RESEARCH ON THE INFLUENCE OF ONION OIL AS ADDITIVE ON THE OPERATION OF DIESEL ENGINE POWERED BY BIODIESEL

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ABSTRACT

The conventional fuel used to produce electrical energy and the burning of the conventional fuel causes global warming. Also, there is a depletion of these fuel and hence there is a need of alternative fuels. The biodiesel is a renewable fuel and it is a sustainable fuel. The biodiesel can be derived from waste cooking oil (WCO) as it increases the commercial value of the WCO. The biodiesel has lower oxidation stability and hence onion oil which has good anti oxidation value was added with WCO biodiesel. The engine tests were carried with WCO biodiesel added with onion oil shows that the addition of onion oil improves the thermal efficiency and improvement in cylinder pressure and heat release rate. We conclude that the onion oil can be used as additive to the WCO biodiesel.

Keywords: alternative fuel, biodiesel, additive, engine, performance.

INTRODUCTION

The world's energy consumption has been increasing steadily for several decades because to a number of variables, including population increase, urbanization, industrialization, and economic development and this energy derived from fossil fuels. Over the past ten years, the International Energy Agency estimates that the world's energy consumption has increased by roughly 2.3 % annually, and it is projected that global energy consumption will continue to increase, although at a slower rate, reaching around 25 % higher in 2040 compared to 2017 [1]. The increase in global energy consumption is due to a variety of factors, including: the world's population has been increasing steadily, with the United Nations projecting a global population of 9.7 billion by 2050 [2]. The urban areas tend to have higher energy demands per capita due to greater access to energy-intensive services such as transportation, air conditioning, and heating. This force increases in energy demand; however, the availability of conventional fuels is limited and hence focuses is on the non-conventional, particularly sustainable energy sources [3]. The limited conventional fuel availability makes alternative fuels as replacement to this fuel. The energy demand of developing countries such as India is predicted to increase in near future due to increase in industrial and commercial activities [4].

The biofuel which is one of the non-conventional fuels, is the sustainable alternative fuel and it has several advantages as compared to non-conventional such as geothermal fuel. The temperature, length of the reaction, amount of catalyst, and oil to alcohol ratio, affects the biodiesel conversion from vegetable oil and it has to be optimised to get higher biodiesel output [5]. The presence of oxygen in the biodiesel minimises engine's emission level and enhances biodiesel's biodegradability. The biodiesel's properties are affected by fatty acids and a study was carried out to predict properties using fatty acid [6].

The biodiesel's lower oxidation stability is a negative and various methods are used to enhance its stability [7]. The oxidation stability of the biodiesel is increased by the application of many synthetic antioxidants; however, the synthetic antioxidants have side effects and therefore a number of organic antioxidants are added to improve the oxidation stability of the biodiesel [8]. The biodiesel's qualities are greatly enhanced by the use of natural additives, especially oxidation stability [9]. The natural extracts such as ginger and basil have excellent antioxidants properties and easily available in the market [10]. The use of natural antioxidants increases the biodiesel's oxidation stability significantly and impacts the engine's performance and emissions [11]. It is reported that the engine's oxides of nitrogen level decreases with increase in biodiesel saturation level [12].

The commercial antioxidants like propyl gallate have a big impact on emissions and engine performance, however natural antioxidant is preferred due to its advantages [13]. The onion oil is a natural extract derived from onions and it has been more well-known recently as a result of its many advantages. One of the notable properties of onion oil is its antioxidant activity and antimicrobial properties [14]. Onions are rich in a group of antioxidants known as flavonoids, particularly quercetin. When onion oil is extracted, it retains a significant amount of quercetin, making it an excellent source of this beneficial compound. Compared to white onions, red onions have a higher total polyphenol concentration [15]. It is suggested that the onion oil can be a substitute for the synthetic antioxidant [16].

The most common method for obtaining onion oil from onions is steam distillation. The process of obtaining onion oil involves the following steps. After being picked, the fresh onions are cleaned to get rid of contaminants. To make the extraction procedure easier, the onions' outer layers are peeled off and typically sliced into smaller pieces. The onions are diced and added to a distillation equipment. The onions are then heated by the introduction of steam. The onions' vital oil disappears when they heat up. Steam and the evaporated essential oil ascend via a condenser. The vapor condenses back into a liquid condition as a result of the condenser cooling it. Essential oils do not mix with water, therefore when the condensed liquid is collected, the oil separates from the water. Since onion oil is lighter than water, it floats to the top and is simple to remove from the mixture. After being separated, the onion oil is usually filtered to get rid of any contaminants before being bottled [17, 18].

EXPERIMENTAL

Biodiesel production

In this project, WCO was converted into energy through the production of biodiesel. The biodiesel has lower oxidation stability and hence addition of antioxidant will enhance is necessary. It has been suggested that 1600 ppm of onion oil extract produces more antioxidant properties and hence onion oil of dosage of 1000 and 2000 ppm was added to WCO to increase antioxidant property of WCO [19]. The properties of the biodiesel were determined as per the ASTM procedure. The engine testing was carried out while maintaining a steady speed by varying the load from zero to full load of the engine. The engine performance parameters were recorded at steady state condition.

Engine tests

A diesel engine running at a steady speed was used for the engine testing and it is connected to eddy current dynamometer to vary the engine loads. The eddy current dynamometer was used to adjust the engine load from low to full. The important observations were made once the engine reached steady state. Subsequently, the engine load was increased to even higher levels, and the same procedure was used to document the observations. Initially engine test was conducted with diesel and then with WCO biodiesel added with 1000 and 2000 ppm of onion oil. Fig. 1 shows the engine experimental setup and the engine capacity is 5 horsepower capacity at the rated speed of 1500 rpm and it is naturally aspirated.

RESULTS AND DISCUSSION

The WCO was converted into biodiesel using a two-step transesterification process. The important properties were determined, and Table 1 lists the fuels' characteristics, and it can be seen that adding onion oil increases the WCO biodiesel's volatility.

Fig. 2 depicts brake thermal efficiency (BTE) of the engine at different loads and it shows that the value of this efficiency increases with increase in load due

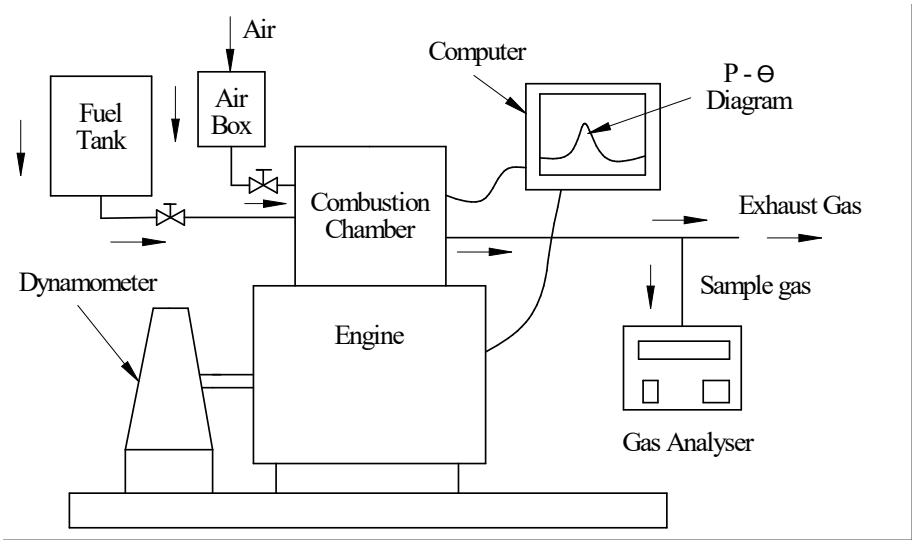

Fig. 1. Engine test setup.

Table 1. Comparison of fuel properties.

Property	Diesel	WCO biodiesel	WCO biodiesel 1000 ppm	WCO biodiesel 2000 ppm
Flash Point, ºC	68	152	147	141
Fire Point, ºC	74	159	153	145
Density, kg m^{-3}	830	857	860	862
Viscosity, $mm^2 s^{-1}$	2.56	4.25	4.21	4.18
Calorific Value, MJ kg^{-1}	42.5	38.4	38.45	38.94

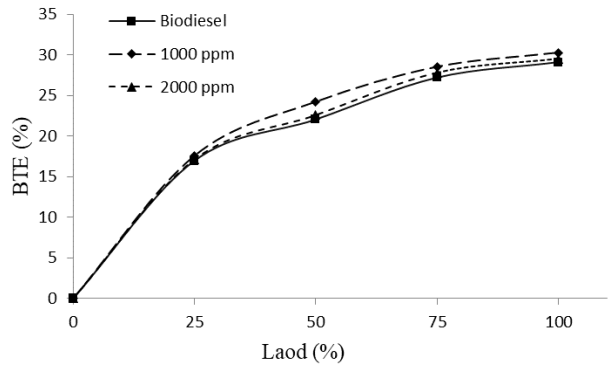

Fig. 2. BTE at different loads.

to reduction in frictional losses. The efficiency of the WCOB added with onion oil is higher than the diesel. The higher volatility of the onion oil results in better spray formation and combustion of the WCOB. The volatile compounds in the onion oil have low boiling points, making them more likely to evaporate at lower temperatures compared to other oils with higher boiling points. This enhances the evaporation of the WCOB and improves the combustion of the WCOB. The onion oil of 1000 rpm results in higher efficiency as compared to 2000 rpm and hence the optimum onion oil addition is 1000 rpm. Similar type of work reported with clove oil shows improvement in efficiency by 9 % and the present work also shows similar nature [20].

Fig. 3 depicts cylinder pressure at different loads, and it shows that the value of cylinder pressure reaches maximum and then gradually reduces. The area below the pressure curve shows the work done by the engine. From the figure, it is observed that the 1000 ppm results in higher cylinder pressure as compared to 2000 rpm. This is because, the WCOB burns more efficiently, increasing cylinder pressure. The onion oil's volatile components also contribute to the oil's increased volatility, which enhances combustion and pressure.

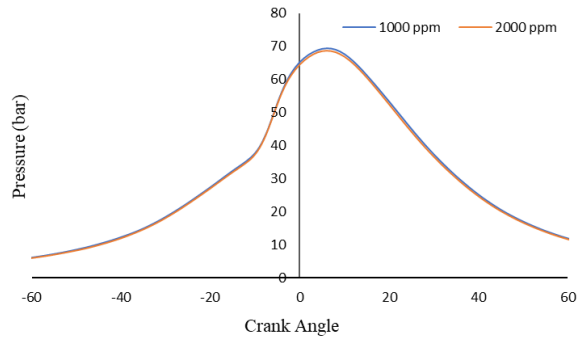

Fig. 3. Pressure at different crank angles.

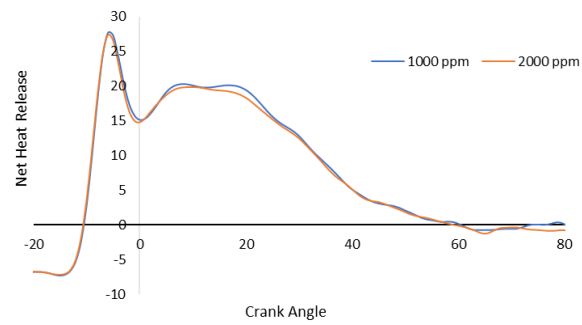

Fig. 4. Heat release rate at different crank angles.

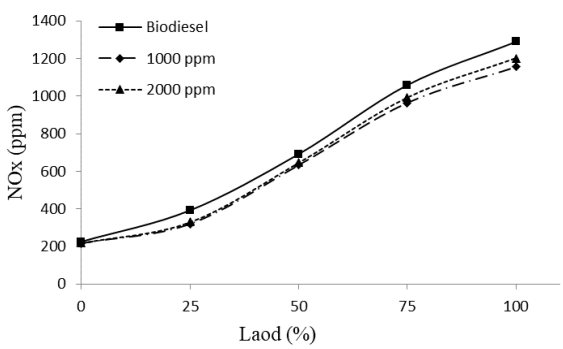

Fig. 5. NOx value at different crank angles.

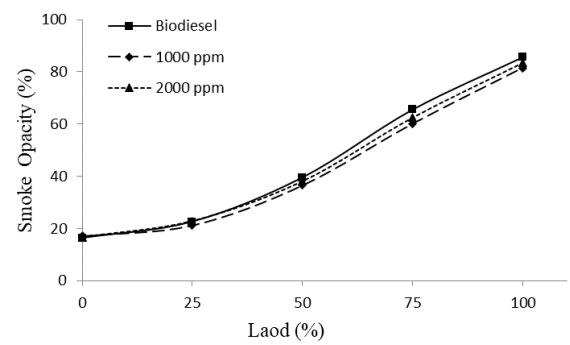

Fig. 6. Smoke opacity at different loads.

The heat release rate of the fuel at different crank angles is shown in the Fig. 4. The net release rate reaches maximum value and then decreases and then increases. Then gradually reduces due to expansion of the gases which results in work output of the engine. The net release rate of the fuel with 1000 rpm is higher than the 2000 ppm due to better evaporation of WCOB aided by the onion oil.

One of the major emissions of the diesel engine is oxides of nitrogen (NOx) and from the Fig. 5, it is observed that this emission level increases with increase in load due to increase in fuel consumption by the engine. The oxides of nitrogen emission with onion oil is lower than the diesel. However, 2000 ppm results in slightly higher oxides of nitrogen emission as compared to 1000 ppm. In literature it is reported that the addition of natural additive to the biodiesel reduces oxides of nitrogen emission by 12 % [21].

Fig. 6 represents smoke emission of the engine at various loads of the engine. The smoke emission increases with increase in smoke opacity due to increase in fuel consumption. The onion oil addition to the WCOB reduces the smoke emission. The figure shows that the onion oil addition of 1000 ppm results in lower smoke value due to the better combustion which reduces the smoke value.

CONCLUSIONS

The WCO has significant potential for the production of biodiesel and it also plays crucial role in the conversion of waste into fuel. The onion oil has significant ani oxidant value and has better volatility. The onion oil was added to the WCOB with different dosages (1000 and 2000 ppm). The addition of onion oil to the WCOB affects the diesel engine performance.

The onion oil dosage of 1000 ppm results in better performance and lower emission as compared to 1000 ppm. We draw the conclusion from this work that onion oil can be utilized in place of the synthetic additive that is sold commercially as a renewable additive.

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