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ANALYSIS OF ETHANOL BLENDED BIODIESEL ON VCR ENGINE

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ABSTRACT

In this present research work, waste cooking oil biodiesel combined with diesel fuel blends were used as alternative fuels for diesel engines. The six different types of blends namely B5, B10, B15, B20, B25 and B30 were prepared. The optimization of production of biodiesel from waste cooking oil from transesterification process was evaluated on varying the various parameters such as reaction time, KOH concentration and molar ratio. An experimental investigation was carried out to evaluate the performance and emission characteristics of a cooking oil biodiesel blends at various compression ratios like 12, 14 and 16 on a compression ignition engine and important fuel properties were determined. The performance parameters analyzed include BP (Brake Power), BSFC (Brake Specific Fuel consumption), BTE (Brake Thermal Efficiency) and exhaust gas concentration including oxides of nitrogen, HC and CO. The calorific value of optimized waste cooking oil biodiesel was lower than diesel fuel. The flash and fire point of waste cooking oil biodiesel were determined to be 154oC and 160oC respectively which are higher than diesel fuel. The bsfc for all blends decreases as the compression ratio increases and at all compression ratios bsfc remains higher for the higher blends as the biodiesel percent increase. The blends of biodiesel with small content in place of petroleum diesel can help in controlling air pollution and easing the pressure on scarce resources without significantly sacrificing engine power and economy.

Keywords: *Biodiesel, Transesterification, Properties, Performance, Emission.*

I. INTRODUCTION

Due to scarcity and increasing costs of conventional fossil fuels, biodiesel as a fuel has become more attractive fuel. Experts suggested that current oil and gas reserves would tend to last only for few decades. To fulfill the rising energy demand and replace reducing oil reserves renewable fuel like biodiesel is within the forefront of other technologies. Biodiesel has proved to be a possible alternative for diesel in compression ignition engine. Biodiesel burns like petroleum diesel as it involves regulated pollutants. Diesel fuel can be replaced by biodiesel made from vegetable oils. Biodiesel is now mainly being produced from soybean, rapeseed, and palm oils. India enjoys some special advantages in taking up plantation of tree-borne oil seeds for production of bio diesel due to vast unutilized land. The use of biodiesel results in substantial reduction of un-burnt carbon monoxide and particulate matters. It has almost no sulphur, no aromatics and more oxygen content, which helps it to burn fully. Its higher cetane number improves the combustion. Sunflower and rapeseed are the raw materials used in Europe whereas soyabean is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats. In India vast research has been done on biodiesel from jatropha oil. It is proposed to use non-edible oil for making biodiesel, as consumption from edible oil is very high in India. Increase in the molar ratio of alcohol to vegetable oil increases the yield of methyl ester from vegetable oil up to a particular limit After a higher molar ratio than a particular limit the glycerol becomes difficult to separate. Amount and type of catalyst

also affects the conversion rate from vegetable oil to methyl ester. For oils having less fatty acid content alkaline transesterification is used and for oils having higher fatty acid content acid transesterification is used. Stirring helps I higher conversion rate of methyl ester from vegetable oil. Impurities present in vegetable decreases the conversion rate into methyl ester. The proposed study has been carried out with biodiesel derived from cooking oil with the following objectives

- Optimization of production of biodiesel extracted from waste cooking oil through transesterification process.
- Determination of the properties of optimized biodiesel produced from waste cooking oil.

- Evaluation and comparison of the various performance parameters of waste cooking oil biodiesel such as brake power, brake specific fuel consumption, brake thermal efficiency, mechanical efficiency with diesel fuel.
- Evaluation and comparison of various emission characteristics of waste cooking oil biodiesel such as hydrocarbon emissions, carbon dioxide emissions, carbon monoxide emissions and nitrogen oxide emissions with diesel fuel.

II. MATERIALS AND METHODS

The combustion characteristics, engine performance and exhaust emission levels are measured by testing waste oil like cooking oil, fried oil, palm acid oil and some plant oil like rice bran, soya and dhatura biodiesel/diesel fuel blends 5%(B5), 10% (B10), 15%(B) 20%(B20), 25%(B25) and 30% (B30), % (B50) In addition, pure diesel fuel (B0) on a four-stroke, single cylinder, variable compression ratio diesel engine. The engine has a bore of 87.5mm stroke of 82 mm, and displacement of 582 cm^3. The emission and performance tests were performed at compression ratios of 12 to 18:1 and at engine speeds ranging from 1000 to 1500 rpm, increasing in 250 rpm increments at full maximum load for each speed at each compression ratio. The properties of the biodiesel produced from waste oil used in this study was measured at Petroleum Company. The engine was coupled to a conventional D.C. electric dynamometer (Dynamometer arm length 185mm) which besides loading the engine, can be used as a starter motor to start the engine or to motor the engine when measuring friction power. K type thermocouples were used to measure the temperature of exhaust gases, and the temperature of the cooling water. The cylinder pressure was measured and recorded against the crank angle for each 0.5 degree increment. The data from the engine under test can be collected for a given cycle, displayed, and saved on the computer connected to the unit. The amounts of carbon monoxide CO (vol%) and carbon dioxide CO2 (vol%), nitrogen oxides NOx (ppm), unconsumed oxygen O2 (vol%) in the exhaust, as well as the amounts of unburned hydrocarbons.

III. EXPERIMENTAL PROCEDURE

For the development of experimental work, the following steps were taken:

- Development of a program of selective collection of used vegetable cooking oil.
- Development of a process to produce biodiesel from used vegetable cooking oil
- Preparation of the blends of biodiesel and commercial diesel.
- The conducting of dynamometer tests on an internal combustion diesel engine in order to analyze its performance with commercial diesel fuel, biodiesel, and blends.
- Realization of the gas emission tests with the use of different fuels.

One hundred liters of vegetable cooking oil was collected and processed in a single batch in an attempt to guarantee uniformity. The pre-treatment of cooking oil for the production of biodiesel was adapted from as schematized in Fig. 1.

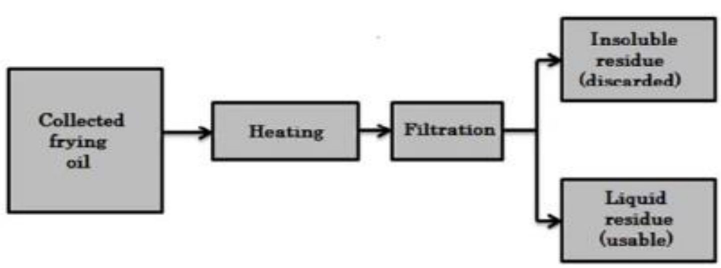

Fig.1. Pre-treatment process of cooking oil

The transesterification process used can be viewed in the diagram shown in Figure 2. This process includes drying and filtration of the residual cooking oil, the mixture of anhydrous ethyl alcohol with the catalyst potassium

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hydroxide, the reaction of the oil with mixed alcohol/catalyst (transesterification reaction), the separation of the phase rich in esters and that rich in glycerin, and the washing of biodiesel.

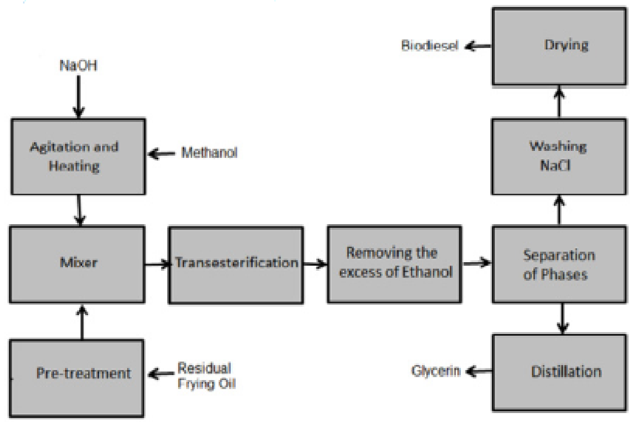

Fig. 2. Process of Transesterification

The procedure used to convert the cooking oil to biodiesel in this experiment is explained by Geris et al. For the production of potassium methoxide, 1.503g of potassium hydroxide (NaOH) was dissolved in 35 ml of methanol with stirring and temperature control (45°C) until complete NaOH dissolution. The volume of methanol and the mass of NaOH for the transesterification reaction were designed to achieve more effective ester production. The transesterification reaction was performed in a heater with mechanical stirring. 100 ml of used soybean oil was loaded in a flat-bottomed flask (500 ml). The oil was immediately heated in a water bath, while being stirred, with the aid of a magnetic stirrer until the temperature reached 45 °C. Then, a freshly prepared solution of potassium methoxide was added, keeping the reaction mixture for 10 min at 45 °C while being stirred. The solution became denser and clearer. After transesterification, the solution was transferred to a separating funnel to allow decantation and phase separation. The upper part, contained biodiesel, and the lower, contained glycerol, soaps, a base excess, and alcohol (gas separation timeout: 15 min). The lower phase was collected in a 50 ml beaker and yielded 6 ml of solution. Biodiesel volume (upper phase) was 94 ml. 50 ml of sodium chloride (NaCl) were added to wash the biodiesel. A total of 92 ml of biodiesel was obtained in the process. Following this procedure, catalysts were acquired for the production of a batch of 100 liters.

IV. PREPARATIONOF BIODIESEL BLENDS WITH DIESEL

The commercial diesel oil used in the tests was obtained from a local automotive supply network and had the following features:

- Calorific value: 44.816 (KJ/kg)
- Density: 857 (kg/m3) at 25 ºC
- Viscosity: 3.32 (mm2 /s) at 40 ºC
- Flash Point: 69 ºC
- Sulphur: 0.121 (% m/ m)

Mixtures were processed with different percentages of commercial diesel and biodiesel placed in PET containers and properly identified. The fuels were classified as 100% commercial diesel, 100% biodiesel (B100), addition of 5% biodiesel to diesel (B5), addition of 20% biodiesel to diesel (B20), and addition of 50% biodiesel to diesel (B50).

V. EMISSION CHARACTERISTICS

The variation of hydrocarbon emissions with load for diesel B5, B10, B15, B20, B25, B30 are compared at two different compression ratios. It was observed that with increase in load the hydrocarbon emission increases .It is due to entering of rich fuel air mixture in the combustion chamber because of increase in fuel consumption. This leads to improper combustion due to which unburnt hydrocarbon emissions increases. It was also observed that with increase in blend content the HC emission decreases. This is due to the high cetane no. of biodiesel blends. Higher cetane no. lowers the combustion delay which improves the combustion. Another reason for low hydrocarbon emission with the increase in blend content is due to more oxygen content than diesel fuel. It was observed that HC emissions for diesel fuel were highest and for B30 blend it was lowest. The HC emissions for different fuels with load at CR 16 and CR 14 are illustrated in the Fig 17 and 18 respectively. The carbon monoxide emissions results from incomplete combustion. The CO emissions for diesel fuel, B10, B20, B30 with load are compared at CR16 and CR14. It was observed that with increase in load the CO emissions increased .This is due the injection of rich air fuel mixture which led to incomplete combustion of fuel. It was observed the CO emissions of B10 blend were nearly same as that of diesel fuel. But with further increase in blend content the emissions were observed to be decreased. This may be due to the higher oxygen content which leads to complete combustion. The CO emissions were decreased with increase in compression ratio because of increase in air temperature which lowers the delay period and improves the combustion. The CO emissions for the B30 blend at CR16 were found to be the lowest among all fuels. The CO emissions for Diesel, B10, B20, and B30 with load at CR14 compression ratios are illustrated in the Fig 20. The NOx emissions of diesel, B10, B20, B30 with load at compression ratios CR14 and CR16 were compared. NOx emissions are temperature dependent. It was observed that NO emissions increase with increase in load. This is because of increase in temperature inside combustion chamber at high loads. NOx emissions were observed to be increased with increase in blend content. This is because of high oxygen content in the biodiesel fuel. Nitrogen from air can easily mix with oxygen and produces the NOx emissions. These emissions were observed to be increase with compression ratio due to lower ignition delay which increases the peak pressure and temperature. The NOx emissions for diesel, B10, B20, B30 with load at CR16 and CR14 are illustrated in the following Fig 21 and 22 respectively. It can be seen from the figures that NOx emissions for the diesel were lowest at both compression ratios. The NOx emissions of B20 blend were observed to be highest at all loads and both compression ratios. The CO2 emissions for diesel B5, B10,B15, B20, B25, B30 with load at CR16 and CR14 were compared. It was observed that with increase in load the CO2 emissions increases due to better combustion at high loads. The CO2 emissions with diesel were highest .As the blend content increased, the CO2 emissions were decreased. Carbon dioxide is formed on complete combustion of the fuel in oxygen. Here, carbon dioxide formation is less due to the fact that biodiesel in general is a low carbon fuel and has a lower elemental carbon to hydrogen ratio than diesel fuel. The CO2 emissions were observed to be increased with the compression ratio this is due to the lower ignition delay that led to better combustion. The variation of CO2 emissions with load at CR16 and CR14 are illustrated in the Fig 23 and 24 respectively. It was observed that CO2 emissions were lowest for B30 blend at all loads for both compression ratios.

VI. CONCLUSION

The use of the cooking oil as a raw material for biodiesel production has proved to be of substantial value as compared with other choices of raw materials of various origins, such as the planting of oleaginous and the use of oils of animal origin since cooking oil is available in large quantities in the community and would otherwise be dumped, leading to environmental problems. The residual cooking oil showed relevant characteristics, such as high flash point, which enabled its storage and handling. Gains related to the reduction of toxic gas emissions resulting from combustion processes were remarkable considering the large reduction of CO and CO2 emissions. The studies point to a possible NOx emission reduction via improvements in the density, additives, and stoichiometric balance of biodiesel.

The technical feasibility of using biodiesel, considering the physical-chemical aspects, was presented positively and interpreted by the torque and power tests conducted, with little variability regarding the percentage of biodiesel in the mixture with diesel. Considering the specific consumption of biodiesel compared to diesel, despite having a

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small increase, it is passive in terms of improvement in reducing energy consumption through the use of additives, the improvement of density, and in the transesterification process. The use of cooking oil as the base for the production of biodiesel has proven to be viable and can be seen as an alternative solution to the problem of the improper disposal of used oil. Waste cooking oil has a great impact in terms of soil and water contamination if it is disposed of in an incorrect manner.

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