Research Paper Engineering

An Experimental Investigation of Hho Gas And Varying Compression Ratio on Emission Characteristics of Constant Speed Diesel Engine

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ABSTRACT

Fossil fuels are available in limited reserves. Nowadays, more researchers focus on protecting the environment and maintain the greenhouse effect. So, in this study, we use the hydrogen gas with diesel fuel in CI engine. Many processes of hydrogen production are found by researchers. Some processes are not economical so, in this paper use the cheaper method of hydrogen production which is electrolysis process. The HHO gas was produced by the process of water electrolysis with various electrode designs in a hydrogen generator. This paper presents the concern with the HHO gas addition on emission and combustion characteristics of a Constant speed CI engine with variable compression ratio like that 16, 17 and 18 and loads(1,3,5,7,9). The effect will be shown on the graphs of CI engine for the CO, HC, CO2 and NOx with the use of HHO and a variable compression ratio at 16, 17 and 18 and loads.

KEYWORDS CI engine, Compression ratio, electrolysis, Electrolyte, HHO gas.

INTRODUCTION

Hydrogen is a colourless, odourless and non-toxic. It is the lightest element in all elements. It can find in the universe. It is mostly found in its molecular form combined with another chemical as a compound. An example is water, where it is combined together with oxygen, and methane, combined here with carbon. Different techniques are used for production of HHO gas. Such like that electrolysis, catalysts and electrodes are used. The energy of the hydrogen bond is 436 KJ/Mol. [2]

Many existing energy systems are based on fossil fuels (hydrocarbons), particularly crude oil. These hydrocarbons are made of atoms of hydrogen and carbon. Remove all carbon from the energy cycle and what is left is a hydrogen energy system. Hydrogen does not occur naturally in any significant quantities, it is almost always combined with other atoms, such as in water molecules or hydrocarbons. As a result, hydrogen has to be manufactured, a process which requires energy. This energy can be recovered thermally, by combustion or electrochemically in a fuel cell. Hydrogen is therefore a means of storing energy and is often referred to as an 'energy carrier' or 'energy vector'. Hydrogen is not naturally occurring, it must be manufactured. It can be made from fossil fuels (a process which results in the emission of CO_2), from biomass, or it can be produced by the electrolysis of water (which consumes electrical energy). A renewable hydrogen energy system would generate hydrogen from renewable energy, for example, via electrolysis, or by the chemical reformation of biomass.

Ali Can Yilmaz (2010) et al has taken HHO (Hydroxy gas) gas as a supplementary fuel in a four cylinder, four stroke, and compression ignition (CI) engine without any modification and without the storage tanks and measure its effects on exhaust emissions. Long opening of the inlet manifold, the HHO flow rate was increased and air flow rate decreases. It was creating the negative effect on engine torque, exhaust emission and volumetric efficiency (decreases). Therefore Hydroxy electronic control unit (HECU) was designed or manufacture. Decrease the HHO flow rate by decreasing voltage and current automatically by programming data logger and take the advantage of exhaust emission. [1] **Sankar. T (2014) et al** used HHO gas with diesel and karanj oil and performed the experiment on the single cylinder four stroke diesel engine. They had been using the karanj oil and HHO as an alternative fuel. The performance and emission levels were calculated for the different blended ratio. The blended ratios were D100%, D+HHO, K100%,K+HHO, K25%+D75%+HHO, K50%+D50%+HHO, K75%+D25%+HHO. The loading can be increased from 0 to 16kg. In ratio D75%+K25%+HHO we can get the emission of CO=0.04%, CO2=4.8%, HC=29ppm, SFC=1.81kg/Sec. [3]

ELECTROLYZERS BUILD PROCESS

One important use of electrolysis of water is to produce hydrogen.

$$2H_2O\,(l) \rightarrow 2H_2(g) + O_2(g)$$

This has been suggested as a way of shifting society toward using hydrogen as an energy carrier for powering electric motors and internal combustion engines. [3]

Actually, water is "burned hydrogen" or "hydrogen ash". Water is the by-product resulting from operating a vehicle on hydrogen. In more technical terms, then, water is a lower energy form of hydrogen. To turn water back into a fuel, energy must be pumped into the water causing it to dissociate, freeing the hydrogen. For this reason, we do not consider hydrogen to be a source of energy. It is, rather, an energy vector--a convenient form of energy that can be stored safely and then used efficiently without affect the environment. [3]

The simplest process for dissociating water employs the use of electrical energy and is known as electrolysis. When two metal plates are placed in water in the presence of a catalyst and connected to a source of electricity, water molecules are pulled apart into hydrogen and oxygen. Hydrogen bubbles collect on the negative plate (cathode) while oxygen bubbles gather on the positive plate (anode). Since hydrogen and oxygen exist in water at a ratio of two to one, twice as many hydrogen bubbles form as oxygen bubbles. [3]

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This electrolysis equipment utilizes various schemes and technologies to increase the quantity of hydrogen produced per unit of energy consumed. The measure of hydrogen produced by an electrolyzer verses the electricity consumed is referred to as the electrolyzer's efficiency. If the amount of hydrogen produced by an electrolyzer were exactly equivalent to the electrical energy put into the unit, then the device would be said to be 100 percent efficient. In reality, commercial electrolysis equipment ranges in efficiency from 40 to 80 percent. [3]

Each electron which is passed through water in an electrolysis device liberates one atom of hydrogen. Two electrons, then, produce one hydrogen molecule (H2). Avogadro's number of electrons (6.02 x 1023) produces one gram of hydrogen. Since each electron produces one hydrogen atom, the efficiency of an electrolysis device can be determined by measuring the electric voltage required to operate the cell. A cell operating at the theoretical voltage of 1.23 volts is 100 percent efficient. The amount of voltage above 1.23 required to operate the cell is wasted. The objective, then, is to make a cell that will operate as close to this voltage as possible. Distilled or de-mineralized water is added to the hydrogen generator once every tank full of fuel and is usually done when checking your oil. If the water is not added no damage is done to the engine or to the hydrogen generator (electrolyzer). [3]

Mineral water should not be used because the minerals will stay behind in the electrolyzer and eventually you will have mud inside. Rain water can be used, as well as air conditioner drippings. It only uses 12-16 ounces of water every tan full of gasoline. If you use mineral water, it will cloud up, get muddy and cause the electrolyte to need rinsing or cleaning out in weeks or months. You can use demineralized tap water if your city pipeline gets filtered. [3]

When an electrolysis solution is placed in the body, and a current provided across the electrodes, water is caused to decompose into hydrogen and oxygen. These combustible gases are then passed into the internal combustion engine to increase the efficiency and power thereof. In one embodiment a reservoir is provided to ensure that the level is maintained in the cell. Safety features include a low level sensor switch and low level shut off, a temperature sensor and high temperature cut off, and a pressure sensor and high pressure cut off. [3]

EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, engine connected to eddy current type dynamometer for loading. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The setup has a stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. The Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provides for the engine electric start arrangement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, and specific fuel consumption. [5]

[11]

Figure 1 Experimental setup

Table 1 Technical specification of the engine.

No. of cylinder	Single cylinder
No. of stroke	4
Cylinder dia.	87.5 mm
Stroke length	110 mm
C.R. length	234 mm
Orifice dia.	20 mm
Dynamometer arm length	185 mm
Fuel	Diesel
Power	3.5 kW
Speed	1500 rpm
C.R. range	12:1 to 18:1
Inj. Point variation	0 to 25 BTDC

Table 2 Technical specification of HHO kit

Electrode (anode- cathode)	316L stainless steel plates
Voltage and current	12 V- 10 A
Electrolyte	KOH
Reactor container volume	2.5 L

FIVE GAS ANALYZER

Figure 2 gas analyzer

This instrument is used for measure the emission which shows in above figure.
Purging is required before take the reading where first time used.

Take the reading of emission at every changing loads and compression ratios.
This instrument measures the CO, HC, CO_2, O_2, NOx and temperature.

EXPERIMENTAL PROCEDURE
Experimental Procedure:

- Start the engine and wait for the steady state condition.
- Start the HHO kit and wait for hydrogen production and wait for steady state condition of it.
- After the steady state condition of engine, taken a reading of emission for conventional diesel for various compression ratios (16, 17 and 18) and loads (1, 3, 5, 7 and 9 kg).
- Now, hydrogen introducing with diesel and wait for the steady state condition and constant flow rate of hydrogen.
- Before starting the reading, engine must be reached at steady state condition for correct reading of emission.
- And then take reading of emission for various compression ratios (16, 17 and 18) with varying loads (1, 3, 5, 7 and 9 kg).
- Then, from the reading of emission plot the graphs and conclude some result which given below.

RESULT AND DISCUSSION
Effect on emission
Effect on CO Emission

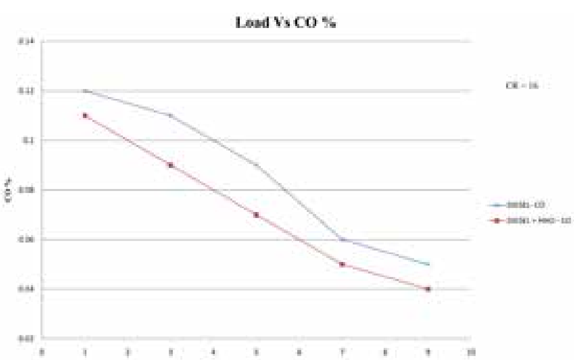

Figure 3 Load Vs CO at CR 16

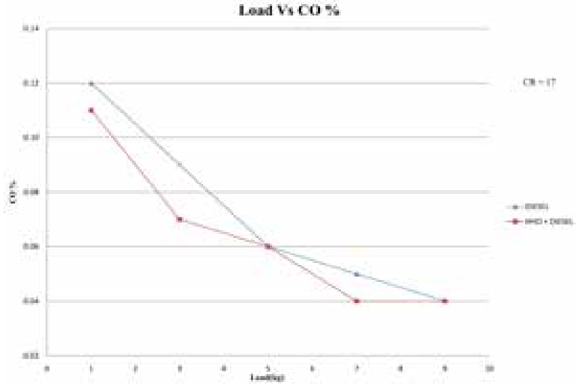

Figure 4 Load Vs CO at CR 17

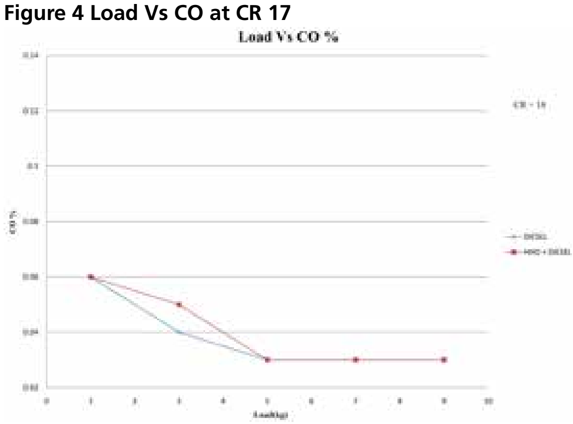

Figure 5 Load Vs CO at CR 18

When introducing the HHO in diesel engine with constant flow rate, decrease in CO compared to diesel engine. Sometimes CO is decreased at compression ratio 16 and sometime no drastic change in CO at higher compression ratio.

2) Effect on HC Emission
Figure 6, 7, and 8 shows the load Vs HC graph which indicate the effect on Indicates Thermal Efficiency at 16, 17 and 18 compression ratio.

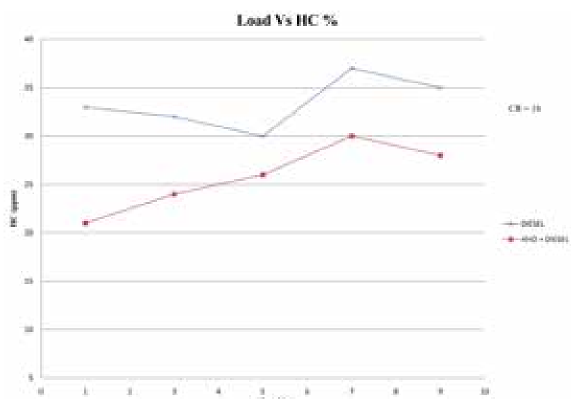

Figure 6 Load Vs HC at CR 16

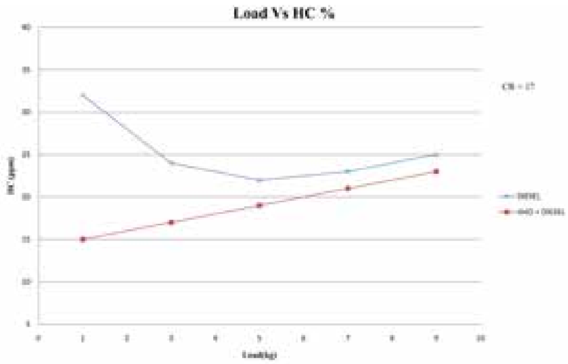

Figure 7 Load Vs HC at CR 17

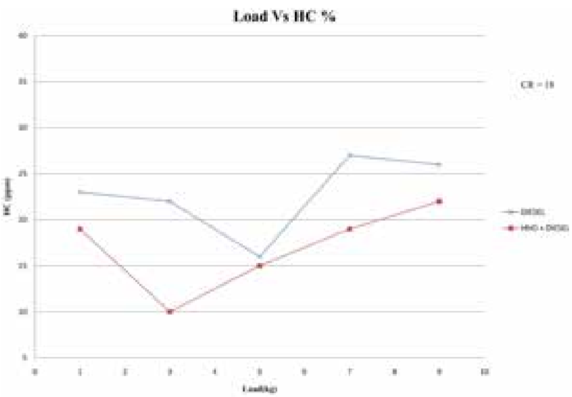

Figure 8 Load Vs HC at CR 18

When introducing the HHO in diesel engine with constant flow rate, decreases in HC compare to diesel. The increasing in compression ratio decreases the formation of HC emission.

3) Effect on CO2 Emission

Figure 9, 10, and 11 shows the load Vs. CO2 graph which indicate the effect on CO2 at 16, 17 and 18 compression ratio.

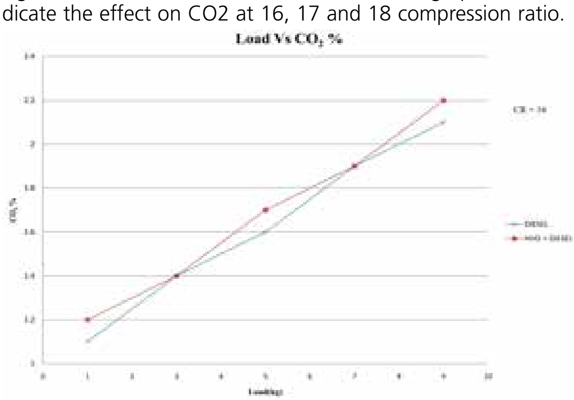

Figure 9 Load Vs CO2 at CR 16

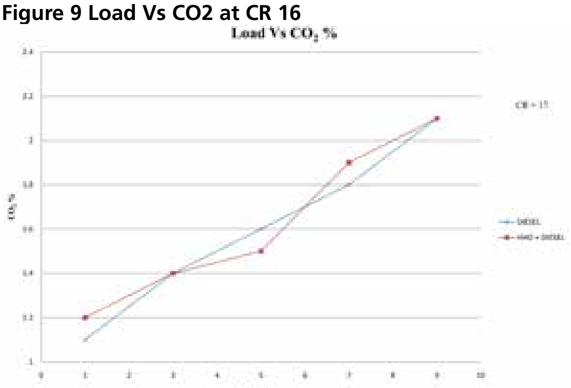

Figure 10 Load Vs CO2 at CR 17

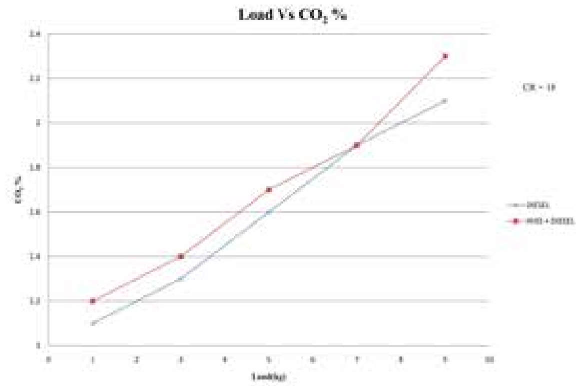

Figure 11 Load Vs CO2 at CR 18

When introducing the HHO in diesel engine with constant flow rate, CO2 is increases compared to diesel Engine.

If combustion is good CO2 emission will be more this effect is produced at low load conditions at higher load condition. If combustion is not good, then CO2 emission will be less this effect is produced at high load condition at higher compression ratio. [4]

4) Effect on NOx Emission

Figure 12, 13, and 14 shows the load Vs. NOx graph which shows the effect on NOx at 16, 17 and 18 compression ratio.

When introducing the HHO in diesel engine with constant flow rate, NOx is increases compare to diesel Engine.

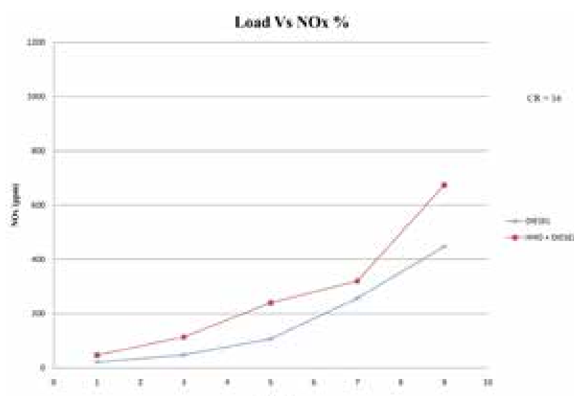

Figure 12 Load Vs NOx at CR 16

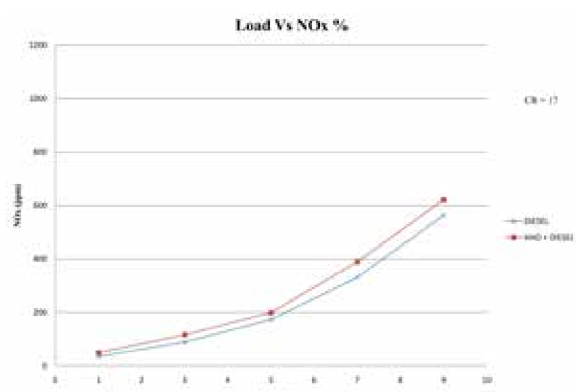

Figure 13 Load Vs NOx at CR 17

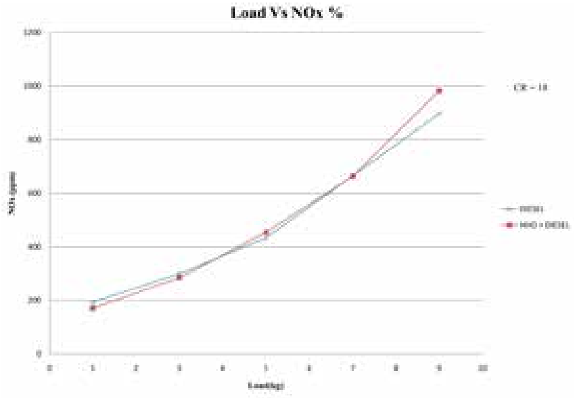

Figure 14 Load Vs NOx at CR 18

NOx is formed during the combustion because of three factors, high temperature, oxygen concentration, and residence time. If these three factors present in a combustion chamber, the NOx formation is more [4].

When compression ratio increases, increase in the pressure of gases in the cylinder is to be done. As a result, increase in temperature is done. So the effect is that increase in NOx emission.

CONCLUSION

The HHO gas is taken for experimental but it is secondary fuel, which could help in reduce the emission of CI engine. Hear one experiment is conducted to know the combined effect of HHO gas and compression ratio on the emission of a diesel engine.

This experiment measures the effect of different compression ratio at 16, 17 and 18.

At compression ratio 16 shows the drastic change in CO but minor change in HC and NOx and no drastic change is seen in CO2.

At compression ratio 17 minor changes are seen in all emission parameters.

At compression ratio 18 shows the drastic change in HC, CO2 and NOx but minor change is seen in CO.

So, hear conclude that compression ratio 18 is better to reduce the engine emission.

FUTURE SCOPE

The HHO gas is taken for experimental but it is secondary fuel, which could help in increase the performance of CI engine and reduce the emission. From the graph not conclude that at which load or compression ratio is most preferred for reduce engine emission. So, find the optimum value of load and the compression ratio at which reduce emission of diesel engine.

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