Production and Characterization of Biodiesel from Spent Coffee Powder and Performance Test in a Diesel Engine

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Abstract— The biodiesel is an alternative diesel fuel that can be produced from renewable feed stock such as vegetable oil waste fry oil and animal fat, however due to technical deficiency they are rarely used purely or with high percentage in unmodified diesel engine. Waste coffee powder is used as to produce bio diesel. The oil is extracted from waste coffee powder using solvent extraction method and production of bio diesel is carried out by transesterification method. Various thermal properties such as Specific gravity, Flash point, Fire point, Viscosity, Calorific value were tested by blinding of bio fuel with diesel in different proportion. To test the produced biodiesel and its blends in a Diesel engine. The brake thermal efficiency and Brake specific fuel consumption of B20 almost matches with petro diesel and Emission of CO and CO2 was considerably reduced as the load increased for biodiesel blends compared to petro diesel, the 20 % blend gives better performance and also it is eco-friendly.

Keywords: Bio-Fuel, Coffee Powder, Bio-Diesel

I. INTRODUCTION

Considering where the world stands today we can see that Energy is one of the greatest components in charge of development of countries. Countries with predominant energy assets grow speedier than those with lesser assets. This development has prompted taking off energy requests which are met specifically or in a roundabout way to a great extent by fossil fuels. The current circumstance is such that the energy created is insufficient to take care of the demand. Additionally the energy part just takes into account the necessities of the created and the immature locales don't have entry to customary energy sources.

Energy interest is appropriated amongst four broad parts: Transportation, Private, Business, and industrial. As far as oil use, transportation is the biggest area and the one that has seen the biggest development sought after in recent decades. This development has to a great extent originated from new interest for individual use vehicles fueled by internal burning engines. This segment likewise has the most astounding utilization rates and 55% of oil use around the world.

With a specific end goal to achieve vitality security the world needs to turn towards elective fuel sources like biofuels. In the course of the most recent 25 years the world has seen an extensive development in the utilization of option fills. A decent case is ethanol which is blended with normal petroleum fills and utilized as a part of auto motors. Another case is biodiesel produce from vegetable oil. Biodiesel has turned into an exceptionally prevalent arrangement in the course of the most recent decade with an assortment of sources accessible for its creation.

Considering the present rate of vitality utilization fossil energizes won't keep going long. English petroleum's yearly write about worldwide oil holds says that as of the end of 2013 earth has almost 1.688 trillion barrels of unrefined petroleum which will most recent 54 years at current rates of extraction. This is a genuine danger to the world and its development.

A. Coffea Arabica

Fig. 1: Coffee Plant and Fruits

Coffea Arabica is an esteemed animal categories and has been developed and chosen for a few centuries. It as of now speaks to seventy five percent of the world espresso creation. Coffea arabica starts from Arabia, and flourishes in area that is rich in minerals. Its better- known sub-assortments incorporate Moka, Maragogipe, San Ramon, Coronaries and Bourbon.

The Arabica makes a flavoury, full-bodied espresso that is sharp in taste with rather low caffeine content. As a gathering, Arabica espresso comprises of numerous cultivars that contrast in appreciation of source, climatic prerequisites, tree size, yield design, nature of deciding item, berry size and sickness resistance. Actually, some low-quality Arabica species are substandard compared to the best Coffea Robusta assortments. Arabica beans look somewhat prolonged and have a scope of greenish-blue shades.

B. Coffea Robusta

Coffea Robusta is an assortment that can develop to more than 12 m in tallness. It becomes rapidly in elevations up to 100 m, and is more impervious to nuisances and ailments. This assortment was found in the Congo in 1898 and is generally spread, particularly in Africa, Asia and Indonesia where the atmosphere is inadmissible for the development of Coffee arabica. It speaks to roughly 25% of the aggregate world espresso generation. In light of their higher caffeine content (about twice as much as Arabica) and solid character, Robusta are utilized generally as mixes. Robusta beans are ordinarily little, adjusted and earthy yellow in appearance.

conducted an experiment on a diesel engine and observed significant improvement in engine performance and emission characteristics for the biodiesel fuelled engine compared to diesel fueled engine Thermal efficiency of the engine improved, brake specific fuel consumption reduced and a considerable reduction in the in the exhaust smoke opacity was observed by Agarwal[1]. The study of the

characteristics properties of different vegetable oils to find out which oil is going to best suited for as alternative fuel source for this test he used eleven vegetable oils, among them he found that corn, rapeseed, sesame, cottonseed, and soya bean oils are giving good fuel properties Goering [2]. The evaluated the performance and emission characteristics of a diesel engine using 100% refined vegetable oil and its biodiesel He concluded that biodiesel gives good and better performance compared to that of 100% refined oil Altin[3].

From the above literature survey it can be concluded that biodiesel is a potential substitute for petroleum diesel. It can help in reducing the dependency on fossil fuels and eventually replace them. Further it can be concluded that much like other vegetable oil coffee oil is a potential feedstock for the production of biodiesel. It is a very commonly used product hence increasing the availability of waste powder for extraction of oil. In the upcoming sections of this report the detailed procedure of producing coffee biodiesel is explained.

II. MATERIALS AND METHODS

A. Soxhlet Extraction Process

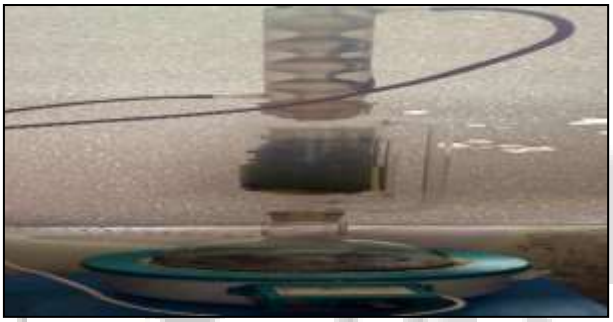

Fig. 2: Soxhlet Extraction Process

In Soxhlet extraction shown in figure 2, the sample (spent coffee powder) is wrapped in a porous cellulose paper(filter paper) and it is placed in an extraction chamber (Extractor) which is suspended above a flask containing the solvent (Hexane). The flask is heated and the solvent evaporates and moves up into the condenser where it is converted into a liquid that trickles into the extraction chamber containing the sample. The extraction chamber is designed so that when the solvent surrounding the sample exceeds a certain level it overflows and trickles back down into the boiling flask. At the end of the extraction process, which lasts a few hours, the flask containing the solvent and shell extract is removed. Finally the solvent in the flask is distilled to get the required sample. From the above procedure it is found that the oil content in the coffee powder is around 20%.

Fig. 3: spent coffee powder drying before extraction and coffee powder after extraction

Solvent Used	Quantity of Coffeepowder	Quantity of coffeeoil	Yield (%)
Methanol	50 grams	6.5grams	13
Ethanol	50 grams	7.5 grams	15
Hexane	50 grams	10 grams	20

Table 1: Extraction of coffee oil from different solvents

B. Determination of Free Fatty Acid Content in the Oil

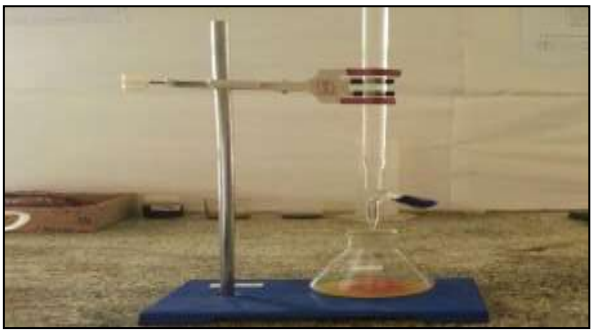

Fig. 4: Test for fatty acid content in the oil

Prepare 0.1N Sodium Hydroxide solution by mixing 4 grams of NaOH crystals with 1 litre of water. Take 25 ml of 0.1N NaOH solution in a clean and dry burette. Take 50 ml of Isopropyl alcohol in a clean and dry 250 ml conical flask. Add few drops of NaOH solution and shake well. Measure 10 grams of oil to the flask and shake it well. Heat the mixture above 60º C. Allow the mixture to cool a little. Add few drops of phenolphthalein indicator. Titrate against 0.1N NaOH from burette. Titrate till colour persists for at least one minute. Note down the burette reading.

Free fatty acid content is obtained by using the below formula

$$FFA = \frac{28.2 * 0.1N\ NaoH * Ttraton\ value}{weght\ of\ ol}$$

$$FFA = \frac{28.2 * 0.1 * 3}{1}$$

$$\mathbf{FFA = 8.43}$$

C. Blending

Blending is the process of mixing the biofuel and diesel in a proper ratio. This blending can be ordinarily done with the help of a flask and volume measures. The exact proportion of oil and the diesel are separately mixed in a flask and followed by constant stirring in a magnetic stirrer. This stirring ensures proper mixing of biofuel and the diesel. Below are the notations for different fuel samples which are blended.

Sl.No	Notation	Biofuel Percentage	Diesel Percentage
1	B10	10%	90%
2	B20	20%	80%
3	B30	30%	70%
5	B100	100%	00 %

Table 2: Blending of spent coffee powder biodiesel

III. RESULTS AND DISCUSSION

Sl. No	Properties	Standard	Range	Obtained
1	Flash point (°C)	ASTM D93	>130 *	135
2	Kinematic Viscosity (Cst)	ASTM D445	1.9-6.0	3.85
3	Specific gravity	ASTM D4052	0.87-0.90	0.875
4	Calorific value (kJ/kg)	ASTM D240	--	33790
5	Ash, %w/w	IS:1448 (P 4)	0.5max	Nil

Table 3: comparison of fuel properties with ASTM standards

Liquids with a flash point less than 60.5°C (140.9 °F) are considered flammable, while liquids with a flash point above those temperatures are considered combustible. It can be seen from the graph, that flash point keeps increasing with blends. For pure biodiesel (B100) it was found to be 135°C. Hence all the blends are found to be satisfactory.

Viscosity keeps on increasing with blends. For biodiesel as per ASTM specifications the viscosity can be in the range of 1.9-6.0. The viscosity range for Spent Coffee Powder biodiesel and its different blends is found to be in the range of B10-B100 (2.62-3.85). Hence the viscosity is found to be satisfactory.

Specific gravity keeps on increasing with blends. For biodiesel as per ASTM specifications the Specific gravity can be in the range of 0.87-0.90. The Specific gravity range for Spent Coffee Powder biodiesel and its different blends is found to be in the range of 0.85-.087. Hence the viscosity is found to be satisfactory.

The calorific value of fuel is defined as the amount of heat liberated by the complete combustion of a unit quantity of fuel. In SI units, for solid and liquid fuels, it is expressed in terms of kJ/kg of fuel and for gaseous fuels in kJ/m3 at STP (Standard temperature and pressure). The two types of calorific values are higher calorific value and lower calorific value.

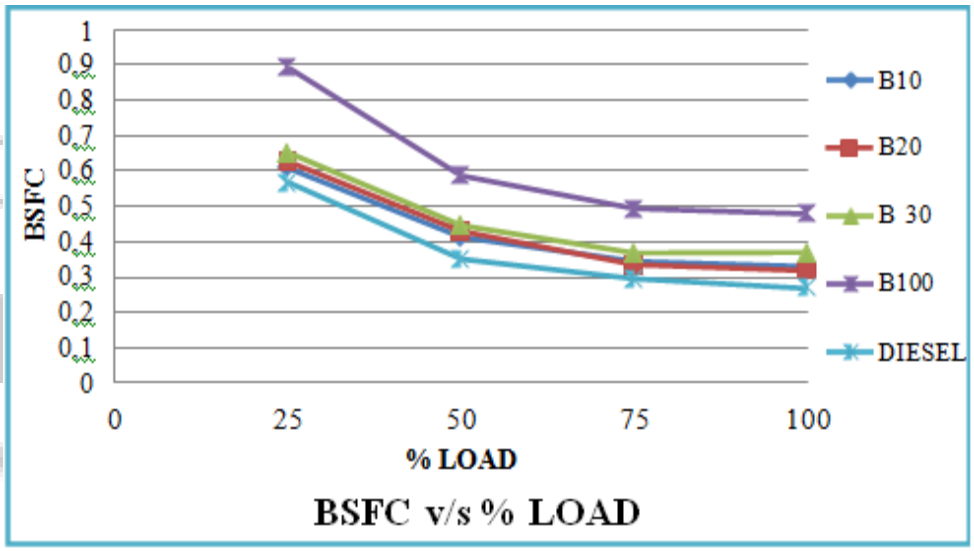

Fig. 4: Variation of BSFC with % load

BSFC decreases as the % load increases for all fuel blends in accordance with standard pattern. B20 blend has less fuel consumption compared to other blends. Higher proportion blends have higher brake specific fuel consumption; this may be because of higher viscosity of fuel which results in poor atomization of fuel. B100 has higher BSFC compared to all other blends.

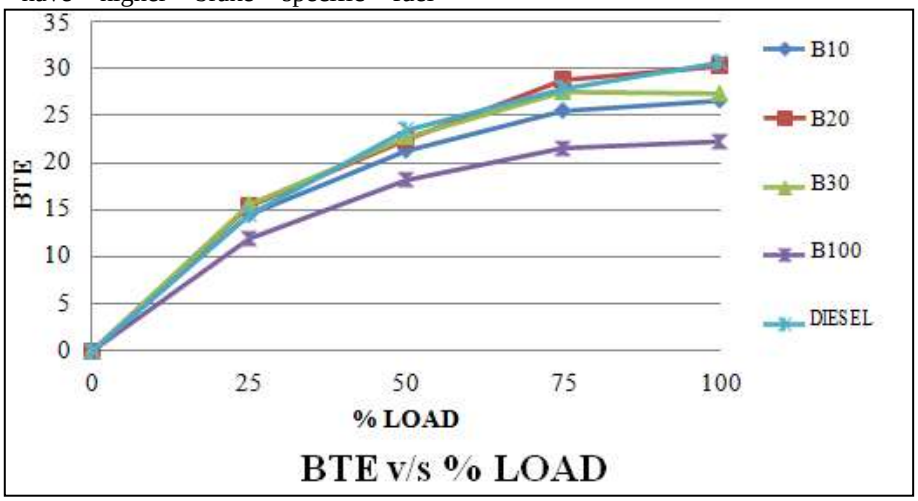

Fig. 5: Variation of BTE with % load

Brake thermal efficiency increases for all blends as % load increases. B20 blend has higher brake thermal efficiency compare to other blends, this may be due to B20 blend has higher calorific value and lower viscosity compare to other blends which results in good atomizing and combustion of fuel and hence thermal efficiency of B20 blend is high compare to other blends. Increased concentration of Biofuel in the blend results in higher viscosity of fuel which causes poor atomization; hence brake thermal efficiency of higher blends is low.

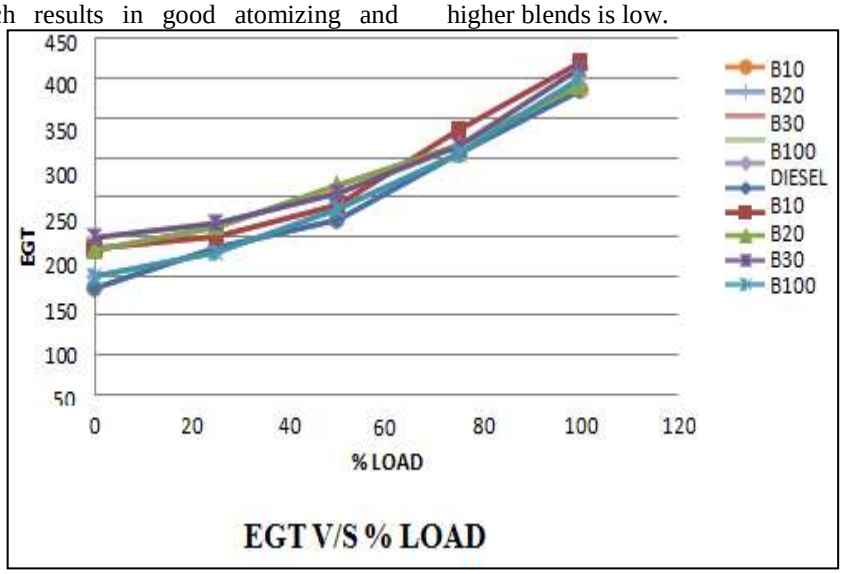

Fig. 6: Exhaust gas temperature v/s % load

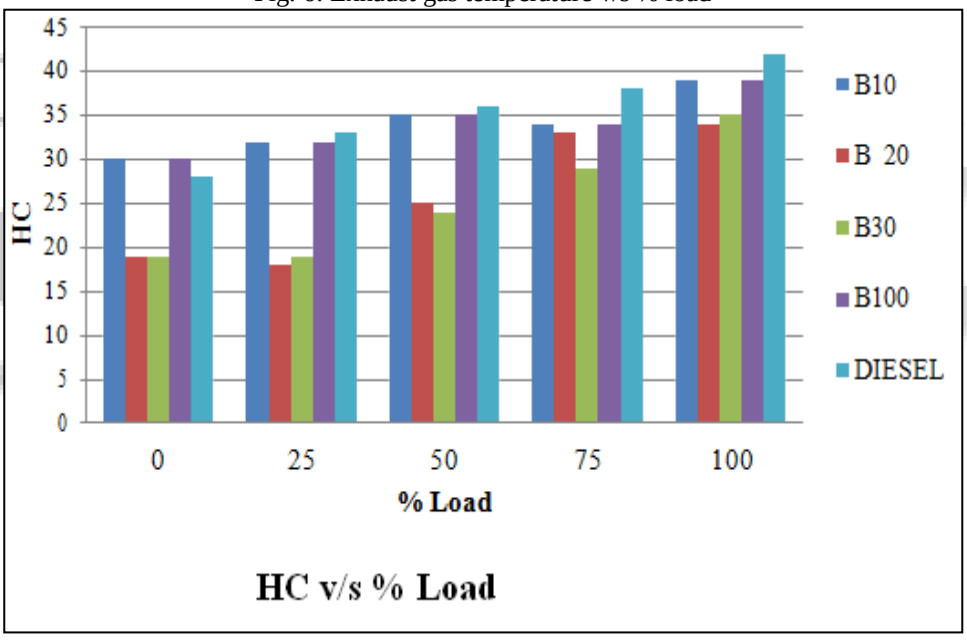

Fig. 7: HC Emission in ppm for spent coffee powder biodiesel

As the load increases Hydrocarbon emission will increase for all blends. Diesel Fuel has highest HC emission since the viscosity of the blend is more and thus at higher loads fuel will not burn completely which results in formation of higher HC emissions. B20 has lower hydrocarbon emission at higher loads compare to other blends.

IV. CONCLUSIONS

In this project we have built up a real time model that In this study, oil is extracted from Spent Coffee Powder and biodiesel is produced by transesterification process. The produced biodiesel is blended with diesel in 10%, 20% and 30% proportions. The properties of the biodiesel and its blends are determined. The produced biodiesel is tested in a four strokes, single cylinder, vertical, water cooled diesel engine to determine the performance and emission characteristics.

The results of the experimentation can be briefed as:-

Coffee Oil can be produced from Spent Coffee Powder. SCPBD can be obtained from coffee oil and used as a alternative fuels in existing diesel engine without modification of basic engine. Spent coffee Powder may contain approximately 20% - 30% of oil and using Hexane as a solvent I was able to produce 20% yield in Solvent extraction Process. The obtained properties of produced methyl ester met the ASTM D6751 biodiesel standards. The production of Bio-Diesel from Spent coffee Powder may provide valuable, local, regional and National benefits. It is observed that the brake thermal efficiency and Brake specific fuel consumption of B20 almost matches with petro diesel.

Emission of CO and CO2 was considerably reduced as the load increased for biodiesel blends compared to petro diesel. HC emission reduced for B20 at full load compared to petro diesel. Based on the above results it can be concluded that 20 % blend gives better performance and also it is eco friendly

V. SCOPE FOR FUTURE WORK

The present work is an experimental study on production of biodiesel and performance characteristics of direct injection compression ignition engine using the mixture of Spent Coffee Powder biodiesel as fuel at 210 bar and compression ratios like 16.5:1, under various loads. Further work can be done in the following areas.

A study of performance and emission of the engine with the biodiesel blends can be carried out by varying the injection Pressure. By optimizing the injection pressure better BTE can be achieved.

The performance and emission characteristics of the engine with variation of compression ratio of the engine can be studied for all blends.

Experimentation can be carried out on multi cylinder engines to study the behaviour of these fuels to ascertain the usage in the practical engines.

Along with biodiesel blends some oxygenated fuel additives can be added and Performance characteristics can be analyzed.

Preheated fuel can be used in order to get the reduction in viscosity which will result in similar characteristics to that of petro diesel. The heat energy required for preheating of fuel can be obtained by utilizing the heat of exhaust gases

Performance evaluation of all these blends can be carried out for different injection timings to optimize injection timing for best performance and minimum emission characteristics.

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