A Review on Combined Effect of HHO Gas and Compression Ratio on the Performance and Emission Characteristics of Diesel Engine

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Abstract— The increasing industrialization of the world has led the demand of petroleum based fuels. Fossil fuels are obtained from limited reserves. Nowadays, more researchers focus on protecting the environment. So, use the hydrogen gas with diesel fuel in CI engine. The oxygen enriched hydrogen-HHO gas was produced by the process of water electrolysis. Hydroxy gas was produced by the electrolysis process of different electrolytes (KOH, NaOH, and NaCl) with various electrode designs in a leak proof Plexiglas reactor (hydrogen generator). This review paper presents the concern with the effectiveness of oxygen enriched hydrogen-HHO gas addition on performance and combustion characteristics of a CI engine with variable compression ratio. The effect will be shown on the CI engine of the brake thermal efficiency, carbon monoxide, un-burn hydrocarbon, and carbon dioxide and NOx emission with the use of HHO and a variable compression ratio.

Key words: CI engine, electrolysis, Oxygen enriched hydrogen-HHO gas, performance characteristics, Electrolyte, compression ratio

I. INTRODUCTION

The increasing demand for petroleum fuel associated with limited non-renewable stored quantities has resulted in a huge increase in crude oil prices. In the last few years, ordinary people experienced this by paying more at the pumps. Consequently, we have seen a shift toward automobiles that consume less fuel. This has encouraged researchers to seek an alternative fuel that can be used in engines without the need for a dramatic change in the vehicle design. It has been shown that using pressurized hydrogen gas as a fuel in internal combustion engines (IC engines)has many advantages such as more engine power and lower pollutant concentrations in exhaust gases.

Among these alternative fuels, hydrogen fuel attracts the researchers because of its simple reaction with oxygen into water as a clean method for energy conversion, the high-energy density, the wider flammability limits, the high burning velocities and also their significant structure of non-content of carbon atoms. Today, hydrogen is mostly produced by steam reforming or partial oxidation of hydrocarbons (76% from natural gas and 23% of light or heavy oil distillates). However, for small hydrogen quantities, or when high-purity hydrogen is required, processes such as water electrolysis, ammonia decomposition or methanol reforming are also used. Water electrolysis is one of the most important industrial processes for hydrogen production today, and is expected to become even more important in the future.

II. REVIEW OF LITERATURE

In this paper briefly discusses about the previous work carried out by the researchers in the various fields which are related to the topic and helped one gain to build platform for my work.

R. B. Durairaj (2012) et al In their study focus on the production of the Oxy-hydrogen gas and it was added with to bio-diesel. This Oxy-hydrogen gas has been preheated with the help of waste heat recovered from the automobile exhaust. The use of HHO gas in conventional engines result in a reduction in emission of unburned hydrocarbons, carbon monoxide and particulate. Also, preheating of the air improves the thermal efficiency and reduces the vibration of the engine.

Production of Oxy-hydrogen by three ways,

1) Electrolysis
2) Catalysts
3) Electrodes

Lean mixture ratio combustion in IC engine which has the potential of producing low emission and higher thermal efficiency. Due to this combustion process was done in an efficient manner and the hydrogen was four times higher effective compare to ordinary fuels. And also leads to increase in efficiency and torque and horsepower of the engine, increase in the performance of the engine. [1]

W.B. Santoso (2013) et al in their study hydrogen utilization as diesel engine fuel at low load operation was investigated and also the combustion characteristics of this dual fuel engine. The engine was run at a constant speed of 2000rpm and 10Nm load. The resultant parameter like that Specific energy consumption, indicated efficiency and cylinder pressure was investigated. The reaction progress variable and combustion rate of reaction were slower as shown by the CFD calculation. The engine was a single cylinder, air cooled, direct injection diesel engine. The compression ratio of the engine was 20.5. Hydrogen was supplied from a high pressure cylinder (150bar) and then reduced to a pressure of 1.5 bar using pressure regulator. The engine was coupled to a SCHNENCK eddy current dynamometer. At steady state conditions parameters were measured and recorded: fuel consumption, air consumption and exhaust gas temperature and cylinder pressure.

The Commercial CFD software was used to simulate the combustion process of the diesel hydrogen dual fuel engine. The effect of hydrogen enrichment was measured on performance and combustion of CI engine. In the performance of CI engine the parameter's effects of energy sharing, specific energy consumption (SEC) and indicated efficiency vs. hydrogen flow rate is shown in figure 1, 2 and 3.

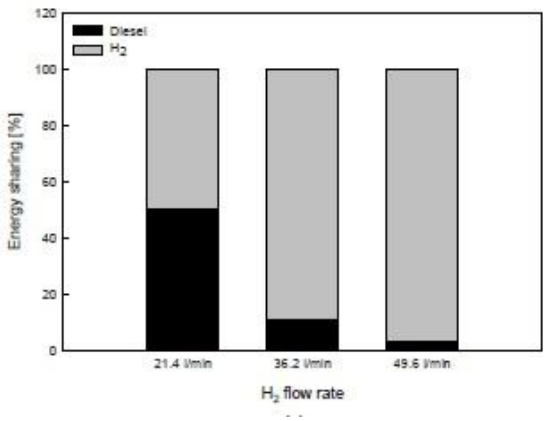

Fig. 1: Diesel energy replacement by hydrogen [2]

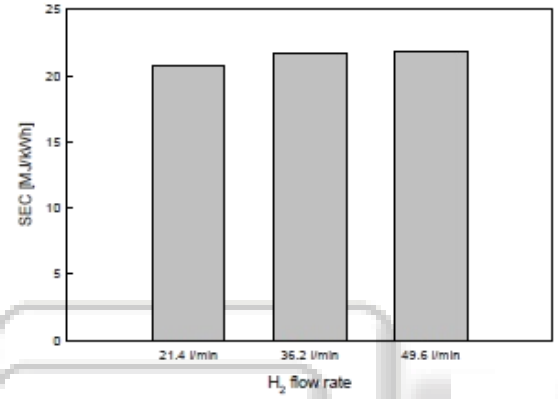

Fig. 2: Specific energy consumption [2]

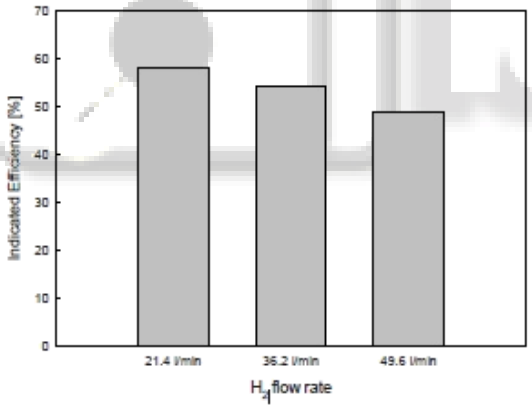

Fig. 3: Indicated efficiency [2]

A Diesel reduction of 50, 90 and 97 % was achieved during the experiment. At low load operation, the efficiency, and decrease with hydrogen enrichment. [2]

Dipen V. shah (2014) et al in their study, HHO was helped in the complete combustion and reduced the emission of the harmful gas. The Hydrogen was mixed with air and improves the combustion efficiency by complete combustion. The HHO gas was in the proportion of 0.45%, 1.6% and 3.45% with the air. Also reduce the fuel consumption and increase the brake power.The effect of HHO gas on specific fuel consumption and on brake power are shown below,

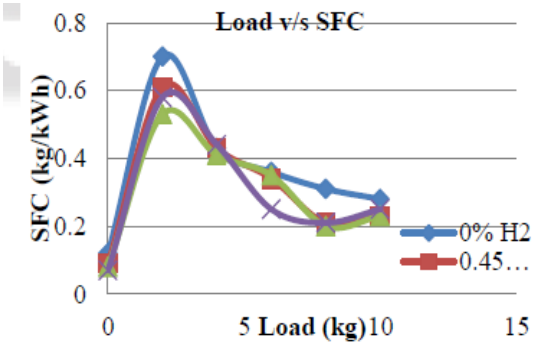

Fig. 4: Load Vs SFC [3]

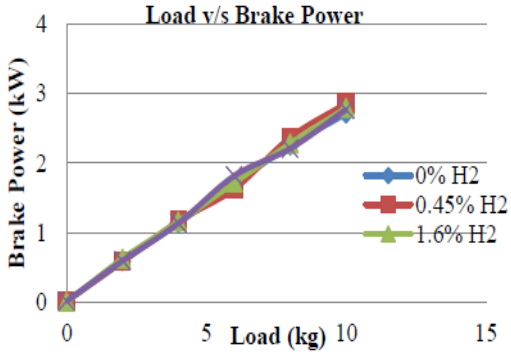

Fig. 5: Load Vs brake power [3]

The fuel consumption was decreased by use of HHO gas with air, which is shown in figure 7.The brake power is increased by the use of HHO gas with air, which is shown in figure 8.The effect of HHO gas on CO emission which is shown below,

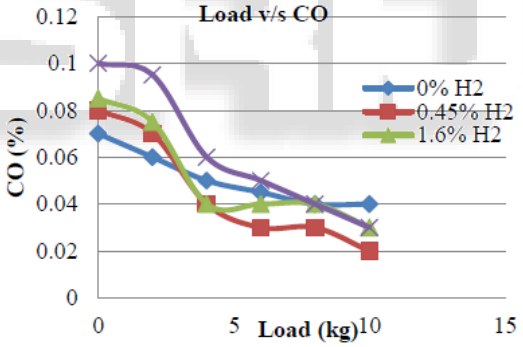

Fig. 6: Load Vs CO emission [3]

The CO emission decreased due to the complete combustion of fuel by use of HHO gas with air.[3]

C. Naresh(2014) et al was measured the performance and exhaust gas analysis of a single cylinder diesel engine using HHO gas.

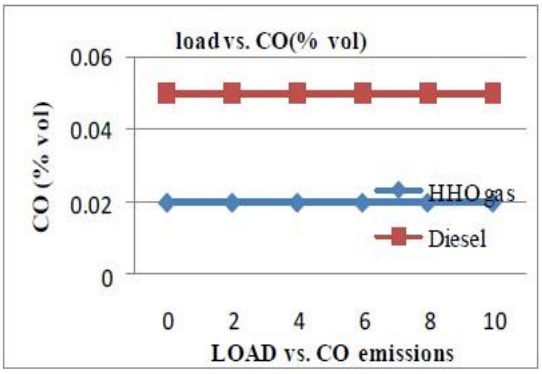

Fig. 7: Load vs. CO (%vol) emissions [4]

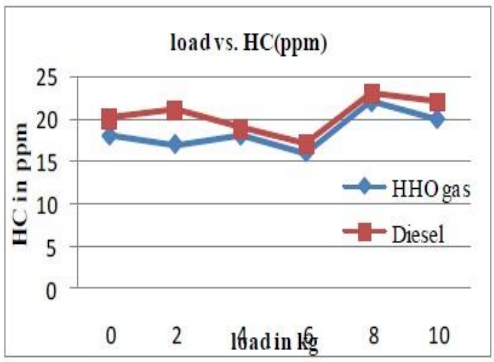

Fig. 8: Load vs. HC (ppm) [4]

As the load increases brake power increases. The brake power developed by the engine operated on HHO gas was more as compared with pure diesel. The Mechanical efficiency of the engine increase, for engine operated with HHO gas was more as compared whit pure diesel. Brake thermal efficiency, indicated thermal efficiency of engine increase, for engine operated with HHO gas was more as compared with pure diesel. Total fuel consumption of the engine increase, for engine operated with HHO gas were more as compared with pure diesel. Emissions like that carbon monoxide, hydrocarbon, carbon dioxide, The NOx were greatly reduced for the engine operated with HHO gas compared to pure diesel engine. [4]

Ankit Agarwal (2015) et althis review paper presents that using the different alternative fuels with different compression ratio and injection pressure, and it was compared with diesel fuel. The alternative fuels were such like that, Ethanol, Methanol, Jatropha Methyl Ester, Mahua Methyl Ester and Pangomia Methyl Ester in 20% blending with diesel fuel. In this paper compression ratio and injection pressure were 16.5, 17.5, 18.5 and 200,225,250 bar considered respectively. As the increasing the compression ratio and injection pressure, improve the performance characteristics at full load condition and emission characteristics NOx increase and HC and CO decrease. For BTE and BSFC gives the better result ofincreasing the injection pressure.[5]

Santosh Kumar Kurre (2013) et al was experimented on four stroke diesel engines and found that the effect of compression ratio on diesel engine performance and emission with diesel-ethanol blends. The engine was run with different compression ratios were 17, 17.5 and 18 with E10, E15 and E20. As compression ratio increased the HC was deceased and when ethanol blend increased HC was increased as compression ratio increased. As compression ratio increased the NOx increased and for lower blend NOx decreased. Brake specific fuel consumption decreased with compression ratio increased and brake thermal efficiency, increased with all compression ratio and exhaust gas temperature increase with compression ratio for all blends.[6]

This review paper presented by Hani Chotai (2013) et al and they were found the effect of varying the compression ratioof performance and emissions of a diesel engine fueled with biodiesel. The operation parameter like that compression ratio, injection pressure and injection timing were used to measure the emission and performance characteristics. The effect on brake specific fuel consumption, brake thermal efficiency, CO emission and exhaust temperature were studied. This paper results were shown that as increasing compression ratio until the certain limit increases brake thermal efficiency, decrease brake specific fuel consumption and decreasing CO emissions. [7]

III. Conclusion

From this study, shown that the effect of the operating parameter, compression ratio on the compression ignition engine. Also shown that the effect of using hydrogen as a supplementary fuel in the engine.

HHO gas was helped in the complete combustion and reduced the emission of the harmful gas. Various methods of hydrogen production are studied in these papers. NaOH was the most appropriate catalyst for hydrogen production.

As increasing compression ratio until the certain limit increases brake thermal efficiency, decrease brake specific fuel consumption and decreasing CO emissions.
From this study will investigate the combine effect of HHO gas and various compression ratios on diesel engine.

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