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Performance of a Diesel Engine run with Mustard-Kerosene blends

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Abstract

Increasing oil prices and global warming activates the research and development of substitute energy resources to maintain economic development. The methyl esters of vegetable oil, known as biodiesel are becoming popular because of their low ecological effect and potential as a green substitute for compression ignition engine. Diesel engines are more efficient and cost-effective than other engines. Vegetable oils can be used in the diesel engine by pure form or by trans-esterified form. In this paper pure mustard oil blending with kerosene at different proportion like m20, m30, m40, m50 and M100 (pure mustard) has been used in different load condition in 4 stroke single cylinder diesel engine mounted on a hydraulic dynamometer bed. Physical properties of different blend like heating value, density, viscosity, flash point and fire point has been determined before engine testing. The engine data was taken applying load from 6 kg to 15 kg at constant rpm 2000.From this study we find that among , the blends m20 and m30 has the minimum bsfc 257.94 gm/kw-hr at 12.5 kg load & 269.67gm/kw-hr at 12.5 kg load condition respectively. Hence m20 can beconsidered as suitable blend for mustard blending with kerosene for diesel engine .

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Keywords: Bio-diesel, Blend of bio-diesel, Mustard, bsfc, bhp.

1. Introduction

Due to gradual depletion of world petroleum reserves and the impact of environmental pollution there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, vegetable oil is a promising alternative because it is renewable, environment friendly and produced easily in rural areas, where there is an acute need for modern form of energy [1-2].

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In recent year's systematic effort have been made by several research workers to use as fuel engines. It is said that energy consumption pattern is an indicator of the socio-economic development of a country. It is also a measure of the quality of life. Energy consumption is growing day by day along with technological development of a country [3-4]. Although the industrialized and developed world consumes most of the energy resources, the demand of energy in the developing world has also increased in recent decades due to their economic take off and sustainability [5-6]. Internal combustion (IC) engines are widely employed in many development activities using a greater portion worlds energy resources .From the very beginning, the IC engines are being fuelled mostly by petroleum products like petrol and diesel. IC engines use only a small fraction of distillation products of crude oils [7-8]. These crude oils have limited reserves. Any shortfall of petroleum fuels in the world market will therefore have a great impact on the economy of non-oil third world countries. Vegetable oils from crops such as Soyabean, Peanut, Sunflower, Rape, Coconut, Karanja, Neem, Mustard Jatropha, linseed and Coster have been evaluated in many parts of the world in comparison with other non-edible oils [9-10]. Different countries are looking for different vegetable oils depending on their climate and soil condition. As for example Soyabean oil in USA, rapeseed oil and sunflower in Europe, Olive oil in Spain, palm oil in south east Asia, mainly in Malaysia and Indonesia, coconut oil in Philippines are considered to substitute diesel fuel [11]. Different researchers results show that vegetables oils are promising alternative fuels for CI engine. In view of growing energy demand of our country it is thus reasonable to examine the use of Mustard Oil as a substitute fuel for IC engine [12].

2.1. Problems of using straight vegetable oil in diesel engine

Most natural fats contain a complex mixture of individual triglycerides; because of this, they melt over a broad range of temperatures. Most vegetable oils have a range of boiling and melting temperature rather than a specified one. Straight vegetable oil (SVO) has comparatively higher density & viscosity than fossil fuels. Higher viscosity and higher density limit the use of vegetable oils directly into diesel engine cylinder. Problems associated using straight vegetable oil (SVO) in diesel engine can be classified in two groups, namely: operational and durability problems. Operation problems are related to starting ability, ignition, combustion and performance. Durability problems are related to deposit formation, carbonization of injection tip, ring sticking and lubrication oil dilution [13].

2.2. Overcome of the problems

First point blending, cracking/pyrolysis, emulsification or trans-esterification of vegetable oil may overcome these problems. Heating and blending of vegetable oil with fossil diesel also reduces viscosity and improve volatility of vegetable oil but its molecular structure remains unchanged; hence poly-unsaturated character remains. Blending of vegetable oil with diesel at diffrent proportion like 20%, 30% etc. however reduces the viscosity drastically and the fuel handling system of engine can handle the vegetable oil diesel blends without any problems. Preheating is required to such a temperature to attain the viscosity comparable to diesel fuel and then the oil can be introduced into the engine following direct or indirect injection system. It has been experienced that vegetable oil has the advantage of miscibility with diesel or kerosene and the blended fuels do not change the quality of solution for a long time at any mixed ratio. Thus a solution can be prepared by blending vegetables oils with either diesel or kerosene to reduce the viscosity thereby making the oils suitable for engine operation. This blend can be introduced into the engine where a partial substitution is possible. Vegetable oil when mixed with methanol or ethanol in presence of a catalyst (Usually sodium or potassium hydroxide) at about 50^0C, glycerol is replaced and an ester is formed –where fatty acids do not create problems in respect of instauration. This method of fuel modification improves fuel properties to meet the requirement of diesel engine, especially the low viscosity and high cetane number requirements. Another method of using a single vegetable oil is to make emulsion with a certain percentage of water immediately before injection but this technique requires some engine modifications for making emulsions. Using a single vegetable oil in diesel engine a long ignition delay is experienced having its high Self Ignition Temperature (SIT). Addition of enhancer with the oil before introducing into engine reduces the ignition delay and gives better engine performance [14].

3. Physical properties of mustard and its blends

In this experiment pure mustard oil is blended with the kerosene at 20%, 30%, 40% and 50% by volumetrically.These blends are named as m20, m30, m40, m50 and M100 (pure musatrd). The physical properties of these blends i.e density ,viscosity,heating value,flash point and fire point were determined in the fuel testing laboratory. Density of fuel at different temperatures were measured by a standard 25 ml marked flask. Viscosities of fuels were measured as per ASTM standard D88-56 [15] using saybolt viscometer and accessories. Heating values of fuels used in this research were measured experimentally following ASTM standard D240-87 [16] using an oxygen bomb calorimeter. Flash point and fire point of test fuels were measured as per ASTM standard D93-85 [17] using Pensky-Martens closed tester.

Table 1. Physical properties at room temperature (22 ºC)

Blends	Calorofic value (MJ/Kg)	Density (kg/m^3)	Viscosity (mm^2/sec)	Flash point (°C)	Fire Point (°C)
m20	42.8	837.00	2.68	45	55
m30	40.5	855.00	4.45	50	60
m40	38	863.00	6.86	55	70
m50	35.96	871.84	9.16	65	80
M100	32.43	934.00	63.4	310	350
D100	44.80	836.96	3.96	72	90

4. Engine performance study

The blends m20, m30, m40, m50 and M100 are tested in a single Cylinder 4 stroke diesel engine at various load.The loads were applied through a water brake dynamoter from 6 kg to 15 kg. The brake power (BP), brake specefic fuel consumption (BSFC), brake thermal efficiency (BTE) and brake mean effective presure (BMEP) were calculated against the applied loads. All data were derated as per **BS5514** standards. The specification of the engine & dynamometer are given in table 2.

Table 2. Specification of the engine & dynamometer

Engine		Dynamometer	
Model	S 195 G	Model	TFJ-250L
Method of starting	Hand starting	Max. braking horsepower (PS)	250
type	Single Cylinder, Horizontal, Four- stroke,	Revolutions at max. braking horsepower point (rpm)	2500-5500
Cylinder dia	95 mm	Max. braking torque (kg.m)	71.6
Piston stroke	115 mm	Max. revolutions (rpm)	5500
Nominal speed	2000 rpm	Max^m braking water quantity (Lit/min.)	75
Rated power	9.00 KW	GD (Kg. m^2)	0.25
Cooling system	Water Cooling Evaporative	Main bearings	Ball and roller bearings drip-feed lubricated
Fuel Injection Pressure (MPa)	12.75+/-0.5 kgf/cm^2	Weight(Kg)	575 kg

5. Engine Performance analysis

Fig: 1 shows the variation of BSFC with BP for different bio-fuel blends with kerosene. The curve shows that bsfc is higher at low load and decreases with the increase of load upto 12 kg after that bsfc increased again. From graph it is evident that the bsfc of pure mustard M100 is the highest and the minimum bsfc for diesel fuel D100. This is mainly due to the relationship among volumetric fuel injection system, specific gravity, viscosity, and heating value of the fuel. As a result, more biodiesel blend is needed to produce the same amount of energy due to its higher density and lower heating value in comparison to conventional diesel fuel. Again as biodiesel blends have different viscosity, so biodiesel causes poor atomization and mixture formation and thus increases the fuel consumption rate to maintain the power.The curve for pure mustard is always higher than the other blends in all load condition.Besides, The curve for the diesel fuel is lower than all blends.The minimum bsfc is obtained for D100 (232.57 gm/kw-hr) at 12 kg load . The second minimum bsfc obtained for m20 is 257.94 gm/kw-hr at 12.5 kg load. The minimum bsfc obtained for blends m30, m40, m50 and M100 are 269.67gm/kw-hr, 292.49 gm/kw-hr, 370.53 gm/kw-hr, and 525.69 gm/kw-hr respectively. The bsfc is a measure of overall efficiency of the engine. It is also inversely proportional to the thermal efficiency. So the lower value of bsfc indicates the higher of overall efficiency of the engine. The second minimum bsfc obtained for m20 is 257.94 gm/kw-hr at 12.5 kg load. The bsfc is a measure of overall efficiency of the engine. It is also inversely proportional to the thermal efficiency. So the lower value of bsfc indicates the higher of overall efficiency of the engine.

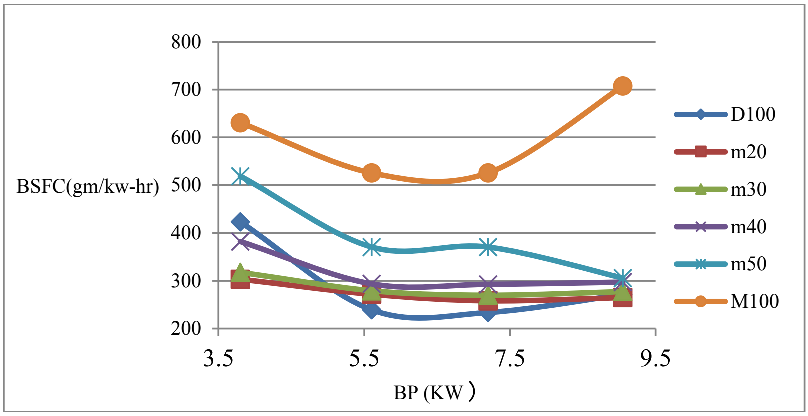

Fig: 1. Variation of BSFC with BP for kerosene blend

Fig:2 shows the relation in between BP and BTE for different blends of mustard with kerosene. The brake thermal efficiency of the pure mustard oil (M100) is lower than all other blends in all load condition. The maximum brake thermal efficiency efficiency found for the blends D100,m20,m30,m40,m50 and M100 are 35.03%, 32.61%, 32.96%, 32.38%, 32.76% and 21.11% respectively.The lowest brake thermal efficiency is 21.11 % at 12 kg load for pure mustard oil and the highest brake thermal efficiency for D100 i.e pure diesel fuel at 35.03% at 12 kg load.

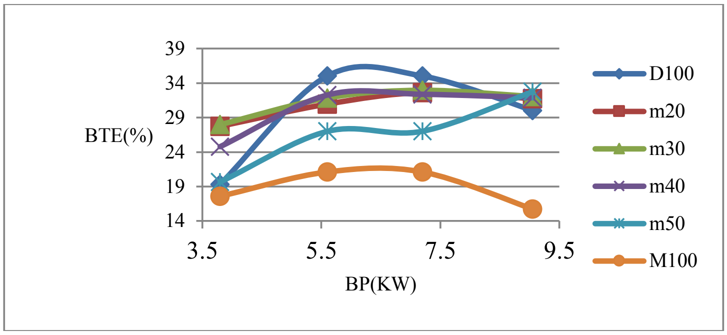

Fig: 2 .Variation of break thermal efficiency with BP

Fig: 3. depicts about variation in exhaust gas temperature with BP for different blends of kerosene. The exhaust gas temperature increases with the increase of load .Pure diesel shows the lowest exhaust gas temperature in lower load condition and shows the highest exhaus gas temperature at the higher load condition. But at middle load condition i.e. 9 to 12 kg M100 shows the highest exhaust gas temperature. Except pure mustard oil all other blends shows the similar characteristics. At starting condition, higher exhaust gas temperature but low power output for biodiesel blends indicate late burning to the high proportion of biodiesel. This would increase the heat loss, making the combustion a less efficient.

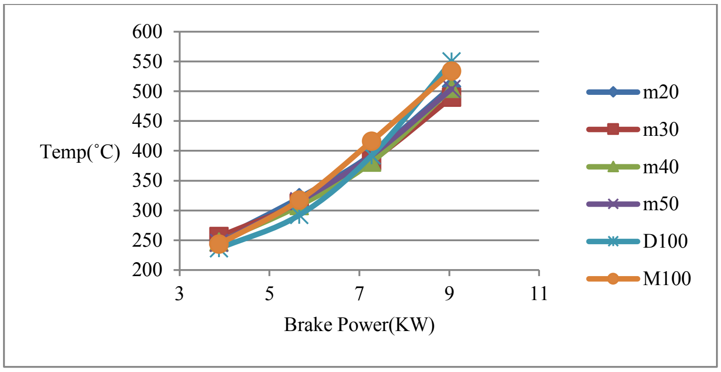

Fig: 3. Variation of exhaust gas temperature with BP

Fig:4 shows the relation in between lube oil temperature and BP for different bio-fuel blends. The lube oil temperature increases with the increase of engine load, and higher lube oil temperature found for pure diesel at all load condition than any other blends. But for pure mustard oil, lube oil temperature becomes the lowest at all load condition because of its more lubricity property.Besides, m50,m40,m30 and m20 shows gradually higher lub oil temperature than M100.

Fig: 5. shows the variation of bmep for different bio-fuel blends with BP.The mean effective pressure is the average pressure developed on the piston head over a cycle in the combustion chamber of the engine which measures the capacity of the engine to do work. A little variation of mean effective pressure has been observed during the experiment for each blend. The bmep gradually increases with the increase of engine load and the highest bmep was obtained at 15 kg load for each blends. The regular shape of the curve indicates that the proper combustion has done in the combustion chamber of the fuel.

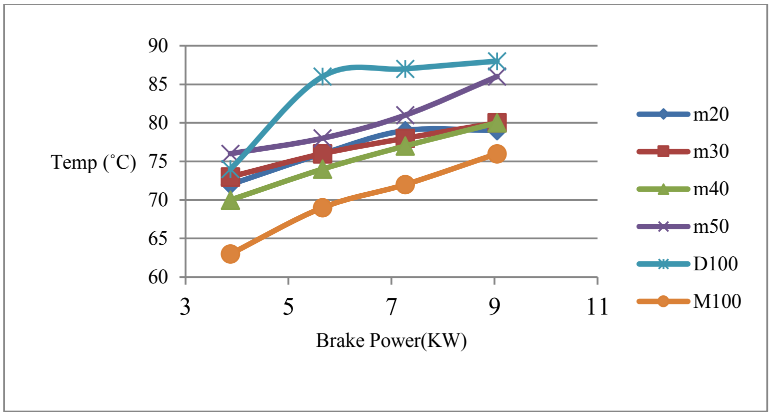

Fig: 4. Variation of lub oil temperature with BP

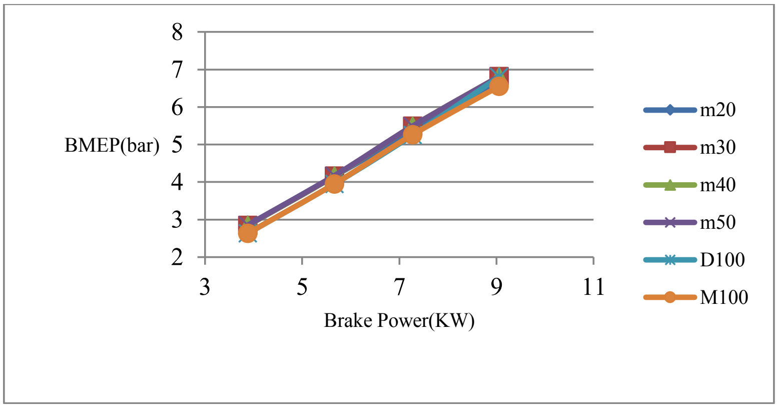

Fig: 5.Variation of brake mean effective pressure with BP

6. Discussion:

Fuel consumption for pure mustard (M100) is higher and lower the brake thermal efficiency than all other blends in all load condition (bsfc 525.69 gm/kw-hr & bte 21%).This is because lower calorofic value of pure musatrd oil than the diesel fuel as needs more fuel to generate same power of diesel. The bsfc increase with the increase of musatard oil percentage with the kerosene.The bsfc also increase with increase of load. For different blends with different heating values, the bsfc values are misleading and hence brake thermal efficiency is employed when the engines are fueled with different types of fuels.The maximum brake thermal efficiency obtained for m30 (32.96%). The bsfc and brake thermal efficiency of blends m20, m40 & m50 (32.61%, 32.38%, 32.76%) are also close to m30 this is because higher calorific value of kerosene.Higher exhaust gas temperature but low power output for pure mustard oil and biofuel blends due to late burning of fuels.Pure mustard oil and biofuel blends shows lower lub-oil temperature due to lubricity property of mustard oil.

7. Conclusion:

- Heating value of the mustard oil (32 MJ/Kg) is much lower than the diesel and kerosene blend (Heating value of diesel and kerosene is 44 MJ/Kg and 46 MJ/Kg). So when mustard oil is used in a diesel engine reduce the power output of the engine. The calorific value of blend m20 and m30 are very close diesel fuel.

- High viscosity is identified as a main problem of using the considered mustard oil directly in diesel engine. However, when this oil is volumetrically blended with kerosene; gives viscosity values very close to diesel fuel that required by the diesel engine. Therefore, 20% to 30% mustard oil can be blended with kerosene as substitute fuel of diesel.
- While Mustard is blended with kerosene found that the bsfc of m20 and m30 are 257.94 gm/kw-hr at 12.5 kg load & 269.67 gm/kw-hr at the same load condition which are close to standard consumption of diesel fuel (233.51 gm/kw-hr) in this engine. Hence, m20 and m30 can be considered as suitable fuel for the diesel engine.
- The bsfc and brake thermal efficiency of the other blends m40 & m50 are also close to m20 but the viscosity and density are higher which is problem for smooth engine running.
- From the overall observation it can be concluded that mustard oil could be a potential substitute for diesel fuel with a little sacrifice of power and efficiency.
- Since mustard oil has extremely limited use at present, its production for use in diesel engine will not only enable the country to attain self reliance but also help mitigate the conventional fuel crisis.

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