Extraction and Performance Analysis of CalophyllumInophyllum Seed Bio Diesel on Single Cylinder CI Engine

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Abstract - In the present study attention is being focused oncomparison of performance of bio-diesel derived from **Calophylluminophyllum**oil when applied in different proportions in compressionignition engine. A single cylinder four stroke diesel enginewas tested at various loads with the blended fuel atthe rated speed of 1500 rpm. **Calophylluminophyllum** oil bio-diesel blendedwith diesel in proportions of 10%, 20%, 30%, 40%and 100% byvolume and pure diesel were used as fuel. Engine performance (specific fuel consumption, brake thermal efficiency, and exhaustgas temperature) were measured to evaluate and compute thebehavior of the diesel engine running on bio-diesel. The results show that the brake thermal efficiency of diesel is higher at allloads followed by blends of **Calophylluminophyllum** bio-diesel and diesel. Experimentally the maximum brake thermal efficiency andminimum specific fuel consumption were found for blends up to 20% **Calophylluminophyllum** methyl ester at all loads among the blends. The reductions in brake specific fuelconsumption and increase in brake thermal efficiency made theblend of biodiesel B20 a suitable alternative fuel for dieselengine.

Index Terms—Diesel engine, Biodiesel, Transesterification, Calophylluminophyllum blends, Performance analysis, Brake thermal efficiency, Specific fuel consumption.

1 INTRODUCTION

Environmental pollution and diminishing supply of fossil fuels are the key factors leading to search for the alternative sources of energy. Bio diesel refers to a non-vegetable oil based diesel fuel consisting of long chain alky (methyl, propyl or ethyl) esters. Bio diesel is typically made by chemically reacting lipids (e.g. non-vegetable, vegetable oil, animal fat) with an alcohol. Bio-diesel production is a modern and technological area for researchers due to constant increase in the prices of petroleum diesel and environmental advantages.

Today, 86% of the world energy consumption and almost 100% of the energy needed in the transportation sector is met by fossil fuels since the world's accessible oil reservoirs are gradually depleting, it is important to develop suitable long term strategies based on utilization of renewable fuel that would gradually substitute the declining fossil fuel production. Bio diesel has seen great increase in recent years. Not only has bio diesel been proved as safe and also biodegradable, it aliases aids in the reduction of harmful air pollutants released during the combustion of conventional fuels.

Bio diesel is a fuel equivalent of petro diesel with the exception of its derivation from biological sources. Both nontoxic and renewable, bio-diesel essentially comes from plants and animals. Bio-diesel can even be made from recycled cooking grease. Although bio diesel can be used in its pure form, it is usually blended with standard diesel fuel. Much attention has been focused on the thought of it one day replacing fossil fuels as the world's primary transport energy source. Bio diesel is safe and can be used in diesel engines with few or no modifications needed.

2 LITERATURE REVIEW

Several Scientists and engineers have carried out research on the effect of bio-diesel and its blends with diesel and an extensive work is in this field. Few relevant works have been studied and the outcomes are summarized in this literature review.

1. Meher et al.studied the effects of catalyst concentration (KOH), alcohol /oil molar ratio, temperature and rate of mixing on the transesterification of karanja oil with methanol. They found that the optimum reaction conditions for methanolysis of karanja oil was 1% KOH as a catalyst, molar ratio 6:1, reaction temperature 65^0 C and rate of mixing was 360 rev/min for a period of 3 hours. The yield of methyl esters was found to be higher by 85% in 15 minutes and reaction was almost complete in two hours with a yield of 97%. With 12:1 molar ratio or higher, the reaction was completed within an hour. The reaction was incomplete with a low rate of stirring (180 rev/min). Further in the optimization study, Meher et al. found that the yield of methyl ester from karanja oil under the optimal condition was 97 to 98%.

2. Rathore et al.studied the kinetics of transesterification of karanja oil into its alkyl esters in supercritical methanol and ethanol without using any catalyst. The effect of molar ratio and reaction temperature on alkyl ester formation was studied. It was concluded that the overall yield of ester was more with methanol as compared to ethanol.

3. Darnokoet al.reported data on palm oil kinetics. It was observed that the rate of alkali-catalyzed (KOH) transesterification in a batch reactor increased with temperature up to 60^0 C. The further increase in temperatures did not reduce the time to reach the maximum conversion.

The free fatty acid and moisture content in the material are the key parameters for determining the viability of the vegetable oil transesterification process. According to Freedman et al.the free fatty acid content should be lower than 1% to carry out the alkali catalyzed reaction. In their study they observed that if the acid value was greater than 1, more NaOH was required to neutralize the free fatty acids. Water also caused soap formation, which consumed the catalyst and reduced catalyst efficiency. The resulting soaps caused an increase in viscosity, formation of gels and made the separation of glycerol difficult.

4. Ma et al. studied the effect of free fatty acids and water content in the transesterification of beef tallow. The presence of water had more negative effects on the transesterification than free fatty acids. They concluded that for best results, the water content and the free fatty acid content in beef tallow should be kept below 0.06 % w/w and 0.5 % w/w respectively.

5. Zullaikah et al. had successfully obtained biodiesel from rice bran oil with high free fatty acids content. A two-step acid-catalyzed methanolysis process was employed for the efficient conversion of rice bran oil into fatty acid methyl esters.

6. Hawash et al. studied the transesterification of jatropha oil using supercritical methanol in the absence of catalyst under different temperature conditions.

7. Ramadhas et al. reported the use of acid catalyst followed by alkali catalyst in a single process using rubber seed oil with high free fatty acid content. The objective of this study was to develop a process for producing biodiesel from a low-cost feedstock like crude rubber seed oil.

8. Iso et al. have studied the transesterification by immobilized lipase in non- aqueous conditions. Noureddini et al. have investigated the bio-diesel production by lipase catalyst. The time taken to get the 67% yield of biodiesel was 72 hours at room temperature. However, the energy input was zero. The reaction time and the cost of lipase were hurdles to commercialize lipase processes.

3. METHODOLOGY

3.1 EXTRACTION OF OIL

In this stage the oil is extracted from calophyllum seed i.e., kernel of the seed which having moisture content at 8% by using the Expeller. Expeller is a mechanical device which is used to extract oil from seeds by means of mechanical pressing or screwing. The Expeller which Ram or screw the seeds at high pressure in which the oil is extracted and residue is collected at the one end. The extracted oil is used for bio-diesel production.

3.2 TRANS-ESTERIFICATION PROCESS

In this process the extracted oil is converted bio-diesel. Trans-esterification is a process in which the Triglyceride is mixed with alcohol in presence of Alkaline catalyst to form Ester and Glycerol is called Trans-esterification. The process conducted at a temperature of 60 to 70 degree Celsius at Atmospheric pressure.

Triglyceride + Alcohol → Ester + Glycerol

(Fat / oil) + (Methanol / Ethanol) → Bio-diesel + Crude Glycerol.

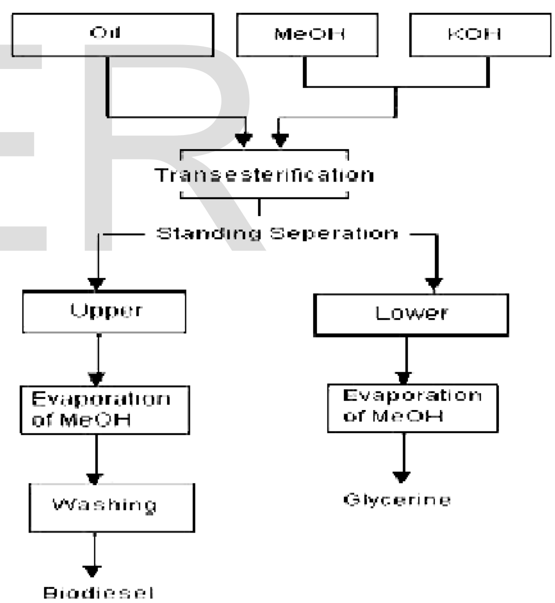

Fig.3.2 Flow Chart of Trans-Esterification Process

3.3 SEPARATION OF BIO-DIESEL

The bio-diesel is obtained from Trans-esterification process. The obtained bio-diesel is not in the pure form and mixed with the crude glycerol. The crude Glycerol is separated by using Gravity separation process. The separated bio-diesel is purified by simple washing and heating process.

4. TECHNICAL SPECIFICATIONS

SL.NO.	PARAMETERS	SPECIFICATION
1	DENSITY at 34°C	0.906

2	VISCOSITY	0.635
3	CALORIFIC VALUE	40600
4	FLASH POINT	174
5	FIRE POINT	176

5. EXPERIMENTAL SETUP

5.1 ENGINE SETUP

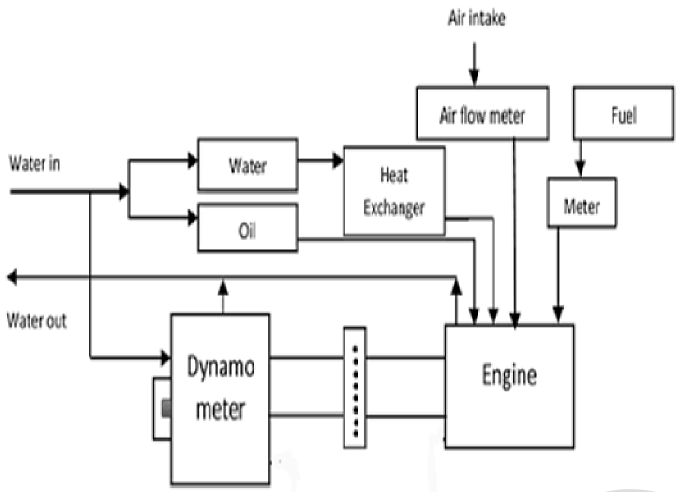

Fig. 5.1 Schematic diagram of the engine test bed.

A single cylinder, Kirloskar Four stroke engine was used to perform the engine test. The engine was coupled with an eddy current dynamo meter which can be operated at a power of 3.7 kW (5HP) with operating speed ranged from 500 to 1500 rpm. The engine test was conducted for injection opening pressure of 200 bar, the schematic diagram of the engine is as shown in the fig. The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current dynamo meter for loading. It is provided with necessary instruments for combustion pressure and crank angle measurements. These signals are interfaced to computer through engine indicator for PQ - PV diagrams. Provision is also made for interfacing air flow, fuel flow, temperatures and load measurement.

The setup has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rota-meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, Swept volume, brake thermal efficiency, volumetric efficiency, overall efficiency, specific fuel consumption, Mass of fuel consumption, heat balance. A computerized diesel injection pressure measurement is optionally provided.

5.2. ENGINE SPECIFICATIONS

Engine	: 5hp, 4-S single cylinder
RPM	: 1500
Fuel	: diesel
Bore	: 80mm
Stroke length	: 110mm
Orifice diameter	: 13mm
Compression ratio	: 16:1
Brake drum diameter	: 0.3m
Weight of hanger	: 1kg
Co-efficient of discharge	: 0.62
Specific gravity of diesel	: 0.8275
Specific heat of exhaust gases	: 1.005KJ/kgK
Specific heat of cooling water	: 4.187KJ/kgK

6. RESULTS AND DISCUSSIONS

6.1Brake thermal efficiency versus load

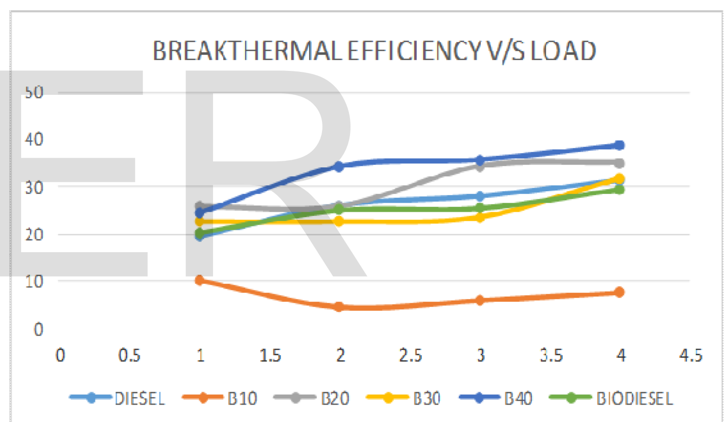

Fig.6.1 Brake thermal efficiency versus load

It was observed that with the increase of the load, brake thermal efficiency increases. Blends are showing good results for Brake thermal efficiency. Especially the BTE for B20 blend of biodiesels characteristics approaching diesel characteristic.

6.2 Specific fuel consumption versus load

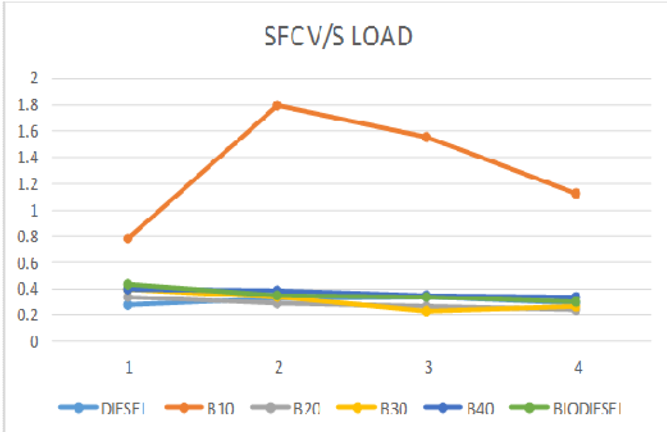

Fig 6.2 Specific fuel consumption versus load

The variation of specific fuel consumption with load for different blends of calophylluminnophyllum oil biodiesel and diesel are shown in above figure. From graph it is observed that the specific fuel consumptions decreased with the increase of load. The specific fuel consumption of biodiesel blends is higher than the diesel in all load conditions due to high viscosity. The specific fuel consumption for B20 biodiesel blend is near to commercial diesel.

6.3 Mass of fuel consumption versus load

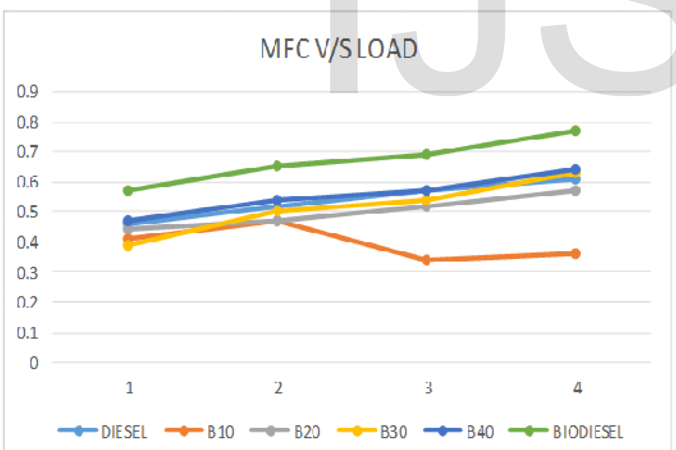

Fig 6.3 Mass of fuel consumption versus load

The variation of Mass of fuel consumption with load for different blends of biodiesel and diesel are as shown in above figure. It was observed that consumption of fuel increases with the increase of load. For B20 calophylluminnophyllum oil biodiesel blend fuel consumption was slightly approaching diesel fuel.

6.4 Brake power versus load

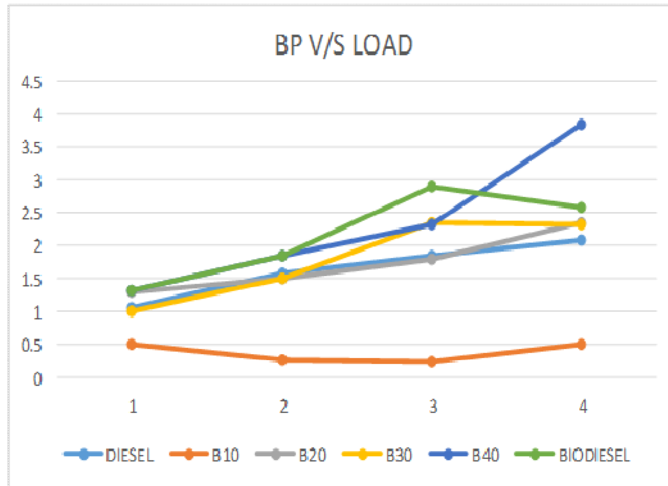

Fig 6.4 Brake power versus load

The variation of Break power with load for different blends of calophylluminnophyllum oil biodiesel and diesel are as shown in above figure. From graph it is observed that the Break power increase with the increase of load.

7. CONCLUSION

Biofuel is gaining more interest as an attractive alternative fuel due to the environmental pollution and diminishing supply of fossil fuel. The competition of edible oil source as a food with fuel make edible oil not an ideal feed stock for production of biodiesel so this shift attention to non-edible oil - CalophyllumInnophyllum. The oil is extracted from collected seeds of CalophyllumInnophyllum and converted into biodiesel by transesterification process. The obtained Biodiesel is then used as a fuel for experiments by using single cylinder four stroke diesel engine. The proportions of blends are 10%, 20%, 30%, 40% and 100% which are tested in the diesel engine. Without any modification in the diesel engine from the experiment results that Break thermal efficiency of engine increases with increase in the biodiesel blend. Specific fuel consumption decreases with increase of biodiesel blend. The exhaust gas temperature increases with increase in the biodiesel blend due to improper mixing and less time required for combustion. By comparing the obtained values it can be concluded that 20% Biodiesel is the best blend since it gives best efficiency consuming less fuel.

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