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Emissions Characteristics of Four Stroke Spark Ignition Engine By Using of HHO Gas With Variable Compression Ratio

KEYWORDS: Carbon dioxide, Carbon monoxide, Hydrocarbon, Compression ratio, Electrolyte, Four Stroke SI engine, HHO gas, Nitrogen oxide.

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ABSTRACT *- In this study, HHO gas was produced by the process of water electrolysis. Electrolytes such that KOH is used as an electrolyte which reacts with electrode and produce the hydrogen. HHO gas was used as a supplementary fuel in a single cylinder, four strokes, spark ignition (SI) engine without any modification. In this experiment the HHO gas was supplied with intake air. The control valve was used for control the supply of HHO gas. The range of amount of HHO gas was placed between 2.57% to 2.74% with intake air. Also compression ratio was arranged at 7, 8 and 9 turn by turn. At this condition load was set at different condition at 1kg, 3kg, 5kg, 7kg and 9kg. After completing this experiment, an analysis was done. The Carbon monoxide, carbon dioxide and hydrocarbon were decreased when compression ratio and % of HHO gas was increased. Also the Nitrogen oxide was increased when compression ratio and % of HHO gas was increased.*

INTRODUCTION

The reserve of petroleum over the world is limited. Decreasing supplies of fossil fuels and steadily rising concentrations of atmospheric carbon dioxide concentrations and levels of atmospheric pollutants are some of major challenges to the modern society. The scientific community is addressing these problems by an attempt to replace fossil fuels with cleaner and renewable sources of energy [4]. Hydrogen gas is an example of a renewable energy source that can be used to partially supplement petrol fuel by enriching supply air. Advantages of introducing hydrogen gas include higher net heating value and diffusivity of hydrogen in air when compared to fossil fuels [5]. In addition, better diffusivity produces a much faster flame velocity that can lead to a better acceleration and torque output from the engine.

HHO GENERATION

HHO gas is a combination of daiatomic hydrogen and monatomic oxygen.. HHO gas is produced by a similar design of the electrolyzer that will split water into its various components [5]. Brown's gas has a plethora of unusual characteristics that seem to defy current chemistry [5]. The goal is to confirm claims of the Brown's gas and to help solidify the current theory of Brown's gas [5].

Electrolysis Process:

This is the simplest method of hydrogen production. It is preferred when cheap electric power, ample water is available and high purity hydrogen is desired. Hydrogen and oxygen are split by electric current from the water. If the electricity is from renewable sources, such as solar or wind, the resulting hydrogen will be considered renewable as well, and have numerous emissions benefits [9].

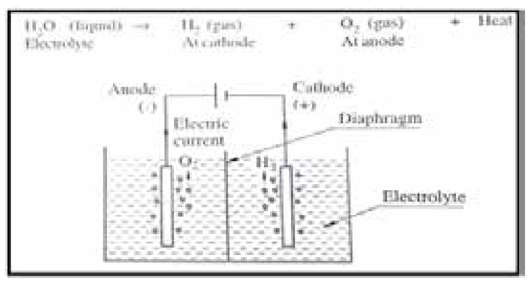

Figure 1 Electrolyte cell [10]

As shown fig., typical electrolyte cell consists of electrodes (nickel plate iron rod- anode and iron plate- cathode) and acid like NaOH or KOH solution in the water as the electrolyte. Direct current decomposes water into H2 and O2 which are released at the cathode and anode respectively. The electrolysis method is the most suitable when primary energy is available as electrical energy [10].

EXPERIMENTAL SETUP AND PROCEDURE

The setup consists of four strokes, single cylinder and water cooled petrol engine. The engine is coupled to eddy current type dynamometer for loading. The compression ratio can be varied without stopping the engine. Set up are provided with necessary instruments fuel flow, load, air flow and temperature measurements. It has stand alone panel box consisting of fuel measuring unit, fuel tank, manometer, fuel flow measurement, air box, transmitters for air. The cooling water is provided by Rotameter and measurement water flow by Calorimeter. A battery charger, battery, starter and is provided for engine electric start arrangement. The setup enables study of VCR engine performance for friction power, indicated power, indicated thermal efficiency, brake power, brake thermal efficiency, mechanical efficiency, specific fuel consumption and Air fuel ratio.

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Figure 2 Experimental setup

Table 1 Technical specification of the engine

Parameter	Details
Make	Kirloskar Oil Engines
Engine	Four Stroke Single Cylinder, Water Cooled
Cylinder Bore	87.50 mm
Stroke Length	110 mm
Orifice diameter	20 mm
Dynamometer arm length	185 mm
Cubic Capacity (Cc)	661.45 cc
Maximum Power	4.5 Kw @1800 rpm
Speed Range	1200 to 1800 rpm
Connecting Rod Length	234 mm
Dynamometer	Eddy Current Type
CR Range	6:1 to 10:1

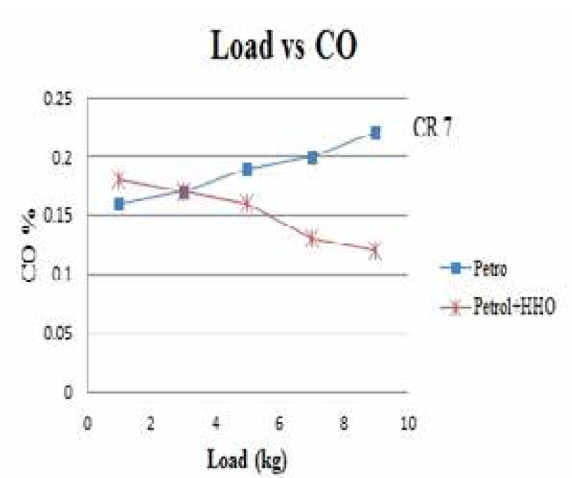
Table 2 Technical specification of HHO kit

Reactor Container Volume	2.5 liter
Electrolyte	KOH
Electrode	Stainless steel plates
Voltage and current	– 10 A

RESULT AND DISCUSSION

Effect on CO emission :

The figure 3 (a), 3 (b) and 3 (c) are plotted in between load Vs. CO% at difference compression ratio, without using HHO gas and with using HHO gas.



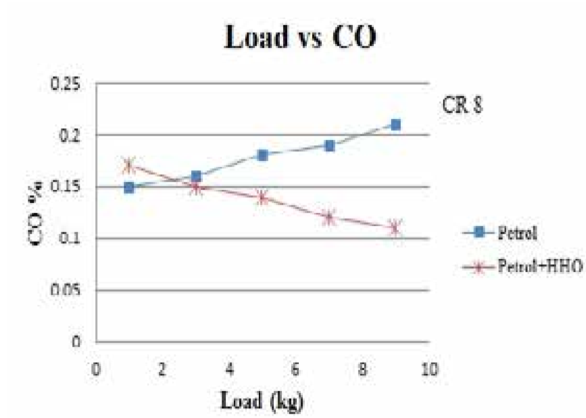


Fig. 3(a) Load V/s CO% at CR 7

Fig. 3(b) Load V/s CO% at CR 8

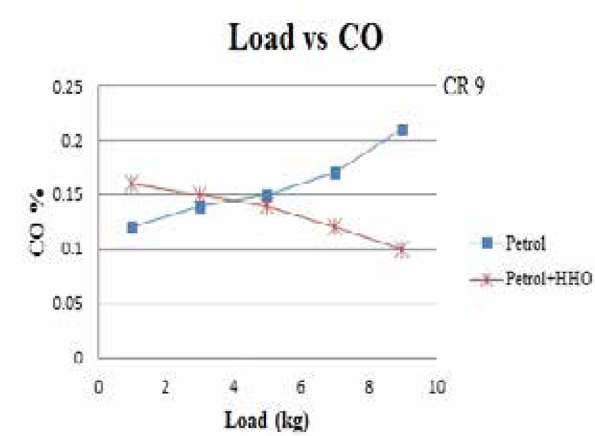


Fig. 3(c) Load V/s CO% at CR 9

Figure 3(a) shows the effect on carbon monoxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 7.

Figure 3(b) shows the effect on carbon monoxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 8.

Figure 3(c) shows the effect on carbon monoxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 9.

The load increases, CO emission increase for Petrol engine and decrease for HHO + Petrol engine. CO is intermediate product of combustion remains in exhaust if there is on enough O2 to convert all carbon to CO2, known as incomplete combustion. When Petrol engine operated with rich air fuel ratio then CO emission is generated. These emissions can be reduced by operating the engines at leaner ratios. HHO + Petrol engine can be operated at leaner ratios, thus resulting in reduced level of CO emissions. Above Figures shows the reduction in Carbon Monoxide emission level for Petrol with HHO gas compared to that of Petrol fuel.

Effect of HC
Figure 4 (a), 4(b), and 4 (c) shows the load Vs. HC graph which indicates the effect on HC emissions at CR 7, 8 and 9 using HHO + Petrol.

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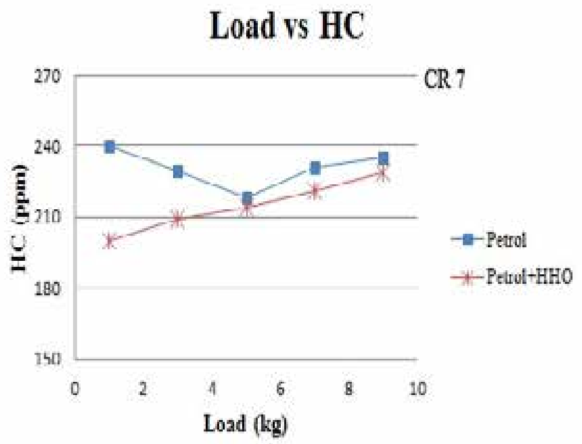


Fig.4 (a) Load V/s HC at CR 7

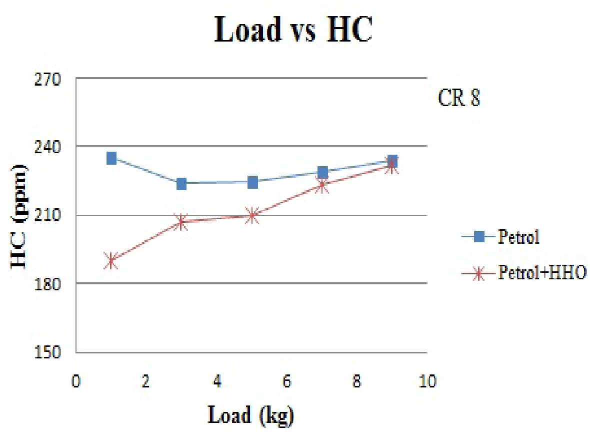


Fig.4 (b) Load V/s HC at CR 8

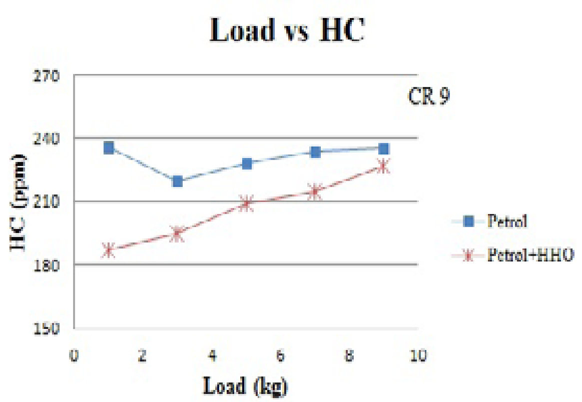


Fig.4 (c) Load V/s HC at CR 9

Figure 4(a) shows the effect on hydrocarbon at different load (1, 3, 5, 7, 9 kg) at Compression ratio 7

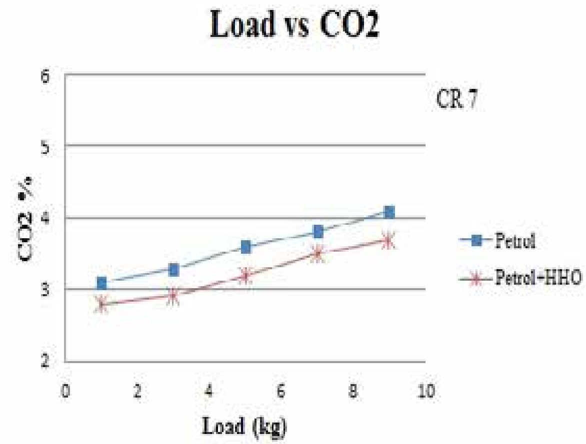
Figure 4(b) shows the effect on hydrocarbon at different load (1, 3, 5, 7, 9 kg) at Compression ratio 8.

Figure 4(c) shows the effect on hydrocarbon at different load (1, 3, 5, 7, 9 kg) at Compression ratio 9.

The HC decrease at initial load condition after than it increases with load for Petrol engine. Petrol engine operates at rich air fuel ratio and thus resulting in increased amount of Hydrocarbon emissions compare to that of HHO gas enriched air operating engines. These graphs indicate that the HC emissions are reduced for Petrol engine with using HHO gas. Hence emission of hydrocarbon reduced with increase in compression ratio, the lower compression ratio decreases the surface volume ratio.

Effect on CO2

Figure 5(a), 5(b) and 5(c) shows the load Vs. CO_2 graphs which indicate the effect on CO_2 at Compression ratio 7, 8



and 9 for Petrol and HHO + Petrol.

Fig.5 (a) Load V/s CO_2 at CR 7

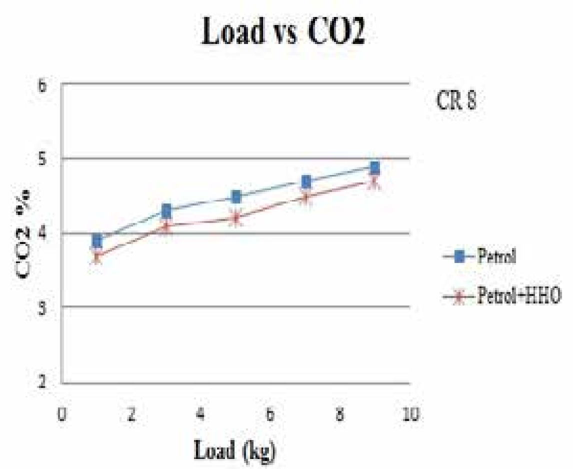


Fig. 5(b) Load V/s CO_2 at CR 8

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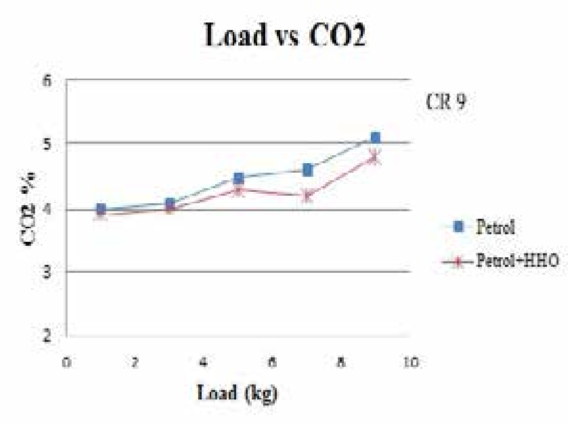

Fig. 5 (c) Load V/s CO_2 at CR 9

Figure 5(a) shows the effect on carbon dioxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 7.

Figure 5(b) shows the effect on carbon dioxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 8.

Figure 5(c) shows the effect on carbon dioxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 9.

The CO_2 % increase when load increase for the conventional Petrol. When compare the CO_2 % of Petrol with respect HHO gas then emission of CO_2 decreases with respect to load. When the compression ratio increased then amount of CO_2 emission increased for Petrol engine and HHO + Petrol engine.

Effect on NO_x

The figure 6(a), 6(b) and 6(c) are plotted in between load Vs. NO_x at difference compression ratio, without using HHO gas and with using HHO gas.

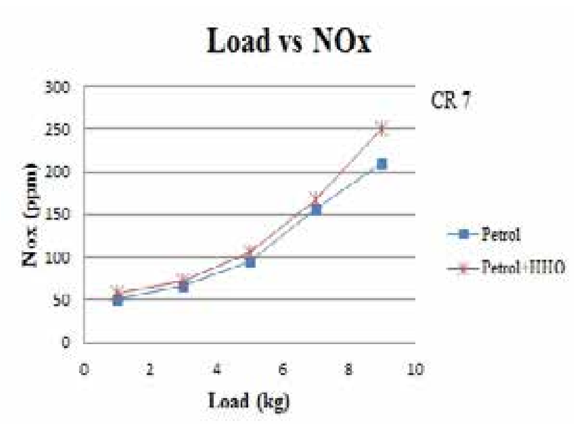

Fig. 6 (a) Load V/s NOx at CR 7

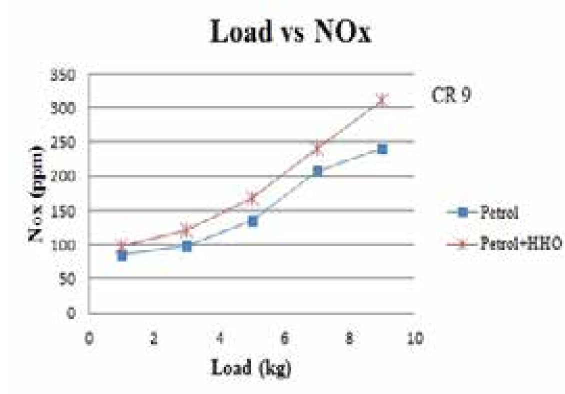

Fig. 6(b) Load V/s NOx at CR 8

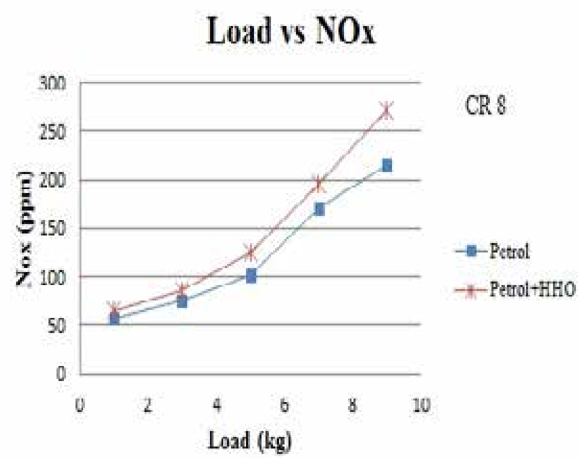

Fig. 6(c) Load V/s NOx at CR 9

Figure 6(a) shows the effect on Nitrogen oxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 7.

Figure 6(b) shows the effect on Nitrogen oxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 8.

Figure 6(c) shows the effect on Nitrogen oxide at different load (1, 3, 5, 7, 9 kg) at Compression ratio 9.

The Figure 6(a), 6(b) and 6(c) shown the curves between load and NOx at various loads. Oxide of N2 generally occur mainly in form of NO and NO2. These are generally formed at high temperature. Hence, high temperature and availability of O2 are the main reason for the formation of NO and NO2. The NOx concentration in exhaust is depend on air fuel ratio and mode of vehicle operation. The maximum NOx levels are observed with air fuel ratios between 14:1 to 16:1. As per shown above figure NOx increase in Petrol engine when increased load. But NOx increased when increased load with presence of HHO gas. When compression ratio increased then NOx increased in the both case without HHO and with HHO gas.

CONCLUSIONS

Experimental investigation of the effect of HHO gas on the performance test on 661 cc single cylinder spark ignition engine carried out. From experiment work the following conclusions are made:

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The range of compression ratio 7 to 9, reducing the carbon monoxide 0.10% to 0.11% with using 2.57% to 2.74% HHO gas respectively at full load condition.

The range of compression ratio 7 to 9, reducing the Hydrocarbon 0.85% to 3.40 % with using 2.57% to 2.74% HHO gas respectively at full load condition.

The range of compression ratio 7 to 9, reducing the carbon dioxide 0.2% to 0.4% with using 2.57% to 2.74% HHO gas respectively at full load condition.

When compression ratio increased, the % of HHO gas also increased with CR. There for the effect of these parameters, occurs on NOx. NOx emission increase with increasing the compression ratio and % of HHO.

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