollution from conventional fuel. In the present experiment, effect of compression ratio on emission and performance of hydrogen oxygen mixture (HHO) with petrol by varying the load has been studied. The experiment conducted on 212cc, single cylinder SI engine and Hydrogen oxygen needed for testing produced from electrolysis of water. Using hydrogen as supplementary fuel along with petrol and increase in compression ratio improve fuel economy and better emission performance except NOx emission found. Reduction in fuel consumption has been noticed and it ranges from 11-17%.**

***Key words* - HHO, various Compression Ratio, hydrogen oxygen enrichment, performance, SI engine.**

I. INTRODUCTION

Hydrogen has long been recognized as a fuel having some unique and highly desirable properties, for application as a fuel in engines. The main feature of hydrogen as a fuel is that it does not occur in its free state naturally. The gas must be manufactured from a wide variety of possible sources while requiring much energy and capital resources.[1]

Hydrogen can be produced by partial oxidation, reforming, water electrolysis and other advance techniques. Hydrogen can be stored by compressing hydrogen gas in the cylinders, liquefying hydrogen in a cryogenic vessel or tank, using metal hydrides and slush hydrogen storage. While on board production of hydrogen eliminates storage requirement but continues and in sufficient quantity production is limitation for this approach for automobile engine. Many researches have been done on hydrogen as alone and also as supplementary fuel with gasoline. Results show improvement in break power, thermal efficiency and specific fuel consumption. Improvement in CO, CO_2 and HC (hydrocarbon) are conformed while NO_x emission marginally increases due to increment in temperature and pressure inside cylinder while using hydrogen as fuel.

As high octane number of hydrogen allows to increase in CR to improve power output and fuel economy. Thus with the change in design parameter compression ratio (CR), benefit of usage of hydrogen fuel can be increase.

Approximately 4% hydrogen produces from water electrolysis [11]. However water electrolysis remain a very minor contributor to the total production of Hydrogen because it uses electricity which considered as high grade energy and can be directly supplied to power production. However, recently and due to exploring expansion in renewable energy production which require in many cases energy storage methods , the interest in water electrolysis has increased[11]. Hydrogen can be produced in sufficiently high purity for fuel cell applications through the electrolysis of water with thermal efficiency ranging from 60% to 75% [1]. Electrolysis production has many advantages which are simplicity of the process, high purity of hydrogen and oxygen, environmental friendly and avaibility of water sources

II. EXPERIMENTAL SETUP

Engine modification, specifications and experimental procedure :

The experiment carried out on 212cc, single cylinder SI engine-generator set whose specifications are given in Table 1. For all run engine run at constant speed of 3000 rpm and load on engine increased from no load, 25%, 50%, 75% and 100%. Compression ratio has been changed by adding extra gasket to cylinder head. By that three compression ratio, 9.5, 7.77 and 6.63 has obtained to study the change in CR effect. HHO gas is added in dual fuel carburetor with Petrol.

Fuel cell and fuel system :

FC breaks water molecules in hydrogen and oxygen by external DC power supply and give 100% clean fuel for automobile. Many researches on FC have been done and are currently going on all around the world. Open literatures and numerous web sites have discussed the FC in detail and in all aspects. For the present work stainless steel plates, separated by 2 – 3mm, KOH electrolytes with 20 gm/ liter in concentration are used in Fuel cell. 24 V DC supply is given to FC. To prevent the back fire HHO gas produce from FC is passed through bubbler unit and oxygen flame arrestor (specially used for oxy-acetylene welding) before introducing in carburetor.

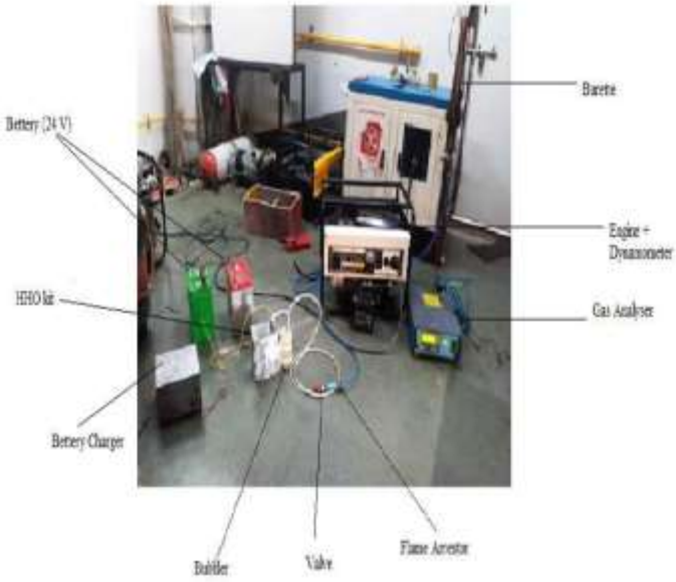

Figure 1 Experimental setup

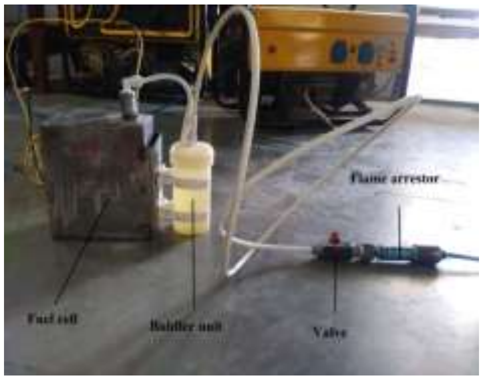

Figure 2 Fuel supply system

Table 1 Engine specification

Parameter	Specification
Type	Four Stroke, forced air cooled
No. of cylinder	One
Bore × Stroke	69.7 mm × 55.4 mm
Clearance Volume	20 cm3
Swept volume	212 cm3
Compression ratio	9.5
Rated Power	2.0 KW
Voltage	230 V

III. RESULT AND DISCUSSION

Fuel consumption and BSFC (Break Specific Fuel Consumption) :

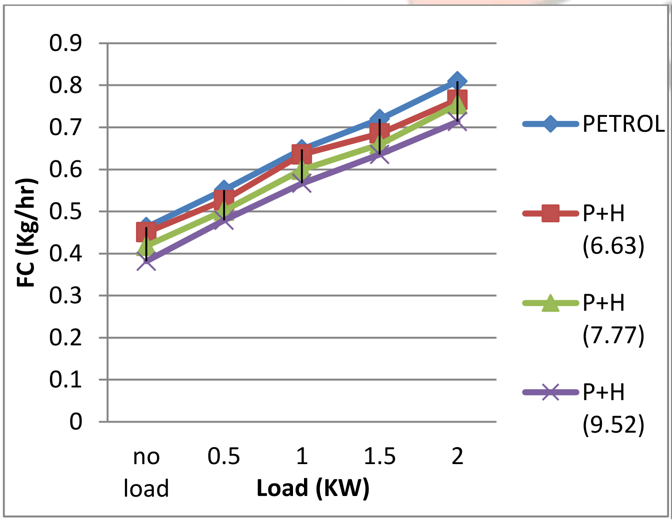

Figure 3 Fuel consumption v/s Load

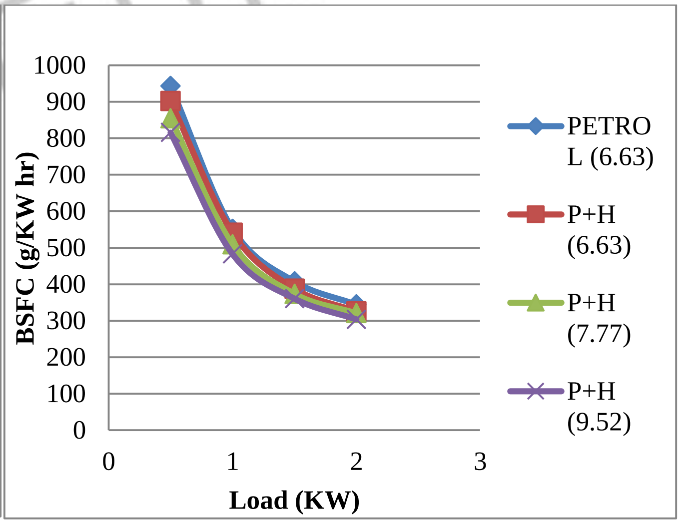

Figure 4 Break Specific Fuel Consumption v/s Load

From the above figures 3 & 4 it is clear that with increment in load need for fuel is also increase. Hydrogen's lower heating value per kg (119 MJ/kg) is higher than gasoline (44.50 KJ/Kg). So with HHO addition energy flow per unit mass of fuel is increased with compare to only petrol fuel. So low amount of fuel is needed for same power production, which results in decrement in BSFC and Fuel consumption with HHO. Figures also shows with increment in compression ratio; FC and BSFC reduces. With addition of HHO around 5.44% reduction in fuel consumption found at 6.63 CR for full load and at the same time increasing CR from 6.63 to 9.52 more 6.81% reduction found. So it is clear that benefit of HHO can be double by increasing CR.

Break Thermal Efficiency :

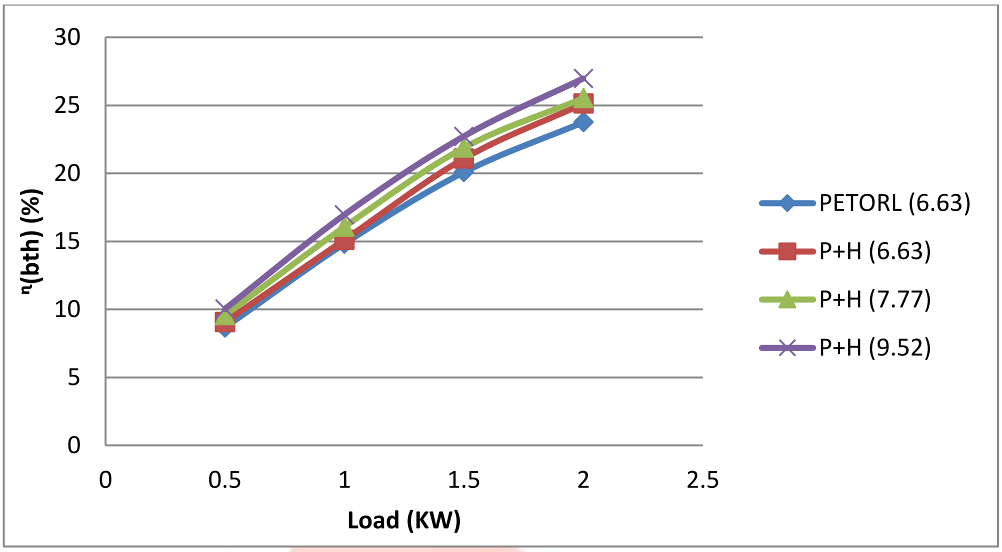

Figure 5 $\eta_{(bth)}$ v/s Load

From the fig. 5 it is clear that break thermal efficiency is increased with load and addition of HHO. HHO is extremely efficient in terms of fuel configuration as hydrogen and oxygen exist as tiny independent clusters of no more than two atoms per combustible unit, while gasoline droplet consist many thousands of large hydrocarbon molecules. This diatomic configuration of HHO gas (H2, O2) results in efficient combustion because the hydrogen and oxygen atoms interact directly without any ignition propagation delays due to surface travel time of the reaction. Due to higher flame speed on ignition, its flame front flashes through the cylinder at a much higher velocity than in ordinary gasoline/air combustion. The heat and pressure wave HHO generates crushes and fragments the gasoline droplets, exposing fuel from their interior to oxygen and the combustion reaction[3] . This effectively enriches the air/fuel ratio since more fuel is now available to burn.

Also increase in CR increases pressure and temperature of combustion process and more energy liberate which can be seen from results. With addition of HHO and increment in CR , maximum 3.2% increase in break thermal efficiency is obtain at full load.

Exhaust gas temp.:

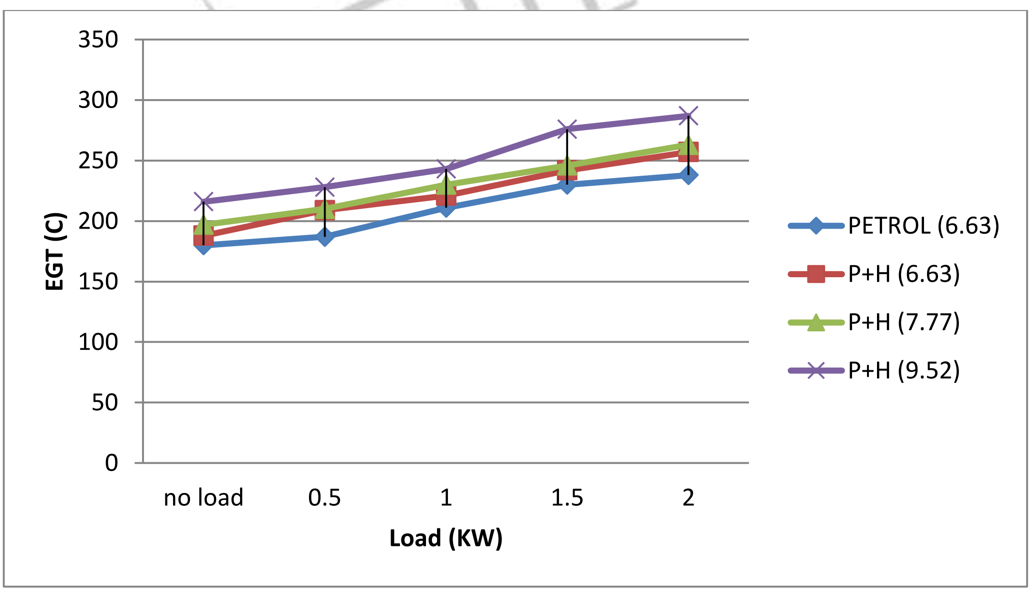

Figure 6 Exhaust Gas Temp. v/s Load

Figure 6 shows that Exhaust gas temperature increases with increase in CR and HHO addition with petrol. Hydrogen fuel has high flame speed and high calorific value which also increases temperature and pressure at combustion. With increase in CR; volume of combustion chamber reduces so flame speed increase which is the reason for increment of pressure in temperature.

CO emission :

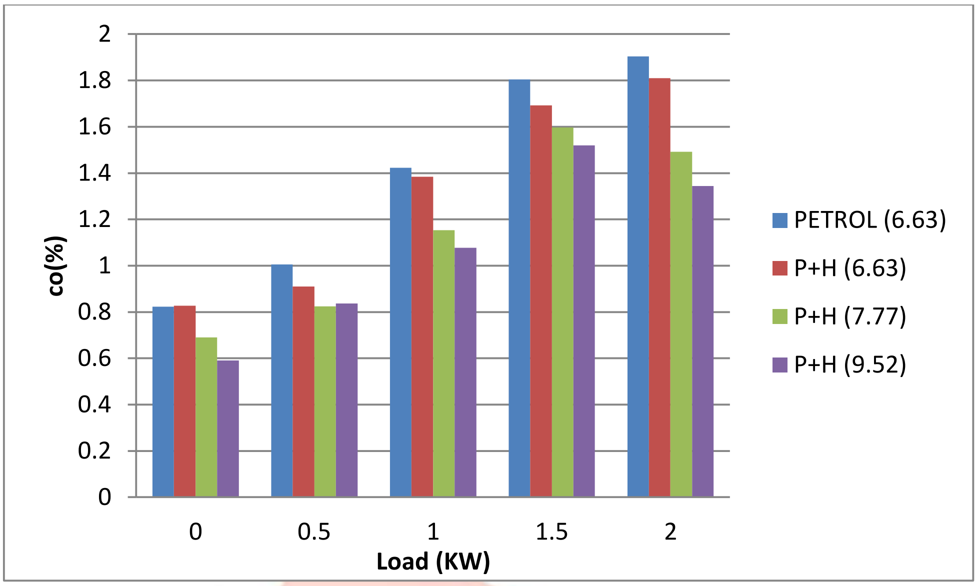

Figure 7 CO v/s Load

CO emission mainly depends on the efficiency of the combustion in the engine and also is affected by the fuel to air ratio of the engine. As discussed above HHO addition increases combustion efficiency and air ratio. Also increased temperature of combustion process due to increase in CR convert more amount of CO into CO2. So fig. 7 shows using a blend of HHO gas with petrol at higher CR ; reduces significantly the presence of carbon monoxide in the exhaust around 29.42%.

CO2 emission :

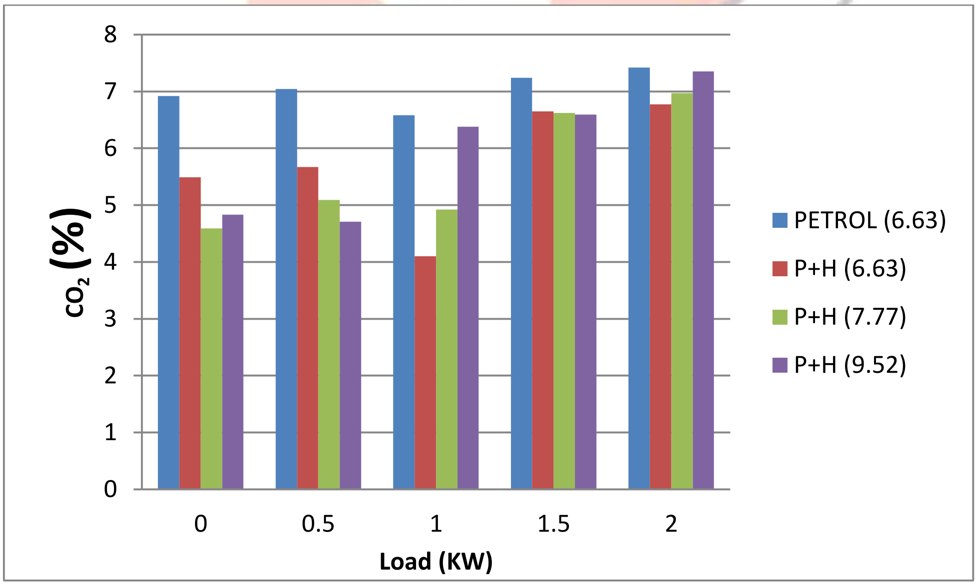

Figure 8 CO2 v/s Load

At high load more fuel is supplied compare to lower load so CO2 emission increase with load. Addition of HHO reduce petrol fuel consumption so at same load CO2 emission is lower than in case of only petrol fuel. Form fig. 8 it is clear that at higher load for high CR more CO is converted into CO_2. So CO_2 emission increases.

O2 emission :

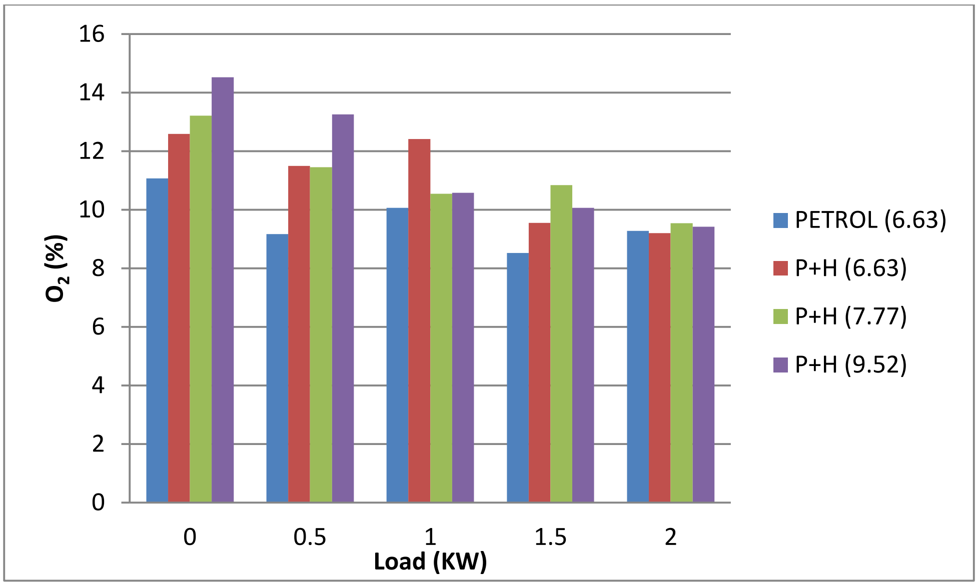

Figure 9 O2 v/s Load

Figure 9 shows the variation of concentration of O2 in exhaust with load. It is clear from graph that with increase in load, O2 concentration is decreased and with HHO supplement O2 concentration increases.

HC emission :

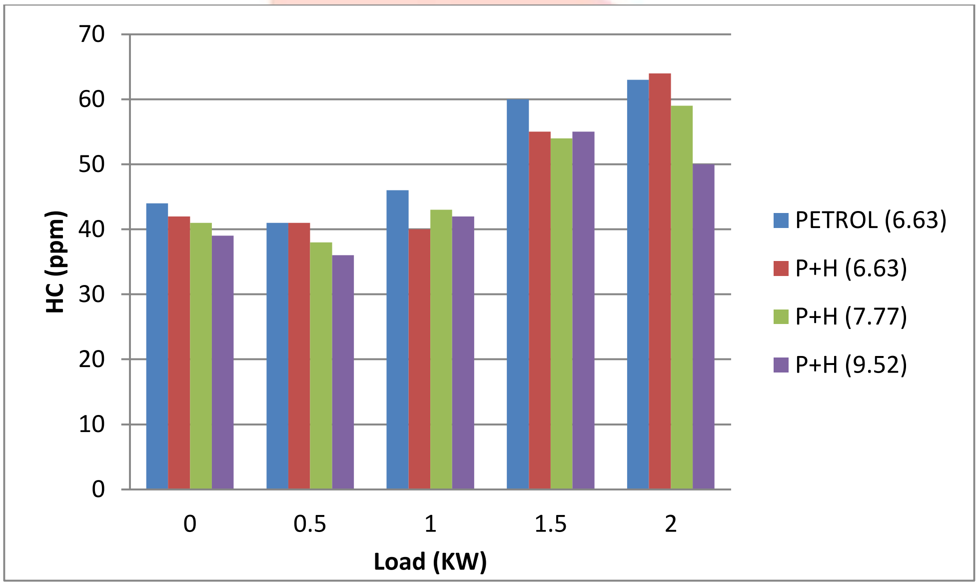

Figure 10 HC v/s Load

Hydrocarbons (organic compounds) are formed because of incomplete combustion of hydrocarbon fuels. Figure 10 shows as load increase fuel consumption increase so, with increase in load HC increase. The blending of HHO with petrol, replace petrol for energy supplement. So with addition of HHO decreases HC emission. At higher load the effect is significant because of higher efficiency. So HHO addition at higher CR reduces HC emission around 20%.

NOx emission :

High NOx emission is usually noticed with highly heated and compressed air that has nitrogen in it. Adding HHO to gasoline and incrase in CR both increases temperature and pressure of combustion process. So as fig. 11 shows addition of HHO increase NOx emission.

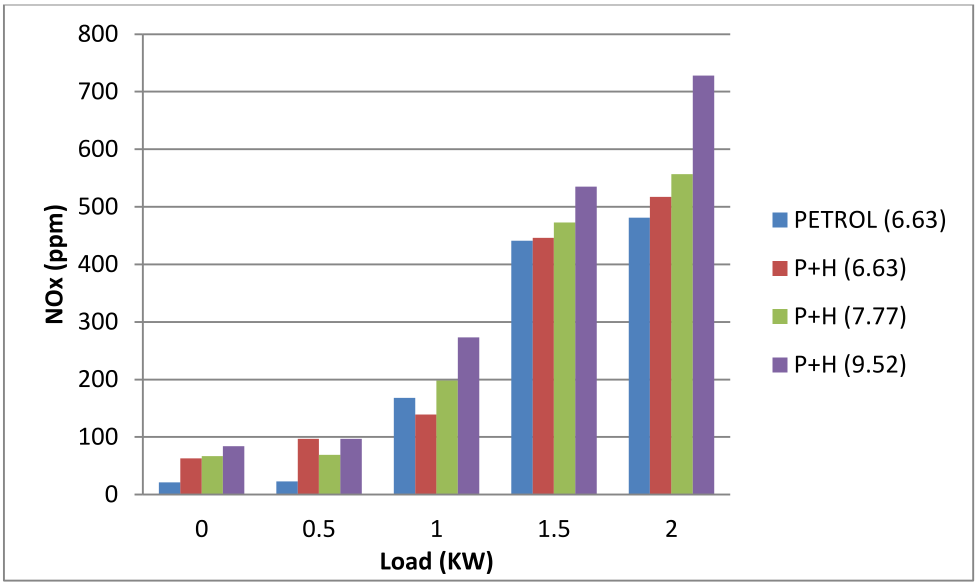

Figure 11 NOx v/s Load

IV. CONCLUSION

From the above discussion following points can be noted:
1) . With addition of HHO around 5.44% reduction in fuel consumption found for 6.63 CR at 2.0KW load. This is because of better combustion; the uniform mixture of air especially due to oxygen avaibility and HHO gas assists gasoline during combustion process and complete combustion is due to its property high flame speed and wide flammability range.
2) By increasing CR from 6.63 to 9.52 with HHO addition 6.81% more reduction found in fuel consumption. So it is clear that benefit of HHO can be double by increasing CR.
3) Engine Break Thermal Efficiency increased by 1.36% after HHO addition at CR 6.63 and increasing CR from 6.63 to 9.52 it increase by 3.20%.
4) Emission of CO, CO2 and HC decrease with HHO addition and increment in CR. CO emission reduce by 29.42% due to increase in air-fuel ratio, better combustion efficiency, high flame speed. HC emission reduce by 20%.
5) NOx emission increases with HHO addition and increment in CR because both phenomena increase temperature and pressure of the combustion process so more nitrogen form air combine with oxygen and produce more NOx.

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