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DEVELOPMENT OF WASTE COCONUT OIL AND EFFICIENCY, POLLUTION AND COMBUSTION CHARACTERIZATION USING DIESEL ENGINE

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ABSTRACT

Energy and fuel emergency is the most noteworthy prerequisites for the presence of person. The present world uses fills from fossil as the key providers of Energy. Wrecking of non-renewable energy sources increments a worldwide temperature alteration, which prompts gigantic oil emergency hence we have to discover the eccentric vitality hotspots for fuel age. In this examination the waste coconut oil was viewed as potential assets for the biodiesel creation. The accessibility and ease of oil are appealing. Motor execution test is done for 5 examples including diesel and 4 examples of biodiesel of which B10, B20, B30 and B50 of waste coconut oil. Brake warm effectiveness and BSFC are acquired at various burdens and for all fuel tests. The outflow tests have been led with coconut oil biodiesels and their mixes with diesel oil and methanol. The test was directed withB10, B20, B30 and B50 of utilized cooking oil mixes and diesel. The outcomes from the investigations recommend that biodiesel from squander coconut oil could be a decent substitute fuel for diesel motor sooner rather than later most definitely. Taking into account equivalent motor execution and decrease in the motor emanations, it tends to be finished up and biodiesel mixes B10, B20 could be utilized in a customary diesel motor.

1. INTRODUCTION

The fossil fuel demand is continuously growing planet over consequential in quick depletion of fossil fuel deposits [1]. Increasing concerns regarding environmental impacts, the soaring price of petroleum products together with the depletion of fossil fuels have prompted considerable research to identify alternative fuel sources. Biofuel has recently attracted huge attention in different countries all over the world because of its renewability, better gas emissions and its biodegradability [2]. Biodiesel is mono alkyl esters of fatty acids derived from vegetable oils and animal fats. It has received increasing levels of attention as a potential alternative green fuel due to its non-toxic, sulfur and aromatic free, biodegradable and renewable material [3]. Biodiesel can be produced by transesterification of biological sources such as edible and no edible oils and animal fats with methanol [4]. Only 30% of the petroleum product is presently produced in India. The 70% remaining petroleum product are imported, which costs 80,000 crore rupees every year. The surprising information is that using bio-diesel fuel up to 5% to the current diesel fuel which is prepared in our nation, a 4000 crore rupees can be saved every year. 288 metric tons of bio-diesel can be produced in India, which will supplement 41.14% of the total demand of diesel fuel consumption in India. The planning commission of India has launched a bio-fuel project in 200 districts from 18 states in India. It has recommended two plant species, viz. jatropha (Jatropha curcas) and karanja (Pungamia pinnata) for biodiesel production. The recent auto fuel policy document states that bio-fuels are efficient, eco-friendly and 100% natural energy alternative to petroleum fuels [5]. It has been found that these vegetable oils can be used as diesel fuels in conventional diesel engines, but this leads to a number of problems related to the type and grade of oil and local climatic conditions. The injection, atomization and combustion characteristics of vegetable oils in diesel engines are significantly different from those of diesel. The high viscosity of vegetable oils interferes with the injection process and leads to poor fuel atomization. The inefficient mixing of oil with air contributes to incomplete combustion leading to heavy smoke emission, and the high flash point attributes to lower volatility characteristics.

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Vol-11 Issue-02 2021

These disadvantages, coupled with the reactivity of unsaturated vegetable oils, do not allow the engine to operate trouble free for longer period of time. These problems can be solved, if the vegetable oils are chemically modified to biodiesel, which is similar in characteristics to diesel [6]. In this paper waste coconut oil is used for the biodiesel production and engine test is carried out for the blends.

1.1. Coconut Oil

Copra is the dried meat, or dried kernel, of the coconut used to extract coconut oil. The earliest evidence of the extracting and use of coconut oil from copra is in early Tamil literature from the 1st century AD. The word originated from the Malayalam word koppra. Coconut oil is extracted from it and this has made copra an important agricultural commodity for many coconut-producing countries. It also yields coconut cake, which is mainly used as feed for livestock. Nowadays, the process of coconut oil extraction is performed by crushing copra to produce coconut oil (70%); the by-product is known as copra cake or copra meal (30%). Once the oil is extracted, the remaining coconut cake is 18-25% protein but contains so much fiber it cannot be eaten by humans. Instead it is normally fed to cattle, goats and sheep. Copra production begins on coconut plantations. Coconut trees are generally spaced 9 m (30 ft) apart, allowing a density of 100-160 coconut trees per hectare. A standard tree bears around 50-80 nuts a year, In India, Tiptur in Tumkur district in Karnataka state is notable for its copra.

2. MATERIALS AND METHODS

2.1. Oil extraction

Copra is sliced into smaller pieces and dried in a sun light for 3-4 days and oil is extracted from oil expeller. Extracted oil is stored for 1 day after which oil is removed from the container. And the fatty acid composition obtained from gas Chromatograph analysis from Bangalore test house. FFA Content of the oil was found to be 3.9 using the titration method. Since FFA was lesser than 4 so single stage transesterification method was employed for the biodiesel production using methanol as alcohol and catalyst used was Sodium hydroxide.

2.2. Biodiesel Preparation

Bio diesel is cost effective if prepared from low cost oils [7] Waste coconut oil biodiesel was prepared through transesterification process from waste coconut oil which was extracted from the coconut kernel of coconut tree. The formation of methyl esters by transesterification of waste coconut oil requires raw oil, methanol and sodium or potassium hydroxide. A reaction time of 90 min to a two hours and reaction temperatures of 60 to 65 °C were required for completion of reaction and formation of esters. The mixture was stirred continuously and then allowed to settle under gravity in a separating funnel. Two distinct layers found after gravity settling for 12 hours. The upper layer was of ester and the lower layer was of glycerol. The lower layer was separated out and the separated ester. The biodiesel thus produced through the above process was blended with diesel in the required proportions. The fuel blend was prepared just before commencing the experiments to ensure the mixture homogeneity.

3. PROPERTIES

The properties of biodiesel, crude oil and diesel fuels are tabulated in table 1. The important properties of waste coconut oil methyl esters are found out and compared with that of diesel. It can be seen that the properties of waste coconut oil methyl esters are quite comparable to that diesel. The result shows that, transesterification improved the important fuel properties of the oil like specific gravity, viscosity, flash point and calorific value. The comparison shows that the methyl ester has relatively closer fuel properties to diesel than that of original waste coconut oil.

Table 1 Property of Crude Oil and Biodiesel

Properties	Diesel	B100	Crude oil
CV in MJ/kg	43.5	35.3	33.69
Viscosity in cSt	4.1	3.7	27.8
Specific gravity	0.840	0.871	0.902
Flash point in °C	55	110	220

From table 1 the flash point of waste coconut oil biodiesel, crude oil and diesel are 110, 220 and 55 ^{o}C respectively. It is the minimum temperature at which the fuel will gives off enough vapors to produce an inflammable mixture above the fuel surface, when the fuel is heated under standard test conditions. Flash point varies inversely with the fuel's volatility. The flash point temperature of the waste coconut oil biodiesel is higher than that of conventional diesel, because the waste coconut oil biodiesel do not have the light fractions. The safety of the waste coconut oil biodiesel is ensured due to higher flash point temperature.

The kinematic viscosity of waste coconut oil biodiesel (3.7), crude oil (27.8) and diesel oil (4.1 cSt) are shown in table.1 This is an important property regarding fuel atomization and fuel distribution. For the biodiesel to be used in diesel engines, the kinematic viscosity must been in the range of 3.5 to 5.0 cSt.

From table.1 the calorific value (CV) of biodiesel, crude oil and conventional diesel oil are 35.3, 33.69 and 43.5MJ/kg respectively. This could be due to the difference in their chemical composition from that of diesel or the difference in the percentage of carbon and hydrogen content, or the presence of oxygen molecule in the molecular structure of waste coconut oil and biodiesel.

From table.1 the specific gravity of waste coconut oil biodiesel, crude oil and conventional diesel oil are 0.871, 0.902 and 0.84 respectively. Fuel specific gravity has importance in diesel engine performance since the fuel injection system operates on a volume metering system. The waste coconut oil biodiesel has higher specific gravity than diesel as shown in Table1. A fuel with low energy content per liter will cause the engine to produce less peak power; however this high specific gravity of biodiesel compensates the lower energy content.

The major properties of the biodiesel blends are shown in tables 2 which were determined using different apparatus like Hydrometer, Red Wood Viscometer, Panskey Martens Apparatus, Cloud point and Pour point apparatus and Bomb Calorimeter. It can be seen from this table 2 that the fuel properties of biodiesel blends are close to that of the diesel hence it is used in a diesel engine without any modification.

Table 2 Properties of blends

Property of Fuel	B50	B30	B20	B10
Specific Gravity	0.855	0.849	0.846	0.843
Viscosity in cSt	3.47	3.37	3.33	3.28
Flash Point in ^{o}C	80	70	65	60
Fire Point in ^{o}C	87	77	70	68
Cloud Point in ^{o}C	9	7	6	5
Pour Point in ^{o}C	-2	-7.6	-10.4	-13.2
CV in MJ/kg	39.4	41.04	41.86	42.68

4. EXPERIMENTAL SETUP

A Kirloskar make, single cylinder, naturally aspirated, vertical type, water cooled, direct injection, TV1 model diesel engine was selected for the present research work the computerized single cylinder diesel engine as shown in figure.2. The detailed technical specifications of the engine are given in table 3. The performance and emission test have been carried out on engine running under variable loads and constant speed. The engine was connected to an eddy-current dynamometer, and a control system was used for adjusting its load.

Table 3 Engine Specifications.

Make	Kirloskar
Model	TV1
Number of cylinders	Single cylinder
Engine capacity	661 cc
Maximum output	5.2 kW at 1500RPM
Bore Diameter	87.5 mm
Stroke	110mm
Compression ratio	16.7:1
Dynamometer	Eddy current dynamometer
Nominal rating	5.5 kW

The block diagram of computerized diesel engine test rig is shown in figure 1 this is the schematic arrangement of test engine. The arrangement consist of the following equipment which is external to diesel engine is exhaust gas analyzer, data acquisition system, computer for monitoring and water circulating system.

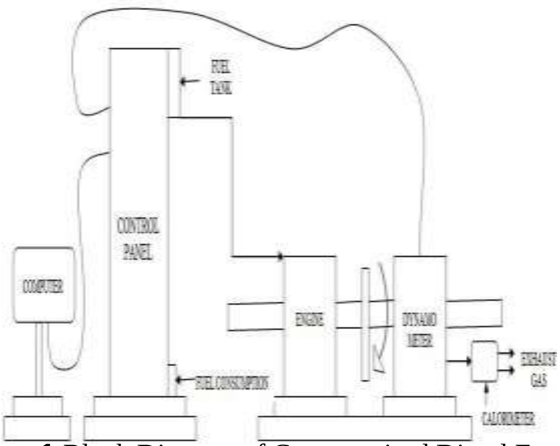

Figure 1 Block Diagram of Computerised Diesel Engine Test Rig

Figure 2 Computerized Single Cylinder Diesel Engine

Operating panel consist of controlling units of fuel supply, dynamometer and air supply system etc.

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5. RESULTS

The engine performance with waste coconut oil biodiesel was evaluated in terms of brake specific fuel consumption, brake thermal efficiency at different loading conditions of the engine. Engine performance test is carried out for 5 samples including diesel and 4 samples of biodiesel proportion which is B10, B20, B30 and B50 of waste coconut oil.

5.1. Brake specific fuel consumption (BSFC)

The variation in BSFC with varying load for different biodiesel proportion of waste coconut oil and diesel is presented in figure.1. BSFC was found to increase with higher proportion of waste coconut oil biodiesel in the blend compared to diesel in the entire load range. As the load increases, BSFC decreases for all fuel blends.

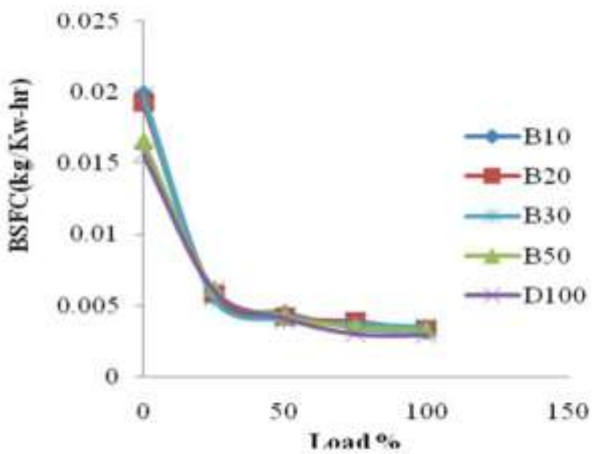

Figure 3 Variation of (BSFC) with Loads for Waste Coconut Oil Biodiesel Blends with Diesel

Brake specific fuel consumption is lowest for the B10 blend at full load is 0.0032. And a maximum value is obtained for B50 at 0% load having a value of 0.0199. This may be due to higher specific gravity and lower calorific value of the biodiesel fuel as compared with diesel fuel. Calorific value of biodiesel is lower compared to that of diesel, therefore increasing proportion of biodiesel in blend decreases the calorific value of the blend which results in increased BSFC. Biodiesel fuel is delivered into the engine on a volumetric basis per stroke; thus, larger quantities of biodiesel are fed into the engine. Therefore, to produce the same power, more biodiesel fuel is needed because biodiesel has a lower calorific value compared to diesel fuel.

5.2. Brake thermal efficiency (BTE)

The BTE of diesel engine obtained for different biodiesel blends of waste coconut oil and diesel is shown in figure.4 as a function of load. It can be seen from this figure that the BTE in general, reduced with the increasing concentration of biodiesel in the blends. The maximum BTE were 45% and 42% for B10 and B20 at full loads, respectively. The low efficiency may be due to low volatility and higher density of the methyl ester of waste coconut oil, which affects mixture formation of the fuel and thus leads to slow combustion. A slight lower efficiency with diesel was reported for the esters due to the lower heating value of the esters than with diesel.

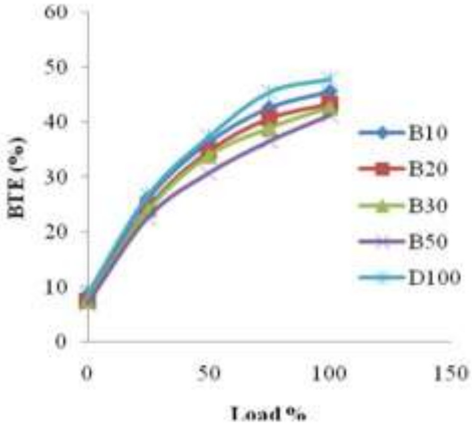

Figure 4 Variation of (BTE) with Loads for Waste Coconut Oil Biodiesel Blends with Diesel

In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. Based on the results it can be concluded that the performance of the engine with biodiesel blends is comparable to that with diesel, in terms of brake thermal efficiency.

6. EMISSION

The engine exhaust emissions such as carbon monoxide and unburned hydrocarbon were measured with a five gas analyzer. The sensor of the analyzer was exposed to the exhaust gas and the observations were recorded.

6.1. Carbon monoxide (CO)

The variation of CO emissions with varying engine load for different biodiesel blends is compared in Figure.5 with the diesel. Carbon monoxide decreases with raise in biodiesel percentage in the blends.

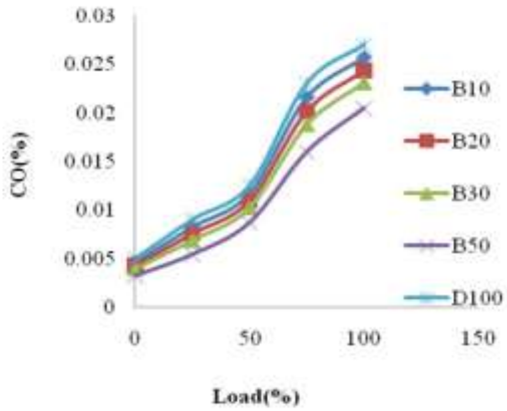

Figure 5 Variations of (CO) Emissions with Loads for Waste Coconut Oil Biodiesel Blends with Diesel

The lower carbon monoxide emission is obtained for B50 and less than all blends and diesel oil at all loads conditions and highest carbon monoxide emission is obtained at B10 but lower than diesel. The CO emission are minimum for blend B50 having value of 0.0035% for 0% load and maximum for B10 full load the value is 0.025%. The amount of CO emission was lower in case of biodiesel blended fuels and biodiesel than diesel because of the fact that biodiesel contained 11 per cent oxygen molecules. This may lead to complete combustion and reduction of CO emission.

6.2. Hydrocarbon (HC)

The variation of hydrocarbon (HC) emission with load for different biodiesel blends tested is plotted in Figure.6. The HC emissions increase with increasing in load. HC emissions decrease with increasing biodiesel percentage in the blend. This decreasing is due to the oxygen content in biodiesel improving the quality of combustion. These reductions indicate that more complete is combustion of the fuels and thus, HC level decreases significantly.

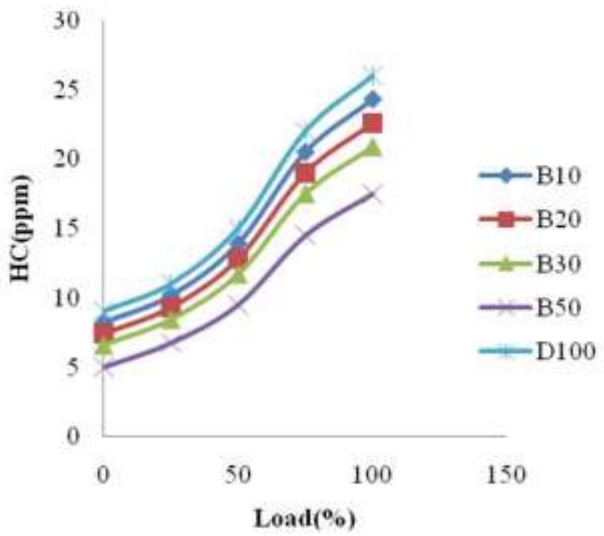

Figure 6 Variations of (HC) Emissions with Loads for Waste Coconut Oil Biodiesel Blends with Diesel

For the biodiesel the HC emission are minimum for blend B50 having value of 5ppm for 0% load and maximum for B10 full load the value is 24 PPM.

7. COMBUSTION CHARACTERISTICS

In diesel engine, cylinder pressure depends on the burnt fuel fraction during the premixed burning phase i.e., initial stage of combustion. Cylinder pressure characterizes the ability of the fuel to mix well with air and burn. High peak pressure and maximum rate of pressure rise correspond to large amount of fuel burnt in premixed combustion stage. In this study, analysis of combustion characteristic of used cooking oil biodiesel blends and diesel were carried out. It is clear from Figure.7 the maximum cylinder gas pressures of the biodiesels are higher than that of the diesel due to the higher BSFC amounts, cetane number, boiling point and oxygen content in the biodiesel.

Biodiesel vaporizes more slowly than diesel fuel and contributes to less air fuel mixture prepared for combustion in the premixed phase .In addition to this biodiesel injected into the engine cylinder could form gaseous compounds of low molecular weight through thermal cracking. The gaseous compounds could be ignited earlier, leading to earlier ignition timing. Moreover, the higher specific gravity of methyl esters lead to advanced injection timing .The earlier injection timing of biodiesel contributed to the advance of the peak cylinder pressure and the maximum heat release rate

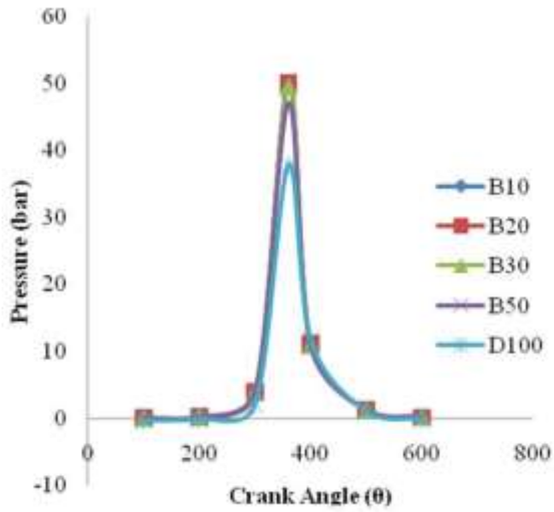

Figure 7 Pressures versus Crank Angle for Waste Coconut Oil Biodiesel Blends with Diesel at 50% Load

8. CONCLUSIONS

The objective of this study is to investigate the combustion, engine performance and emissions of a diesel engine operating on waste coconut oil biodiesel blends and to compare these results with those operating on diesel fuel. Based on the engine tests, it can be concluded that waste coconut oil based biodiesel can be adopted as an alternative fuel for the existing conventional diesel engines without any major modifications. The viscosity of waste coconut oil reduces substantially after transesterification. The specific gravity and viscosity of the waste coconut oil methyl ester formed transesterification were found to be close to those of diesel. The flash point of all the blends was higher than that of diesel. Biodiesel also demonstrated comparatively higher flash point than diesel and was in safe range for storage. All these tests for characterization of biodiesel demonstrated that almost all the important properties of biodiesel are in very close to the diesel making it a potential fuel for the application in compression ignition engines for replacement of diesel fuel. It has been found that all fuel blends had similar combustion behavior. Ignition delay for biodiesel blends was shorter than diesel as a fuel. And hence the lower heat release rate when compared to diesel. While running the engine with biodiesel and its blends, emissions CO and HC were reduced as compared to diesel. These reductions of emissions could be due to complete combustion of fuel. The results from the experiments suggest that biodiesel from used cooking oil could be a good substitute fuel for diesel engine in the near future as far as decentralized energy production is concerned. In view of comparable engine performance and reduction in the engine emissions, it can be concluded and biodiesel blends B10, B20 could be used in a conventional diesel engine.

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Vol-11 Issue-02 2021

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