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INFLUENCE OF PYROGALLOL ANTIOXIDANT ON PERFORMANCE AND EMISSIONS OF A CI FUELLED WITH NEEM OIL BIODIESEL

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ABSTRACT

In current circumstances, energy is considered as a critical factor for economic growth, social development and human welfare. To bridge the ever rising energy requirement, biodiesel an alternative diesel fuel derived from waste vegetable oil, animal fats or vegetable oil is becoming increasingly popular in developing countries. Amongst which the biodiesel derived from neem oil has already proved as potential alternative fuel for CI engine. However the studies which investigate performance and emission characteristics with additives need to be investigated. In the present investigation the neem oil biodiesel was prepared using acid catalyzed esterification followed by trans-esterification process. The performance and emission characteristics of a single cylinder Compression ignition engine was carried with pyrogallol concentration of 0 parts per million (ppm), 250ppm, 500ppm and 750ppm with neem oil biodiesel. The engine performance and emission tests were carried out at a rated speed of 1500 rpm under different loading conditions. An improved performance and emission characteristics of engine was found with addition of pyrogallol as additives in neem oil biodiesel.

Keywords: Esterification, Trans-esterification, Antioxidant, Biodiesel, B100, Pyrogallol

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1. INTRODUCTION

Requirements for energy are increasing swiftly due to fast industrialization and the increased number of automobiles on the road. During recent years high activities can be observed in the field of alternative fuels, due to rapid decrease in world petroleum reserves. Biodiesel and alcohol are considered as alternative fuels. These fuels are being looked to provide employment generation to rural people through plantation of vegetable oils and can be beneficial to sugarcane farmers through the ethanol program. Biodiesel (Methyl esters) is gaining more and more importance as an attractive fuel due to the exhausting crude oil resources. Biodiesel is a biofuel produced from vegetable oils and fats. It is produced by a chemical process known as trans-esterification whereby either ethanol or methanol is reacted, in the occurrence of a catalyst, with oil or fat to produce an ester and glycerol. This process involves a reaction of the oil with an alcohol to remove the glycerin, which is a secondary product of biodiesel production [1, 2].Shiv Kumar et al. [3] suggested that India is deficient in edible oils, the non-edible oils like Mahua, Simarouba, Jatropha, Neem, etc., could be the desirable source in India for the production of biodiesel. In recent years, biodiesel has been used as a renewable and commercial substitute for the fossil diesel due to its properties which are close to that of fossil diesel [4]. Also, biodiesel is popular in under developed and developing countries, due to improvement in the local employment, savings in foreign exchange, etc. When biodiesel is used as fuel in a diesel engine, the considerable reduction in the engine emissions, such as hydrocarbon, particulate, and carbon monoxide emissions, have been reported in the literature [5].

Biodiesel is considered a renewable substitute for fossil diesel, but its poor oxidative stability is an obstacle to its complete acceptance by diesel engine manufacturers. The biodiesel has lower volatility as compared to the diesel. However, it is susceptible to oxidative degradation due to auto-oxidation in the presence of oxygen, which hinders its widespread use. The antioxidant addition is a prospective solution to this problem. It is expected that antioxidants may affect the clean-burning characteristic of biodiesel.

Numerous studies have indicated the considerable increase in engine NOx emissions with biodiesel fuel. The addition of antioxidants may affect the engine emissions as well as the engine performance. Abdul [6] reported that the oxidized biodiesel affects both diesel engine performance and emissions. Erol et al. [7] studied the effect of antioxidant additives on the oxidation stability of biodiesel and the exhaust emissions of the diesel engine. Antioxidant additives such as *Tert*-butylhydroquinone (TBHQ), Butyl-4- hydroxytoluene (BHT), Butylated hydroxyanisole (BHA), and 2-ethylhexyl nitrate (EHN) were individually dissolved on different concentrations in B20 canola biodiesel. Rizwanul et al. [8] performed the experimental investigation on the outcome of the antioxidant addition on engine performance and emission characteristics. Rizwanul et al. [8] carried out the experimental investigation of the (BHA) and (BHT) antioxidant at 1000ppm concentration to B20 palm biodiesel on engine performance and emission characteristics. Varatharajan et al. [9] examined the use of p-phenylenediamine derived aromatic amine antioxidants for NOx reduction in soybean biodiesel (methyl ester) fueled in the diesel engine. Balaji et al. [10] reported that addition of Propyl Gallate antioxidant affects both engine performance and emission.

2. MATERIALS AND METHODS

2.1. Biodiesel Production

The biodiesel was obtained from Neem oil by a dual-step trans-esterification method. The acid value of the biodiesel was reduced by esterification in the initial step. In the subsequent step, the pre-treated Neem oil of first step was converted into biodiesel using alkaline catalyzed trans-esterification.

Acid esterification was carried out using 33% methanol-to- neem oil ratio in the occurrence of 1% H_2SO_4 as an acid catalyst for 2 hours at 60°C in a reaction vessel placed on a magnetic stirrer operating at 400 rpm. The mixture is poured to separating funnel, after completion of this reaction there by allowing settling for at least 3 hours for separation .The lower layer is separated and used for the base trans-esterification. This step is mainly a pre-treatment process and reduces the FFA.

Base trans-esterification was made using 30% methanol-to-acid esterified neem oil ratio in the existence of 1% KOH as base catalyst for 2 h at 55 °C in a reaction vessel placed on a magnetic stirrer operating at 400 rpm. The mixture is poured to separating funnel, after completion of this reaction there by allowing settling for at least 3 hours for separation .After 4 h glycerin will settle at the bottom and Biodiesel separates as top layer. The biodiesel obtained from above discussed stages was washed with warm distilled water to eliminate the excess catalytic agent and impurities existing in the biodiesel. After water wash, the biodiesel was separated and heated to 100°C for 10 min to remove the moisture.

2.2. Engine Test Technique

Engine investigations was made on a Kirloskar Make, mono cylinder, 4-stroke, constant speed, vertical, air cooled, Compression ignition, 4.4 kW diesel engines. The descriptions of the engine are given in Table 1. The engine layout is shown in Figure 3. Throughout the investigation the fuel used were diesel and B100 Neem biodiesel with blends of 0, 250, 500 and 750 ppm Pyrogallol (PY) antioxidant concentration by weight in B100 Neem biodiesel. Measurements of exhaust emissions such as NO_x, CO, HC and smoke density were made using AVL DIGAS-444 five gas analyzer and AVL 415 smoke meter respectively. Under steady state conditions fuel consumption rate, emission levels were obtained for different loads at a constant speed of 1500 rpm for diesel and B100 Neem biodiesel blended with different antioxidant concentration.

Table 1 Specifications of the Diesel engine used

Feature	Detail
General details	Single cylinder, 4 stroke, Vertical, Air cooled Compression ignition engine.
Make	Kirloskar
Bore and Stroke in mm	87.5 and 110
Ratio of Compression	17.5:1
Rated Speed	1500 rpm
Dynamometer	Electrical Dynamometer
Rated Power	4.4 KW

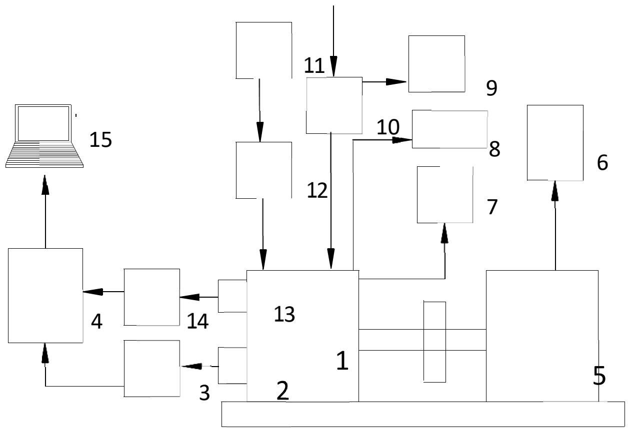

Figure 1 Layout of experimental setup with instrumentation

1) Diesel engine, 2) TDC position sensor, 3) TDC amplifier circuit, 4) A/D card, 5) Electrical loading, 6) Dynamometer controls, 7)Exhaust gas analyzer, 8) AVL smoke meter, 9)U-tube manometer, 10)Air box, 11) Fuel tank, 12) Fuel measurement flask, 13) Pressure pick up, 14)Charge amplifier 15) Personal Computer

3. RESULTS AND DISCUSSION

3.1. Specific fuel Consumption (SFC)

SFC is the ratio of mass flow rate of fuel to the brake power (BP). The SFC decreases with increase in loading .The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. The heat content of B100 was lower than diesel by about 12.99 %. Due to this reason, the SFC was found to be higher than that of diesel. As shown in (Figure 2) SFC for 500ppm PY is lower compared to B100 Neem biodiesel with its blends of antioxidant concentrations at higher loads, it is considered as best antioxidant concentration.

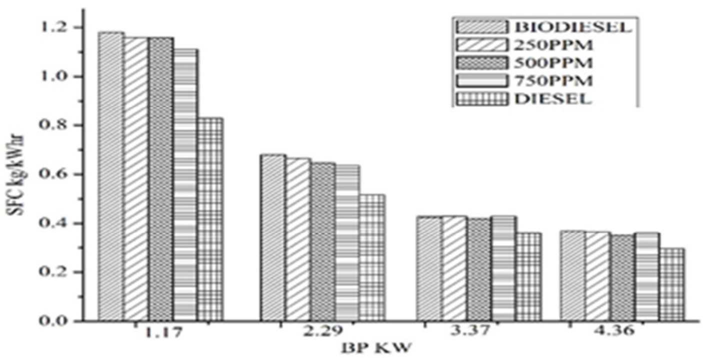

Figure 2 Comparison of SFC with BP for Diesel, Neem biodiesel and its blends of antioxidant concentration

3.2. Brake thermal Efficiency (BTE)

The variation of brake thermal efficiency with brake power is presented in (Figure 3).Brake thermal efficiency increases with increase in loading. This was due to reduction in heat loss and increase in power with increase in load. As shown in (Figure 3) BTE for 750ppm PG is higher compared to B100 Neem biodiesel and its blends of antioxidant concentrations at all loads, it is considered as best antioxidant concentration. The BTE for half load and full load is 10.7 % and 6.9% greater than B100.

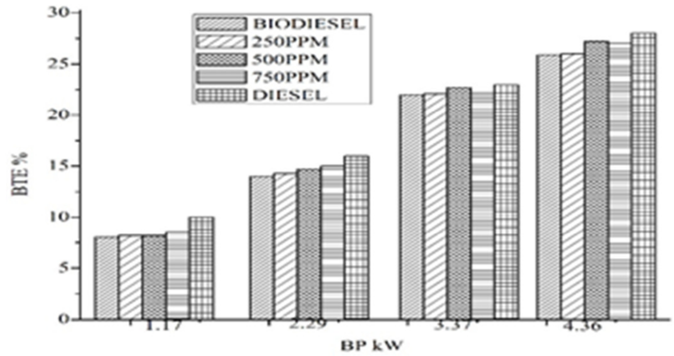

Figure 3 Comparison of BTE with BP for Diesel, Neem biodiesel and its blends of antioxidant concentration.

3.3. Carbon monoxide Emissions

The variation of CO emission with loading is presented in Figure 4. The CO emission levels increases as increase in antioxidant concentration from zero load to 25% loading. The CO emission was found to be constant at 50 % loading for Diesel, B100 and its blends. At higher loads the CO emission levels were lower for 500 ppm PY antioxidant concentration and is considered as best antioxidant concentration. Figure 4 shows that CO emission at full load is 20 % and 40 % less than Diesel for B100 and B100 blend with 500 ppm PY concentration.

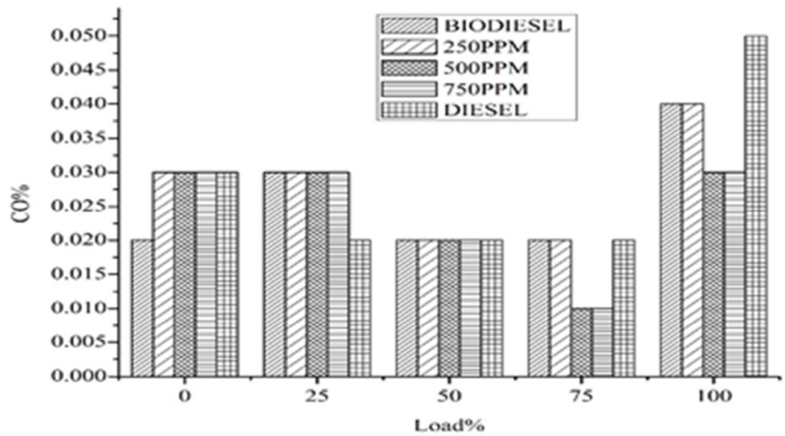

Figure 4 Comparison of CO with Load for Diesel, Neem biodiesel and its blends of antioxidant concentration.

3.4. Hydrocarbon Emissions

The variation of HC emission with loading is presented in (Figure 5). It is observed that HC emission increases linearly with loading for Diesel and B100 biodiesel and there is considerable decline in emission levels of HC with B100 Neem biodiesel as compared to conventional diesel operation. These reductions indicate better combustion of the fuel. As shown in Figure 5 HC emission for 500 ppm PY is lower compared to B100 Neem biodiesel and its blends of antioxidant concentrations at all loads, it is considered as best antioxidant concentration. The HC emission level was found to be 50 % lower than diesel and 9.09 % lower than B100 with its blend of 500 ppm PY when engine is operating at full load.

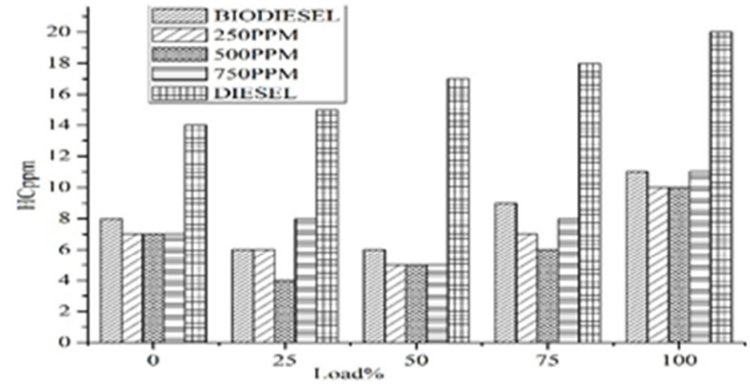

Figure 5 Comparison of HC with Load for Diesel, Neem biodiesel and its blends of antioxidant concentration

3.5 NO_X Emissions

The variation of NO_x emission with loading is presented in (Figure 6). NO_x emissions of B100 biodiesel is more compared to diesel because emissions of NO_x are sensitive to oxygen content; biodiesel has more oxygen which combines with the nitrogen present in air. Due to the presence of antioxidant in B100 blends the NO_x emissions are decreased considerably because it reduces the tendency of fuel to combine with oxygen in the atmosphere. As shown in Figure 6 NO_x emission for 500ppm PY is lower compared to B100 Neem biodiesel and its blends of antioxidant concentrations at higher loads, it is considered as best antioxidant concentration. The NO_x emission was found to be 11.6 % higher than diesel and 7.6% lower than B100 with its blend of 500 ppm PY when engine is operating at full load.

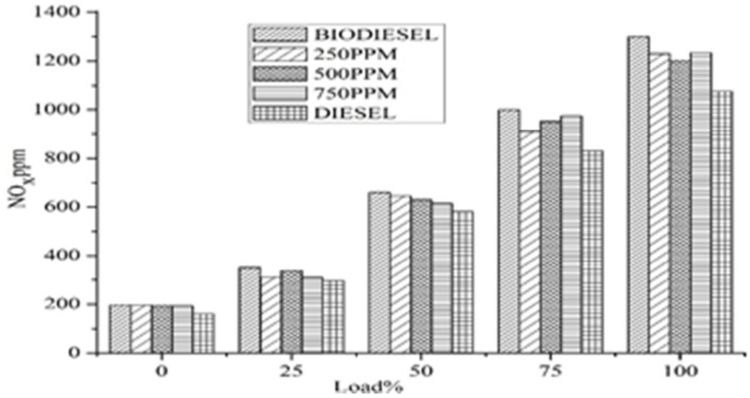

Figure 6 Comparison of NO_x with Load for Diesel, Neem biodiesel and its blends of antioxidant concentration

4. CONCLUSIONS

Based on above discussion, the following conclusions are made:

1. In this work, biodiesel was obtained from Neem oil by a dual step trans-esterification method.
2. The SFC and BTE is considerably lower and higher than B100 Neem biodiesel blended with 500ppm PY at higher loads respectively, it is considered as best antioxidant concentration.

3. The CO and HC emission reduces using B100 Neem biodiesel compared to diesel because of greater proportion of oxygen in biodiesel, and there is further considerable decrease in emission with B100 blended with 500 ppm PY at higher loads.
4. The NO_x emission increases using B100 Neem biodiesel compared to diesel because of greater proportion of oxygen in biodiesel, and there is further considerable decrease in emission with B100 blended with 500 ppm PY at higher loads.
5. The B100 blend with 500 ppm PY is considered to be the best antioxidant concentration to improve engine performance and emission.

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