Effects of addition of hydrogen peroxide on performance and emission properties of compression ignition engine with diesel and biodiesel blends as a fuel – A review study

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ABSTRACT

As we know that the sources of petroleum fuels are limited and it will deplete soon in the future. Also use of conventional fuel in engine increase CO, HC, Nitrous Oxides and particulate matter into the atmosphere. This gives support to engineers and researchers to move towards use of an alternative fuel that can be used in the engine. Many researchers have found that hydrogen is alternative fuel but use of hydrogen as an energy source in compression ignition engines involves some issues such as production, storage and transportation. Study towards the use of fuel that is easy to storage and transport is considered. To achieve the better operation condition literature shows that use Hydrogen as the supplementary fuel, using hydrogen peroxide as the additives in the Diesel fuel as the hydrogen present in it.

Keyword: *diesel engine, performance, emissions, diesel, biodiesel, hydrogen peroxide.*

1. INTRODUCTION

Fossil fuels play significant role in transportation. Continuous supply of fuel should be ensured for further development of country. Recently, significant problems associated with fossil fuel are short supply, non renewability, increase in price, pollution in environment, adverse effect on human life. These problems gave direction researcher to search for an alternative fuel, which gives better sustainable development, energy efficient, management, efficiency and environmental cleanliness has become highly requirement in the present context. In search of this, researcher has found many energy sources like CNG, LPG, ethanol, methanol, hydrogen, bio-diesel and many more. Among these alternative fuels, India has significant scope for development of bio-fuel. Moreover, transportation and agriculture sector depends on diesel fuel. Therefore, it is essential that alternatives to diesel fuels must be developed. In concern for emission and availability, hydrogen has been proven as excellent fuel. Yet, onboard storage problem, absence of infrastructure for producing, transporting and storing large quantity of hydrogen prevents its practical use.

2. HYDROGEN-PEROXIDE AS A FUEL ADDITIVE

Otto, the German scientist, in 1870, used hydrogen gas as a fuel for his IC engine. Since then, researchers have tried to use hydrogen as automotive fuel. Till date all attempts to commercialize IC engines running on pure hydrogen have failed due to problems of storage, transportation, safety and production. Hydrogen is produced from water, which is abundantly available. Moreover, hydrogen is clean fuel with less emission compared to LPG and CNG. Vehicle running on hydrogen can meet stringent emission norms. Hydrogen can also be used as fuel for fuel cell vehicles. IIT Delhi is on forefront of R & D work on hydrogen engines. Attempts are also made to use hydrogen in front of blends with conventional fuel.

2.1 Hydrogen-peroxide Properties

Name of Property	Value
Appearance	Colourless Liquid
Density	1110 kg/m3
Boiling Point	226^{o} C
Freezing Point	-27^{o} C
Viscosity	1.81 cp
Sp. Gravity	1.11

3. LITERATURE REVIEW

In this section detailed study of various literatures has been carried out and results obtained from literatures presented on effect of various hydrogen based additives on performance and emission characteristics of diesel engine.

A. ***Effects of pure hydrogen addition on performance and emission characteristics of CI engine***

L. M. Das, et al. (1991) [1] carried out an experiment in order to see the effect of hydrogen enrichment in IC engine. Neat Hydrogen operated engines produce close to zero ozone, particulates, aldehydes, sulfur oxides, benzene and other toxins and carcinogens which are usually present in a conventional petroleum fuelled engine exhaust. Hydrocarbons and carbon monoxide emissions, which are otherwise extremely small, could be eliminated by regular maintenance and inspection programmes, and by preventing excessive burning of oil.

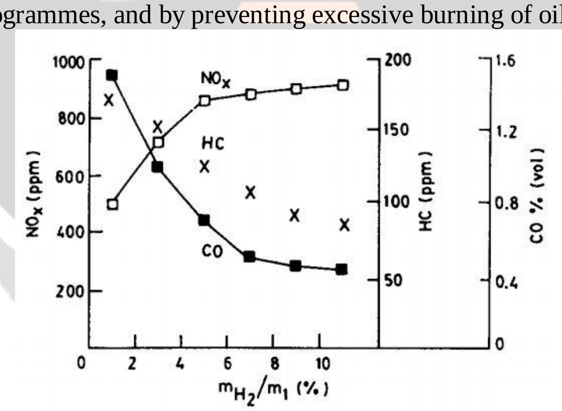

Fig 1 Effect of hydrogen enrichment on the exhaust

Y. Karagoz, et al. (2015) [2] In this work, hydrogen which is in gas phase is sprayed with gas injector from intake port and ignition is provided by diesel fuel coming from diesel injector. Sent hydrogen's energy content is stabilized at 30% in overall fuels and all tests committed are performed in 1100 rpm stable engine speed. Also, in different engine loads (40%, 60%, 75% and 100%) intake air enrichment with hydrogen effect on diesel engine's engine performance, emissions and effect on combustion have been examined.

Obtained results show that in part load conditions enriched with hydrogen, NOx emissions and soot emissions can be taken under control. However on, full load condition (100% engine load), with hydrogen addition, dramatical rise of NOx emissions is observed. Working conditions with hydrogen + diesel fuel, it is obtained that engine load affects NOx emissions significantly.

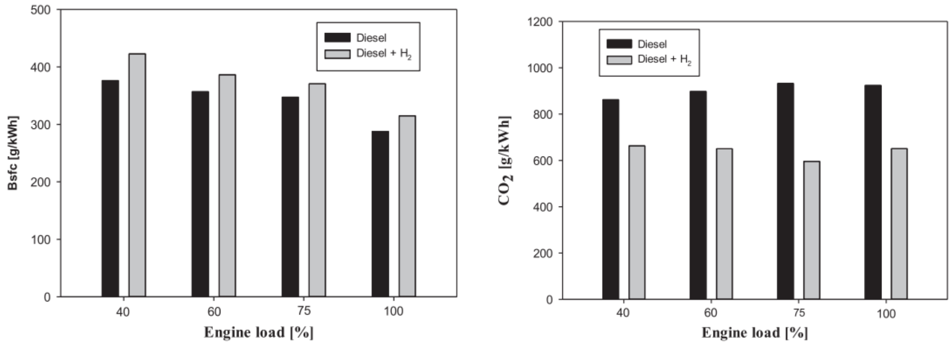

Fig 2 Effect of hydrogen enrichment on BSFC and CO2

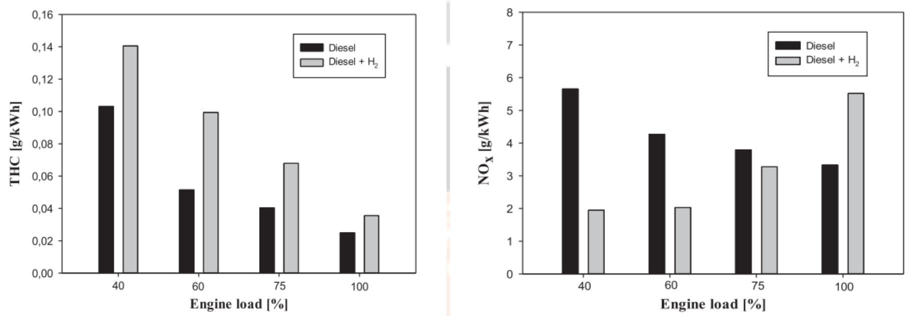

Fig 3 Effect of hydrogen enrichment on THC and NOx

Y. Karagoz, et al. [3] hydrogen fuel was injected into intake manifold using an LPG-CNG injector that is controlled by a self-developed ECU, whereas diesel fuel was directly injected into cylinder using diesel injector. Different hydrogen energy fractions are used in a diesel-fueled CI engine at 1100 rpm constant engine speed and full load. The effect of 0% (pure diesel), 22%, and 53% hydrogen addition of total fuel energy (hydrogen + diesel fuel) on CO, THC, smoke, and NOx emissions, engine performance (BSFC and brake thermal efficiency), and combustion characteristics (in-cylinder pressure, heat release rate etc.) were experimentally investigated. According to obtained results, a great improvement was provided with increasing percentage of hydrogen on CO (67.3% and 69.2%, for 22% and 53% hydrogen enrichment, respectively) and smoke emissions (43.6% and 58.6%, for 22% and 53% hydrogen enrichment, respectively). Even though a slight raise was observed on THC emissions, it is below emission regulations and can be ignored. On the other hand, although a slight increase (almost the same value) was observed with 22% hydrogen addition, a dramatic increase could not be prevented with 53% hydrogen addition in NOx emissions compared with pure diesel fuel (0% hydrogen). Also, peak-in-cylinder pressure values increase d by 7.81% and 36.2% with 22% and 53% hydrogen addition, respectively, in comparison to pure diesel fuel. Furthermore, a 25.77% increase in peak heat release rate was obtained with 22% hydrogen addition and a great increase of 110.94% was acquired with 53% hydrogen enrichment.

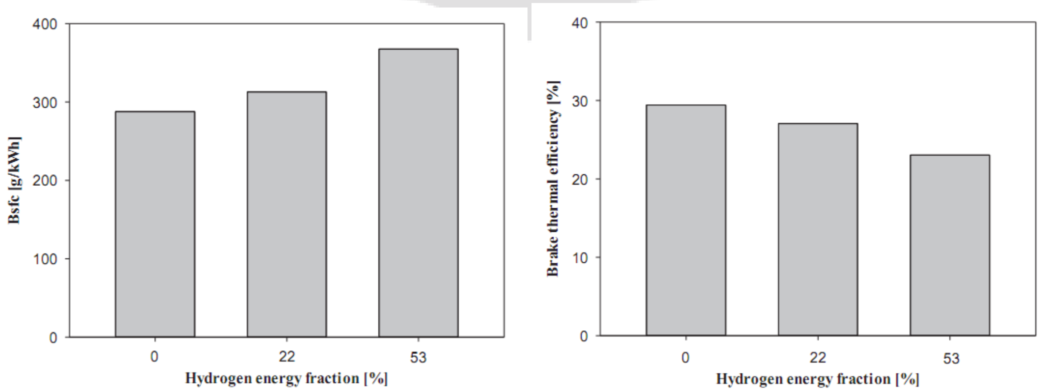

Fig 4 BTE and BSFC vs Hydrogen energy fraction

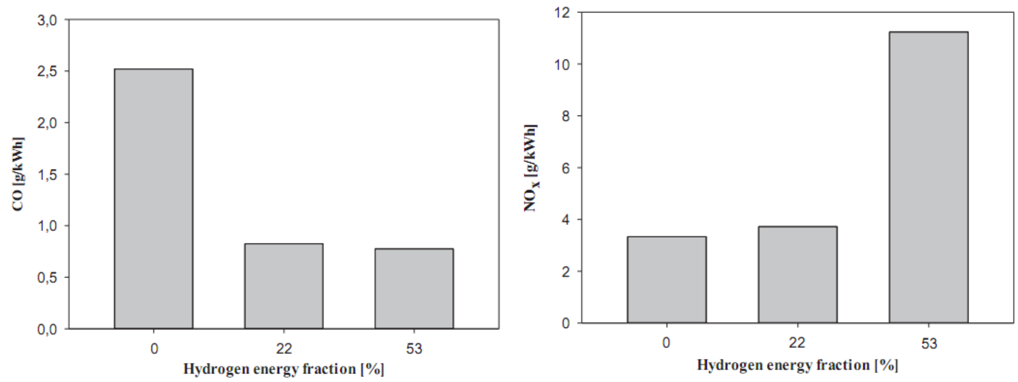

Fig 5 CO and NOx vs Hydrogen energy fraction

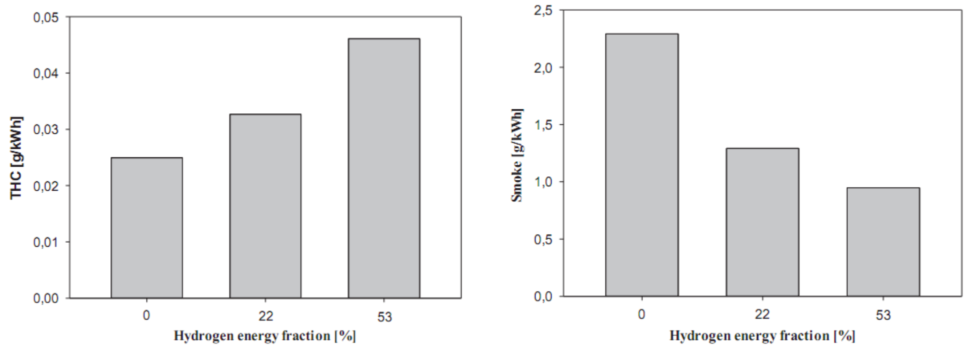

Fig 6 THC and smoke vs Hydrogen energy fraction

M. Parthasarathy, et al. (2015) [4] carried out experimental work on reduction of NOx emission. Hydrogen fuel is more active in reducing smoke emission in biodiesel. A main drawback with hydrogen fuel is the increased NOx emission. To reduce NOx emission, TME-ethanol blends were used in various proportions. After a keen study, it was observed that ethanol can be blended with biodiesel up to 30% in unmodified diesel engine. The present work deals with the experimental study of performance and emission characteristic of the DI diesel engine using hydrogen and TME-ethanol blends. Hydrogen and TME-ethanol blend was used to improve the brake thermal efficiency and reduction in CO, NOx and smoke emissions.

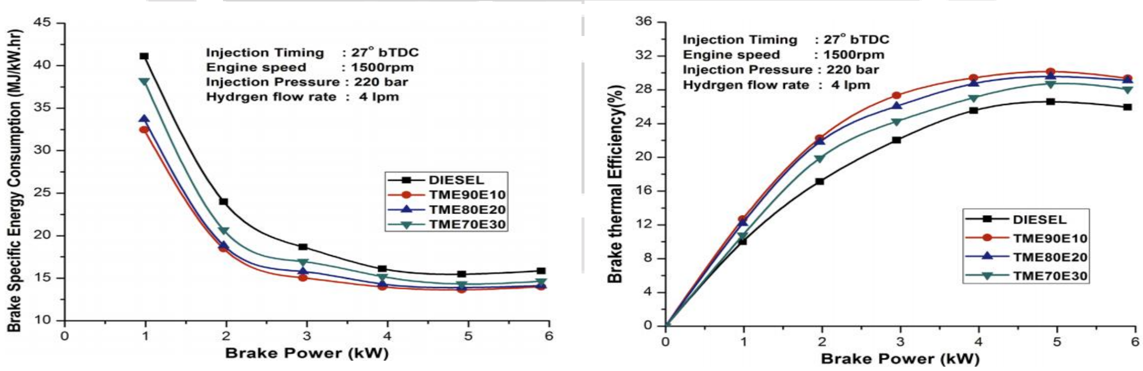

Fig 7 Variation of BSEC and BTE with respect to Brake Power

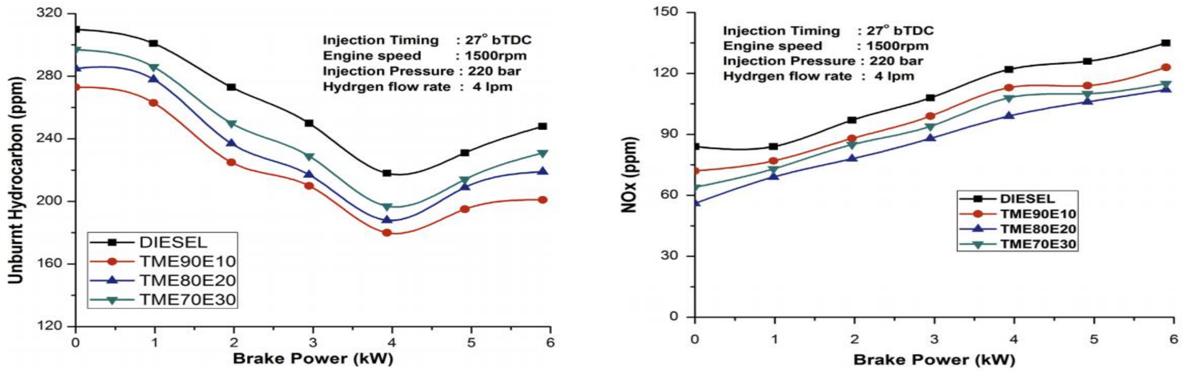

Fig 8 HC and NOx emission with respect to brake power

B. ***Effects of hydrogen peroxide on performance and emission characteristics of CI engine***

Nagaprasad K. S., et al. (2012) [5] conducted an experiment with four stroke multi-cylinder, water cooled compression ignition engine operated with neat diesel and blends of hydrogen peroxide with diesel. Main focus of this research is to investigate the performance of diesel engine by injecting hydrogen peroxide as blends with diesel at 2%, 5% and 10% proportions. In the experiments, injection timing was also changed, which is an important parameter in the study. Results showed that, the efficiency of engine increased by injecting hydrogen peroxide at all fractions along with diesel and the exhaust gas temperature has found to be decreased reasonably. Also, efficiency of engine has increased by advancing the injection timing by five deg for both diesel and its blends with hydrogen peroxide. At injection timing of 15^{O} BTDC, engine was unable to start when 2% and 5% of hydrogen peroxide with diesel is injected.

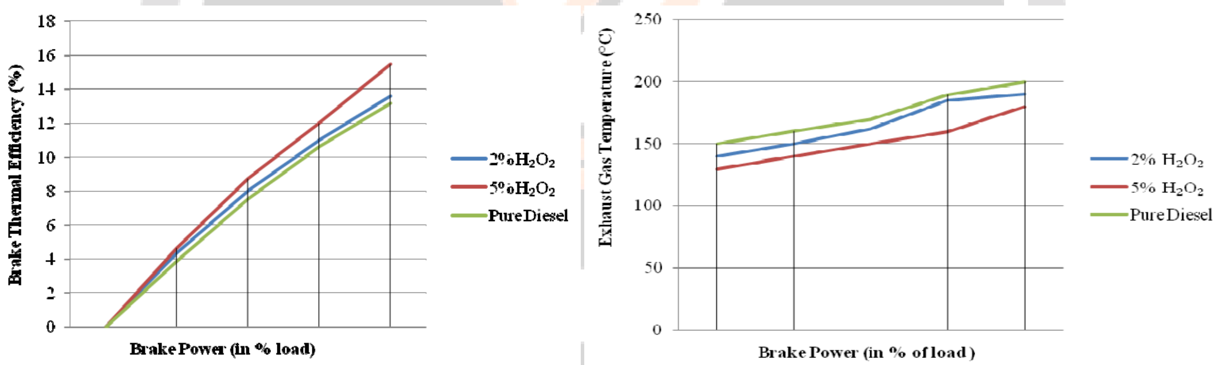

Fig 9 BTE and EGT with respect to Brake Power

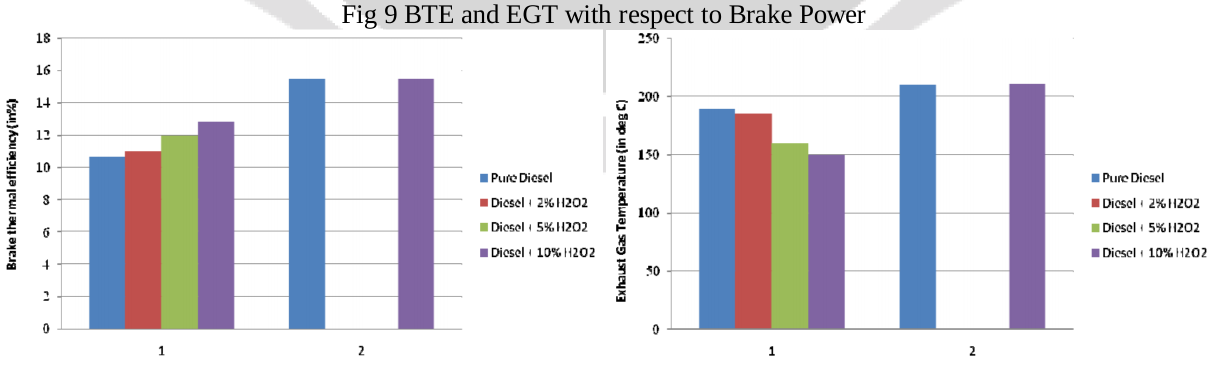

Fig 10 BTE and EGT with respect to Degree of Injection

The maximum efficiency of 15.48% was observed at fifty percent of full load when the engine used 5% of hydrogen peroxide with diesel for injection pressure of 150 bar, and injection timing of 10^{0} BTDC while minimum value of EGT has found to be 180^{0} C at same condition. The efficiency of engine has increased by advancing the injection timing from 10^0 BTDC to 15^0 BTDC for both diesel and its blends with hydrogen peroxide. The engine didn't start when 2% and 5% of hydrogen peroxide with diesel is injected at injection timing of 15^0 BTDC.

Kim-Bao Nguyen, et al.(2014)[6] In the present research, experiments have been performed to study the effects of Jatropha hydrogen peroxide emulsion on combustion, performance, and the emission characteristics of a diesel engine . Hydrogen peroxide in a solution of water at a concentration of 30% was used for making the emulsions with mixing mass ratios of 5%, 10%, and 15%. A single cylinder, four-stroke, high speed, direct injection diesel engine was used for the experiments. The acquired data were analyzed for various combustion parameters such as in-cylinder pressure, ignition delay, ignition duration, heat release, for performance parameters and emissions of CO, CO2 (carbon dioxide), HC, NOx, and PM as well. While running the engine on the Jatropha hydrogen peroxide emulsion fuel, improvements in performance and emissions were found and the optimum mixing ratio of the solution with hydrogen peroxide was 15%.

Zachary M Hammond (2014) [7] The effect of the direct injection of hydrogen peroxide into a port-injected methane fueled homogeneous charge compression ignition engine was investigated numerically. The injection of aqueous hydrogen peroxide was implemented as a means of combustion phasing control. A single-cylinder homogeneous charge compression ignition engine (2.43 L Caterpillar) was modeled using the Cantera 2.0 flame code toolkit, the GRI-Mech 3.0 chemical reaction mechanism, and a single-zone slider-crank engine model. Start of injection timing and the amount of injected hydrogen peroxide were manipulated to achieve desired combustion phasing under a wide range of intake temperatures. As the concentration of hydrogen peroxide is increased, the combustion phasing is advanced up to 22^o for the conditions investigated in this study. This advancing effect is most pronounced at small concentrations (10 g H2O2/kg CH4) and early injection timings (start of injection 25^o before top dead center). The model suggests hydrogen peroxide can be introduced as a means of combustion phasing control while maintaining the low emissions and peak in-cylinder pressures inherent in homogeneous charge compression ignition engines.
It was found that the addition of small concentrations of H2O2 provided a significant advance in combustion timing. In small concentrations, H2O2 could induce combustion of methane under conditions that would otherwise result in a misfire.

4. CONCLUSION

From the above discussion and literature review it can be concluded that

1) A very less study has been done on Hydrogen peroxide as an additive in fuel.
2) One of the main advantage of Hydrogen peroxide mixed system is that it can be controlled with the help of mixing regulation and can be easily integrated with any engine test rig.
3) This review gives the trend of development and experimentation performed on the concept. The use of Hydrogen peroxide as an additive of fuel help in increase in mileage, increase brake power, reducing exhaust emission.
4) Due to its properties such as wide flammability range, high flame speed and short quenching distance of hydroxyl yields fuel to be combusted completely under high and lower speed conditions.

6. REFERNCES

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