

Comparative Analysis of Diesel Engine Using Hydrogen as Additive Fuel with Diesel

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Abstract — This research has been analysing effect of Hydrogen gas on CI engine. In this research performance parameters such as brake thermal efficiency, mechanical efficiency, fuel consumption, specific fuel consumption investigated. This experiment performed with different loads. In this research show that CI engine working using Diesel fuel with Hydrogen additive gas. The lower fuel consumption, increment in brake thermal efficiency and decrement in specific fuel consumption has been analysed.

Keywords: Diesel, Hydrogen, CI Engine, Performance

I. INTRODUCTION

In recent years, the world has been facing an energy crisis due to the depletion of resources and increasingly serious environmental problems. The widespread use of fossil fuels in today's energy infrastructure is considered a major source of anthropogenic CO₂ emissions [1]. Hydrogen is abundant in our environment. It is stored in water (H₂O), hydrocarbons (such as methane, CH₄) and various natural substances. One of the tasks of using hydrogen as gasoline is to efficiently extract hydrogen from these compounds [2]. Hydrogen is the most abundant element in the universe, and despite the challenges of extracting it from water, it is a particularly abundant source of renewable energy, well suited to our future zero demand. carbon for combined heat and power. [3]. So, to improve the fuel economy and reduce the emission of harmful gases it needs alternative fuel. Hydrogen is one of the best alternative fuel and it also helps in reducing the emission of the harmful gases. There are some researches are conducted by this researcher. Birtas, A., Voicu, I., Petcu, C., Chiriac, R., & Apostolescu, N., show the engine was operated at light and moderate loads and speeds, and the impact on emissions was assessed. HRG (hydrogen rich gas) for tractor diesel engines [4]. Wang, H. K., Cheng, C. Y., Chen, K. S., Lin, Y. C., & Chen, C. B was experimented that effect of regulated harmful matters from a heavy-duty Diesel engine by H₂/O₂ addition to the combustion chamber [5]. Greenwood, J. B., Erickson, P. A., Hwang, J., & Jordan, E. A., was conducted following the hydrogen enrichment of ethanol in an ultra-lean internal combustion engine [6]. Deb, M., Sastry, G. R. K., Bose, P. K., & Banerjee, R., was studied of the combustion, performance and emission analysis of a single-cylinder four-stroke direct injection diesel engine using hydrogen in dual-fuel operation were investigated, a hydrogen-powered dual-fuel combustion DI diesel engine [7]. Zhao, Z., Huang, Y., Yu, X., Guo, Z., Li, M., & Wang, T., was researched and tested the effect of adding HHO on gasoline engines with exhaust gas recirculation systems and concluded that the reported efficiency of gasoline engines did not increase significantly [8]. Sandalcı and Karagöz conclusion is to study the combustion characteristics, emissions and performance of hydrogen port fuel injection in

diesel engines. in this use. Increase the percentage of hydrogen in the intake manifold. We can get a decrease in thermal efficiency, an increase in ISFC value indicating a decrease in specific combustion gas emissions, an increase in peak cylinder pressure and an increase in peak heat release rate [9]. Santilli, R. M., was studied that a new gaseous and combustible form of water the various measurements on a mixture of Hydrogen and oxygen called HHO gas produced via electrolyser which mixture is distinctly different than the brown and other known gases [10].

II. EXPERIMENTAL SETUP

Table 1 show different properties of Diesel and Hydrogen additive gas. Hydrogen additive gas which produced from electrolysis process in HHO kit.

Properties of fuel	Diesel	H ₂ additive gas
Density	830 kg/m ³	1.2 kg/m ³
Calorific value	43000 kJ/kg	150000 kJ/kg
Carbon percentage	85%	0%
Auto ignition temp.	280 °C	585 °C

Table 1: Properties of Fuel Used In Experiment

A. Hydrogen Flow Measurement Using Water Displacement Method:

The water displacement method can be used to measure the flow of Hydrogen gas in a pipeline. Here are the steps to follow. Water displacement method schematic diagram shown in Fig.1.

- Set up a container filled with water, such as a graduated cylinder or a burette.
- Connect the container to the pipeline using a valve and a tube. The tube should be inserted into the container so that it is submerged in the water.
- Open the valve to allow Hydrogen gas to flow through the pipeline and into the container.
- As the Hydrogen gas enters the container, it displaces an equal volume of water, causing the water level in the container to rise.
- Measure the volume of water displaced by the Hydrogen gas over a set period of time.
- Use the formula $Q = V/t$, where Q is the flow rate of Hydrogen gas in cubic meters per second, V is the volume of water displaced in cubic meters, and t is the time in seconds.

Convert the flow rate to the desired units, such as cubic feet per minute.

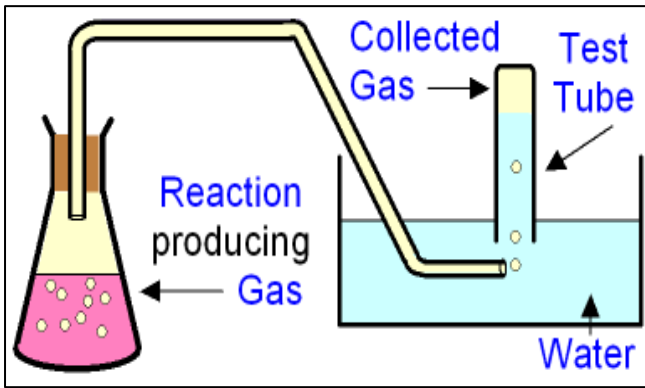


Fig. 1: Schematic diagram of water displacement method [11]

The engine used for the experiment is a four-stroke water-cooled, single cylinder, direct injection, rated power of 3.5 kW at speed of 1600 rpm. Research engine connected to eddy current type dynamometer for loading. Specifications of the engine are given in Table 2.

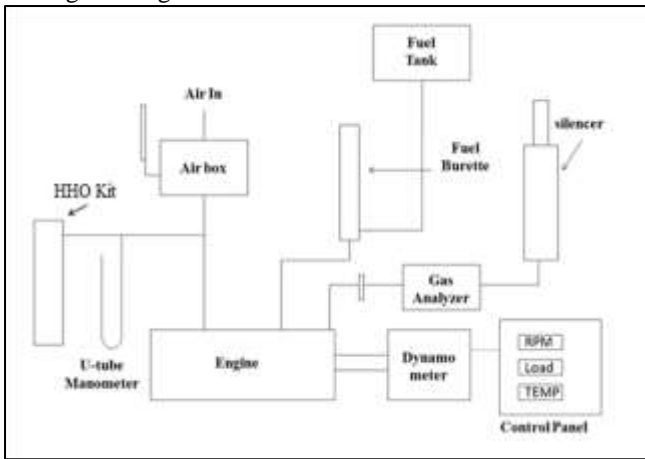


Fig. 2: Schematic diagram of 4-stroke single cylinder Diesel engine test rig [12]

Model	TV1
Make	Kirloskar oil engines
Type	Four stroke single cylinder water cooled
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Combustion principle	Compression ignition
Engine capacity	5.2 kW
Cubic capacity(cc)	0.661 L
778iPeak pressure	77.5 kg/cm ²
Direction of rotation	Clockwise (looking from flywheel end side)
Max. speed	2000 rpm

Table 2: Engine Specification [13] [14]

The experiment has been carried out on single cylinder, four stroke compression ignition engines [13] [14]. In first phase all experiments have been carried out with pure Diesel. [13] [14]. In second phase same sets of experiment have been carried out on the same engine, when was fuelled with Diesel and Hydrogen as additive fuel.

III. RESULTS AND DISCUSSION

A. Effect of Hydrogen Gas on BTHE:

Fig.3 show the variation of Brake Thermal Efficiency (BTHE) used Diesel with Hydrogen gas. The Hydrogen gas has inserted in Diesel engine with constant flow rate. Fig. 3 shows increment in brake thermal efficiency when Hydrogen gas inserted as additive gas with Diesel.

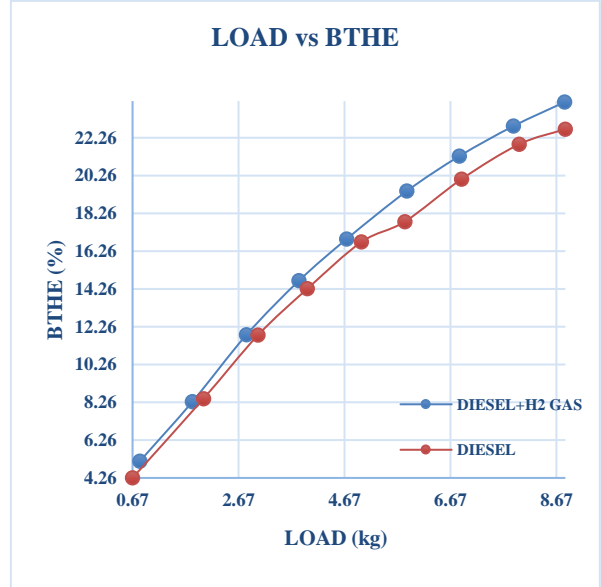


Fig. 3: Load vs Brake Thermal Efficiency

B. Effect of Hydrogen Gas on Fuel Consumption (FC):

Fig.4 show Diesel consumption when Hydrogen has used with Diesel. As Hydrogen gas has inserted in combustion chamber through air intake, it takes part in combustion process delivering tremendous amount of energy and obtain complete combustion. Diesel consumption has decreased when Hydrogen gas inserted as additive gas with Diesel.

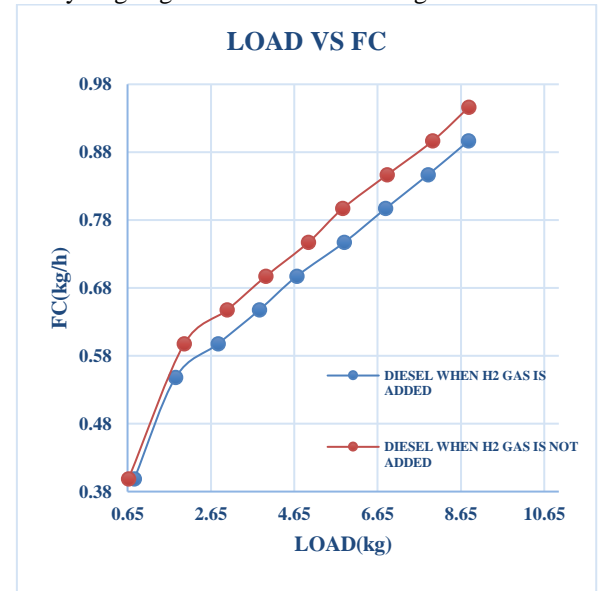


Fig. 4: Load vs Fuel Consumption

C. Effect of Hydrogen Gas on Mechanical Efficiency (ME):

Fig.5 show mechanical efficiency when Diesel, Diesel with Hydrogen gas has used. Small increment in mechanical efficiency has been observed.

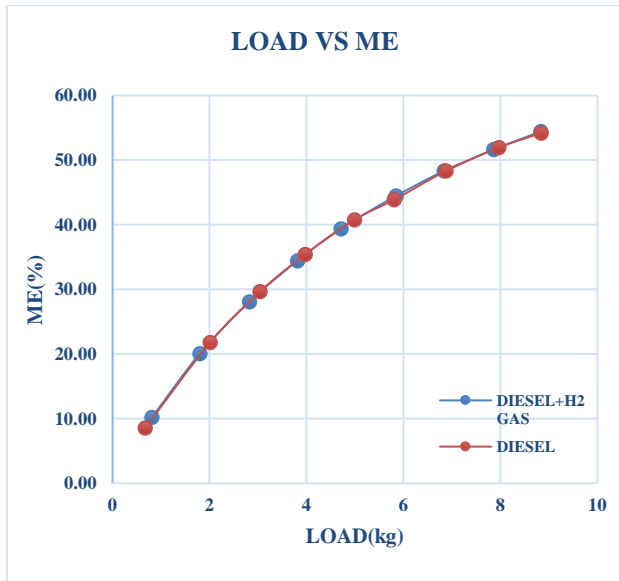


Fig. 5: Load vs ME

D. Effect of Hydrogen Gas on Specific Fuel Consumption (SFC):

Fig.6 show specific fuel consumption when Hydrogen gas used with Diesel fuel. Specific fuel consumption has decreased using Hydrogen gas with Diesel fuel in CI engine.

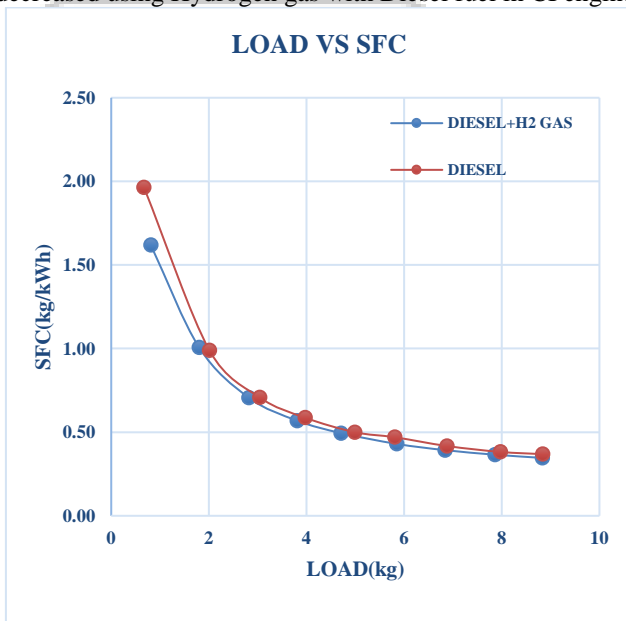


Fig. 6: Load vs SFC

IV. CONCLUSIONS

Experiment has conducted in single cylinder, CI engine by supplying Hydrogen in air intake with Diesel. The Hydrogen gas has used for research as additive fuel, which could help in increase the performance of CI engine.

- Increment in brake thermal efficiency has been observed when Hydrogen gas inserted as additive gas with Diesel.
- Decrement in Diesel consumption has been observed when Hydrogen gas inserted as additive gas with Diesel.
- The mechanical efficiency has increased in small amount.

- Decrement in specific fuel consumption has observed when Hydrogen gas inserted as additive gas with Diesel.

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