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Production and Performance Enrichment of Biodiesel from Mustard Oil and Blend with Different Volume of Diesel

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Abstract:

The experimental investigations were carried out on a compression ignition engine to determine the performance of biodiesel produced from mustard oil and blends with diesel. The properties of Biodiesel blends has been tested in the laboratory and used to determine the performance of the engine parameters such as brake specific fuel consumption (bsfc), Brake horse power (bhp), brake thermal efficiency, brake mean effective pressure (BMEP) and exhaust gas temperature for various loading conditions. The biodiesel was blended with diesel by various volume levels like B20, B30, B40, B50 and B100. The experimental results of biodiesel blends are validated with diesel as fuel.

Keywords: *Mustard oil, Tranestrification process, Biodiesel, Engine performance.*

I. INTRODUCTION

The requirement of energy is growing endlessly due to abundant numbers of industries and vehicles owing to inhabitant's detonation. The available energy sources are fossil fuels like petroleum, natural gas, coal, hydrocarbon and nuclear energy. The most important drawbacks of using petroleum based fuels are producing greenhouse gasses. The diesel ignition emits a number of greenhouse gases. Diesel produced from the fossil fuels is one of the important sources for emitting the gases, which includes NOx, SOx, CO, particulate substance and volatile organic compounds. To avoid and reduce these kinds of problems researchers want to generate an alternative solution like alternate fuels especially from nonconventional energy sources [1].

The usages of fossil fuels for IC engine are not sustainable and increasing atmospheric pollution and the global warming. The limited availability of fossil fuel and an increase in energy consumption urges to develop alternate fuels that are sustainable and renewable. Biodiesel is one of the best alternate diesel engine fuels and well accepted renewable fuels, which are derived from methane and ethanol and plants. They are economically feasible, pollution free and sustainable. These fuels can be produced from plants in rural areas and easily modified for IC engines [2].

Biodiesel is typically produced from animal fat or vegetable oil or algae by reacting with alcohols like methanol or ethanol, in a chemical catalyst presence. The product is mono-

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alkyl esters and glycerin, using transesterification reaction fatty acid esters biodiesel is produced [3]. The transesterification reaction changes the long chain fatty acid esters present in the biodiesel oils into short chain alcohols. The transesterification process is done by using consistent catalysts such as KOH and NaOH these catalysts are vulnerable to the generation of surplus byproducts [4]. The good lubricity and lower sulphur content are the reward of biodiesel and lesser heating rate, high freezing position and corrosion properties are its drawbacks. Availability of limited fossil fuels leads to find other sources like biodiesel also which benefits to the environment [5].

Types of Raw Materials

Some cooked oils like waste fish oil, waste soybean oil, cooking oil, sunflower cooking oil, cucurbitapepolen seed oil, rice bran oil, edible palm and jatrophacurcas oil seeds, jatropha oil, karanja oil, ricinuscommunis oil, neem oil, waste canola oil, waste coffee ground, rapeseed oil, mustard oil was used for the production of biodiesel. The most important anxiety with vegetable oil as fuel is its high viscosity which leads to trouble. The benefits of using vegetable oil as biodiesel are liquid nature, high heat content, readily availability and reliability. Among these above raw materials, mustard oil is used to produce biodiesel because of its availability and minimum cost.

Stages of Biodiesel Production

Biodiesel production involves four stages such as

(i) Feedstock pretreatment: In this stage, dust particles and unwanted materials are removed.
(ii) Determination and treatment: Attentiveness of free fatty acids present in the waste vegetable oil has been determined by filtering with a standardized base.
(iii) Chemical reaction: Add base oil to the alcohol and stirred it until dissolved.
(iv) Production and purification: Product involves biodiesel and byproducts like soap, glycerin, surplus alcohol and quantity of water.

Finally methanol is filtered through refining and reused, soap can be removed or converted into acid.

Production Process

Among several production processes transesterification process is the easiest and inexpensive conversion process of biodiesel production. Figure 1 shows the conversion process of biodiesel through the transesterification process which includes several parameters like reaction time, molar ratio, type of catalyst, the amount of catalyst and operating temperature. A mixture of vegetable oil, alcohol and catalyst are introduced into the transesterification process. After the completion of the reaction, products were taken out from the lower side of the reactor and locate in the separating funnel. At the end of transesterification process two phases were formed.

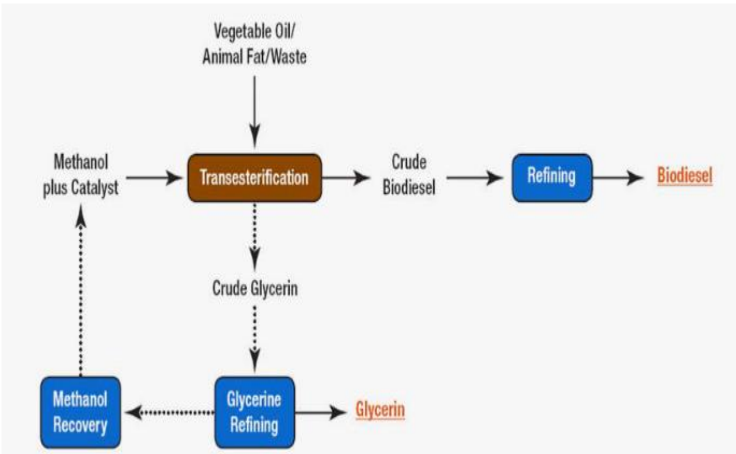


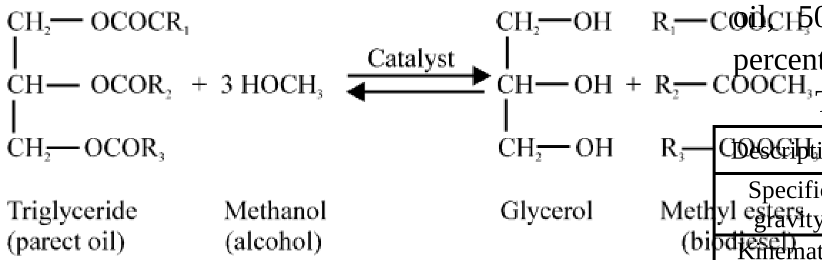
Figure 1. Schematic of biodiesel production process

Upper layer contains a mixture of biodiesel, alcohol, and a few amount of soap. Lower layer contains glycerin, surplus amount of alcohol, catalyst, impurities, and unreacted oil. The upper layer product was purified by keeping mixture at elevated temperature of approximately 80^{o}C for the removal of alcohol.

Transesterfication

Transesterification is the process used to produce biodiesel. An ester reacts through an alcohol to shape an additional ester and a different alcohol. The medium used for the reaction is KOH or NaOH. Three molmethanols react with one mole triglyceride which construct a mixture of fatty esters and glycerin, which is shown in the reaction. The different types of raw materials were used to produce biodiesel through transesterification process [6]. In this production process Methyl alcohol was used as alcohol and NaOH was used as catalyst

8].



II. MATERIALS AND METHODS

Preparation of Bio Dieselfrom Mustard Oil

Mustard oil taken for the preparation of biodiesel is treated well to remove unwanted impurities, dust particles before involving process. In first stage 250ml of methanol was mixed with 150ml of NaOH to produce meth-oxide. The mixture was swirled in a glass vessel awaiting NaOH is totally dissolved in methanol. In the next stage Meth Oxide is added with 1 liter of treated oil. The mixture is heated up to 55^{o}C and kept idle for 24 hours for sedimentation and partition of ester and glycerol, the mixture is gradually settles down into 2 unique layers. Top layer contains 100% of bio-diesel and bottom layer is filled with glycerol which is detached by gravity release or with a centrifuge. A thin layer of impurities were formed between two distinctive film compile of soap and other impurities which are shown in figure 2. When using transesterification it contains moisture, methanol and some amount of soap. If the temperature exceeds the vaporization level it removes both methanol and moisture.

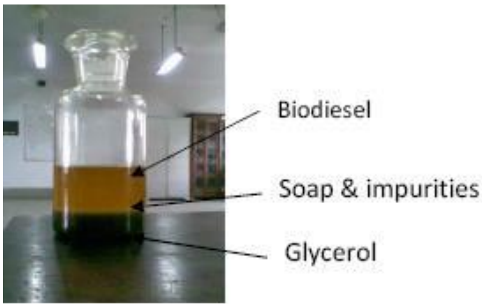


Figure 2. Biodiesel after 24 hrs of partition

The biodiesel is tested in the laboratory to analyze its properties, which is clearly mentioned in table 1. The mustard oil has been blended with diesel by volume like B20 (20% mustard oil, 80% diesel), B30 (30% mustard oil, 70% diesel), B40 (40% mustard oil, 60% diesel), B50 (50% mustard oil, 50% diesel), 100% biodiesel by volume percentages and pure diesel.

Table1: Properties of biodiesel blends

Description	Diesel	B20	B30	B40	B50	B100
Specific gravity	0.901	0.899	0.906	0.912	0.918	0.941
Kinematic viscosity at 35ºC(mm^2/s)	3.87	5.5918	11.528	11.891	11.982	24.982
Flash point (°C)	72	78	83	98	111	140
Density (kg/m^3)	826.2	838.2	840.9	851.6	860.1	880.2
Calorific value (MJ/kg)	44	42.68	42.15	42.09	41.94	39.45

Experimental Setup

The prepared blends are tested to know the suitability of the biodiesel as fuel in CI engines. CI engine is used to conduct the performance analysis of biodiesel with a different blend volume of diesel. Table 2 illustrates the specifications of CI used for this experiment and the setup is shown in figure 3. The experiments were carried out to find out the performance characteristics of CI engine such as brake thermal efficiency, brake specific fuel consumption exhaust gas temperature for various loads with all blends of biodiesel.

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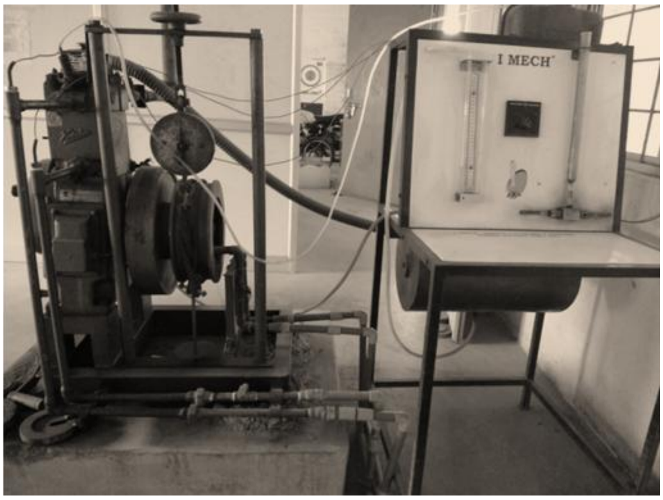

Figure 3. Compression ignition engine test rig

The CI engine is operated at a constant speed of 1500 rpm with 17.5:1 fixed compression ratio for dissimilar loading conditions. Blend of fuels used for the analysis is B20, B30, B40, B50, 100% biodiesel.The fuel was supplied from an externally installed tank with burette for the fuel consumption. Load tests are conducted by changing the load on the brake drum and the fuel consumption would be varied. During the process fuel consumption is noted by calculating the time for every 10 ml of fuel using stop watch.

Table 2: Engine Specifications

S. No.	Engine Parameters	Specifications
1	Type of engine	TAF-1(Kirloskar, Four Stroke)
2	Number of Cylinders	Single cylinder
3	Number of Strokes	Four-Stroke
4	Power	4.4kW (6 HP) @1500 RPM
5	Bore size	87.5mm
6	Stroke length	110mm
7	CC	661.5cc
8	Compression Ratio	17.5:1
9	Rated speed	1500 RPM
10	Cooling Medium	Water

III. RESULTS AND DISCUSSION

Performance characteristics

The values taken from the experimental results were used to determine the engine performance as well as the performance of blended biodiesel. The output results are converted into graphical representation for clear demonstration of performance of biodiesel blends and engine characteristics such as BHP, Bsfc, BMEP and ηbt.

Figure 4 shows the variation of Bhp with Bsfc for different blend ratio and pure diesel. The graph indicates that a blend with biodiesel has higher Bsfc at minimum loading condition and it decreases while increasing loading conditions. The specific fuel consumption rate has been increased while increasing blend ratio with diesel due to the relations between fuel specific gravity, viscosity and heating value. The lower heating value of blended diesel leads to maximize the blending ratio to achieve the same amount of energy which is produced from the diesel. Even though biodiesel produces high brake specific fuel consumption, it causes poor mixture formation and atomization due to different viscosity and which increases the fuel consumption rate to sustain the output power.

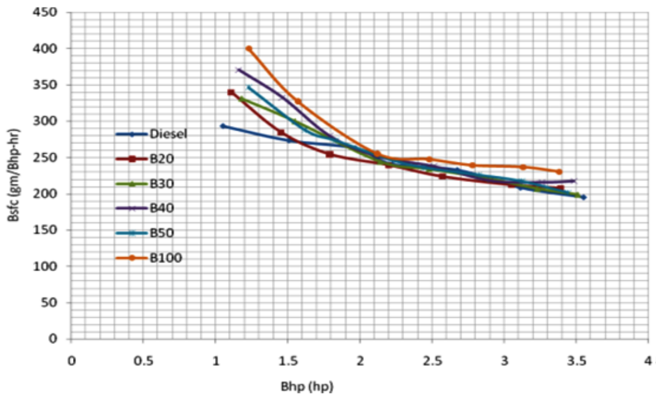

Figure 4. Bsfc vs Bhp for different blends and diesel

Figure 5 give you an idea about the graphical representation between brake thermal efficiency and Bhp for all blends of biodiesel and diesel. The engine brake thermal efficiency can be determined based on the Bsfc also it is inversely related to thermal efficiency.

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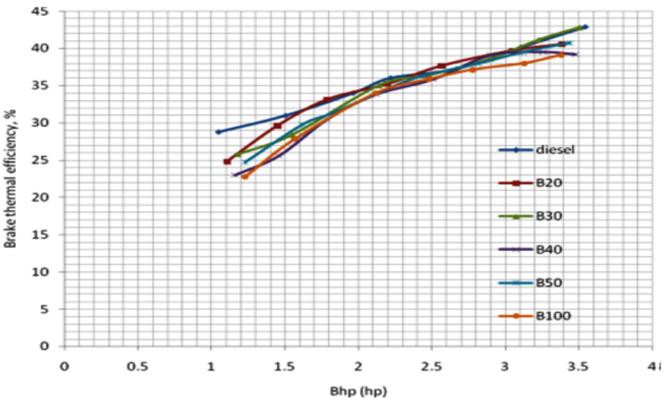

Figure 5. Brake thermal efficiency(η_{bt})vs Bhp for different blends and diesel

Brake thermal efficiency of blend B100 is 20% lesser than diesel, B20 and B30 blends produces 10 to12% brake thermal efficiency, which is also lesser than the output resolute from diesel. Blend of B20 and B30 fuels are economically feasible when compared with B100 biodiesel because which has a lower heating value than diesel. Poor atomization of biodiesel blend generates lower brake thermal efficiency.

Figure 6 shows the relationship between exhaust temperature vs bhp for various blends and pure diesel. When compared to diesel as fuel all biodiesel blends gives higher exhaust temperature except a blend of B30 (30% biodiesel and 70% diesel). In initial stage, exhaust temperature value is getting maximum with short power output for blended biodiesel which designate the late fire of biodiesel. In maximum loading condition, blend of B30 and B40 has produced a minimum exhaust temperature when compared to diesel as fuel. B100 also gives almost similar exhaust temperature.

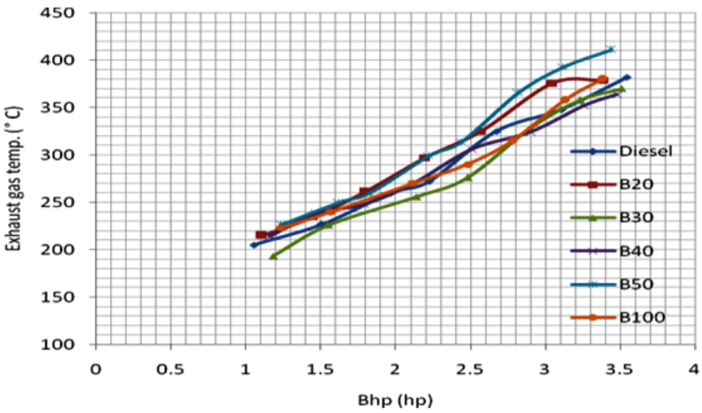

Figure 6. Exhaust gas temperature vs Bhp for different blends and diesel

Figure 7 indicates the graphical representations of output results between bhp and brake mean effective pressure (BMEP) obtained during load test. Brake mean effective pressure value is not changing for the different blend of biofuel as well as pure diesel. The BMEP always increases linearly with respective to BHP.

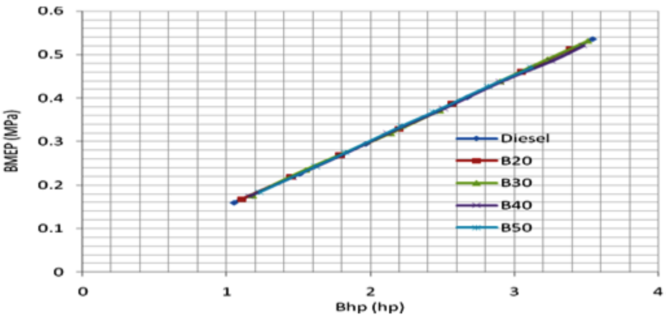

Figure7. BMEP vs Bhp for different blends and diesel

IV. CONCLUSION

Biodiesel produced from mustard oil is tested using a CI engine for various loading conditions and various blends of biodiesel as fuel. The performance factors such as Bsfc, Bhp, ηbt, BMEP and exhaust temperature are being carried out and validated with diesel as fuel.

- Inferior heating value of blended biodiesel leads to increase the bsfc when evaluate with diesel as fuel.
- Power loss of the engine was minimum when blended biodiesel is used as fuel while comparing with fossil fuel.

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- Engine Efficiency is not affected when using biodiesel as fuel.
- The use of biodiesel provides clean energy emission
- Usage of biodiesel causes to reduce global warming and improves rural development.
- Although the operating cost of CI engine is expensive when blended biodiesel is used as fuel because the diesel engine has to be modified.
- The shortage of fossil fuel occurs due to the high use of fossil fuel with minimum resources. So it can be resolved by using various kinds of renewable energies.

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