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Experimental Investigation of Hydrogen Induction in a 4-stroke Diesel Engine Working on Simrouba Biodiesel

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Abstract

An attempt has been made evaluate the performance parameters and emission parameters of a 4-stroke diesel engine induced with Hydrogen based liquid additives with Simrouba biodiesel blends. Distilled water is used as the hydrogen liquid additives as it is the easily available Hydrogen Based liquid compound. At higher temperatures that exist inside the engine these compounds will dissociate into hydrogen and oxygen. The Hydrogen will combust with the fuel and the oxygen so released will assist the complete combustion of the fuel thereby improving the performance of the engine. Engine performance parameters like Brake power, Brake Specific Fuel Consumption, Brake Thermal Efficiency and emission parameters like HC, NOx, and CO2 emissions were evaluated for various proportions of mineral diesel replacement by distilled water for various loadings.

Keywords: Hydrogen Liquid Additives, Simrouba Biodiesel Blends

1. Introduction

As the mineral diesel oil is rapidly getting exhausted an alternative source of energy is found in the form of Biodiesel, here simrouba biodiesel is used as blends, the major problem with the usage of biodiesel is that the efficiency of the engine reduces, which can overcome by the use of hydrogen based liquid additives in this case Distilled water.

Unfavorable pumping, inefficient air-fuel mixing which leads to incomplete combustion, high flash point leading to an increase in carbon deposition are caused due to the high viscosity of vegetable oil (30-200 Centistokes) when compared to the viscosity of Diesel (58-64 Centistokes). Because of the above concerns, modification of the fuel blends need to be made to match the combustion related properties of the blend with that of Diesel oil. Decrease in viscosity and increase in volatility are the major purposes of this fuel modification. In order to achieve this, distilled water which is an impurity free water obtained by distillation (boiling and condensing) is used as an additive.

2. Fuel blend Properties

Viscosity: It is the parameter that controls the injection characteristics as unfavorable pumping is caused by high viscosity.

Density: Density of the various blends is determined by hydrometer showed in Table 1.

Flash and Fire Point: The minimum temperature at which the oil gives off sufficient vapors to ignite for a moment, when a test flame is brought near it. The fire point of the oil is the lowest temperature at which the vapors of oil catches fire and continuously burns.

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Table 1. Properties of blends.

Fuel property	Units	Diesel	S30+DW0	S29+DW1	S28+DW2	S27+DW3
Viscosity	Cst	3.141	3.482	4.113	4.301	4.755
Density	kg/m3	824	832	866	912	928
Calorific Value	kJ/kg	44800	41105	40923	40221	39877
Flash Point	^{0}C	45	79	86	89	96
Fire Point	^{0}C	48	85	92	95	102

3. Experimental Setup

A single cylinder, water-cooled, four stroke, direct injection computerized diesel engine is used to perform the experimentation. During starting of the engine, first engine allows to run using diesel for few minutes, after that start supplying bio-diesel blend until it shows steady readings on monitor. Once engine reaches steady state start recording results at different load 1.5kg, 3kg, 5kg, and 7kg with 1500rpm as the engine constant speed. The results on various engine parameter like performance parameters (BSFC, BTE) and emission parameters CO and NOx are considered at corresponding loads to be recorded.

Table 2. Engine specification.

Engine parameter	Specification
Engine Model	AVI Kirloskar
Number of cylinder	Single
Rated power	3.7 kW
Number of Strokes	Four
Bore Dia.	80mm
Stroke length	110 mm
Compression ratio	16.5
Engine Speed	1500 rpm
Cooling method	water cooled
Loading type	Eddy current dynamometer

4. Result and Discussions

It is seen from the Figure 1 that the Brake Specific Fuel consumption reduces with the increase in the Distilled water percentage, this is because the distilled water would dissociate into hydrogen and oxygen, the hydrogen having high calorific value would combust with the fuel and the oxygen so dissociated would assist the complete combustion of the fuel, also the Brake Thermal efficiency increases because the energy released by the combustion of the fuel is high thereby improving the efficiency of the process.

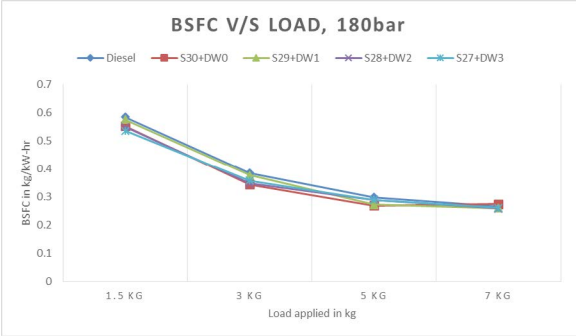

Figure 1. BSFC v/s load.

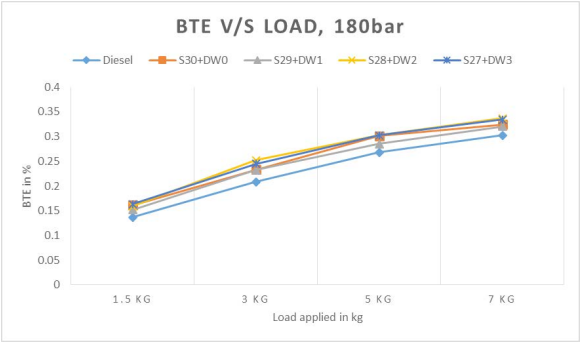

Figure 2. BTE v/s load.

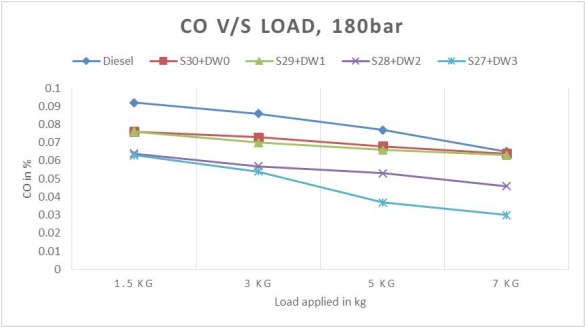

Figure 3. CO emission v/s load applied.

From the Figure 3, it can be seen that the Carbon monoxide emissions are reduced, this is because the Distilled water would dissociate into hydrogen and oxygen and this excess oxygen content helps in the

complete combustion of the fuel and most of the CO would be converted into Carbon dioxide, which is a favorable condition in any engine

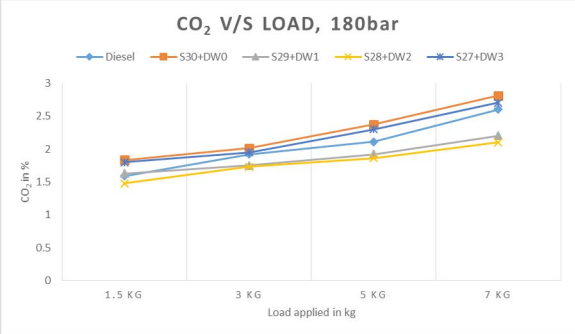

Figure 4. CO_2 emission v/s load.

It can be seen from the Figure 4, that carbon dioxide emission is increased with biodiesel only when compared to Pure mineral diesel, with 3% of Distilled water the carbon dioxide emissions are as same as that of only with Simarouba biodiesel, but with 1% and 2% of Distilled water the CO_2 emissions are reduced considerably and with 2% of Distilled Water the CO_2 emissions are at the minimum.

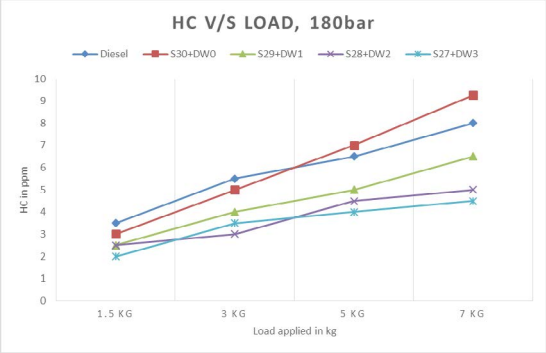

Figure 5. Hydrocarbon emission v/s load.

The Hydrocarbon emissions are reduced with the increase in the percentage of Distilled Water, this is because HC emissions are due to the incomplete combustion of the hydrocarbon fuel. With the addition of Distilled water, the Oxygen percentage of the fuel increases which is dissociated at the engine operating temperatures, thereby leading to the complete combustion of the hydrocarbon fuel, resulting in the reduction of the unburnt hydrocarbon percentage in the emissions.

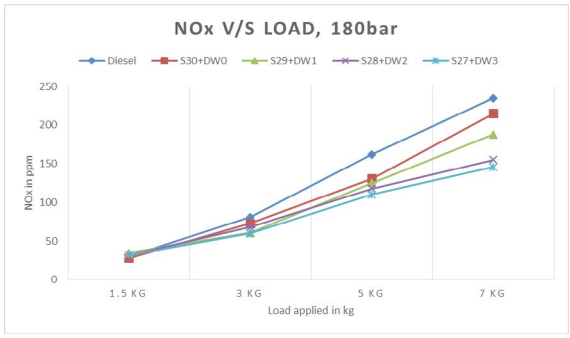

Figure 6. NOx emission v/s load.

NO_x is a very unfavorable condition when it comes to emissions, Oxides of nitrogen are formed due to the increased temperature inside the engine cylinder. Distilled water reduces the temperature inside the engine cylinder as it absorbs the heat to dissociate into hydrogen and oxygen, thereby reducing the NO_x emissions from the engine.

5. Conclusions

Usage of Hydrogen based liquid additives, in this case Distilled Water improves the Combustion parameters of the engine like Brake Thermal Efficiency and reduces the Brake Specific Fuel Consumption, this is because the dissociation of Distilled Water into Hydrogen and Oxygen increases the combustibility of the fuel inside the combustion chamber during the process of combustion, thereby improving the overall efficiency of the engine.

Usage of Distilled Water also reduces the emissions like NO_x, CO and unburnt hydrocarbons, this is because the fuel would combust completely with the excess oxygen which is obtained by the dissociation of distilled water into hydrogen and Oxygen. It can absorb the heat for its dissociation thereby reducing the in cylinder temperature of the engine, which leads to the reduction in NO_x emissions.

Increase of the Distilled Water content increases the overall performance of the engine and also reduces the emissions.

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