ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering and Technology, Madurai, Tamil Nadu, India

An Experimental Investigation on the Effect of Cetane Improver with Biodiesel in CI Engine

P.R. Ayyappan[1], P.Karthikeyan[2]

[1]Assistant Professor (Senior Grade), Department of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

[2]PG Student, Department of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

ABSTRACT— Biodiesel developed from non-edible oils promise to be a very important prospective alternative fuel for diesel engines in India. Vegetable oil has slightly lower calorific value than diesel fuel. This can be attributed to presence of oxygen in the molecules of vegetable oils. Vegetable oil has cetane number about 35 to 40 depending upon the composition where as diesel fuel has a cetane number around 45. Certain functional groups and poor volatility is responsible for their comparatively low cetane number. Increasing the cetane number of diesel fuel, either by lowering aromatic content of the fuel through hydro treating and by addition of chemical cetane improvers, is a cost-effective option to reduce diesel engine emissions. Jatropha - curcas as a non-edible methyl ester biodiesel fuel source is used to run single cylinder, four-stroke diesel engine. An attempt has been made in this paper to give an overview by comparing its performance and emission characteristics with diesel – biodiesel blend by adding with cetane improver & diesel – biodiesel blend of B50. The blends of Jatropha methyl ester and diesel with EHN could be successfully used in diesel engines without any modification with acceptable performance and better emissions.

KEYWORDS— Biodiesel, Jatropha, Emission

I. INTRODUCTION

The ever increasing number of automobiles has lead to increase in demand of fossil fuels (petroleum). The increasing cost of petroleum is another concern for developing countries as it will increase their import bill. The world is also presently confronted with the twin crisis of fossil fuel depletion and environmental degradation.

Fossil fuels have limited life and the ever increasing cost of these fuels has led to the search of alternative renewable fuels for ensuring energy security and environmental protection. For developing countries fuels of bio-origin can provide a feasible solution to this crisis. Certain edible oils such as cottonseed, palm, sunflower, and rape seed can be used in diesel engines. For longer life of the engines these oils cannot be used straightway. The viscosity (more than 10 times that of diesel fuel) volatility of these vegetable oils is higher that leads to poor fuel atomization and inefficient mixing with air, which contribute to incomplete combustion. Goering et al. (1982) [4], Bagby (1987) [3] and these can be brought down by a process known as "transesterification". Chemically transforming the plant oils to bio-diesel by alcoholysis (trans-esterification) was considered as the most suitable modification because technical properties of esters are nearly similar to diesel. Ma and Hanna (1999) [6], Meher et al. [7] (2006). Through, trans-esterification, plant oils are converted to the alkyl esters of the fatty acids present in the oil. Lang et al. [5] (2001), Ramadhas et al. [9] (2005). Biodiesel has a higher cetane number than petroleum diesel, no aromatics and contains upto 10% oxygen by weight. The characteristics of biodiesel reduce the emissions of carbon monoxide (CO), hydrocarbon (HC) and particulate matter (PM) in the exhaust gas as compared with petroleum diesel. Agarwal, A.K. (2007), Agarwal, D et. Al. (2008) [1, 2]. Pramanik [8] (2003) has investigated the use of Jatropha oil blends with diesel fuel in direct injection diesel engine. It has been reported that 50 % of Jatropha oil blends can be substituted for diesel fuel in CI engine.

It has been reported that the Jatropha oil exhibited higher specific fuel consumption and lower exhaust gas temperatures compared to diesel fuel.

II. EXPERIMENTAL METHODOLOGY

The experimental set-up is illustrated in Fig. 1, which is a single cylinder four stroke, naturally aspirated direct injection and water cooled diesel engine. The specifications of the test engine are given in Table 1.

Table 1 Specification of Diesel Engine

Make	Kirloskar
Rated Brake Power	5 Hp
Rated Speed	1500 rpm
Number of Cylinder	One
Bore	80mm
Stroke	110mm
Cooling System	Water
Starting	Manual
Compression ratio	16.5

The fuel properties were determined and are listed in Table 2, for diesel, Jatropha biodiesel, Jatropha B50 and B50 with EHN.

Table 2 Properties of fuel

Property	Diesel	Jatropha	B50	B50+ EHN
Density (g/cc)	0.832	0.943	0.852	0.847
CV (kJ/kg)	44000	38500	43323	49672
Flash Point (°C)	99	182	94	-
Kinematic Viscosity (Cst)	36.9	5.7	14.6	-
Specific Gravity	0.853	0.848	0.882	-

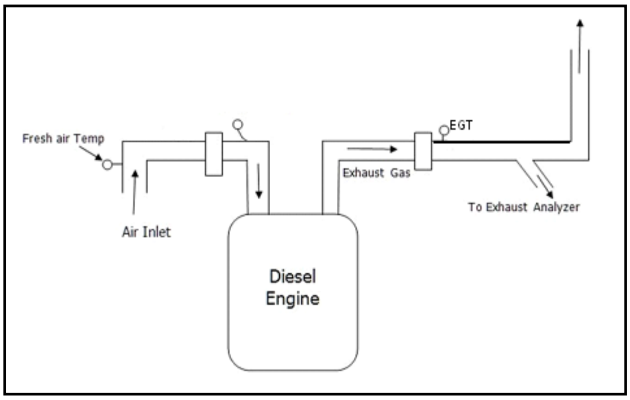

Fig. 1 Experimental setup

The engine was allowed to reach its steady state by running it for about 10 minutes. The engine was sufficiently warmed up and stabilized before taking all readings. After the engine reached the stabilized working condition, the load applied, fuel consumption, brake power and exhaust temperature were measured. The values were recorded thrice and a mean of these was taken for comparison. The engine performance and Exhaust emissions were studied at different loads. The brake specific fuel consumption, brake specific energy consumption and thermal efficiency were calculated. The emissions such as CO, HC, and NOX were measured using exhaust gas analyzer. The engine is operated at constant speed of 1500 r/min.

The first stage of experiment is performed with pure diesel at different loads from no load to full load. The second stage of experiment is conducted using various blends of diesel – biodiesel blend of B50 and B50 with cetane improver EHN (designated as B50EHN). These performance and emission characteristics for different fuels are compared with the result of baseline diesel.

III. RESULTS AND DISCUSSION

The engine was run on different loads to investigate the effect of adding cetane improver with engine performance and emissions. The performance and emission data was analyzed and presented graphically for thermal efficiency, BSFC, exhaust gas temperature, CO, CO_2, HC and NO_x emissions.

A. Performance Analysis

The results obtained from the experimental investigation using diesel and biodiesel fuel of B50 blends with EHN as cetane improver with the load variations are presented in graphical form.

1) Brake Thermal Efficiency: Figure 2 illustrates the variation of BTE at different load by varying the percentage of biodiesel (B50) and by adding the cetane improver with the blend (B50). Brake thermal efficiency increased with increase in load in the engine. This may due to reduction in heat loss and increase in power with increase in load. Maximum brake thermal efficiency was obtained for diesel at full load. At full load the blend (B50) with EHN was slightly lesser than diesel. Jatropha B50 blend shows lesser BTE than diesel at all loads.

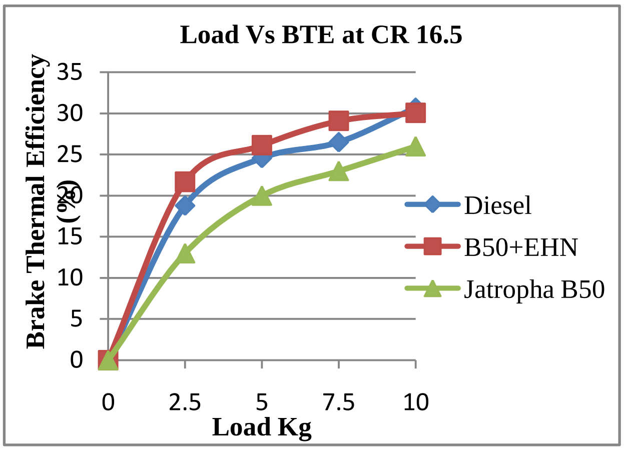

Fig. 2 Effect of variation of Load on BTE

2) Brake specific fuel consumption: The variation of brake specific fuel consumption with load of the engine for diesel, B50+EHN, and jatropha B50 blends is shown in Fig. 3. Brake specific fuel consumption decreased with increase in load of the engine for all fuels. This reduction could be due to higher percentage of increase in brake power with load as compared to fuel consumption. Brake specific fuel consumption for B50+EHN, and jatropha B50 blends varied from 0.7 to 0.34, 0.434 to 0.33 kg/kw-h and was higher than that of diesel fuel (0.459 to 0.3 kg/kW-h) as the load was increased from no load to full load.

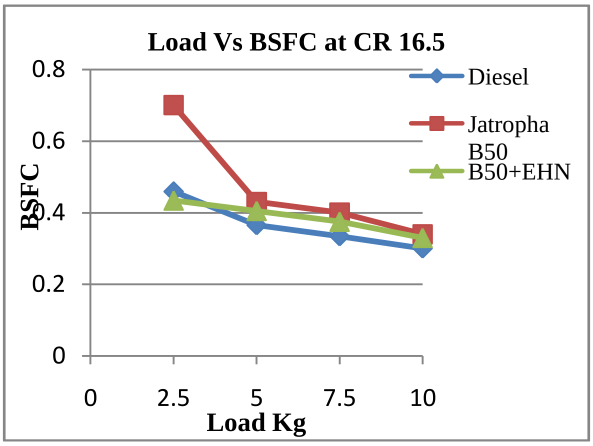

Fig. 3 Effect of variation of Load on BSFC

The increase in brake specific fuel consumption with increase in concentration of blends in diesel fuel is attributed to lower heat values.

3) Exhaust gas temperature: Fig. 4 exhibits the variation of exhaust gas temperature at different loads and fuels. Exhaust gas temperature increased with increase in load on the engine. This may be attributed to increase in quality of fuel injected with the increase in load. The increased quantity of fuel generated greater heat in combustion chamber. Maximum exhaust gas temperature of 375^{o}C was obtained for jatropha B50 blend with EHN at full load. Exhaust gas temperature increased for all fuel types because of pressure rise in combustion chamber and an increase in fuel injection rate with increase in brake load. Secondly, this may due to better utilization of heat released during combustion of fuels and increase in brake thermal efficiency on blended fuels. The addition of cetane improvers reduces the ignition delay which is responsible for reduction of combustion temperatures.

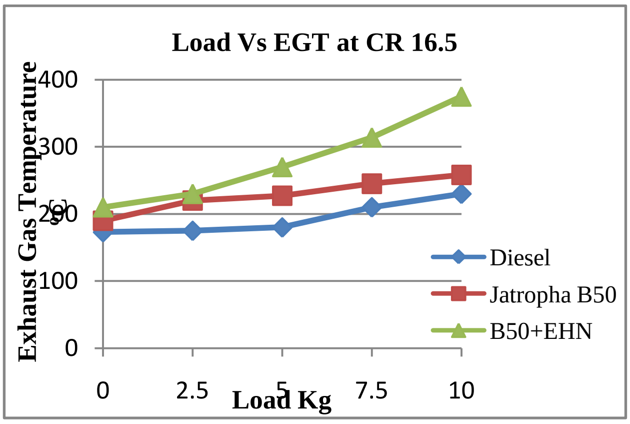

Fig. 4 Variation of exhaust gas temperatures with load of engine for different fuels

B. Exhaust emission analysis

1) CO emissions: Fig. 5 displays the variation of CO emissions with the increase in load. Carbon monoxide emission increased with increase in load of the engine. This may be due to the fact that as the load is increased, the fuel consumption is also proportionately increased and also due to insufficient air in the combustion chamber.

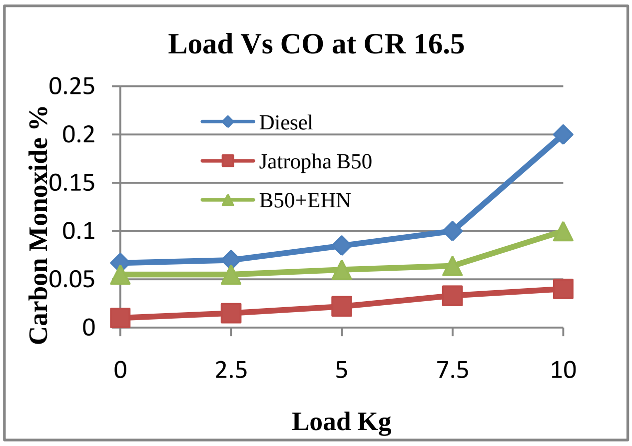

Fig. 5 Variation of CO emission with load of engine for different fuels

There may be incomplete combustion of fuel and hence increased CO. This reduced emission of CO in both jatropha B50 blend and B50 with EHN when compared to diesel at all loads may have resulted due to increased combustion efficiency which is reflected in terms of higher brake thermal efficiency because of presence of the oxygen molecules in the blended fuels. CO concentration in exhaust gas was 0.2, 0.04 and 0.1% at full load for diesel, jatropha B50 and B50 with EHN fuels respectively.

2) CO_2 emissions: Fig. 6 shows the emission levels of CO_2 for different loads. Test measurements reveals that the CO_2 emission for all blends were less as compared to diesel at all loads. The rising trend of CO_2 emission with load is due to the higher fuel entry as the load increases. Biofuels contain lower carbon content as compared to diesel and hence the CO_2 emission in comparatively lower.

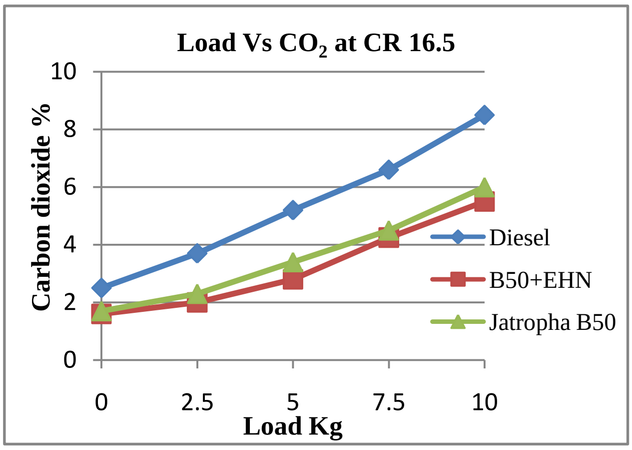

Fig. 6 Variation of CO_2 with respect to loads

3) HC emissions: The HC emission variation for different fuel blends is indicated in Fig. 7. It was observed that the HC emission decreased up to a load of 5 kg and then increased slightly with further increase in load of diesel. The HC emission for the fuel blends also followed a similar trend but comparatively the values are lower. The presence of oxygen in the jatropha oil aids combustion and hence the hydrocarbon emission reduced.

However at higher loads the effects of viscosity have increased these emission levels for the blends.

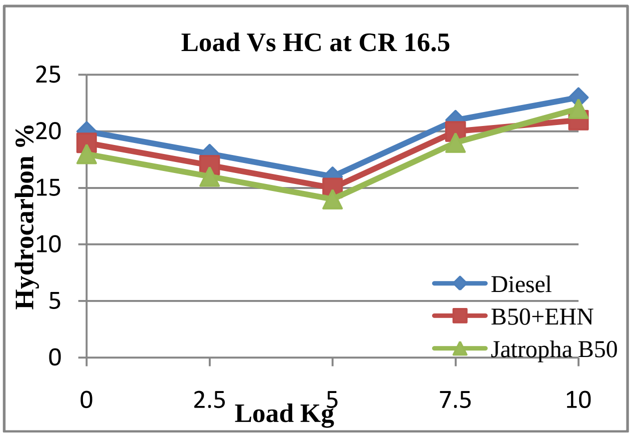

Fig. 7 Variation of Unburned HC with Loads

4) NO_x emissions: The variation of NO_x emission for different fuel blends is indicated in Fig. 8. The NO_x emission for diesel and all the fuel blends followed an increasing trend with respect to load. For the blends an increase in the emission was found at all loads when compared to diesel. NO_x is formed generally at high temperatures. Since the exhaust gas temperatures are higher the NO_x emissions are also higher. Another factor causing the increase in NO_x could be the possibility of higher combustion temperatures arising from improved combustion because larger part of the combustion is completed before TDC for ester blends compared to diesel due to their lower ignition delay. So it is highly possible that higher peak cycle temperatures are reached for ester blends compared to diesel. By adding cetane improver with the blend B50 was found that decreasing NO_x emission while compared to jatropha B50 blend.

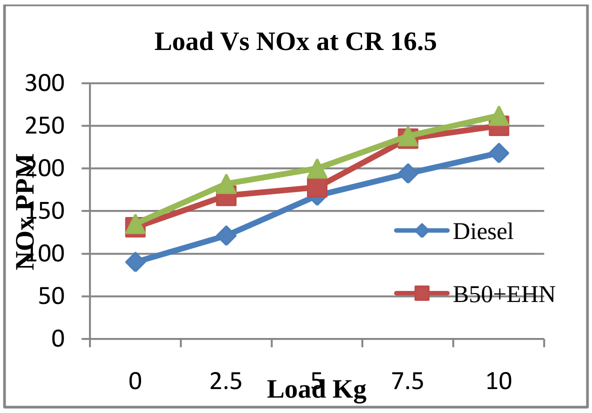

Fig.8 Variation of oxides of Nitrogen with loads

IV. CONCLUSION

Engine performance and emission results of blends of trans esterified jatropha oil blend B50 and B50 with EHN were compared with the results obtained with diesel. The following are the major conclusions that are drawn.

- The Brake thermal efficiency for B50+EHN was higher at full load but slightly lesser than diesel. The BSFC at all loads for all blends shows higher value when compared to diesel.
- The exhaust gas temperatures are higher when compared to diesel at all loads.
- The exhaust emissions such as CO, CO_2, HC are lesser compared to diesel fuel from no load to full load.
- The NOx emission for diesel and all blend fuels shows the increasing trend with respect to the Load of the engine.

Based on the engine performance and also from emission point of view, the blend B50+EHN was comparable and better in some aspects than that of diesel fuel. Hence it is concluded that the CI engine could be operated without affecting the performance of the engine with 50% blending of jatropha methyl ester biodiesel with diesel and EHN.

REFERENCES

[1] Agarwal, A.K. (2007). Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Progress in Energy and Combustion Science, 33(3), 233-271.

[2] Agarwal, D.; Kumar, L.; and Agarwal, A.K. (2008). Performance evaluation of a vegetable oil fuelled compression ignition engine. Renewable energy, 33(6), 1147-1156.

[3] Bagby, M. O. (1987) Vegetable oils for diesel fuel: opportunities for development. ASAE paper no. 87-1588. American Society of Agricultural Engineers, St. Joseph, MI.

[4] Goering, C. E., Schwab, A. W., Daugherty, M. J., Pryde, E. H. and Hezkin, A. J. (1982). Fuel properties of eleven vegetable oils. Transactions of ASAE, 1472-1476.

[5] Lang, X., Dalai, A., Bakhshi, K.., Reaney, M. J. and Hert, P. B .(2001).Preparation and characterization of biodiesels from various bio oils. Bio resouce Technology, 80, 53-62.

[6] Ma, F., and Hanna, M. A. (1999) Bio diesel production: a review. Bio resource Technology , 70, 1-15.

[7] Meher, L. C,. Sagar, D. V., and Naik, S. N. (2006). Technical aspects of biodiesel.

[8] Pramanik, K. (2003). Properties and use of jatropha oil and diesel fuel blends in compression ignition engine. Renewable Energy, 28(2), 239-248.

[9] Ramdas, A. S., Jayaraj, S. and Muraleedhran, C. (2005) Characterization and effects of using rubber seed oil as fuel in compression ignition engines. Renewable Energy, 30, 795-803.