International Journal of Research in Engineering, Science and Management
Volume-1, Issue-11, November-2018
www.ijresm.com | ISSN (Online): 2581-5792

Review of Performance and Emission Characteristics of HHO Gas as a Fuel

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***Abstract*: HHO gas, which is obtained by the electrolysis of water, is a promising alternative fuel. This paper presents a review of important features and techniques used for producing HHO gas. Various aspects of the thermodynamics and chemical kinetics of electrolysis reactions are discussed. Design and operating parameters for improving the gas production rate are identified. Widely different hypotheses regarding the structure and composition of HHO gas are compared in depth. The state of the art on the use of HHO gas in Internal Combustion (IC) engines is presented in the latter part of the paper. It is seen that the introduction of HHO gas increases engine torque, power and thermal efficiency, while simultaneously reducing the formation of NOx, CO, HC and CO2. The major challenges in using HHO gas in engines are identified as system complexity, safety, cost and efficiency of electrolysis.**

***Keywords*: Combustion, Pollutants and global warming**

1. Introduction

Fossil fuels are the primary source of energy for power plants, automobiles etc. in today's world. Combustion in engines produce harmful gases such as carbon dioxide, carbon monoxide, oxides of nitrogen, unburned hydro carbon etc. Some of the ill effects of these pollutants are global warming, acid rain and various health issues. Several alternative fuels have been explored in the recent times with the intent of reducing the dependence on fossil fuels and achieving lower emissions. This paper presents the state of the art of HHO gas, which is renewable alternative fuels possessing several benefits over fossil fuels. HHO gas is prepared by electrolysis of water. During electrolysis process, the direct current is passed through water after addition of electrolyte (eg: NaOH, KOH, NaCl) which renders the solution electrically conductive. The resulting ionization reactions culminate in the decomposition of water into hydrogen and oxygen. The mixture of hydrogen and oxygen gas in nearly stoichiometric proportions proposed in the electrolyze is known by various names such as HHO, hydroxyl gas, oxy-hydrogen and Brown's gas.

2. Literature review

Vaibhav Khopade and et al have proposed fuel from water to run an IC engine vehicle by electrolysis of water we get Brown's gas (HHO gas), which can be used as additive fuel for IC engine. HHO blended fuel is introduced to combustion chamber of IC engine. While burning of charge HHO gas reduces the specific fuel consumption. By using HHO gas as additive will reduces the combustion temperature. Extra oxygen molecule (H-H-O) ensures clean burning of fuel which results low emission. This is low cost system, which can be used to any petrol engine. Tamer M. Ismail and et al have done performance of hybrid compression ignition engine using hydroxy (HHO) from dry cell. The HHO dry cell uses the electrolysis process in order to produce the HHO gas from water, which is ionized by adding NaOH as the electrolyte. Three types of HHO dry cell were used, namely alpha, beta and omega cells. Many measured data were done to choose the best one of the HHO dry cells. Oxygen sensor, MAP sensor, and MAF sensor were used to control the fuel injection. From the recorded measured experimental data, the beta cell has shown a good performance for the engine. The amount of HHO gas needed to be supplied to a 1500 CC engine is 0.375 LPM. The results also showed that there is a 17% reduction in fuel consumption and a 17% reduction in CO, a 27% reduction in HC, a 15% increase in O2 and a 1% increase in CO_2. Aaditya and et al have examined hydrogen powered petrol engine. This form of alternative fuel is provided by a hydrogen generator mounted in the vehicle. Once set up is ready, the hydrogen gas (fuel) will be produced from water, an electrolyte compound, and electricity supplied from a battery provided. Here we are designing a mixed fuel two wheeler engie.ie in a conventional SI engine we are incorporating traces of hydrogen along with gasoline in order to minimum consumption of gasoline as well as to increase the power of vehicle. Here in addition, a hydrogen generating unit is made to produce hydrogen .It is actually an electrolysis unit having high grade stainless steel/graphite/semiconductors as electrodes in a closed container and mixture of distilled water & suitable ionic solution(KOH or NAOH) as electrolyte. Power for electrolysis is taken from an additional battery provided (12V).This battery can be recharged from a dynamo/alternator/motor provided on the vehicle. Keyword- KOH, NAOH, SI engine, electrolysis of water, hydrogen cell.
Prem kartikkumar SR and et al have explored effectiveness of oxygen enriched hydrogen-HHO gas addition on diesel engine performance, emission and combustion characteristics. HHO gas was produced by the process of water electrolysis. When potential difference is applied across the anode and cathode

electrodes of the electrolyzer, water is transmuted into Oxygen Enriched hydrogen-HHO gas. The produced gas was aspirated into the cylinder along with intake air at the flow rates of 1 lpm and 3.3 lpm. The results show that when Oxygen Enriched hydrogen-HHO gas was inducted, the brake thermal efficiency of the engine increased by 11.06%, Carbon monoxide decreased by 15.38%, unburned hydrocarbon decreased by 18.18%, Carbon dioxide increased by 6.06%, however, the NOX emission increased by 11.19%. Balaji Subramanian and et al have produced and used HHO gas in IC engines. The state of the art on the use of HHO gas in Internal Combustion (IC) engines is presented in the latter part of the paper. It is seen that the introduction of HHO gas increases engine torque, power and thermal efficiency, while simultaneously reducing the formation of NOx, CO, HC and CO_2. The major challenges in using HHO gas in engines are identified as system complexity, safety, cost and efficiency of electrolysis. Bhavesh V.Chauhan and et al have Investigated HHo gas and varying compression ratio on emission characteristics of constant speed diesel engine. 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 ike 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.

A. Production of HHO gas

When electricity flows between two metal conductors that are immersed in water, the water molecule is broken down into its two basic atoms - Hydrogen and Oxygen; through a process called Electrolysis of Water. This electricity is DC (direct current) flowing from the negative Cathode to the positive Anode (like from a battery). Normally water by itself is like an insulator and will not conduct DC electricity, so to make this happen we have to add a little catalyst, called an "Electrolyte". The electrolyte allows current to flow between the -ve side and the +ve side of the plates. 5% KOH is added into the water which acts as electrolyte solution. As the current is released to flow from one plate to another, the combined voltage and current begin to separate the molecular bond holding the atoms together and the Hydrogen and Oxygen atoms separate, and begin floating to the surface. The Hydrogen and Oxygen in the water separate and become a new blend of gases made up of its original atoms Hydrogen, Hydrogen and Oxygen; hence the terminology "HHO gas".

B. Effect on emission effect on co emission

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.

C. Effect on HC emission

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.

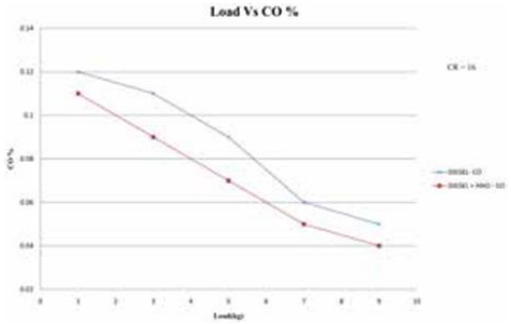


Fig. 1. Load vs. CO at cr 16

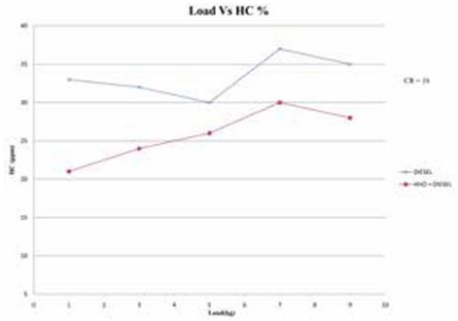


Fig. 2. Load vs. HC at CR 16

D. Effect on CO2 emission

When introducing the HHO in diesel engine with constant flow rate, CO_2 is increases compared to diesel Engine. If combustion is good CO_2 emission will be more this effect is produced at low load conditions at higher load condition. If combustion is not good, then CO_2 emission will be less this effect is produced at high load condition at higher compression ratio.

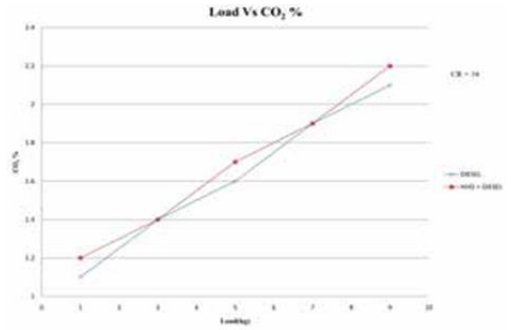


Fig. 3. Load vs. CO_2 at CR 16

E. Effect on NOx Emission

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.

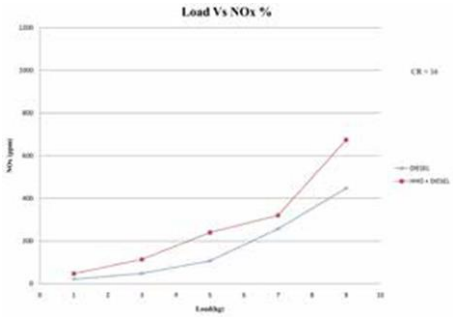
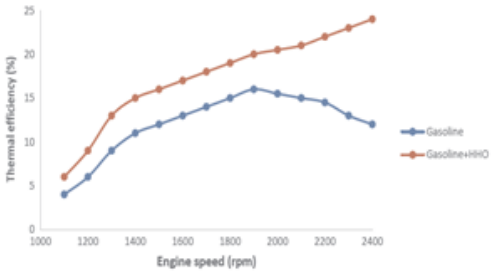
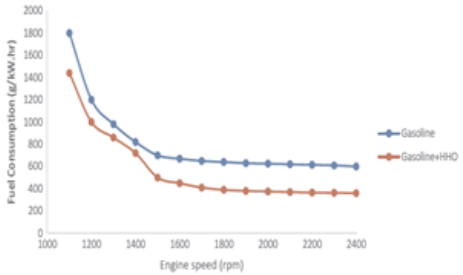


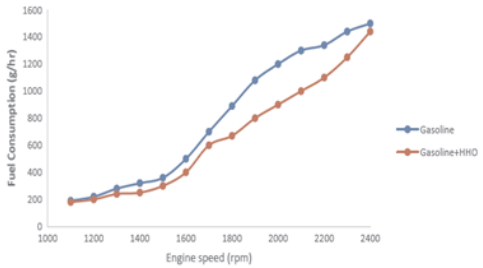
Fig. 4. Load vs. NOx at CR 16

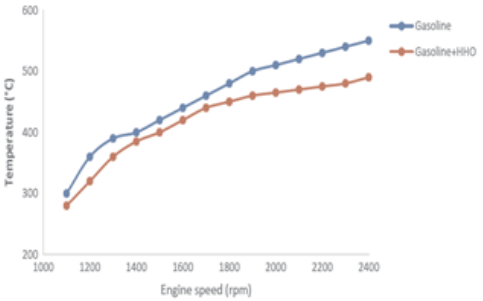
F. Engine performance

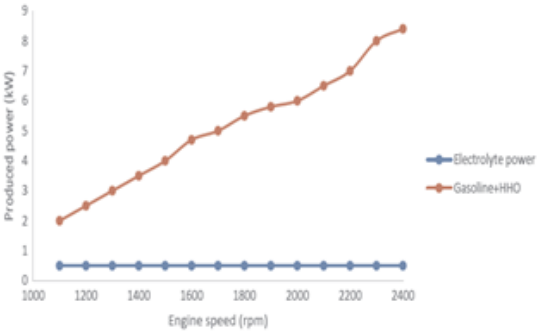
The measuring conditions have to be constant at the two steps; the recorded coolant temperature was 91 °C, the engine is at the idle condition and the scan tool was reading no trouble code. The exhaust gases were analyzed and measured using the Gas Analyzer. Adding HHO gas to the fuel/air mixture has the immediate effect of increasing the octane rating of any fuel. ‘‘Octane Rating’’ means how much that fuel can be compressed before it ignites. More efficient combustion translates to less fuel being consumed. The performance test was performed on the test engine prior and then after inserting the fuel cell. The estimations have been performed by the standard conditions that can be found in numerous internal combustion engine reading material. The below mentioned diagram demonstrate the impacts of the energy unit on the motor execution. The below mentioned diagram demonstrates the impact of the power device on the break efficiency, uncovering an expansion in the efficiency of around 8% for the energy cell. The below mentioned diagram shows the effect of using fuel cell on the thermal efficiency with variable engine speed. From the analysis of this figure, it has been shown that using HHO gas to the engine enhances the thermal and combustion efficiencies of the engine. The HHO gas improved the thermal engine efficiency with a range of 30–53% depending on the engine speed. The below mentioned diagram are indicative of worry regarding fuel utilization and show a huge decrease in specific fuel consumption. The below mentioned diagram shows the effect of using fuel cell on exhaust gas temperature with variable engine speed. From this figure, it can be noticed that the exhaust gas temperature is directly related to the engine speed, and that using the HHO gas reduces the exhaust gas temperature. This is due to the power device that gives better ignition and cleaner gasses. The below mentioned diagram demonstrates the extra power delivered by utilizing the energy cell. It is unmistakably observed that the fuel cell delivers more power than gasoline solely. The percentage of increase in power was varied from 75% to 95% according to the engine speed.











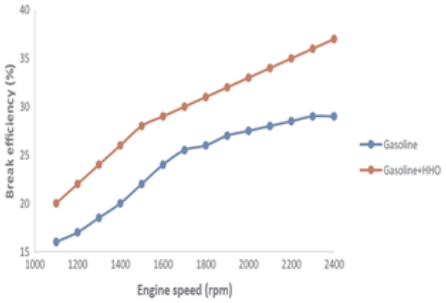


Fig. 5. Engine speed vs. Break efficiency

3. Conclusion

A summary of the production techniques, properties and use of HHO gas has been presented here, highlighting its variability as a promisable renewable alternative fuel. HHO gas, which is prepared from electrolysis of water, is a mixture of hydrogen and oxygen. Several researchers have hypothesized the likelihood of a 'magnecular' structure of HHO, and referred to the present traces of clusters of H and O atoms, dimmers and water vapour in it. The presence of hydrogen in the HHO gas makes it a promising alternative fuel. The rate of production of HHO gas by electrolysis depends on many factors such as electrode material, geometrical parameters, type and concentration of electrolyte, amount of current passed etc. Various technique have been proposed to enhance the rate of electrolysis such as conditioning electrodes, increasing the electrode surface area, increasing electrolyte concentration, using higher current density, using natural gas instead of air for steam electrolysis etc. While HHO gas has been shown to improve engine performance and emissions, its use requires additional equipment such as water tank, bubbler unit, flame arrester etc. as well as increased current demand on the battery.

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