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A Production of biodiesel from rice bran oil and experimenting on small capacity diesel engine

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Abstract: *Increased environmental awareness and depletion of resources are driving industry to develop viable alternative fuels from renewable resources that are environmentally more acceptable. Vegetable oil is a potential alternative fuel. The most detrimental properties of vegetable oils are its high viscosity and low volatility, and these cause several problems during their long duration usage in compression ignition (CI) engines. The most commonly used method to make vegetable oil suitable for use in CI engines is to convert it into biodiesel, i.e. vegetable oil esters using process of transesterification.*

Rice bran oil is an underutilized non-edible vegetable oil, which is available in large quantities in rice cultivating countries, and very little research has been done to utilize this oil as a replacement for mineral Diesel. In the present work, the transesterification process for production of rice bran oil methyl ester has been investigated. The various process variables like temperature, catalyst concentration, amount of methanol and reaction time were optimized with the objective of producing high quality rice bran oil biodiesel with maximum yield. The optimum conditions for transesterification of rice bran oil with methanol and NaOH as catalyst were found to be 55 °C reaction temperature, 1 h reaction time, 9:1 molar ratio of rice bran oil to methanol and 0.75% catalyst (w/w). Rice bran oil methyl ester thus produced was characterized to find its suitability to be used as a fuel in engines. Results showed that biodiesel obtained under the optimum conditions has comparable properties to substitute mineral Diesel, hence, rice bran oil methyl ester biodiesel could be recommended as a mineral Diesel fuel substitute for compression ignition (CI) engines in transportation as well as in the agriculture sector.

Keywords: *Biodiesel, Rice bran oil, Transesterification*

I. Introduction

Due to global depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emission there is an urgent need for suitable alternative fuel. The various alternative fuel options researched for diesel are mainly biogas producer gas, methanol, ethanol and vegetable oil. Out of this which rice bran oil is one of the promising alternate fuel for diesel engine. Rice bran oil is a non conventional, in expensive and low–grade vegetable oil. Crude rice bran oil is also source of high value added by-products are derived from the crude rice bran oil and the resultant oil is used as a feed stock for bio diesel, the resultant bio diesel could be quite economical and affordable. Rice bran oil is the oil extracted from the germ and inn er husk of rice. It is the notable for its very high smoke point of 490° F (254° C) and its mild flavour, making it suitable for high temperature cooking method such as stir frying and deep frying. It is popular as cooking oil in several asian countries including japan and china. Rice bran oil contains a range of fats, with 47% of its fats monounsaturated, 33% polyunsaturated, and 20% saturated. The fatty acid composition of rice bran oil is palmitic 15.0%, Stearic acid 1.9%, Oleic acid 42.5%, Linoleic acid 39.1%, Linolenic acid 1.1%, Arachidic 0.5%, Behenic 0.2%.

II. Transesterification

Due to very high free fatty acid, rice bran oil was converted into methyl ester by the two stage process.IN the first stage rice bran oil was reacted with CH3OH in presence of an acid catalyst (H2SO4) to convert free fatty acid inyo fatty ester. A specified ammount 1000g of rice bran oil was taken in a round bottom flask and heated up to 60-65°C. In a separate flas CH3OH (950 g) and H2SO4 (22 g) were taken and properly mixed and then stirred for 4 h and maintained at 60°C.It was allowed to cool overnight without stirring. When acid number of the mixture reaches to less than 1,the second stage was started .During this stage mixture 1000g obtained from the first stage was taken in around bottom flask and heated upto 60°C methanol(200ml) and KOH 4.5g were properly mixed in other flask and then introduced into the round bottom flask containing the mixture from first stage. The mixture stirred vigorously for 2h and then allowed to cool overnight. Glycerol was seperated by adding wram water at 60°C to the mixture. Glycerol and soap formed during the process settled down the bottom. Top layer containing rice bran oil methyl ester 91% was removed with the help of a separating funnel and wasted two times with water and dried.

III. Engine Test

A diesel engine with single cylinder, direct injection it is widely used in agriculture and industrial purpose. It is a single cylinder, four stoke, vertical, air cooled engine having bore X Stroke (mm) 78X62 respectively. At rated speed 3000rpm,it develops power of 4.4kw with diesel engine. It hasa provision of loading electrically since it is coupled with a single-phase motor through flexible coupling .The engine can be kick started using decompression lever and is provided with centrifugal speed governer. The inlet valve opens at before top dead centre (BTDC) and closes at 35.5□ After bottom dead centre(ABDC).The exhaust valve opens at35.5□ before Bottom dead centre(BBDC)and closes at 4.5□ After Top dead

centre(ATDC).The 220v ac alternator coupled with engie has sufficient capacity to absorb the maximum power produced by the engine. Fuel injection pressure was maintained at 200bar throughout the experiment. The engine was tested with 20, 40, 60, 80% and full rated output and full rated speed of 3000rpm only. The engine ran smoothly throughout the study and no major problem was reported. The engine produced and 10% excess power without any difficulty

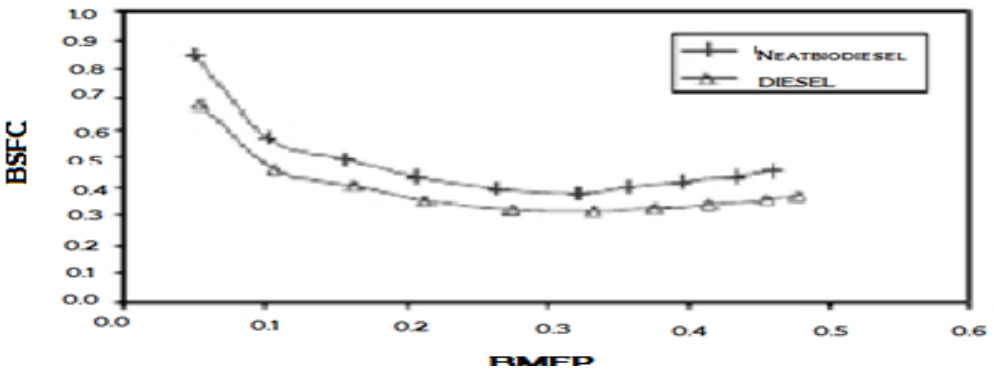
Comparative analysis of rice bran oil biodiesel and diesel

Fuel properties	Rice bran oil biodiesel	DIESEL
Density(gm/cc)	0.872	0.831
Viscosity(cSt)	4.81	3.21
Flash point(□ C)	157	76
Cetane number	51.6	47.2
Calorific value(KJ/KG)	41382	44585

IV. Result & Discussion

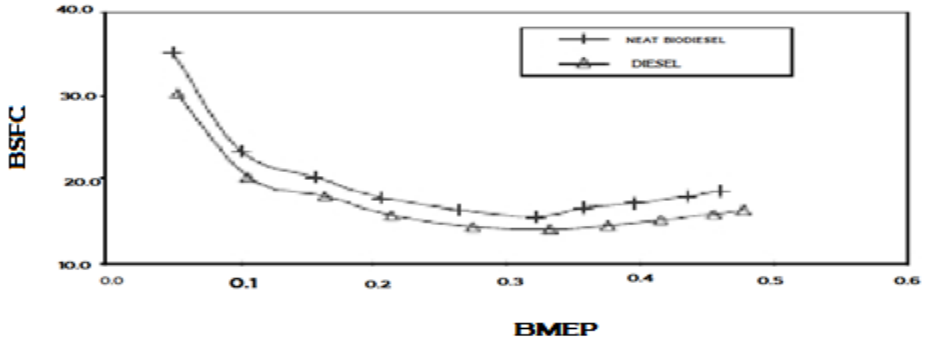
The power developed by engine at varying load for diesel and biodiesel suggests that maximum power is higher in case of diesel (3.911kw) than biodiesel (3.757kw).This is primarily because of less heating value of biodiesel as compared to diesel variation of fuel consumption rate for diesel and biodiesel of rice bran oil suggests that fuelfl ow rate is marginally higher in case RBOME than diesel. Higher density of biodiesel leads to more discharge of fuel injection pump thereby increasing fuel consumoption rate. Brake specific fuel consumption (BSFC) (FIG-1) is higher for RBOME as compard to diesel at the entire brake load, because of less heating value and more consumption of RBOME as compared to diesel engine .BSFC for RBOME and diesel are as follows minimum load 0.848, 0.687 and am load 0.450, 0.367 kg/Kwh.

FIGURE 1 :



Since both the fuels have different calorific values, viscosity and density, BSFC is not a reliable tool to compare the fuel consumption per unit power developed. A better approach is to compare the two fuel on the basis of energy required to develop unit power outpur, kown as brake specific energy cosumption (BSEC).The BSEC (Fig 2) corresponding to maximum load for diesel was 16.311kJ/Kwh where for biodiesel it was 18.603kj/Kwh, which sugest that energy required by bio diesel to develop unit output is more in comparison to diesel.

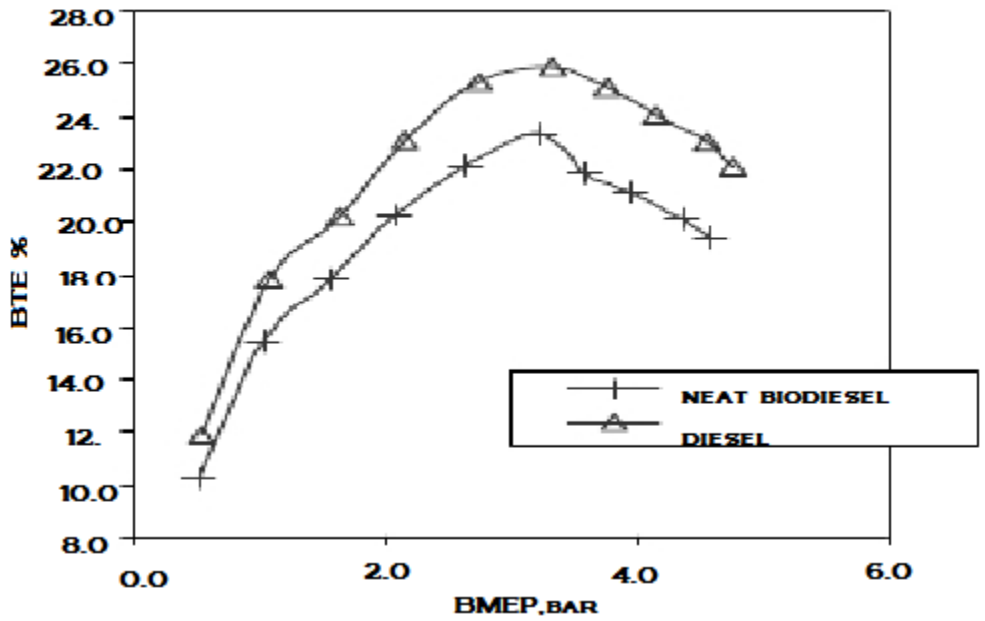
FIGURE 2 :



BSFC vs BMEP

Brake thermal efficiency (BTE) (Fig 3) for RBOME and diesel are as follows:

FIGURE 3 :

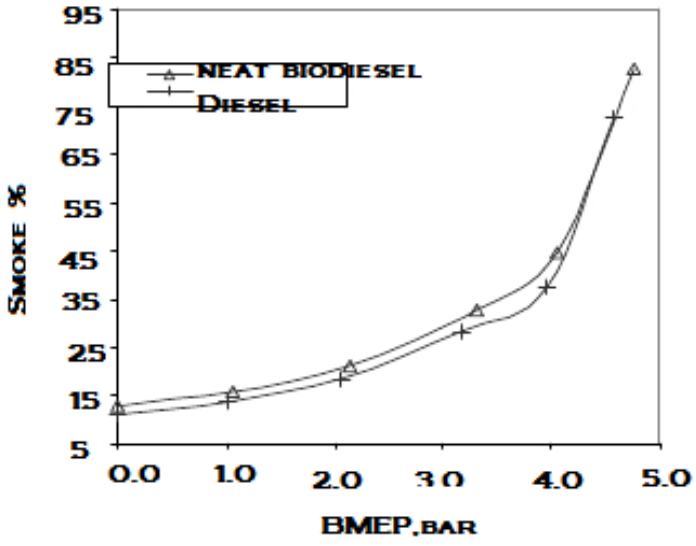


Brake thermal efficiency (BTE) vs BMEP

At minimum load -10.53%, 11.88%
At maximum load-19.35%, 22.07%

Here efficiency is observed higher in case of diesel than the biodiesel at all values of load this could be attributed to inbuilt 10% oxygen content in biodiesel, which helps in better combustion and higher cetane rating of the fuel. Smoke capacity (Fig 4) has been observed higher in case diesel then the methyl ester at all value of value of loads. This is probably because of inbuilt oxygen content and lower sulfur content in biodiesel.

FIGURE 4 :



Smoke capacity vs BMEP

V. Conclusion

Biodiesel made from high free fatty acid rice bran oil using two stage formulation process had viscosity and density similar to diesel. Calorific value of biodiesel was around 7% lower that of diesel. Flash point of biodiesel is quite high as compared to diesel making is safer to safer to store and transport. Sulfur in biodiesel is very low as compared to diesel and is an important feature interm of reduction of sulphur-oxide from the exhaust emission. The HFFR test suggests that lubricity of biodiesel in comparison to diesel. Biodiesel was used as a fuel in an unmodified, small capacity diesel engine. The power developed from the engine with biodiesel as a fuel was 4% lower as compared to diesel, because of lower heating value of biodiesel. BSFC and brake specific energy consumption were also higher due to some reason.BTE was higher in diesel as compared to biodiesel. Smoke capacity was lesser of biodiesel than diesel making it more environmental friendly fuel. The study suggests that it is possible to convert high FFA RBO into biodiesel which has similar properties to diesel and can be used to fuel an existing unmodified diesel engine without any difficulty.

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