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Performance Analysis of Four Stroke Multi Cylinder Internal Combustion Engine Running on Diesel Fuel Blended with Transesterified Sesame Oil

Prapul Chandra A C[1], Sharath Chandra M S[2], Gangadhar T G[3],Narahari G A[4]

[1]*RV College of Engineering, Bengaluru, R V Vidyanikethan Post Mysuru Road Bengaluru - 560 059*
[2]*Rollecate Engineering Service Pvt. Ltd N- 401, Manipal Centre, Dickenson Road,, Bengaluru, Karnataka, 560042,*
[3]*SJBIT, No.67, Uttarahalli Main Road, Kengeri, BGS Health & Education City, Bengaluru, Karnataka 560060*
[4]*Vivekananda Institute of Technology,Gudimavu, Kumbalagodu(P), Kengeri(H) Bengaluru-560 074*

Abstract

Bio-diesel is a fatty acids alkyl ester, which can be derived from any vegetable oil by Transesterification. Bio-diesel is renewable, bio-degradable and non-toxic fluid. In this experiental study, Sesame oil was tranesterified with methanol using pottasium hydroxide as catylist to obtain respective methyl esters. Various properties of bio-diesel and Sesame oil and methyl esters are evaluated and compared in relation to that of conventional diesel oil. Experimentally tests has been carried to evaluate the performance and characterstics of diesel and bio-diesel. Neat Sesame methyl ester and diesel were used to run a C.I. engine. A 4-stroke, single cylinder,water cooled diesel engine was used for experiment. Blends of 10%,20%,30%,40% & 50% Sesame methyl ester/diesel ratios by volume were used. Various engine performance parameters such as mechanical efficiency, specific fuel consumption, brake thermal efficiency ,indicated thermal efficiency and heat balance sheet were calculated from the acquired data. The performance and characteristics of the engine are analysed and compared.

Keywords: Bio-diesel, Trans-esterification, Sesame oil

INTRODUCTION

Biodiesel is not like a diesel fuel, but made from vegetable oil or animal fat. It is biodegradable though, so it is much less harmful to the environment if spilled. It is made through a process called trans-esterification. This process makes vegetable oil and animal fat into esterified oil, which can be used as diesel fuel, or mixed with regular diesel fuel. [1]

Biodiesel is the name of a clean burning alternative fuel, produced from domestic renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engine with little or no modifications. Biodiesel is simple to use as biodegradable, non-toxic and essentially free of sulphur and aromatics. [2]

Biodiesel (fatty acid alkyl esters) is a cleaner-burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils and animal fats. Just like petroleum diesel, Biodiesel operators in compression-ignition engines. Blends of up to 20% biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipments. These level blends (20% and less) don't require any engine modifications and can provide the same payload capacity and range as diesel. [3]

Higher blends even pure biodiesel (100% Biodiesel, or B100); can be used in many engines built since 1994 with little or no modification. Transportation and storage require special management. Material compatibility and warrantee issues have been resolved with higher blends. Using Biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbon, carbon monoxide, sulphates, and polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons and particulate matter. These reductions increase as the amount of biodiesel blended into diesel fuel increases. The best reductions are seen with B100.[4]

The use of biodiesel decreases the solid carbon fraction of particulate matter (since the oxygen in biodiesel enable more complete combustion to CO2 and reduces the sulphate fraction (biodiesel contains less than 24 ppm sulphur), while the soluble or hydrocarbon fraction stays the same or increases. Therefore, biodiesel works well with new technologies such as catalysts (Which reduce the soluble fraction of diesel particulate but not the solid carbon fraction), particulate traps and exhaust gas recirculation. An emission of nitrogen oxides increases with the concentration of biodiesel in the fuel. Some biodiesel produces more nitrogen oxides than others and some additives have shown promise in modifying the increases. More R&D is needed to resolve this issue.[5]

Physical Characteristics of Biodiesel

Table 1: Characteristics of Bio-diesel

Characteristics	**BIO-Diesel**	**Esterified sesame oil**
Specific Gravity	0.87 to 0.89	0.88
Kinematic viscosity@400C	3.7 to5.8	5.7
Cetane number	46 to 70	53
Higher Heating Value (KJ/Kg)	9290 to 41769	--
Sulphur, wt%	0.0 to 0.002	0.0083
Cloud point	-11 to 16	12
Pour point	-15to 13	7
Lower Heating Value (KJ/Kg)	36440 to 38442	40676.84

Table 2: Fuel properties of diesel and sesame seed oil

Property	Diesel	Sesame seed oil
Viscosity (mm²/Sec at 311^0 K)	2.68 -2.72	33-36
Cetane number	46- 48	45-54
Cloud point (K)	257-259	285-287
Pour point (K)	239-242	264-266
Carbon residue (% by weight)	0.34-0.48	0.10-0.11
Ash content (% by weight)	0.01-0.02	0.006-0.08
Acid value (mg NAOH/g oil)	-	0.05-0.06
Lower heating value (MJ/Kg)	45.0-45.3	40.1-40.6

TRANESTERIFICATION PROCESS

Esterification is the conversion of a non ester into an ester. Transesterification is the conversion of one ester into another, i.e. a glycerine ester into an alkyl ester in the case of biodiesel where methanol replaces the glycerine. The biodiesel molecule is indeed smaller and less complex. Biodiesel has lower viscosity than raw vegetable oil because the transesterification process shortens the carbon length of the fatty acid molecules in the oil transesterification converts the triple chain triglyceride vegetable oil molecule to three single chain methyl ester molecules, but the chain lengths of the fatty acids themselves remain the same. The fatty acids composition of the biodiesel depends on the feed stock and is changed by transesterification. Transesterification process converts triglycerides esters into alkyl esters (biodiesel) by means of a catalyst (NaOH) and an alcohol reagent (usually methanol, which yields methyl esters biodiesel). In transesterification the triglyceride molecule is broken into three separates methyl esters molecules plus glycerine as a by-product. Triglycerides are esters, esters are acids such as fatty acids combined with an alcohol, and glycerine is a heavy alcohol. The catalyst breaks the bond holding the fatty acid chains to the glycerine, fatty acid chain then bond with the methanol.

Transesterification process happens in three stages. First, one fatty acid chain is broken off the triglyceride molecule and bonds with methanol to form a methyl ester molecule, leaving a diglyceride molecule (two chains of fatty acids bound by glycerine). Then a fatty acid chain is broken off the diglyceride molecule and bonded with methanol to form another methyl ester molecule, leaving a monoglyceride molecule. Finally the monoglycerides are converted to methyl esters.

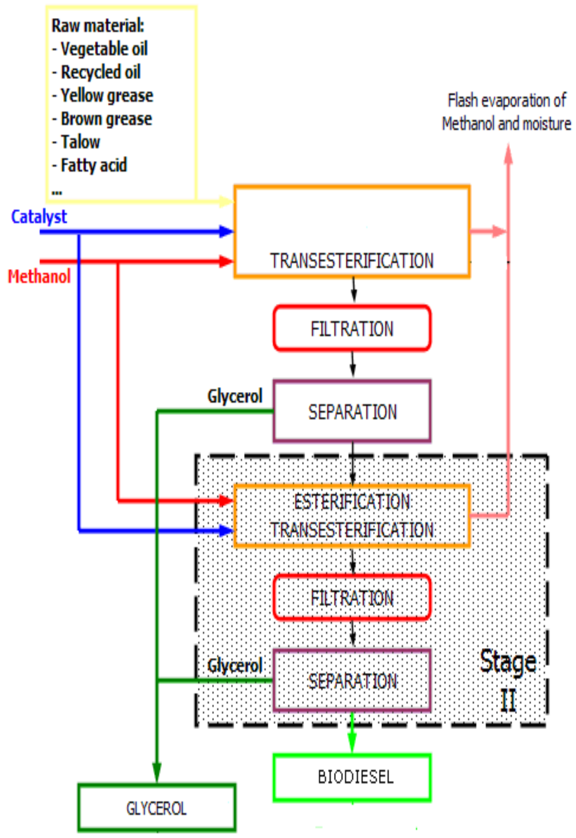


Fig 3: Flow chart of Tranesterification process

EXPERIMENTAL SETUP

Procedure for Transesterification Process

1. Take 100ml of oil in a round bottom flask.
2. Weigh 0.6 grams of NaOH pallets using electronic balance.
3. Take 20ml of methanol in a beaker, add NaOH and dissolve by stirring.
4. Add methanol and NaOH mixture to round bottomed flask containing oil.
5. Keep the flask on the magnetic stirrer (fig 4) and using magnetic bit stir the mixture for 30min without heating.
6. Then switch on the heater and heat the mixture for 60minutes with temperature maintaining between 50-600C
7. Pour the mixture into the separating funnel. (fig 5).
8. The mixture is allowed to settle by gravity in a separating funnel overnight.
9. Separate the Glycerol and Collect the methyl ester from the funnel.
10. Heat the collected methyl ester up to 90^0 C to evaporate methanol if present (fig 6).
11. Filter the heated methyl ester using filter paper. (fig 7).
12. Finally collect the filtered methyl ester in a bottle.

Fig 4: Magnetic Stirrer

Fig 5: Separating Funnel

Fig 6: Heating of collected methyl ester

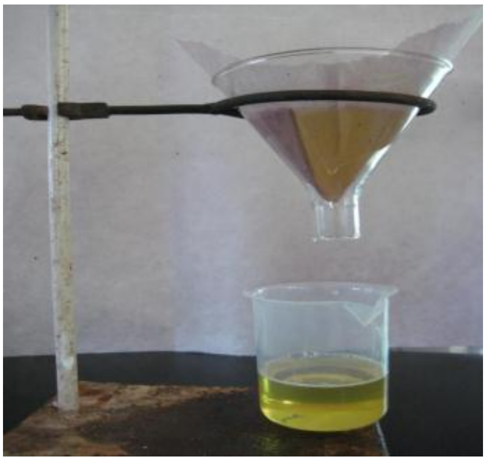


Fig 7: Filtering of Collected Methyl Ester

SPECIFICATIONS OF THE ENGINE

Engine	Single cylinder, 4 stroke, Water cooled, Diesel, Make kirloskar, Model TV1, Rated power 5.2 kW, Speed1500 rpm, Bore 87.5mm,Stroke 110mm, Compression ratio 17.5. Capacity 661 cc.
Dynamometer	Type eddy current make SAJ.
Carden shaft	For engine and dynamometer.
Crank angle sensor	Resolution 1 Deg, Speed 5000 RPM with TDC Marker pulse.
Temperature :	Digital, PT-100 type temperature sensors (6 Points)

RESULT & DISCUSSION

PERFORMANCE CHART FOR PURE DIESEL

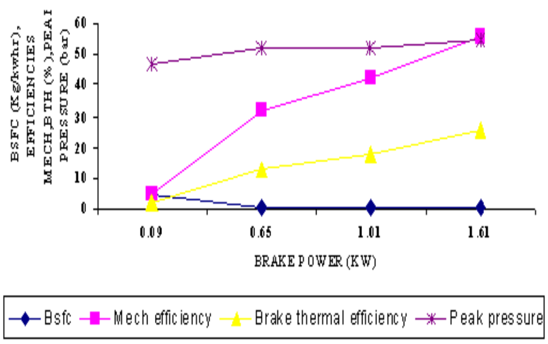


Fig 8: graph of performance chart for pure diesel

Above graph shows that as by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency and decreasing of specific fuel consumption reaches the lowest specific fuel consumption with higher values of mechanical and brake thermal efficiency at 1.61KW and hence economically suitable condition to run the engine will be at1.61KW. Also peak pressure increases up to 0.65KW of B.P and onwards it is almost constant.

PERFORMANCE CHART FOR 10% SSO +90% DIESEL

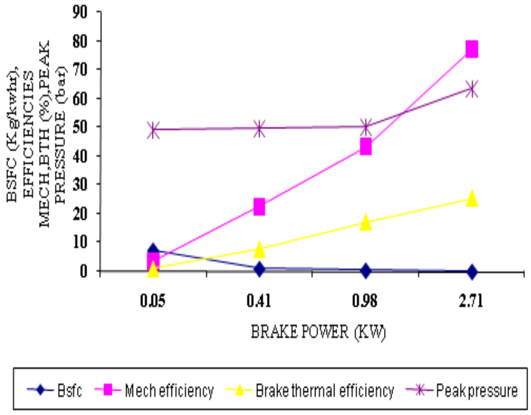


Fig 9: graph of performance chart for 90%diesel+10%SSO

Above graph shows that by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency but decreasing of brake specific fuel consumption. BSFC reaches the lowest value and brake thermal efficiency, mechanical efficiency reaches the higher value at 2.71KW of BP. Brake thermal efficiency increases gradually up to peak load. Mechanical efficiency increases gradually up to 0.98KW of BP and onwards sudden increasing the efficiency. Peak pressure is almost constant up to 0.98KW of BP and onwards it increases

PERFORMANCE CHART FOR 20% SSO +80% DIESEL

Above graph shows that by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency but decreasing of brake specific fuel consumption. BSFC reaches the lowest value and brake thermal efficiency, mechanical efficiency reaches the higher value at 2.62KW of BP. Brake thermal efficiency increases gradually up to peak load. Mechanical efficiency increases gradually up to 0.993KW of BP and onwards sudden increasing the efficiency. Peak pressure is almost constant up to 0.993KW of BP and onwards it increases.

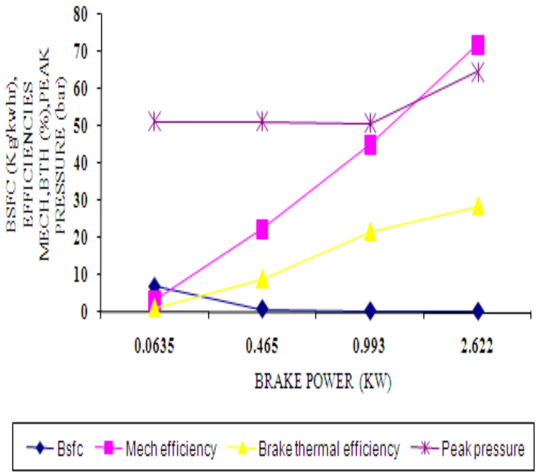


Fig 10: graph of performance chart for 80%diesel+20%SSO

PERFORMANCE CHART FOR 30% SSO +70% DIESEL

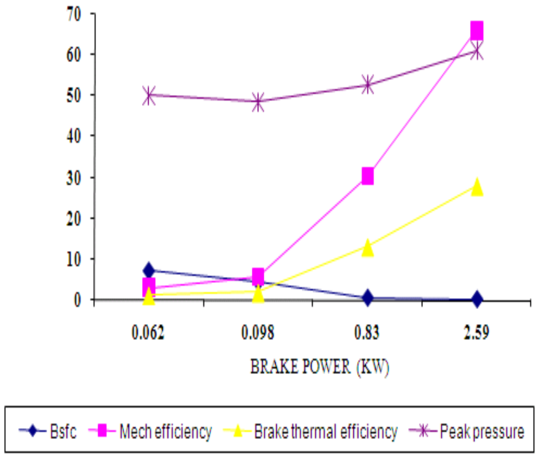


Fig 11: graph of performance chart for 70%diesel+30%SSO

Above graph shows that by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency but decreasing of brake specific fuel consumption. BSFC reaches the lowest value and brake thermal efficiency, mechanical efficiency reaches the higher value at 2.59KW of BP. Brake thermal efficiency increases gradually up to peak load. Mechanical efficiency increases gradually up to 0.83KW of BP and onwards sudden increasing the efficiency. Peak pressure is almost constant up to 0.83KW of BP and onwards it increases

PERFORMANCE CHART FOR 40% SSO +60% DIESEL

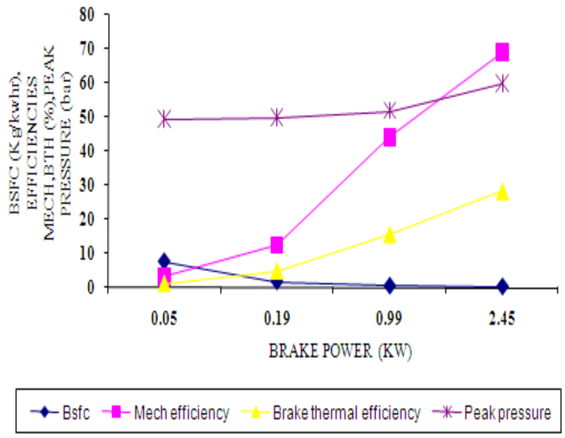


Fig 12: graph of performance chart for 60%diesel+40%SSO

Above graph shows that by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency but decreasing of brake specific fuel consumption. BSFC reaches the lowest value and brake thermal efficiency, mechanical efficiency reaches the higher value at 2.45KW of BP. Brake thermal efficiency increases gradually up to peak load. Mechanical efficiency increases gradually up to 0.19KW of BP and onwards sudden increasing the efficiency. Peak pressure is almost constant up to 0.99KW of BP and onwards it increases.

PERFORMANCE CHART FOR 50% SSO +50% DIESEL

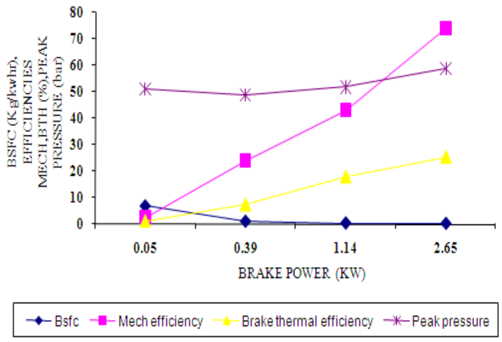
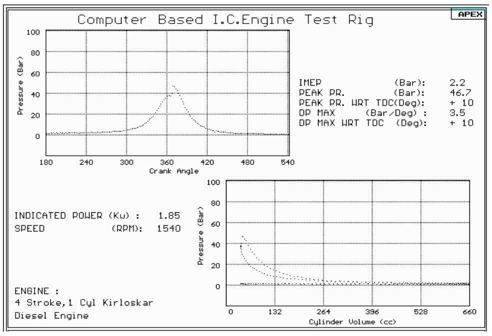


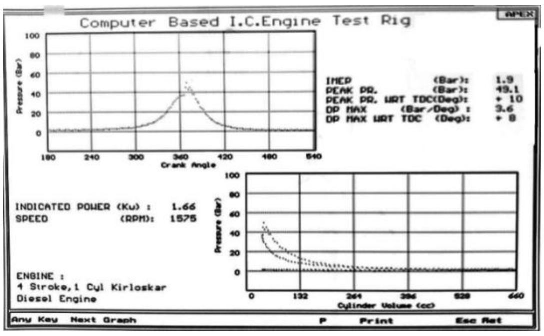
Fig 13: graph of performance chart for 50%diesel+50%SSO

Above graph shows that by increasing the brake power, increasing of mechanical efficiency, brake thermal efficiency but decreasing of brake specific fuel consumption. BSFC reaches the lowest value and brake thermal efficiency, mechanical efficiency reaches the higher value at 2.65KW of BP. Brake thermal efficiency increases gradually up to peak load. Mechanical efficiency increases gradually up to 1.14KW of BP and onwards sudden increasing the efficiency. Peak pressure is almost constant up to 1.14KW of BP and onwards it increases

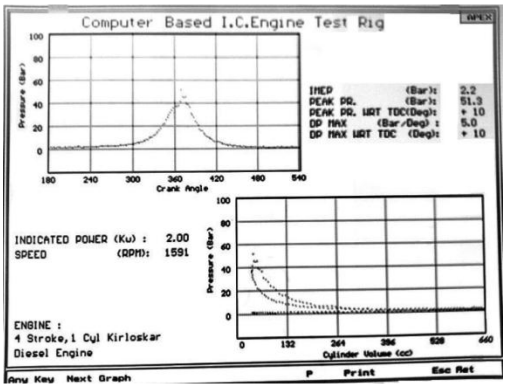
PRESSURE (P) V/S CRANK ANGLE (θ) DIAGRAM FOR PURE DIES



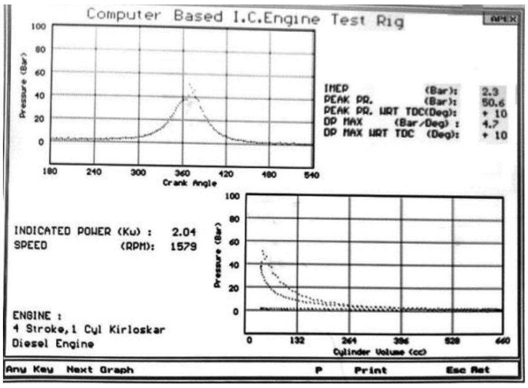
FOR 10% SSO +90% DIESEL



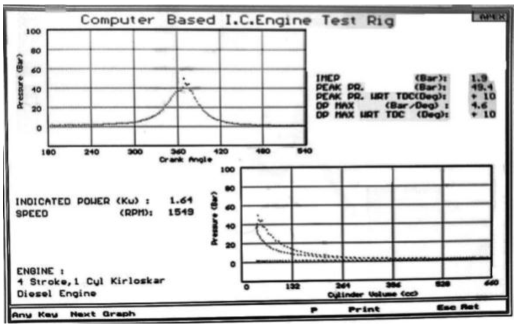
FOR 20% SSO +80% DIESEL



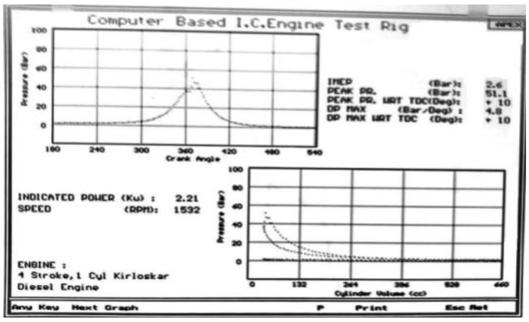
FOR 30% SSO +70% DIESEL



FOR 40% SSO +60% DIESEL



FOR 50% SSO +50% DIESEL



CONCLUSION

In our dissertation work, we carried out performance analysis on I.C engine with diesel – Esterified sesame seed oil blend and the results are compared and thus we concluded that,

- It is impossible to run the existing engine with pure sesame seed oil because of its high flash and fire point, so blending with diesel is necessary.

- Transesterification process reduces the viscosity of the oil and it improves the fuel properties of the sesame seed oil.
- The flash point, fire point and viscosity of the blended oil slightly increases with increase in percentage of blends, but these values are closer with the values of pure diesel.
- No ash particles are observed for an esterified sesame seed oil.
- BSFC decreases with increasing BP up to 1.5 KW onwards. Value of BSFC of the blends is same as that of diesel.
- Friction power decreases with increasing percentage of blend. Density, kinematic viscosity, flash point & fire point are increases with increasing in the percentage blend but these values are within the limit recommended by Indian Oil Corporation.
- Brake thermal efficiency & mechanical efficiency increases with increasing the brake power & at maximum load blended oil gives the higher efficiency than that of the diesel.
- No engine modification is required to run up to 50% of blend.
- 40% blend having higher mechanical, brake thermal efficiency & lower BSFC. So, 40% blend can be considered as economical percentage of blend with the diesel.

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