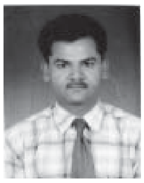
Improvement in Performance and Emission Using Coconut Oil as a Diesel Substitute

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Abstract: Diesel engines, unlike their petrol counterparts, are omnivorous in fuel consumption habits and can easily run on vegetable oils without any major changes in the engine. Using raw oils in diesel engines led to such problems as the sticking of fuel injectors and piston rings due to choking, and the thickening of lubricating oils, resulting in clogging of filters, but these were overcome in a large measure by pre-conditioning of the fuel by a chemical process using methanol or ethanol called 'Transesterification'. Coconut oil can be adapted as additive fuel for the existing bio diesel engines without major modifications. If diesel engines turn vegetarian in our country, which has a great potential for producing vegetable oils from the evergreen tropical forests and plantations, it will be a big achievement in terms of reducing the sky-rocketing petroleum bills! Edible coconut oil is subjected to Transesterification process to reduce its viscosity and resulting coconut methyl ester known as biodiesel used in 5 H.P. Single cylinder diesel engines. Result shows that heated B-100 blend gave better performance and produced lower smoke emission than other fuel blends.

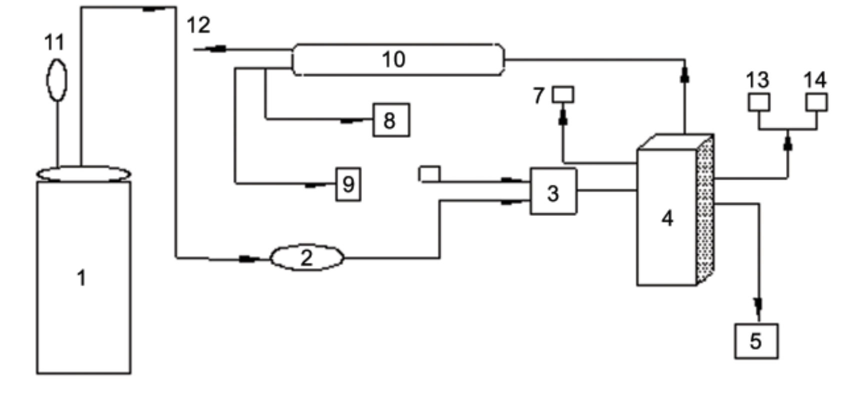
Key words: C.I. engine, diesel, biodiesel, coconut oil, engine emissions

Introduction

Current model vehicles have installed special rubber tubing capable of handling fuels with bio-diesel's solvent characteristics. Performance-wise, bio-diesel gives no abnormal combustion problems since it has physico-chemical properties much like those of diesel. But there is a very small penalty in power and fuel consumption on account of slightly lowering heat value, because of the 10-12% oxygen content in the fuel itself. Another disadvantage of biodiesel is that it tends to reduce fuel economy (McCormick, Terry and Natarajan 2006). Energy efficiency is the percentage of the fuel's thermal energy that is delivered as engine output, and biodiesel has shown no significant effect on the energy efficiency of any test engine.

Materials and Methods

Equipment consists of a single cylinder, water cooled, vertical diesel engine mounted over a sturdy frame with a 3.5 KVA dynamometer coupled to D.C. generator used to load the engine with water rheostat loading arrangement. A digital multichannel temperature indicator measures temperatures at various points. Various measurements provided enables to evaluate the performance of the engine at various loads. A smoke analyzer used for the measurement of smoke in the exhaust. Two fuel tanks used, which contain diesel and coconut oil, oil supply ensured by maintaining the proper opening of valve fitted in oil tank, quantity measured by burette enabled engine fuel consumption measurement method. An air tank fitted with an orifice was connected to the air-induced manometer. A thermocouple is connected to the exhaust manifold of the engine to measure exhaust gas temperature, and two thermocouples were used to measure the inlet and exhaust coolant temperatures. The engine allowed to reach steady state and the various readings were noted down.



1. Oxygen cylinder
2. Gas flow meter
3. Mixing chamber
4. Kirloskar engine
5. Coolant water thermometer
6. Exhaust gas thermometer
7. Orifice Meter
8. NO× meter
9. Smoke meter
10. Exhaust
11. Pressure gauge
12. To atmosphere
13. Diesel tank
14. Jatopha oil tank

Fig 1. Bio Disel Engine Test Rig

Test with Coconut Oil Blends

Coconut oil burns more slowly than diesel, which results in a more even pressure applied to the pistons during their movement in the cylinders of the engine. This in turn leads to less engine wear, a quieter engine and better fuel economy. Also, as the coconut oil burns slower and has better lubricating qualities than diesel, the engine gets less hot and there is less wear, which helps to prolong engine life (Donahue and Foster 2001). Coconut oil has a special feature of readily mixing with diesel. It remains crystalline solid at temperatures below 20˚C, but it is clear liquid when it is blended with ordinary diesel fuel (ODF). Further, apart from other vegetable oils, the fraction of coconut oil in blends did not create separation or form any layers on the inside wall of the fuel tank.

There is a high production of coconut oil in tropical countries like India, Sri Lanka and Malaysia and so could be a good partial replacement for conventional ordinary diesel fuel one major drawback is that the price of coconut oil is slightly higher than that of conventional petroleum fuels. But it is the least cost alternative in terms of the global emissions management because coconut oil based fuels produce reduced exhaust emissions. The engine warmed up for a long period of time. By keeping all the engine parameters constant, the fuel along was modified to various blends. The gas analyzer first calibrated, the probe of analyzer was properly introduced into the exhaust pipe and also fixed at the center of the exhaust pipe so that maximum temperature of exhaust gas exposed to the probe. These setting were periodically checked during the period of the experiments. The results of experiments, namely, brake power, brake specific fuel consumption (BFSC), brake thermal efficiency, smoke emission noted down and compared with base diesel fuel performance. The problems associated with most vegetable oils are the large variation of viscosities than that of the ODF, which lead to flow related problems. However, transesterification, micro emulsion, pyrolysis, dilution could overcome such problems, which reduce the viscosities of the vegetable oils. Alternatively this difficulty could also be overcome by preheating. This method was adopted in this work and the performance and emission tests carried out and compared with that of ODF.

Make	Kirloskar AV-1
Class	Single cylinder, 4-stroke direct injection, water cooled
Pozwer output, kW	3.7 (5 Bhp)
SFC, g/kWh	240
Speed, rpm	1500
Bore, mm ф	80
Stroke, mm	110
Swept volume, cc	553
Fuel Injection Pressure, bar	170
Injection Timing bTDC	29
Dynamometer	3.5 KVA capacity D.C. generator
Compression Ratio	15

Table 1. Specification of Diesel Engine Test Set-up

Engine Modification

A 12V, 150W heater was fixed between the injector and fuel injection pump and close to fuel injector. The heater was fixed with an aim of preheating the fuel 10ºC before the combustion, to reduce the viscosity and physical delay of combustion. The performance test was then carried out under the same operating condition and the procedure followed for testing of coconut oil blends without heater was repeated. The performance and emission tests were started using 100% ODF and then fuel was replaced by blended fuels. Experiments conducted using various vegetable oil methyl esters increased the power output and reduced emission. Moreover vegetable oils were renewable energy that most vegetable oils contained substantial amount of oxygen in their molecular structure and sulphur content was almost negligible (Pundir 2007). Optimum performance obtained for 20% coconut oil blend biodiesel. The possible reasons for increased thermal efficiency are more complete combustion and additional lubricity of coconut oil. Hence power lost to overcome friction between mating parts of the engine is reduced. So, the energy saved by decreased friction horsepower additional contribution towards useful energy, cooling losses and exhaust losses. The exhaust gas temperature decreased with increasing coconut oil blends. The exhaust temperature is lower because oxidation of hydrocarbons is occurring during the expansion stroke rather than in the exhaust. Hence, a positive sign glow in this method (Karim and Ward 2003).

The trend of the efficiency curve improved for preheated fuel from 100% diesel to 100% coconut oil. Optimum performance was obtained for 100% coconut oil, whereas, for blended coconut oil without heater it is only 40%. So preheating increases the efficiency as a whole and it is more than non-preheated biodiesel. When the blending ratio was increased more than 50% it starts decreasing. The possible reason for increased thermal efficiency could be the reduction in viscosity of injected fuel and shortened physical delay of combustion. Preheated fuel improves spray characteristics due to proper mixing with air and hence the physical delay is reduced (Heywood 1988).

Properties	Fuel blend									
	100%	100%	Diesel + Percentage coconut oil methyl ester							
	Diesel	Coconut oil	10	20	30	40	50	60	80	100
Cal value kj/kg	42500	37260	41976	41452	40928	40404	39880	39356	39128	39312
Specific gravity	0.83	0.918	0.838	0.847	0.856	0.865	0.874	0.882	0.891	0.893
Flash point	56	260	101	110	121	125	132	139	152	161
Cetane number	52	37	49	47	46	44	44			
K.Viscosity,Cst 40˚C	3.60	26.22	3.70	3.93	4.70	4.80	4.89	4.92	5.18	5.30

Table 2. Comparison of Properties of Coconut Oil and Diesel

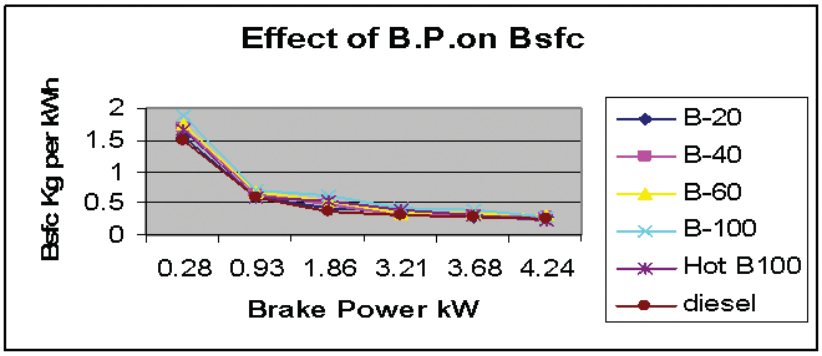


Figure 2. Effect of power on BSFC

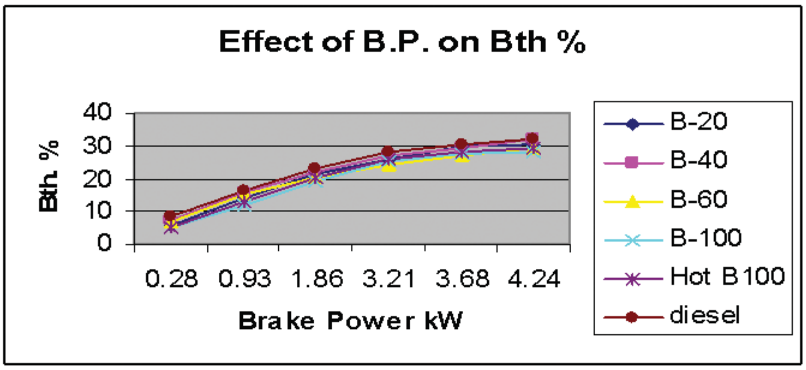


Figure 3. Effect of Power on Bth%

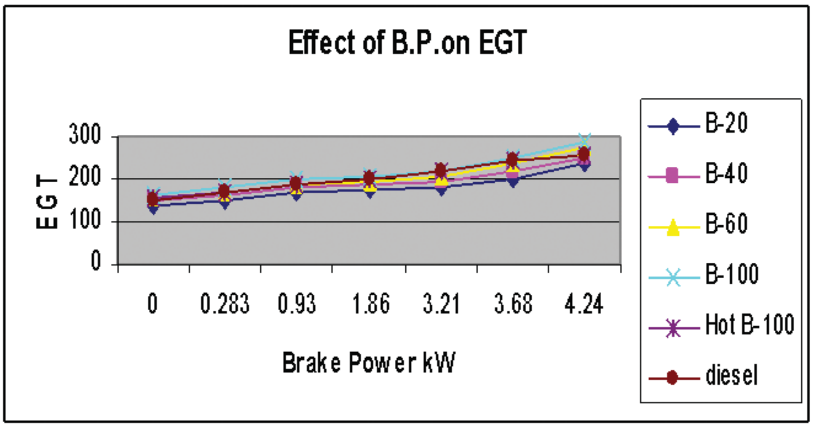


Figure 4. Effect of Power on Exhaust Gas Temperature

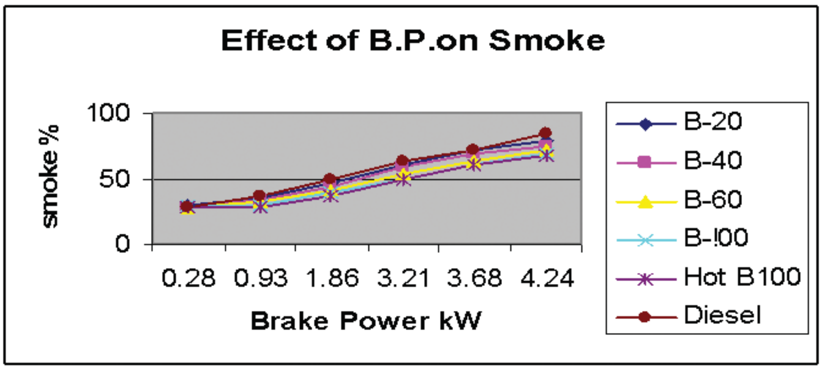


Figure 5. Effect of Power on Smoke

Results and Discussion

Based on experimental data it is observed that with respect to brake power, there is variation in Exhaust gas temperature, brake thermal efficiency, specific fuel consumption, and exhaust smoke emissions.

Figure 2 shows the variation of brake specific fuel consumption (BSFC) with brake power. It shows that the BSFC for blends B100 (100% biodiesel, 0% diesel), B60 (60% biodiesel, 40% diesel), and B40 (40% biodiesel, 60% diesel), are higher than base line diesel fuel. The higher BSFC values in case of vegetable oil esters and its blends can be attributed to the slightly higher density and lower energy content. It is observed that BFSC is lower for hot B100 blend and comparable with base diesel fuel.

Figure 3 shows the variation of brake thermal efficiency (Bth) with brake power for coconut oil methyl ester and its blends. For all the blends the Bth increases with increase in load. Among all the blends B20, B40, B60, B100. The B40 has maximum brake thermal efficiency; i.e., 32.06% at full load. The efficiency for B40 has lower brake thermal efficiency by 1.70% when compared to base diesel fuel.

Figure 4 shows the variation of exhaust gas temperature of the various blends at different power conditions. Maximum gas temperature obtained as the proportion of coconut oil blend increases it shows that as the percentage of coconut oil increases complete combustion of fuel takes place as it provides more oxygen for burning. Exhaust gas temperature of Heated B-100 blend are very close to diesel fuel.

Figure 5 shows the variation of exhaust smoke with variation of brake power for coconut oil methyl ester and its blends here is decrease in the exhaust smoke at all loads for all the blends. The decrease in smoke for hot B100 may be due to more heat being liberated due to better combustion through better fuel atomization in the combustion chamber. This would have resulted in higher heat in the exhaust.

Conclusions

- B100 has Brake thermal efficiency 4.05% lower and heated B100 fuel blend has 2.84% lower than diesel respectively, 1.21% Increase in the break thermal efficiency observed at all loads for heated B100 blend as compared to B100 blend.
- Brake specific fuel consumption for B100 is higher at all loads and Lower for heated B100 blend.
- Decreasessmokedrasticallyastheproportion of coconut oil in blend increases.

- Based on the exhaustive engine tests, it can be concluded that coconut oil can be adapted as additive fuel for the existing bio diesel engine without major modifications. Preheated (100%) coconut oil blends were found to be better in terms of both emission and performance. Without preheating 20% coconut oil blends gave optimum results, but SFC and emissions were higher than those of preheated blends. With respect to the cost analysis, even though the cost of coconut oil is higher than that of diesel, under emission management scenario, this is a least cost alternative to the existing system.

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