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Study of Performance and Emission Analysis of Hydrogen-Diesel Duel Fuel Engine

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Abstract - *Diesel engines are inevitable parts of our daily life and will be in the future. Expensive after-treatment technologies to fulfil normative legislations about the harmful tail-pipe emissions and fuel price increase in recent years created expectations from researchers for alternative fuel applications on diesel engines. In this project, the effects of performance, emission of the Compression Ignition (CI) engine fuelled with hydrogen and diesel is examined. It was observed that the unburned hydrocarbons and carbon monoxide discharge had reduced on addition of hydrogen to the diesel engine. This study investigates hydrogen as additive fuel in diesel engines. Hydrogen was introduced into intake manifold using gas injectors as additive fuel in gaseous form and also diesel fuel was injected into cylinder by diesel injector. The experiments were conducted on single cylinder water cooled, direct injection (DI), diesel engine at a constant speed. Hydrogen was stored in a high pressure cylinder and supplied to the inlet manifold through a water-and-air-based flame arrestor.*

1. INTRODUCTION

The introduction of increasingly restrictive emission laws by governments is leading to a lesser dependence on the use of diesel as the main fuel. There are several possibilities for fulfilling the new requirements: the increasingly demanding development of current combustion engines, the use of alternative fuels that reduce emissions compared to fossil fuels, the dual combustion of diesel or gasoline with additives, or the use of electric vehicles. From the point of view of alternative fuels, hydrogen is considered the best candidate to be mixed with diesel to satisfy the characteristics required by the engine.

The reasons why hydrogen is considered the best candidate are:

1. It is one of the main sources of clean energy (it is the most abundant element in the universe, although H2 does not exist freely in nature)
2. It can be produced from renewable energy
3. It has a very high-energy potential.
4. H2 production and storage is currently undergoing extensive research. Due to its low density, it requires large storage areas and it is expensive; current technology allows that H2 tank pressure be about 700 bar.

Hydrogen is seen as the most suitable alternative fuel due to the variety of methods available to produce it as well as the reduction in emissions it offers on combustion. Moreover, hydrogen acts as a combustion enhancer due to its high flame speed, high diffusivity and broader flammability limit.

The hydrogen addition to diesel improves the performance of diesel engines because it increases the H/C ratio of the entire fuel and reduces the combustion duration results in lower carbon based emission such as HC, CO, and smoke. Further, faster combustion becomes closer to constant volume causing an increase of the engine's efficiency. The hydrogen fuel decreases the heterogeneity of the mixture results in better combustion process. The addition of hydrogen to diesel

Hydrogen (H2) is a clean burning fuel and seems a very popular gaseous fuel for CI engine applications as it can replace large amount of liquid-injected pilot fuels in dual fuel (DF) engines. When H2 is used in DF engine run with standard diesel, CO and smoke emissions in the engine out gas were found to decrease by 50% and 38% respectively and at operation yielded higher BTE.

So, taking into considerations the suitability of hydrogen as alternative fuel in diesel engine, this project work deals with the hydrogen enrichment in a Diesel engine and Optimization of Combustion process for Hydrogen-Diesel Duel fuel Engine.

2. Literature survey

B.Rajendra Prasath, [1] it is evident from the study, it is advantageous to use hydrogen enriched air as a fuel in internal combustion engines. Addition of hydrogen with air in SI engine or C.I engine provides significant impact on engine brake thermal efficiency and brake power. NOx emission in both S.I engine and C.I engine also reduces to the maximum considerable amount. This makes it possible to run the engine leaner, resulting in lower emissions of CO2, CO and HC. Finally it is concluded that hydrogen for both S.I engine and C.I

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engine provides the significant advantageous and play a major role to provide cleaner environment.

Kenneth Gillingham, [2]. This analysis reveals four underlying points: (1) the PDV of a hybrid policy far exceeds that of a hydrogen ICE or FCV policy up to 2050, (2) if policymakers decide to invest in hydrogen anyway for the long-run benefits past 2050, then there may be a place for hydrogen ICE vehicles in the eventual fleet mix due to their lower cost and greater power. (3) if we are to promote hydrogen, the fuel savings and carbon benefits from earlier introduction of hydrogen ICE vehicles may provide large enough benefits to pay for the infrastructure and R&D costs of a hydrogen ICE policy, and (4) these benefits are contingent on the use of hydrogen generated by central station generation fossil fuels (natural gas or coal with sequestration). These conclusions must be understood in the context of the assumptions that generated them, especially given the considerable uncertainties surrounding key components of the analysis

Chaganti Sri Krishna Sharma, [3] Hydrogen can be used in both the spark ignition as well as compression ignition engines without any major modifications in the existing systems. An appropriately designed timed manifold injection system can get rid of any undesirable combustion phenomena such as backfire and rapid rate of pressure rise. Internal combustion engine powered vehicles can possibly operate with both petroleum products and dual-fuels with hydrogen.

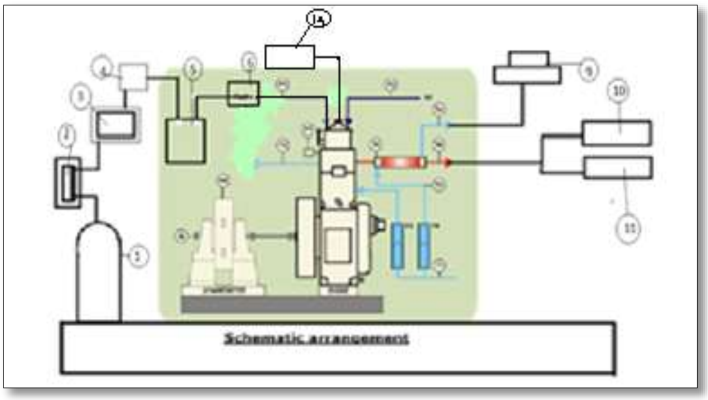
Akhileshpati Tiwari, [4] it is evident from the study, it is advantageous to use hydrogen enriched air as a fuel in internal combustion engines. Addition of hydrogen with air in SI engine or C.I engine provides significant impact on engine brake thermal efficiency and brake power. The higher the compression ratio and/or the specific heat ratio, the higher the indicated thermodynamic efficiency of the engine. The compression ratio limit of an engine is based on the fuel's resistance to knock. A lean hydrogen mixture is less susceptible to knock than conventional gasoline and therefore can tolerate higher compression ratios.

Maulik Desai, [5] here they conclude that there is no any carbon contain in our fuel so there is no emission of carbon oxide in exhaust. So, its ecofriendly. Secondly the basic parameters like RPM, Break Power and Break Thermal Efficiency of hydrogen engine is slightly higher than petrol engine.

3. Properties of Hydrogen and Diesel :-

Properties	Units	Hydrogen	Diesel
Carbon Atoms per Molecule		0	13.5
Hydrogen Atoms per Molecule		2	23.6
Oxygen Atoms per Molecule		0	0
Lower Heating Value	MJ/kg	120	43
Critical Temperature	K	33.2	569.4
Critical Pressure	bar	13	24.6
Absolute Entropy at 298K	J/kg-K	64828.4	3445.47
Auto ignition temperature	k	813	530

4. Experimental setup :



- Hydrogen cylinder: - it store the hydrogen gas within it. It an enclosed container for safety purpose.

- Rota meter: - it is used to measure the flow of fluid. The floating float height is used to estimate the flow of fluid.
- Gas flow meter: - it is also a measuring device to measure the flow of gas.
- Flame trapper: - both inline and wet type and dry type flame trapper is to trap the flame and avoid the chances of accident.
- Diesel engine: - it is used for testing and conducting trails on it.
- Eddy current dynamometer: - it is to measure the brake power as well as to measure the torque of output shaft of engine.
- PC with exhaust gas-analyzer and smoke meter: - are attached together to calculate required data of combustion and emission.
- Diesel tank: - it is used to store diesel for experimentation.

 Engine Details :

IC Engine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length

110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 18.00, Swept volume 661.45 (cc)

- Combustion Parameters :

Specific Gas Const (kJ/kgK) : 1.00 Air Density (kg/m3) : 1.17 Adiabatic Index : 1.41 Polytrophic Index : 1.28 Number of Cycles : 10 r

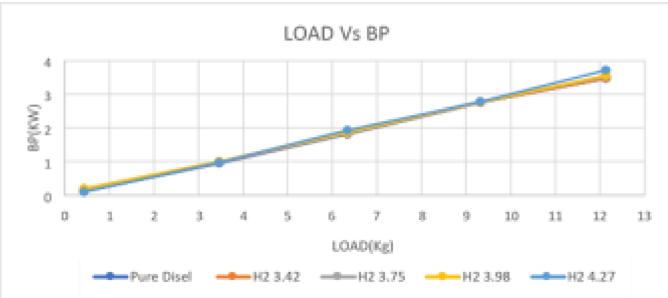
- Performance Parameters :

Orifice Diameter (mm) : 20.00 Orifice Coeff. Of Discharge : 0.60 Dynamometer Arm Length (mm) : 185 Fuel Pipe dia (mm) : 12.40 Ambient Temp. (Deg C) : 27 Pulses Per revolution : 360 Fuel Type : Diesel Fuel Density (Kg/m3) : 830 Calorific Value of Fuel (kj/kg) : 42000

5. Result and discussion

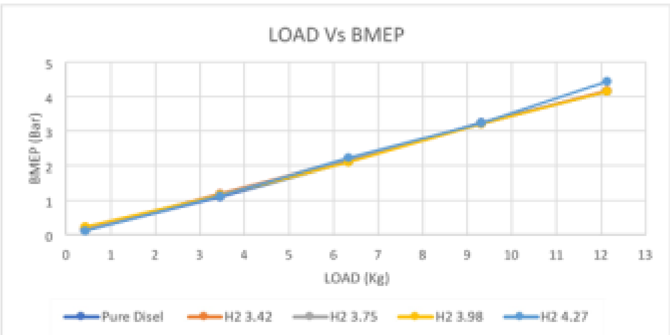
PERFORMANCE RESULTS :

Load vs. Break Power : .



The experimental result shows the variation of Break Power with respect to load variation. It is observed that when we blend H_2 3.98 ml/sec into diesel it produces same break power as it is produced by pure diesel.

Load VS Break Mean Effective Pressure :

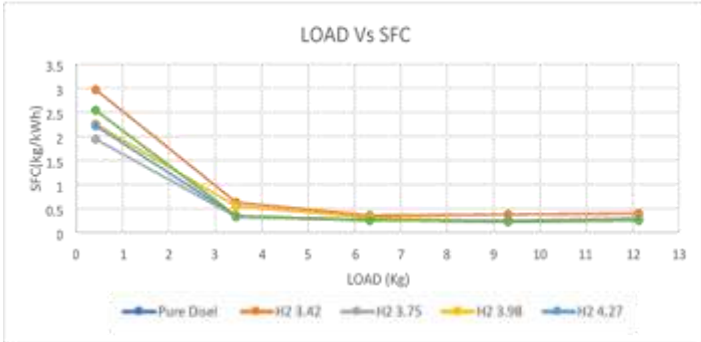


The experimental result shows the variation of break mean effective pressure (BMEP) with respect to load variation. It is observed that when we blend H_2 3.98 ml/sec into diesel it produces same break mean effective pressure as it is produced by pure diesel.

Load vs. Break Thermal Efficiency :

The experimental result shows the variation of break thermal efficiency (BTHE) with respect to load variation. It is observed that when we blend H_2 3.98 mile/sec into diesel it increases the break thermal efficiency as it is produced by pure diesel.

Specific Fuel Consumption :

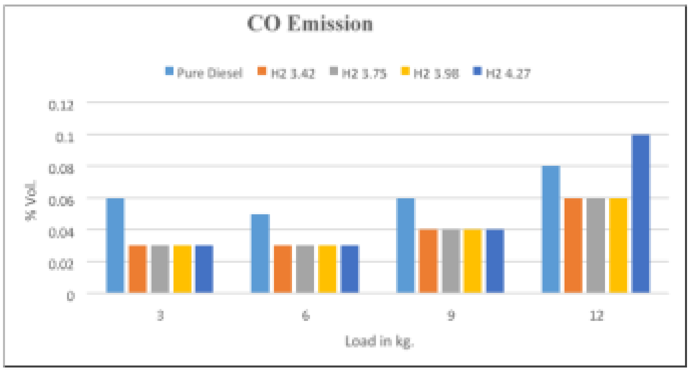


The experimental result shows the variation of specific fuel consumption with respect to load variation. It is observed that when we blend H_2 3.98 ml/sec into diesel it decreases the specific fuel consumption as it is produced by pure diesel.

EMISSION :

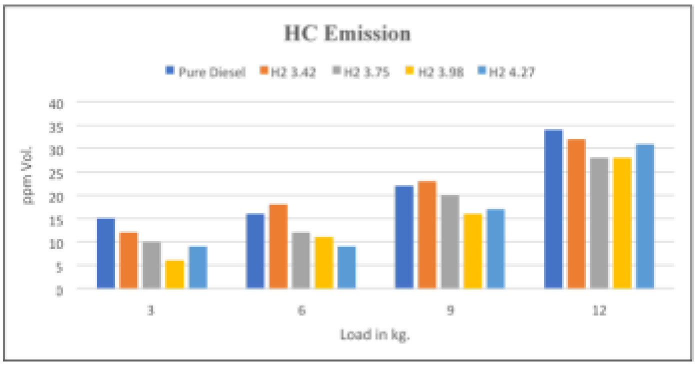
Analysis for hydrogen enrichment:

CO EMISSION :



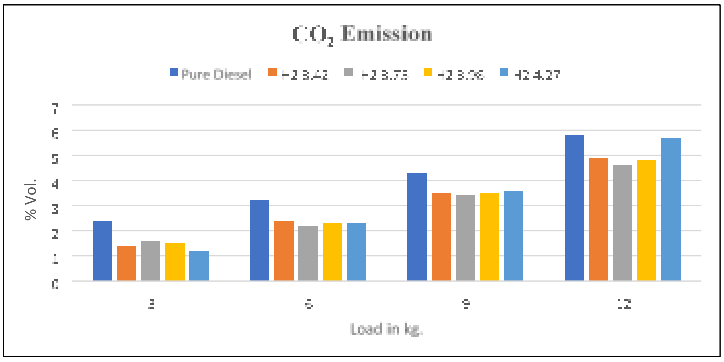
It is observed that CO is higher with diesel as compared to H_2. With diesel CO emission observed is 0.06% vol. When we introduced H_2 then in gives 0.03 % vol. but under high applied load at 12 kg the output CO is more as compared to diesel engine. But the CO emission is reduced during load between 3 to 9 kg.

HC EMISSION



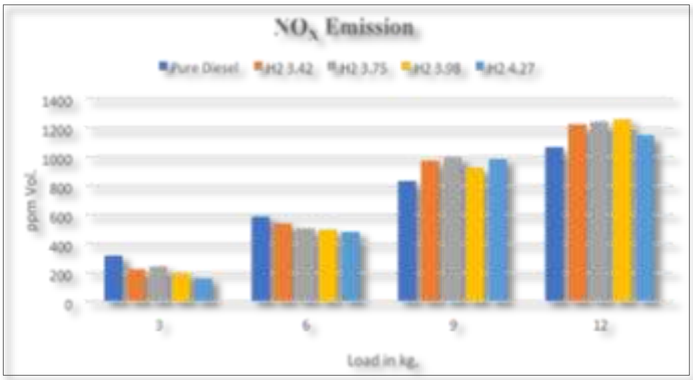
The graph shows variations in HC. It is observed that when we introduce H_2 more than 3.75 ml/sec it gives less HC emission than the pure diesel.at 6kg load pure diesel gives 16 ppm vol^m of HC whereas for 3.75 ml/sec of H2 it gives 12 ppm vol^m of HC. The overall HC emission is halved and it is beneficial for any range of load as the HC emission during high load is also less than diesel.

CO_2 EMISSION :



The variation in CO_2 emission is as shown in graph. It is observed that CO_2 is higher with diesel as compared to H_2. With diesel CO_2 emission observed is 3.20% vol^m when we introduced H_2 3.75 ml/sec then in gives 2.2 % vol^m. The most favorable outcome is of CO_2, as it is the most domination gas for global warming and for climatic change. The CO_2 emission are less as compared to pure diesel engine.

NO_X EMISSION :



kg load pure diesel gives 587 ppm volm of NO_X whereas when we introduces H_2 then it emits less NO_X.at 3.75 ml/sec of H_2 it gives 507 ppm volm of NO_X. The NO_x emissions are within limit but when at maximum load is increased the emission of NO_x are increased.

6. CONCLUSIONS

Hence after conducting the trial and experimentation we Concluded that for, Performance :

1) After enrichment of hydrogen with diesel there is negligible change in brake power with respect to pure diesel fuel engine because of constant speed engine and centrifugal governor.
2) The brake mean effective pressure increases and also brake thermal efficiency increases.

3) Specific fuel consumption decreases due to enrichment of hydrogen in engine.
4) The performance of the engine is increased due to enrichment of hydrogen in engine.
Emission :
1) Due to the complete combustion of charge there is a drastic change in emission of engine.
2) The CO and NOx got reduced after enrichment of hydrogen.
3) The smoke value is also reduced after enrichment of hydrogen.
4) The CO2 and HC values are also reduced after enrichment of hydrogen.
Hence after this results we conclude that it is beneficial to blend hydrogen with diesel for diesel engine, as it has reduced emission without change in its performance parameters of engine with respect to pure diesel engine.

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