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EXPERIMENTAL COMPARISON OF OXYGENATED VIS-A-VIS NANO DOPED BIODIESEL-ETHANOL BLENDS IN A CI ENGINE

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ABSTRACT

Recent days due to rapid depletion of petroleum products and their ever increasing costs have led to an intensive search for alternative fuels. Biodiesel is one such option to use as a fuel in diesel engines. But due to technical deficiencies, they are rarely used purely or with high percentage in an unmodified diesel engine. Therefore in this study Biodiesel-Ethanol blend with higher percentage of biodiesel is used in an unmodified diesel engine. When ethanol added to biodiesel increases brake specific fuel consumption and decreases combustion rate due to its low cetane number. To overcome the above problem and to increase the performance of Biodiesel-Ethanol blend, we have decided to dope high content oxygenated additive and high energy density nano particles. Diethyl Ether is used as a high content oxygenated additive fuel in this study for increasing combustion rate, decreasing Break specific fuel consumption and to reduce the emission. Alumina nano particles are used as additive in this study due to its high energy density, shorten the ignition delay, increasing combustion rate and to reduce the emission. The present investigation was established to compare performances of oxygenated and nano doped biodiesel-ethanol blend in a CI engine.

Key words: Nano doped bio diesel, Ethanol blend.

INTRODUCTION

The ever increasing energy demand in power generation and transport sectors, together with the limited available fossil fuel and their resulting negative environmental effects, have promoted researchers to find alternate fuel that can replace conventional fuels. Among the alternate fuels, biodiesel received increasing attention because they are renewable, non-toxic, and biodegradable. Use of biodiesel may also prolong engine component life. They can be used in diesel engine without modification, sometimes

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modification is recommended as their properties may differ from those of diesel. Their ability to reduce emissions is another factor that makes biodiesel an attractive alternative. Some of disadvantages of alcohol fuels are low lubricity, difficulty of vaporization and high auto-ignition temperature lead to more specific fuel consumption and decreases combustion rate. For improvement of performance, reduction in emissions from the diesel engines, various techniques such as fuel additive, fuel modification, engine design alteration, exhaust gas treatment, etc. have been tried. Several researchers have contributed their efforts on additives are incorporated along with the biodiesel fuel.

The present investigation was doping oxygenated and nano additives in the biodiesel-ethanol blend in a CI engine and comparing performance and emissions with the diesel fuel.

Nano technology in fuel additive

Resent advances in Nano science and nanotechnology enable production, control and characterization of Nano scale energetic material, which had shown tremendous advantages over micron sized materials. Because of the high surface area, metal nanoparticles offer shortened ignition delays, decreased burn rate, and more complete combustion than micron-sized particle doping. Using Nano scale energetic materials as fuel additives to enhance combustion of traditional liquid fuels is an interesting concept. Studies on ignition and combustion behavior of liquid fuels with Nano scale additives, however, are rare. So in this work Alumina nano particles are chosen due to its higher energy density, improved power output of engine and thus reduces the emissions like CO_2, NO_x, etc., better combustion characterizes and economic.

Alumina as fuel additives

The main purposes for converting additives to nano sized particles are:

- Nano sized metal particles have the surface area suitable to catalyze the combustion reaction of fuel and increases the rate of combustion compared to milli and micro forms.
- Shorten the ignition delay.
- Enhance thermal conductivity, mass diffusivity and radiative heat transfer
- Another important advantage of nano particle is its size, because there is no chance for fuel injector and filter clogging as in the case of micron sized particles.

Transesterification

It is the process of catalytic breaking of higher molecular weight triglyceride to alkyl ester and glycerine. It is a series of consecutive reaction, in which Triglyceride is converted in to Diglyceride, which in turn converted to Monoglyceride and glycerine. Usually in transesterification excess methanol was used to drive the reaction towards the end of the product. Basically there are five key parameters namely, Methanol to oil ratio, Catalyst to oil ratio, Temperature, Mixing speed, Time. The raw Jatropha oil was filtered to remove all insoluble impurities followed by heating at 100°C in hot air oven for 20 min to remove all moisture. In the first step, the higher fatty acid oil was processed using 0.6 w/w ratio of methanol to oil in presence of concentrated Sulphuric acid as a catalyst (1 wt% of oil). The reaction takes place for one hour at optimum temperature of 50°C and stirred at 300 rpm in a three neck flask with heater. After the reaction the mixture was allowed to settle in a separating funnel for 5 hours. The methanol water mixture was separated and processed oil was removed.

Fig. 1: Raw jatropha oil, methanol & catalyst, separating funnel, flask cum stirrer & external heater

Fig. 2: Magnetic Stirrer

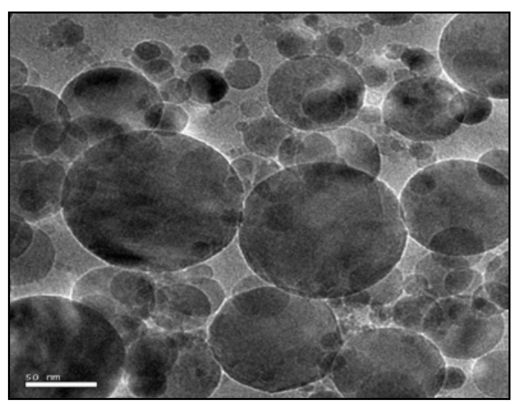

Fig. 3: SEM images of nano particle

Preparation of nano fluids

Nano fluid is not merely the addition of nano particles to the base fluid. Nano particles generally having higher surface area and hence surface energy will be high and it tends to agglomerate and form a micro molecule and starts to sediment. In order to make nano particle to be stable in base fluid, it should be evolved to surface modification.

Equipments used

- Ultra sonicator
- Magnetic stirrer

Ultra sonicator

It is a device which mixes the nano particle in the base fluid in molecular basis. Usually nano particles have higher surface energy and it forms agglomeration. Thus it affects the stability of the nano fluid. Ultra sonicator will generate ultrasonic waves, thus it breaks the agglomeration of the particle and form a stable nano fluid.

Magnetic stirrer

A magnetic stirrer or magnetic mixer is a laboratory device that employs a rotating magnetic field to cause a stir bar (also called "flea") immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid. Magnetic stirrers often include a hot plate or some other means for heating the liquid.

Steps followed in the nano fluid preparation process:

- Prepare the Biodiesel-ethanol blend in the required ratio.
- Weight the required amount of sample (nano particles to be mixed) in an electronic weighing machine.
- Disperse the weighed nano particles in the prepared Biodiesel-ethanol fuel.
- Stirring the nano fluid for 30 minutes in the water-bath type ultra-sonicator.

Performance characteristics

The following section illustrates the performance attributes such as brake specific fuel consumption for the neat diesel fuel, Biodiesel-Ethanol blend (BE20), 10% DEE additive in Biodiesel-Ethanol Blend (BE20-10DEE) and 50 ppm Alumina nano additive in Biodiesel-Ethanol Blend (BE20-50AL) with the reference to load. The readings are taken at 25%, 50%, 75%, and 100% of engine loads. Brake powers were measured and BTEs were calculated to evaluate the engine performance.

Variation of brake specific fuel consumption

Biodiesel-ethanol blend consumed more specific fuel consumption due to heavier molecular structure of biodiesel and higher rate of vaporization of ethanol. The DEE additive in biodiesel-ethanol blend (BE20-10DEE) and alumina nano additive in biodiesel-ethanol blend (BE20-50AL) fuels were shown a marginal improved brake specific fuel consumption compared to that of Biodiesel-ethanol blend fuel as depicted in Fig. 4.

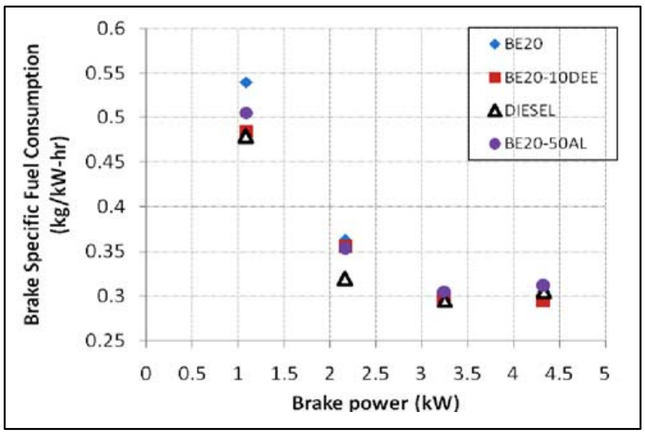

Fig. 4: Variation of brake specific fuel consumption with load

On the other hand, DEE additive Biodiesel-ethanol blend fuel leads to lower specific fuel consumption than nano dopped Biodiesel-ethanol blend. This is due to higher oxygen content in DEE additive Biodiesel-ethanol blend fuel. The lower brake specific fuel consumption observed is 0.29 kg/kW-hr for BE20-10DEE, whereas it is 0.31, 0.30, and 0.30 kg/kW-hr for the BE20-50AL, BE20 and neat diesel at the full load respectively.

Emission characteristics

The following section illustrates the emission characteristics (such as NOx, CO, HC, and smoke opacity) for the neat diesel fuel, Biodiesel-Ethanol blend (BE20), 10% DEE additive in Biodiesel-Ethanol Blend (BE20-10DEE) and 50 ppm Alumina nano additive in Biodiesel-Ethanol Blend (BE20-50AL) with the reference to load. The readings are taken at 25%, 50%, 75% and 100% of engine loads.

Variation of oxides of nitrogen (NO_x)

The variation of NO_x with respect to load is shown in Figure 5. It is found that at the higher loads, higher burning temperature in the combustion chamber is observed and facilitates more NO_x emissions according to Zeldovich NO thermal mechanism. The magnitude of NO_x emission for the neat diesel is high compared to that of other tested fuels due to usurious exhaust gas temperature.

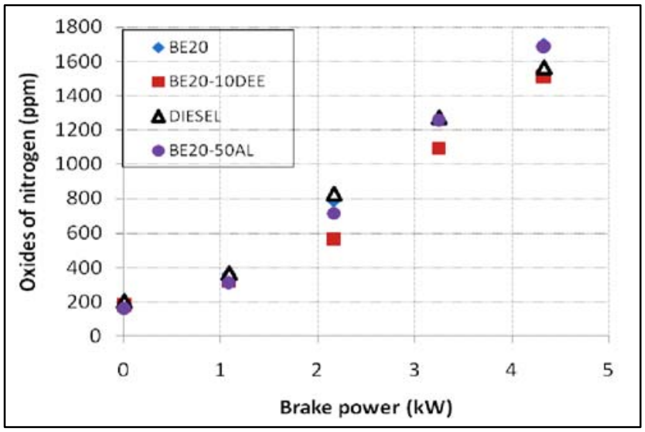

Fig. 5: Variations of oxides of nitrogen with load

Contrastingly, the magnitude of NO_x emission is drastically reduced for the Biodiesel-Ethanol blend fuel compared to that of neat diesel. This could be due to the ethanol present in the fuel which has lead to heat sink effect during the combustion in the engine cylinder. In the case of aluminia nanoparticles blended Biodiesel-Ethanol blend fuels, the magnitude of NO_x emission is further reduced compared to that of Biodiesel-Ethanol blend fuel due to shortened ignition delay and lower cylinder peak pressure. However DEE additive Biodiesel-Ethanol blend has low NOx emission than nano additive Biodiesel-Ethanol blend. This is due to lower cylinder peak pressure. The magnitude of NOx emission observed is 1514 ppm for BE20-10DEE, whereas it is 1688, 1702 and 1567 ppm for the BE20-50AL, BE20 and neat diesel at the full load respectively.

Variation of carbon monoxides (CO)

DEE additive Biodiesel-Ethanol blend has lower CO emission due to enrichment of oxygen will promote further oxidation. It is seen that the magnitude of CO emission for the alumina nanoparticles blended Biodiesel-Ethanol blend fuels is marginally lower than the neat Biodiesel-Ethanol blend fuel. This could be probably due to the oxidation of CO into CO_2. Owing to the above phenomena, there is an improved uniform dispersion of nanoparticles leading to catalytic activity and in the combustion chamber, and in turn resulting reduced CO emissions. Overall DEE additive Biodiesel-Ethanol blend, low magnitude of CO emission observed is 0.02%, whereas it is 0.02, 0.025, and 0.04% for the BE20-50AL, BE20 and neat diesel at the full load, respectively.

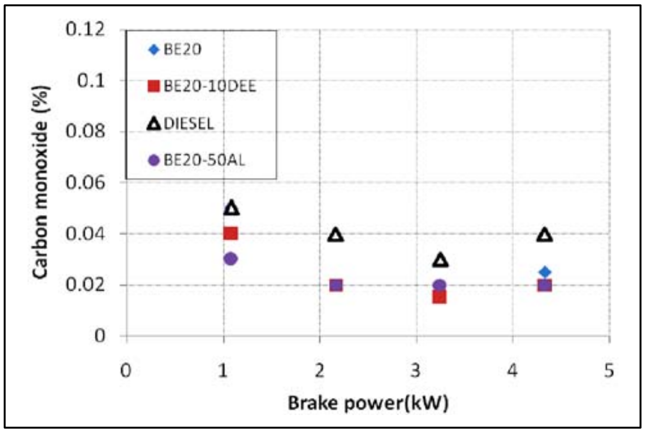

Fig. 6: Variation of carbon monoxides with load

Variation of unburned hydrocarbons (HC)

The variation of unburned hydrocarbon emissions with respect to load is shown in Fig. 7.

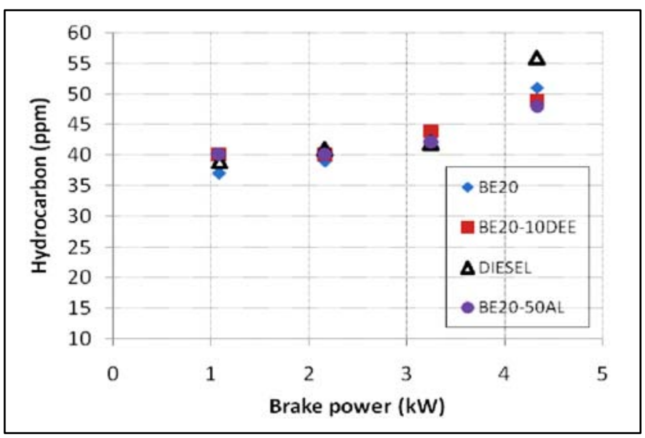

Fig. 7: Variation of unburned hydrocarbons with load

It is observed that the magnitude of HC emissions of alumina nanoparticles blended Biodiesel-Ethanol blend fuels is marginally low compared to that of DEE additive Biodiesel-

Ethanol blend fuel. This could be probably due to secondary atomization, shorten ignition delay, and catalytic activity aluminium nanoparticles leading to the better combustion. In the case of Biodiesel-Ethanol blend fuel, HC emissions are enhanced due to reduced gas temperature, and incomplete combustion. The magnitude of HC emission observed is 48 ppm for BE20-50AL, whereas it is 49, 51 and 56 ppm for the BE20-10DEE, BE20 and neat diesel at the full load, respectively.

Variation of smoke opacity

The variation of the smoke opacity for the tested fuels is depicted in Figure 8. It is examined that the magnitude of smoke opacity for the DEE additive Biodiesel-Ethanol blend fuel is low compared to that of Biodiesel-Ethanol blend fuel. Owing to improved ignition character, the magnitude of smoke opacity is drastically reduced. The alumina nanoparticles blended Biodiesel-Ethanol blend fuels also show the similar characteristic trend as that of DEE additive Biodiesel-Ethanol blend fuel, with the further reduction of smoke. The incorporation of aluminum nanoparticles to the Biodiesel-Ethanol blend fuel has induced shortened ignition delay, enhanced evaporation, and improved ignition characteristics.

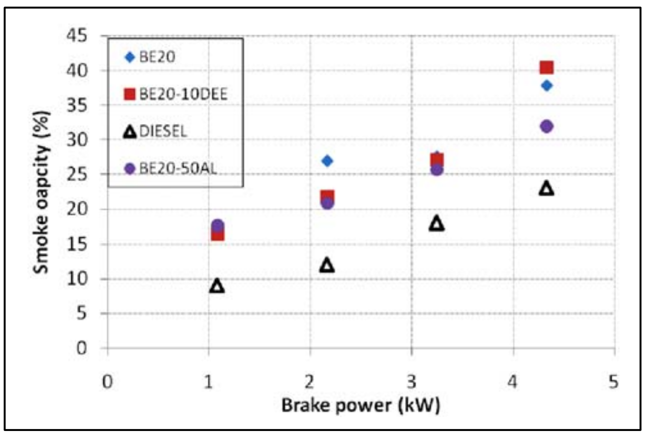

Fig. 8: Variation of smoke opacity with load

CONCLUSION

An experimental study on the use of Biodiesel-Ethanol blend has been conducted on a direct injection diesel engine, with additives of DEE and alumina nano particles. The main conclusions from this investigation are as follows:

(i) The brake specific fuel consumption of the engine is substantially improved with the addition DEE additive and aluminium nanoparticles to Biodiesel-

Ethanol blend fuels at all the loads. The lower brake specific fuel consumption observed is 0.29 kg/kW-hr for BE20-10DEE, whereas it is 0.31, 0.30, and 0.30 kg/kW-hr for the BE20-50AL, BE20 and neat diesel at the full load respectively.

(ii) The NOx emission are considerably less for DEE additive Biodiesel-Ethanol blend and aluminium nanoparticles blended Biodiesel-Ethanol blend fuels compared to that of Biodiesel-Ethanol blend fuels at all the loads. The magnitude of NOx emission observed is 1514 ppm for BE20-10DEE, whereas it is 1688, 1702 and 1567 ppm for the BE20-50AL, BE20 and neat diesel at the full load respectively.

REFERENCES

1. Nadir Yilmaz, Performance and Emission Characteristics of a Diesel Engine Fuelled with Biodiesel–Ethanol and Biodiesel–Methanol Blends at Elevated Air Temperature, Fuel, **94**, 440-443 (2012).
2. Nadir Yilmaz and Tomas M. Sanchez, Analysis of Operating a Diesel Engine on Biodiesel–Ethanol and Biodiesel–Methanol Blends, Energy, **46**, 126-129 (2012).
3. Jincheng Huang, Yaodong Wang, Shuangding Li, Anthony P, Roskilly, Hongdong Yu and Huifen Li, Experimental Investigation on the Performance and Emissions of a Dieselengine Fuelled with Ethanol–Diesel Blends, Appl. Thermal Engg., **29**, 2484-2490 (2009).
4. J. Sadhik Basha and R. B. Anand, Effects of Nanoparticle Additive in the Water-Diesel Emulsion Fuel on the Performance, Emission and Combustion Characteristics of Diesel Engine, Int. J. Vehicle Design, **59(2/3)**, 164-181 (2012).
5. J. Sadhik Basha and R. B. Anand, Role of Nanoadditive Blended Biodiesel Emulsion Fuel on the Working Characteristics of a Diesel Engine, J. Renewable Sustainable Energy, **3**, 023106 (2011).

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