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Performance Test of a Diesel Engine with Different Esters of Alternative Fuel

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Abstract

Vegetable oil as a biomass energy can be considered as possible alternative fuel. At present the world is highly dependent on petroleum fuels for generating power, vehicle movement, agriculture and domestic useable machinery operations and for running different industries. Thus the demand of the petroleum fuel increases simultaneously. However the reserve of the petroleum fuel is limited. As a result, attention has gone to the search of renewable source of fuel which can meet the demand. The present experimental study reports the performance characteristics of a diesel engine by using methyl esters of neem oil and methyl esters of sunflower oil in comparison to 100% diesel operation. The properties of esterified vegetable oil are almost similar with the diesel fuel. The thermal efficiency curves for both diesel and esterified oils are comparable as well. However, the maximum value of thermal efficiency of esterified oils is slightly less than diesel fuel. Both oils perform as fuels for diesel engine with acceptable BSFC. Volumetric efficiency is continuously decreased with increasing RPM for both diesel and biodiesel. Cylinder wall temperature is a considerable factor for this case. Exhaust gas temperature of vegetable oil is lower than diesel fuel because of incomplete combustion. These two promising options of alternative fuel can be investigated further as potential substitute of diesel.

1. Introduction

The use of vegetable oil as fuel for diesel engine is not new Dr. Rudolph Diesel used peanut oil to fuel one of his engines at Paris exposition of 1900 [1,2]. After the second world war the limited resource of conventional fuels high price and energy crisis have sent the scientists worldwide scrambling on a search of alternative fuels [3]. After the 1973 oil embargo, it was very important to study the alternative sources of fuel diesel engines because of the concern over the availability and price of petroleum based fuels the present source of fuels used in IC engine and diesel will deplete within about 30 years if consumed at the same rate what is currently going on. For this reason researchers are undertaking research pertinent to several renewable sources of energy including biodiesel. There are several possible alternative source of fuels, for example, vegetable oils, alchohols such as methanol & ethanol; hydrocarbon gases such as CNG LPG hydrogen producer gas etc. [4] Among them, vegetable oils present a very promising alternative to diesel oil since they are renewable and one produced easily in rural areas where there is an acute need for modern forms of energy . In Bangladesh diesel is primarily used for transportation agriculture and electric power generation. Diesel is becoming scarce and costlier and hence there is a need to preserve diesel for only automotive and agriculture uses. Sustaining this demand country has to face a big amount of import bill for crude oil in this case alternative fuels provide a new dimension in the fuel technology.

This choice of the vegetable oil for diesel engine fuel naturally depends upon the local conditions. And the production of vegetable oil is very simple and in mainly agricultural country as ours it can be made quite economically [4]. The auto ignition properties of vegetable oils are almost the same as those of diesel fuels and hence can be used in diesel engines with little or no engine with little or no engine modification [5]. However some problems are associated with we use vegetable oil as alternative fuels in diesel engine. These problems can be minimizes by various ways and the process of esterification is best among those as it is more suitable than other process. Methyl alcohol and NaOH is used for the esterification process. Srinivasa and Krisna (1991)

reported that vegetable oil present a very promising alternating to diesel oil since they are renewable and are produced easily in rural areas where there is an acute need for modern forms of energy. A number of oils are being considered worldwide for using engine. The vegetable oil tested were Karanji oil (Pongamia Glabra), pithraj, rice bran oil and plam oil on a single cylinder diesel engine. The inherent properties of vegetable oils make them suitable for use in Cl engine. Nabi et al (2009) prepared biodiesel from non-edible renewable karanja (Pongamia Pinnata) oil, determined properties and investigated influence of biodiesel on engine performance and emissions. Engine experiment result showed that all biodiesel blends reduced engine emissions including carbon monoxide (CO), smoke and engine noise, but increased oxides of nitrogen (NOx) [6]. They also extended their work by using Pitraj *(*Aphanamixis polystachya*)* in diesel engine successfully in 2010 [7].

However for longer use Methyl esters are preferable because of their lower viscosity and lower smoking tendency. The smoke emission with methyl esters is a little higher than with diesel oil but here again optimized injection timing could reduce the smoke emission foresters. Bari & Roy [8] explained that the properties of rice barn oil as a fuel are determined experimentally and it is observed that the properties of rice bran oil acceptable to use in diesel engine except viscosity. Because of high viscosity rice bran oil cannot be directly used in the engine at normal temperature (20^0 to30^0 C) However it is established here that rice bran oil can be used in the engine even at normal temperature if kerosene is blended with it. Alternatively preheating of the oil overcomes the difficulty of high viscosity and can be used directly in the engine. In this work rice bran oil was blended with kerosene and the mixture was used to test the performance of a four stroke diesel engine. The test result leads to the conclusion that rice bran oil can be a very prospective substitute of diesel fuel. Ludwig Elsbett and workers:[9]: shows in their paper Economic and environmental aspects of different liquid fuels are discussed with particular emphasis on vegetable oil as a future form of solar fuel. A presentation is given of a DI diesel engine running on vegetable oil and the advantages of vegetable oil in combination with this engine compared to engines running on diesel fuels. Vegetable oil does not require additional energy for processing nevertheless a costly proposal was made to esterize vegetable oils with methanol using sodium as a catalyzer producing glycerin as methyl ester is a poisonous substance very aggressive to many materials such a proposal does not offer any advantages as there is no need for important qualities of glycerin anyhow and methanol can only be produced with considerable energy inputs.

In the present investigation Methyl ester of neem & Methyl ester of sunflower is used as both of them can be grow as domestic field in Bangladesh. Test was conducted with Methyl esters of both fuels in a DI diesel engine to compare the performance with diesel fuel.

2. Methodology

In this work, laboratory quantities of vegetable oils were sampled from local areas nearby Rajshahi, Bangladesh and processed to methyl esters. Sunflower oil is chosen as edible oil while Neem is chosen as in edible to compare with diesel fuel. Basic reaction for transterification process is shown in figure 1. Firstly, NaOH is mixed with methanol to produce sodium methoxide, then this sodium methoxide is poured and vigorously mixed with vegetable oil. The temperature of the mixture is kept constant (500^0C) until the reaction is completed. Now biodiesel is separated from the mixture and washed by water. Waste oil is treated before conversion into biodiesel to remove impurities.

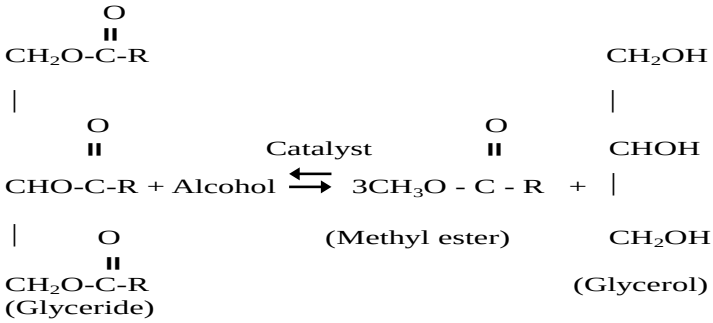

Figure 1: Transesterification reaction

A four-stroke single cylinder (specification shown in table-1) naturally aspirated stationary DI diesel engine is used. All experimental data are taken after 30 minutes of engine start after which the exhaust line temperature is no further increased i.e. constant and there is almost no fluctuation of emissions. This condition of the engine is chosen because of the consistent data at this condition. Tests are carried out at the warmed up condition of the engine at different engine loadings and at 700-1200 rpm. Loads are measured by electric dynamometer. The diesel fuel used in this study is No. 2 diesel fuel with a lower calorific value of 43000 kJ/kg and cetane number of 50.

Table 1: Engine specifications

Engine type	4-stroke DI diesel engine
Number of cylinders	One
Bore × Stroke	80 × 110 mm
Swept volume	553 cc
Compression ratio	16.5:1
Rated power	4.476 kW @ 1800 r/min
Fuel injection pressure	14 MPa (900-1099 r/min) 20 MPa (1100-2000 r/min)
Fuel injection timing	24° BTDC

3. Results and discussion:

The physical characteristics of vegetable oil esters are closer to those of diesel oil the comparison of this characteristic with of diesel and vegetable oil was shown below:

Table 2: Comparison of esterified vegetables oil with diesel

Esterified Oil	Calorific value (Kcal/kg)	Viscosity (Centipoise)	Specific gravity (gm/ml)
Methyl ester of neem	8450	42.5	0.865
Methyl ester of Sunflower	8600	29.25	0.887
Diesel oil	10200	5.5	0.84

As shown in the table, calorific value of both sunflower and neem were very close to diesel. Normally vegetable oils show higher density and viscosity than diesel and higher in this case density values were found near the diesel but viscosity was considerable amount higher than the base diesel. A very positive gain by esterification process is the high cetane number of esters is in the range of 50 and above indicated their superiority.

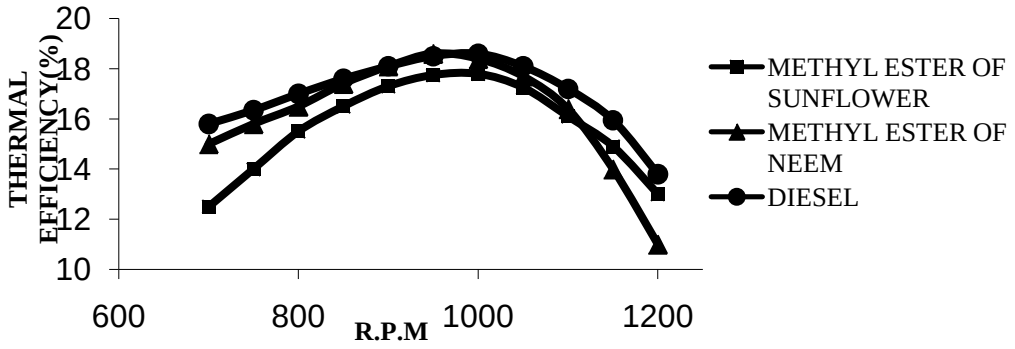

Figure 1: RPM VS Thermal efficiency

The experimental results, in all the cases the performances of the engine with esterified vegetable oils were compared with the diesel oil operation. The variations of thermal efficiency of the selected diesel engine with diesel fuel and methyl esters are shown in figure 1 for comparison. The thermal efficiency with all the three fuels was found very close to one another. The esterification improves cetane number, reduced viscosity and changes chemical structure of the vegetable oil which is desirable for diesel engine [10] hence, the thermal efficiency of the esterified oil is improved. Thermal efficiency for esterified vegetable oil is lower than diesel oil must be attributed to lower calorific value and poor velocity.

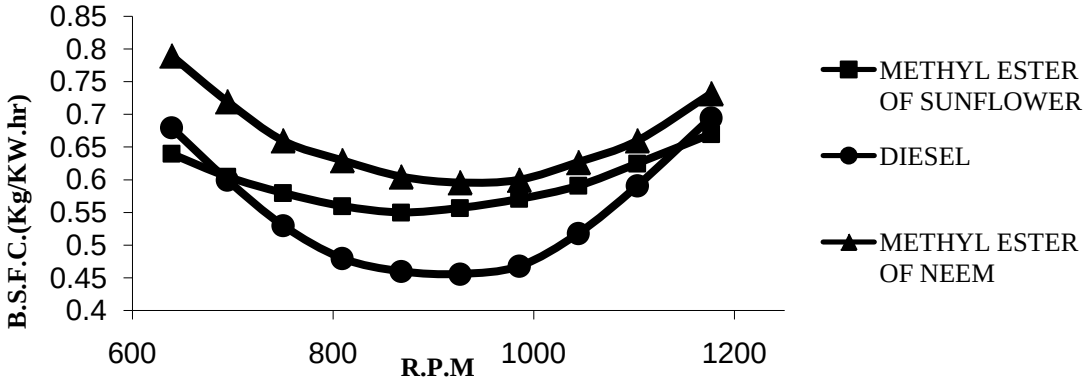

Figure 2: RPM VS B.S.F.C

Figure 2 flaunts the BSFC comparison of diesel oil with esterified sunflower and neem oil in respect to RPM. BSFC was found to reduce with respect to increasing thermal efficiency or vice versa with the increasing of rpm but increased after 1000 RPM. BSFC for esterified vegetable oil was slightly higher than diesel oil.

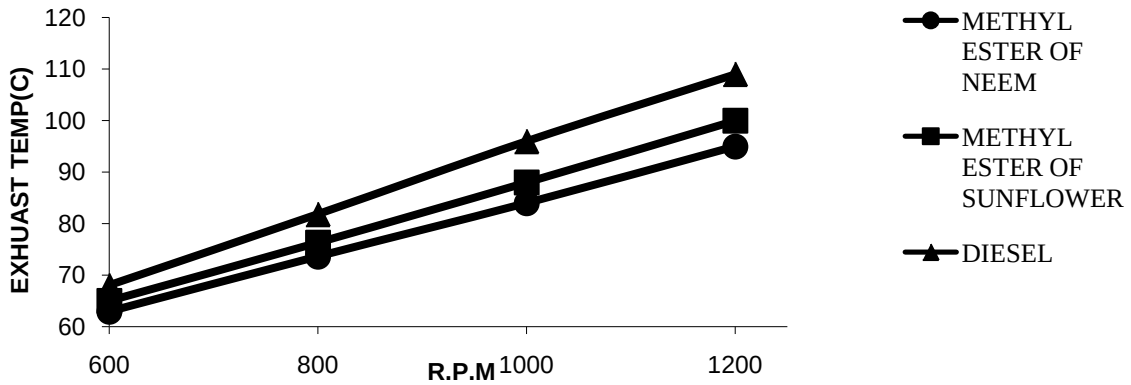

Figure 3: RPM VS Exhaust gas temperature

Variation of the exhaust gas temperature with respect to rpm (Fig. 3) indicates that vegetables oil produce lower exhaust temperature compare to reference diesel. BSFC for the esterified vegetable oil was higher than diesel oil but thermal efficiency was not as high as diesel oil. So this condition indicates the incomplete combustion when esterified vegetable oil is used. For this reason exhaust gas temperature of esterified vegetable oil is low.

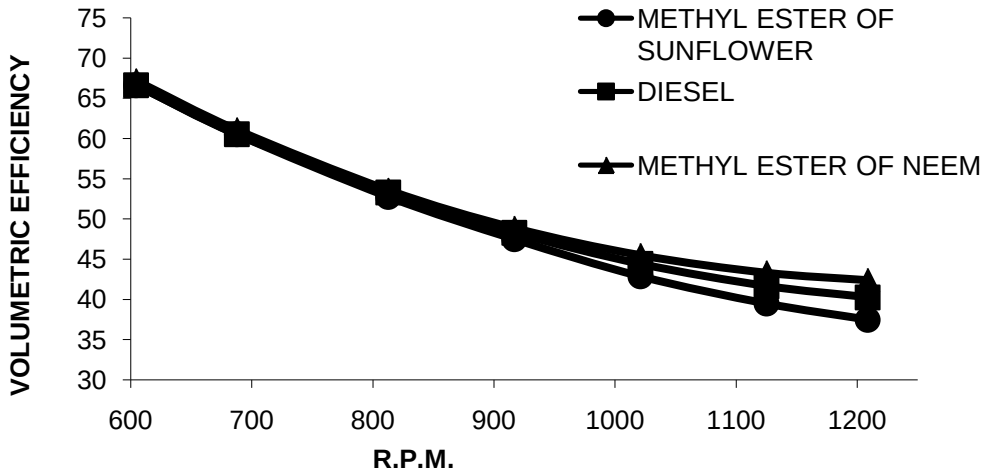

Figure 4: RPM Vs Volumetric efficiency

The variations of volumetric efficiency with rpm are illustrated by figure 4. Volumetric efficiency for esterified vegetable oil was slightly lower than diesel oil. Volumetric efficiency intermittently decreased with respect to increasing rpm. Cylinder wall temperature was ascending when rpm and for this reason less density of air induced in the cylinder consequently volumetric efficiency diminished.

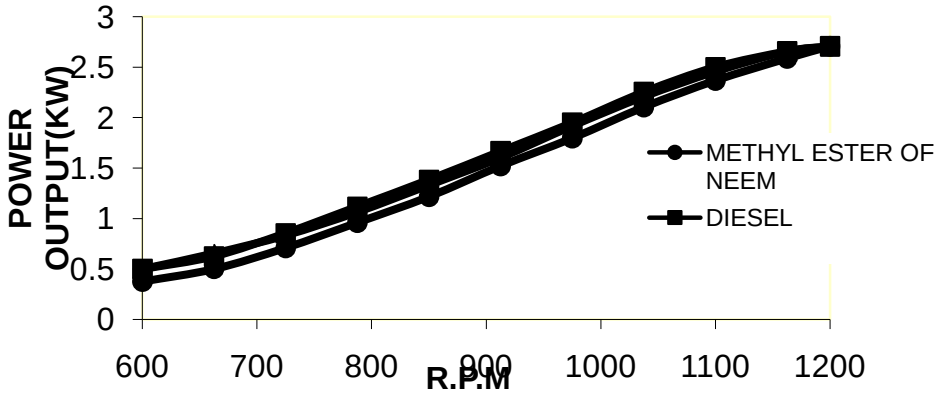

Figure 5: RPM Vs Power output

Figure 5 shows the variation of power output with rpm. Power increases with respect to increasing rpm. Higher rpm consume higher amount of fuel at the same time energy release rate is high which causes increases power output.

4. Conclusions

The following conclusions can be drawn from the study:

i) The properties of esterified vegetable oil are comparable with the diesel fuel
ii) The thermal efficiency curves for both diesel and esterified oils are comparable though the maximum value of thermal efficiency of esterified oils are slightly less than diesel fuel at 950RPM

iii) Both esterified sunflower and esterified neem oil perform as fuels for diesel engine with acceptable BSFC, the BSFC of esterified vegetable oils are slightly higher than diesel fuel
iv) Volumetric efficiency of both diesel and esterified vegetable oils are continuously decrease with increasing RPM Cylinder wall temperature is a considerable factor for this case
v) Exhaust gas temperature of vegetable oil is lower than diesel fuel because of incomplete combustion

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