Experimental Investigation on CI Engine with Hydrogen Peroxide as an Alternate

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Abstract

The current automotive emission norms and environment protection measures are motivating to find alternative techniques and fuels. In this work, experimental investigations are carried out to study the performance characteristics of single-cylinder, four-stroke Direct Injection (DI) Compression Ignition (CI) engine using diesel with hydrogen peroxide (H2O2) as an additive with different proportions i.e. 5, 10, 15, 20, 25 (

Index terms— diesel, efficiency, blends, emulsion, hydrogen, oxygen

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2 Strictly as per the compliance and regulations of:

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3 I. Introduction

Author: Department of Mechanical Engineering, Sri Sivani College of Engineering, Srikakulam, AP-532402, India. e-mail: murali2kindia@gmail.com handling and storage. Andrea Bertola et al [1] reported that the dominating factor of introduction of water in the diesel combustion has been found to be the lower peak combustion temperature that is responsible for lowering NOx emissions. Additional advantages of water-diesel fuel emulsions are considerable lower particulate emissions. Niranjan Kumar et al [2] observed water in oil emulsions are engineered to provide emissions with reduced carbon particulate, lower opacity and lower nitrogen oxide levels. From the previous work, it is observed that the H 2 O 2 and diesel blends as a viable alternative to use in the CI engines without any major modifications. In addition, H 2 O 2 is available in many parts of the world and appears to be very attractive to use in CI engines. The presence of additional oxygen atom in H 2 O 2 molecule enhances the combustion process and effects exhaust emissions. The heat release rate at the beginning of the combustion stage is high in a diesel engine and is a major source of pollutants like NOx. Various methods are being tried to control these emissions. Unfortunately most of the methods that control NOx, affect smoke and particulate emissions adversely. Use of H 2 O 2 and diesel emulsion in diesel engines is one of the methods that can be used for the simultaneous reduction of both NOx and smoke without any penalty in fuel consumption. In this work, H 2 O 2 and diesel blends are used to study the performance of diesel engine to find optimum keeping in emission and performance concern. It is essential to study the various properties of any fuel for implications in engine use, storage, handling and safety [1][2][3][4] and the details are described in the following sections.

4 Hydrogen peroxide properties

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he dependency on fuel imports, limited reserves of petroleum and its pollution leads to find an alternative solution/fuel. In view of this, attempts must be made to develop the technology of alternate clean burning fuels. The alternative, which satisfies all these requirements, is diesel with hydrogen peroxide (H 2 O 2). Hydrogen peroxide is viable, alternative energy storage medium, competing with hydrogen gas, biogas, biodiesel and alcohol. H 2 O 2 is an energy-dense fuel that burns as cleanly as H2, but requires no oxidizer as it is included inside the fuel. Actually, it does not burn; it decomposes violently into water and oxygen if heated above 80 0 C with a release of tremendous energy, close to the energy per mole of H 2 . It also decomposes in light and in the presence of metal ions. One volume of H 2 O 2 releases ten volumes of oxygen when it decomposes. It is like water, so it does not need a pressure vessel to contain it. When it breaks down into water and oxygen it does not form any persistent, toxic residual compounds. It is completely soluble in water. Pure H 2 O 2 is a colorless, when it used to produce energy, creates only pure water and oxygen as a by-product, so it is considered as a clean energy like hydrogen. However, unlike hydrogen, H 2 O 2 exists in liquid form at room temperature, so it can be easily stored and transported. H 2 O 2 has been around T for a long time, so there is a long history of industrial Abstract-The current automotive emission norms and environment protection measures are motivating to find alternative techniques and fuels. In this work, experimental investigations are carried out to study the performance characteristics of single-cylinder, four-stroke Direct Injection (DI) Compression Ignition (CI) engine using diesel with hydrogen peroxide (H 2 O 2) as an additive with different proportions i.e. 5, 10, 15, 20, 25 (% by volume basis) and compared with conventional diesel fuel performance. The performance parameters like brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), Mechanical efficiency (ME), Volumetric efficiency (VE), Exhaust gas temperature (EGT) and Smoke are evaluated to find optimum blend. From the experimental investigations, it is found that diesel engine with D 85 H 15 shown reduction in BSFC, Exhaust gas temperature, Smoke and increase in BTE in comparison with conventional diesel operated engine.

? Storage and handling equipment-preferred metals and plastics are containers like drums, tanks, tank trucks or railcars etc which are of atmospheric vessels with properly designed continuous vent to release the small amounts of oxygen liberated from H 2 O 2

6 II. Experimental Work

In this study, experiments were conducted on a single-cylinder, four-stroke, water-cooled, DI CI engine. The specifications of engine are given in Table2. The photograph of experimental setup is shown in the Figure ??1. The test engine was coupled to a calibrated rope brake dynamometer for loading purpose. Fuel consumption was measured by a calibrated burette and a stopwatch. Air consumption was measured using an orifice meter connected through an air-box and U-tube manometer. A Hatridge smoke meter was used for the measurement of smoke density. Exhaust gas temperature was measured using K-type thermocouple. In this work, all the experiments were conducted at a constant speed of 1500 rpm with load varying from zero to full in steps of 20%. Experimental test procedure followed in this work starts with warming up the engine using test fuel from the fuel tank. The required engine load percentage is adjusted by using dynamometer. Instrument readings for a particular test case are recorded after a sufficiently long time that ensures steady state engine operation. Investigations were done using diesel with hydrogen peroxide (H 2 O 2) as an additive with different proportions i.e. 5, 10, 15, 20, 25 (% by volume basis) to determine optimum blend. For example, D90H10 fuel contains 90% Diesel and 10% of H 2 O 2 by volume. The diesel is mixed with H 2 O 2 in a glass flask; mixture is stirred for about 45 minutes by using a magnetic stirrer, depicted in Figure ??2. As the density of H 2 O 2 is greater than that of diesel continuous stirring is made. This is achieved by magnetic stirrer set up and the fuel mixture is allowed to pass through the fuel pipe to the engine, proper care is taken while stirring. Initially base tests with diesel are conducted for different loads and time taken for consumption of 10cc fuel are recorded for comparison with proposed blends. The blended fuel is fed to the engine by using an aspirator bottle provided with an arrangement for holding a mechanical stirrer. The mechanical stirrer consists of 12 volts DC motor welded to a vertical spindle with rotor blades attached to it. The stirring is done in the aspirator bottle in order to maintain a homogeneous mixture during the test. The stirring should be done without fail to get accurate results. Important features of diesel and H 2 O 2 blend fuel are: i). results in substitution of depleting fossil fuels, ii). Due to introduction of H 2 O 2 into combustion chamber results in fall of peak temperatures further results in reduction of NOx, iii). No major modification to engine is required, iv).Results in higher thermal efficiency and very low smoke level, v). OH radicals are produced when water is introduced near a flame this suppresses NOx levels due to chemical kinetic effects.

7 III. Results and Discussion

The engine was operated with diesel and H 2 O 2 blends. The experimental data presented here using appropriate graphs.

8 a) Specific fuel consumption (SFC)

The variation of brake specific fuel consumption (kg/Kw.hr) with load different blends of hydrogen peroxide with diesel is presented in Figure 3. For the fuels tested, brake specific fuel consumption is found decrease with increase in the load. This is due to the higher percentage increase in brake power with load as compared to the increase in fuel consumption. Fig. 3 shows the fuel consumed for different fuels, D85H15 (15% H_2O_2) fuel shows least fuel consumption compared to other blends and diesel. The variation of exhaust gas temperature with load for different blends of hydrogen peroxide with diesel is shown in Fig. 6; it is observed that with increasing load the temperature of the combustion chamber increased as expected. The rise in temperature is less for blend fuel due to content of H_2O_2 ; the b) Brake Thermal Efficiency Figure 4 shows the variation of brake thermal efficiency (BTE) with load for different blends of hydrogen peroxide with diesel. From Fig. 4, it is observed that, BTE increases with increase in load for all the fuels. The break thermal efficiency D 85 H 15 (15% H_2O_2) is higher compared to other blends and diesel. It is found that as the concentration of hydrogen peroxide is increased, the brake thermal efficiency of the engine has increased. The hydrogen peroxide which is present in the diesel fuel starts decomposing and releases very large amount of oxygen. This oxygen is helpful to reduce the ignition lag as well as assist the complete combustion of the fuel.

9 c) Mechanical Efficiency

To determine mechanical efficiency (ME), initially friction power was estimated based on Willan's line method [6]. Figure 5 shows the variation of mechanical efficiency with load for different blends of hydrogen peroxide with diesel. The trends showed an increase in efficiency with load, similarly increasing for all the fuels considered. All the blends shown close to the neat diesel operated engine. dissociation of H_2O_2 decreases the temperature in the combustion chamber resulting in least exhaust gas temperature. From Fig. 6; it is observed that the EGT is lower with 15% H_2O_2 blend compared to neat diesel. As the concentration of hydrogen peroxide is increased, the exhaust gas temperature of the engine decreased. This happens due to additional oxygen molecule released by hydrogen peroxide that leads to better combustion. The lowest value of exhaust gas temperature has found with 15% of hydrogen peroxide with diesel. Also, decrease in exhaust gas temperature with blends of hydrogen peroxide with diesel fuels, which is indication of reduction in NOx [3] The variation of volumetric efficiency (VE) with load for different blends of hydrogen peroxide with diesel is shown in Fig. 7. It is observed that there was no significant change in the volumetric efficiency throughout operating range concerning to individual fuels tested, which is good agreement with Anand et al [6]. For CI engines, the most important pollutants are smoke and NOx as it was stated earlier. The variation of smoke emissions with load for different blends of hydrogen peroxide with diesel is shown in Fig. 8. From this, it was observed that the smoke emissions were increased with increase with load. Further, with 15% blend of hydrogen peroxide is less with neat diesel.

10 IV. Conclusion

The following conclusions were derived from the experimental investigation over different blends of hydrogen peroxide with diesel on single cylinder Diesel Engine.

? D85H15 shown reduction in BSFC, Exhaust gas temperature, Smoke and increase in BTE in comparison with neat diesel operated engine. ? Based on experiments, it is concluded that D85H15 as an alternative fuel for existing conventional diesel engines without any major modifications. [1]

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Figure 1: Figure 1 :Figure 2 :Experimental

Figure 2:

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Figure 3: Figure 3 :

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Figure 4: Figure 4 :

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Figure 5: Figure 5 :

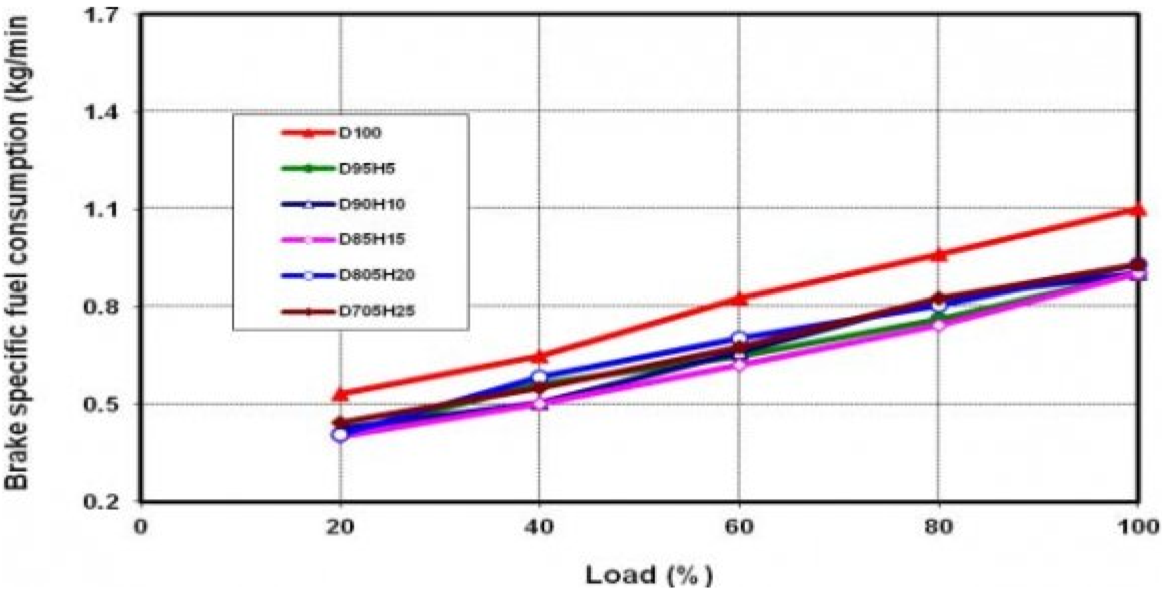

Figure 6: Experimental

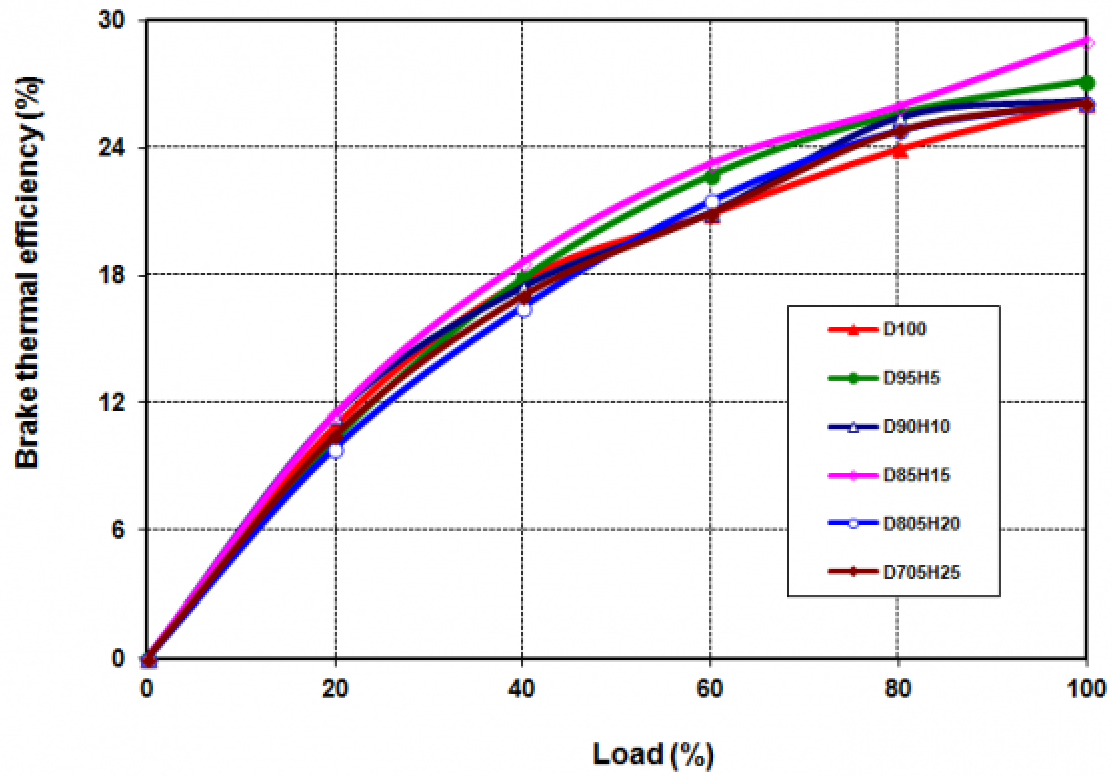

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Figure 7: Figure 6 :

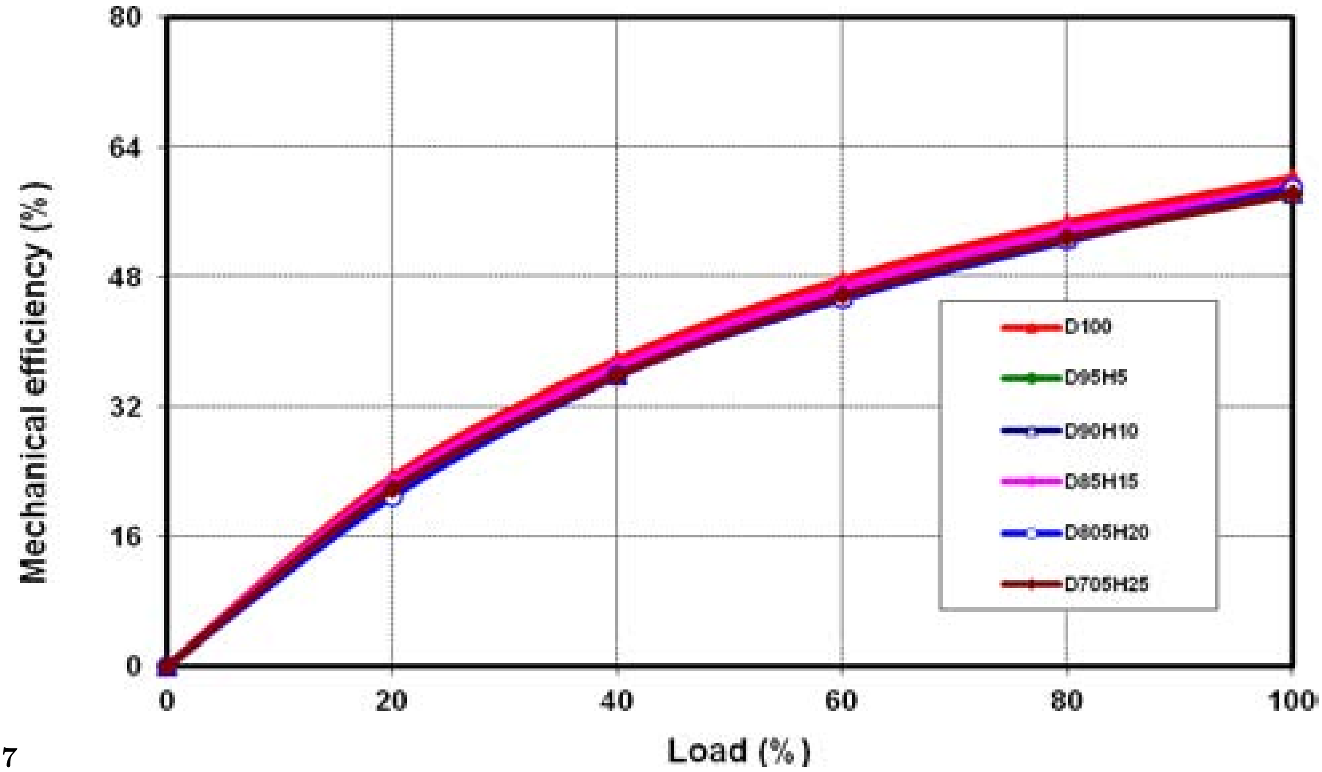

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Figure 8: Figure 7 :

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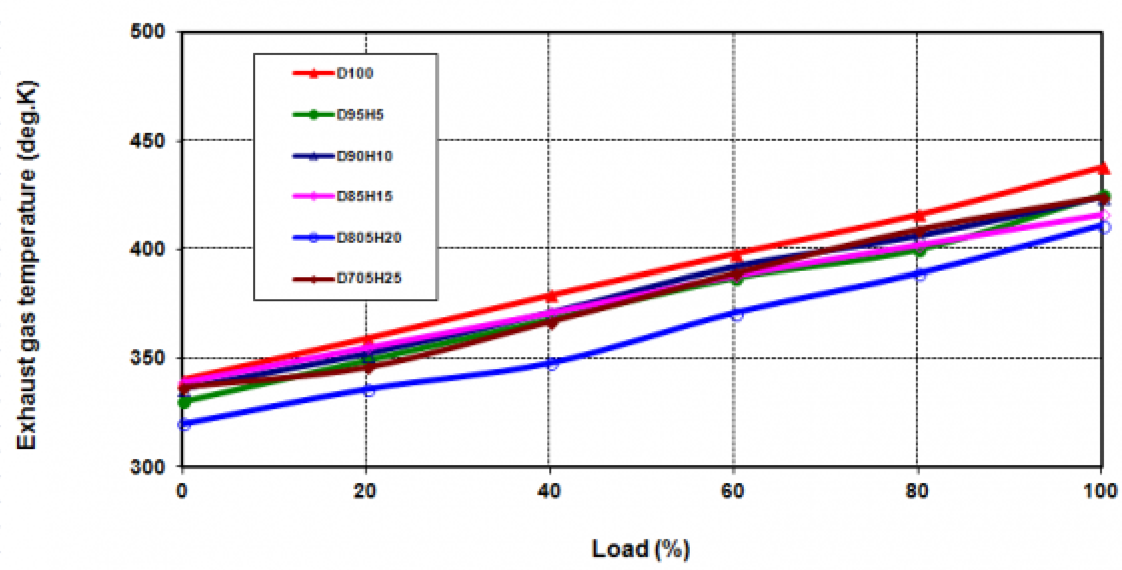

Figure 9: Figure 8 :

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Properties	Diesel	H 2 O 2
Specific gravity	0.84	1.1
Density (kg/m3)	840	1110
Boiling Temp. (°C)	210	225
Viscosity (cP)	2.6	1.8

Figure 10: Table 1 :

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Type	Single cylinder, 4-stroke, direct injection, CI
Cooling	Water cooled
Bore	80 mm
Stroke	110 mm
CR	16.5:1
Rated speed	1500 rpm
Rated Power	3.7 kW

Figure 11: Table 2 :

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