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Effects of Dual-Fuel at Different Engine Parameters

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Abstract

Rapid depletion of fossil fuels is urgently demanding an extensive research work to find out the viable alternative fuel for meeting sustainable energy demand without any environmental impact. looking at the twenty first century, it seems that cleaner and greener form of energy in complete congruence with environment are the only hope for a sustainable future.In the current investigation CNG is used with Jatropha oil methyl ester (JOME) in a dual fuel mode for complete combustion of charge present inside the combustion chamber, and for the reduction of emissions associated with CI engines. The engine trials were conducted on a stationary air cooled constant speed agricultural direct injection diesel engine by increasing load from 0-100%.The effects of the pilot charge on various performance and emission characteristics were evaluated on all range of load. While comparing the results with diesel an increment in Brake Thermal Efficiency (BTE) and reduction in the emissions i.e. CO, HC, smoke were found with the dual fuel mode of CNG-JOME in CI engine.

1. Introduction

Abundant and economical energy is the life blood of modern civilizations. Economic growth in the inexpensive energy is need of current scenario. Many of the developed Western-European countries as well as developing countries depend on imports of energy resources to meet the requirements. Globalization and rapid economic growth has resulted in exhaustive use of energy resources worldwide. [1-3].As already discussed, energy is one of the most important factors concerned for socio-economic development of any country. Many developing countries are not able to fulfill their energy demand from the resources available in their own country and have to depend on other countries for accomplishing it. Diesel Engine plays a crucial role in Indian economy but also contributes to pollution significantly. During April-May 2014, diesel consumption grew 5.9% compared to period 2013. The overall diesel consumption growth for 2013-14 was 6.8%, compared to 7.8% during 2012-13 [4].

According to the data provided by the PPA Cell, petrol consumption in India. This fiscal was 12.35 million tonnes. India is expected to end up consuming 14.82 million tonnes of petrol in the year, registering growth of 4.41% in FY14. Consumption of diesel is expected to be 63.91 million tonnes, registering growth of 6.4% [5].Gasoline engines shows less efficiency compare to diesel engine due to compression ratio. Whereas diesel engine do not face the problem from their size and other limitations. which the SI engine is prone to. In India, diesel engines are used in heavy trucks, city transport buses, locomotives, electric generators, farm equipment, underground mine equipment etc.

The dual problem of fast depletion of petroleum based fuels and air pollution can be judiously handled by switching from fossil fuel based economy to renewable source of energy.Namasivayam et al. [6] experimented with (DME) and HCF as a test fuel. It has been found that at low loads and low speed (1000 rpm) NO emission was reduced by 20%. However, above an equivalence ratio value of about 0.55, NO emissions increased to values approaching those of neat rapeseed methyl ester (RME). For DME HC and CO emission was found higher than that of RME. Tira et al. [7] examined the capability of reformate and H2 combustion to enhance the thermal efficiency and reduce and particulate emission with respect to LPG–diesel dual fuel combustion. It was found that smoke and PM was improved especially in the case of H2 was 2% and 0.5%.Korakianitis et al. [8] utilized hydrogen as a test fuel and determined various performance and emission characteristics. Maximum thermal efficiency were found to be higher for a constant low speed engine.Bedoya et al. [9] developed full diesel substitution is attainable using palm oil biodiesel as pilot fuel on biogas dual fuel engine.

2. System development & experiemntal procedure

Diesel engines are amongst the most useful and efficient prime movers amongst all power producing machines. Due to this reason it has becomes necessary to develop alternative fuels with properties comparable to petroleum based diesel fuels .Bio-fuels are getting a worldwide attention to reduce the greenhouse gases (GHGs) and to develop better environment. Each researcher can proceed for production of particular oil, according to the climate and economical status or condition of the country.

2.1 Production of biodiesel from jatropha oil

Jatropha seed is the main source of biodiesel in the many tribal state of the India and its seed contains 30-40% Jatropha Oil.

Fig. 1(a) Jatropha Oil methyl Ester

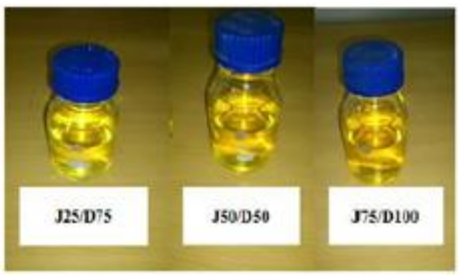

Fig.1(b) Blends of jatropha oil methyl ester

2.2 Selection of diesel engine

Due to robustness and high load carrying diesel engines are preferred more than the gasoline engine in almost every sector like agriculture, marine, and other load carrying locomotives. Also due to economic point of view diesel engine attracted the manufacturers to make diesel engines.

Air pollution created by diesel engine is also more severe than the petrol engine. Also due to bulkiness in terms of more storage capacity

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of engine for moving more goods at same time they consume more fuel and so create more air pollution. Due to this reason by changing some trends to reduce the air pollution or harmful emissions by changing the fuel may bring considerable changes in the environment. Keeping all these specific features of diesel in mind, a typical engine system has been modified as dual fuel engine for present experimental investigations. As introduction of gaseous fuel will leads to lesser emission and give proper combustion.

3. Experimental test rig

The base engine for this work is kirloskar four stroke, single cylinder, direct injection stationary constant speed diesel engine. The modification is being done in intake manifold to run engine on dual fuel mode.

Fig.2: Test Rig

The engine is to be started by hand lever. For conducting the desired set of experiments and together required data from the engine, it is essential to get the various instruments mounted at the appropriate location on the experimental setup. The schematic diagram of the experimental setup with all instrumentation is shown in figure-2.

4. Result and discussion

This work shows a dual mode operation with objective to fuel the diesel engine with blends of Jatropha oil methyl ester and diesel. The performance and emission studies on dual fuel mode with CNG and various blends were evaluated and compare the results with baseline diesel fuel. Fatty acid profile of the biodiesel was determined by gas chromatography. Figure 3 shows the gas chromatogram of Jatropha oil methyl ester. The peak of the graph indicates retention time. Table 4.1 indicates the composition of different fatty acid present in the Jatropha oil. The saturated fatty acid in the present biodiesel is higher than the unsaturated fatty acid, so its cetane number is higher; however, this biodiesel has poor cold flow property.

4.1 Performance characteristics

As we already been satisfied from the literature review that addition of CNG in JOME has a positive effect on the combustion efficiency. CNG makes a homogeneous mixing inside chambers which helps in the complete combustion. During the initial engine trials, a comparative study has been performed and various performance curves were plotted against the brake mean effective pressure.

4.2Brake thermal efficiency (bte)

The variation in brake thermal efficiency (BTE) is shown in figure 4. From the experimental tests result it is observed that there is slight decrease in BTE for all the blends.In figure 4. it is observed that the brake thermal efficiency of CNG with JOME25 at 75% load is 33.45% compared to diesel of 29.3%. However, it is 31.25% for CNG-JOME. The increase in brake thermal efficiency of CNG-JOME25 mode was due to cooling of inlet charge which reduces the temperature about 12-15 ºC and it also due to higher latent vaporization heat of JOME. However, at low loads lesser BTE was obtained due to improper mixing of charge. Cooling of inlet charge leads to the increase in charge density hence an improvement in BTE is noticed. This improvement also supported by the uniform mixing of the charge. However, CNG-JOME produces lowest BTE among dual fueling system at full load due to the lower calorific value and higher viscosity cause improper atomization of the blends which leads to improper combustion.

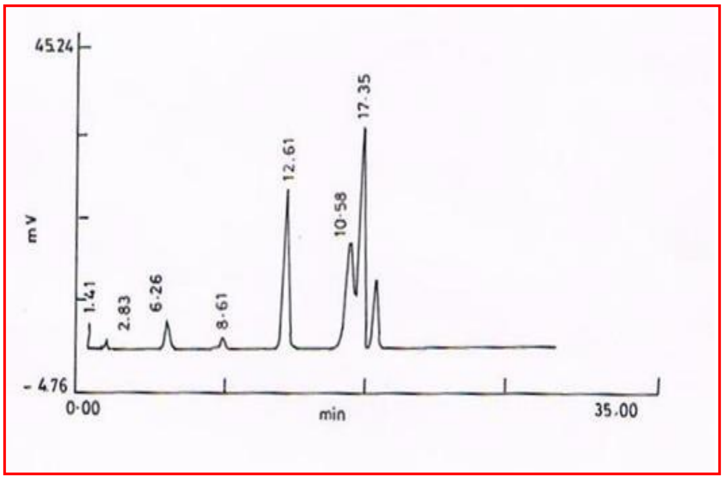

Fig-3 Graph obtained from Gas Chromatograph for Jatropha oil biodiesel

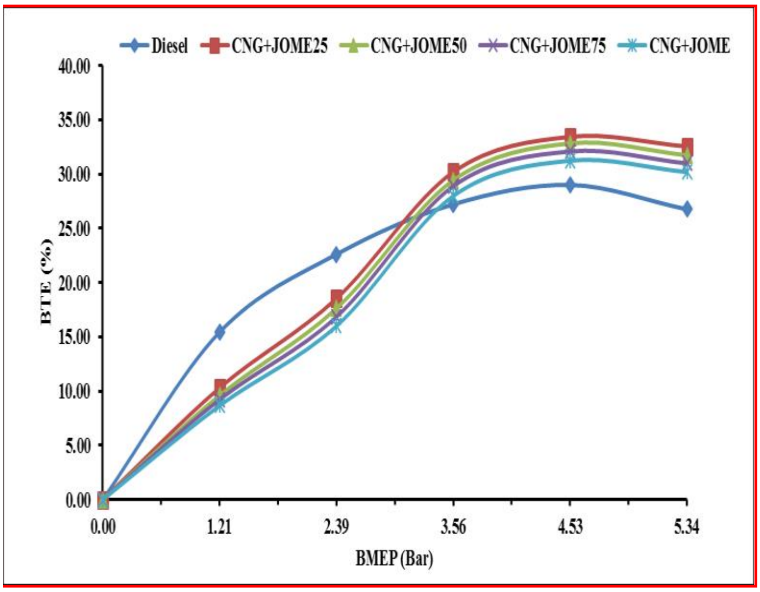

Fig-4 Graph obtained from Gas Chromatograph for Jatropha oil biodiesel

4.3 Brake specific energy consumption (bsec)

In figure 5 it can be seen that, for diesel BSEC decreases with respect to engine load and same was observed for other operating conditions. However, the consumption of CNG-JOME blends was lower than that of diesel for higher and intermediate loads. Therefore, CNG-JOME is an economical substitute for diesel engines. Also BSEC of CNG-JOME blends dual fuel was reduced by 22% than diesel for dual fuel operation at 75% engine load. This decrease in BSEC is due to the homogeneous mixing of CNG and air which results in the better combustion.

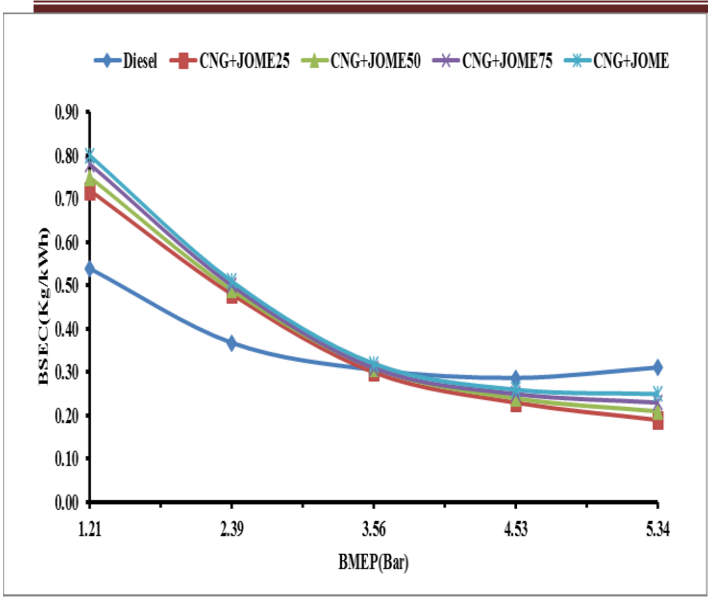

Fig.-5 Brake specific energy consumption

4.4 Effect of bmep on bsec emission characteristics

As we all know that, use of CNG-JOME improves the combustion quality which helps in producing fewer emissions as compared to diesel. Normally, diesel engine accounts for the emissions like CO (carbon monoxide), HC (hydrocarbons), NOx (oxides of nitrogen), and Smoke, which are explained from figures.

4.5 CO emissions

The variation of carbon monoxide emission is shown in figure. 6. At 25% load condition CO emission was noted about 054 ppm for CNG-JOME mode. However, for CNG-JOME25 operation it was found 0.45 ppm. At 75% load, the CO emission of diesel and CNG-JOME operations were found almost same i.e. 0.82 ppm. The lower CO emission of CNG-JOME fuel at higher load was due to the lower carbon content in CNG and also due to increases in amount of oxygen content in biodiesel helps in complete combustion and proper oxidation.

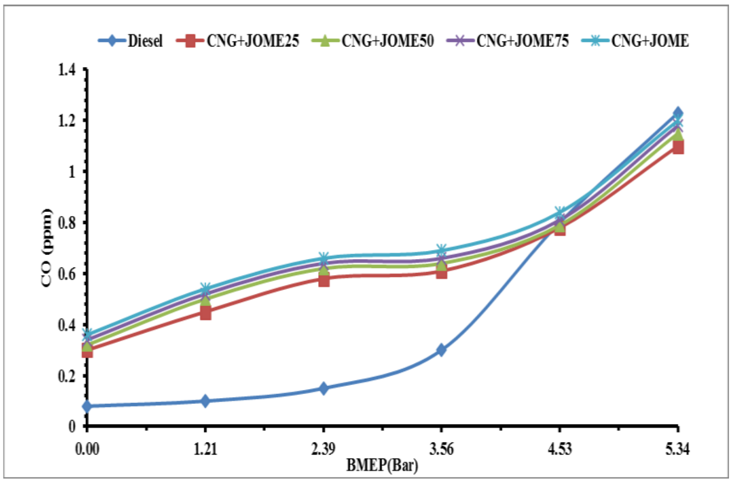

Fig.6 Effect of BMEP on CO

4.6 Hydrocarbon (HC)

It is found that the CNG-JOME shows a high HC emission at low load than other operating conditions. This was due to the improper mixing of charge at lower load which reduces the combustion quality. Also, because of non-availability of oxygen during diffusion combustion period, CNG-JOME has ignition lag and hence it undergoes instantaneous combustion as soon as the ignition starts [8]. While, at higher load it has the lowest HC emissions due to the complete combustion. At all range of loads HC emissions are found higher for CNG-JOME operation than diesel. This was due to the higher viscosity of biodiesel which leads to indecent combustion. At 40% load, hydrocarbon emissions were found maximum for CNG-JOME mode i.e. 95 ppm compared to diesel which produces 34 ppm HC emissions.

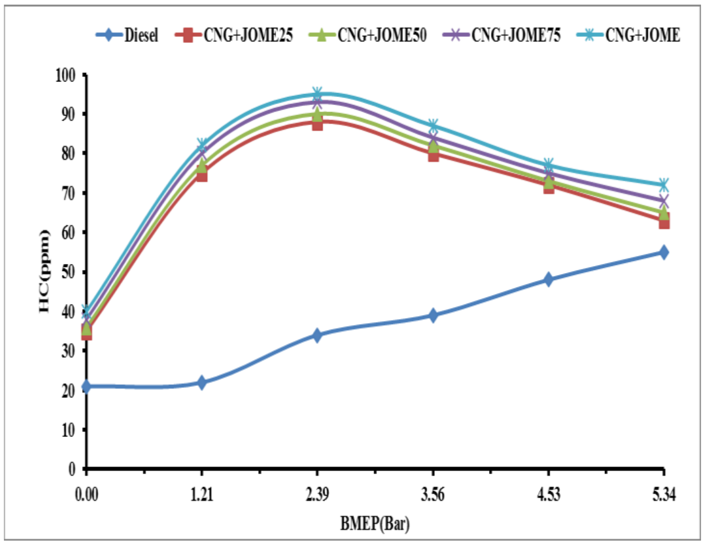

Fig. 7 Effect of BMEP on HC

4.7 Nitrogen oxide (NOx)

The NOx values as parts per million (ppm) of diesel and CNG-JOME operation in exhaust emissions are plotted in figure 7. During the combustion of CNG-JOME operation due to improper mixing of charge. However, at high load higher concentration of NOx was found which is due to the high peak flame temperature generated because of better combustion [9].

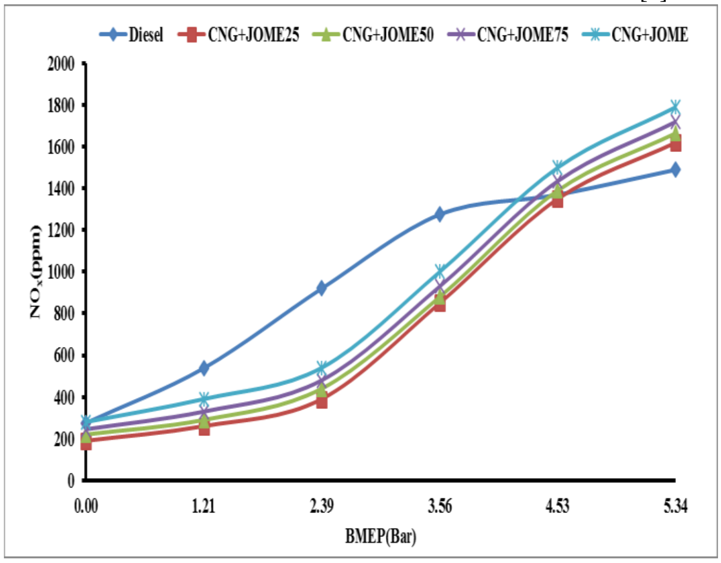

Fig. 8 Effect of BMEP on NOx

5. Conclusions

In the present study, the engine is slightly modified to use it in a dual fuel mode and the experiments were conducted in dual fuel mode using CNG with blends of jatropha oil methyl ester and that of diesel. By the results various drawn conclusions are listed below.

1. Full load brake thermal efficiency was found to be higher than diesel and CNG-JOME25 has highest BTE among all and with increase in JOME percentage in the blend BTE decreases slightly due to lower heating value of biodiesel.

2. Brake specific energy consumption of 13.44 MJ/kWh was observed for diesel at full load, while CNG-JOME dal fuel exhibits 22% lesser than it. Higher BSEC is observed in case of dual fuelling at lower load and tend to decreases with increase in load. At 50% load BSEC is almost equal for all the curves and retains property similar to that condition with diesel. With increase in percentage of

JOME in the CNG-JOME blend, a steady increase in BSEC was observed.

3. Slightly increased NOx emissions are associated at high load with CNG-JOME operation, as higher calorific value of CNG and increased rating of cetane with JOME leads to rise combustion, which rises the in-cylinder temperature resulting in higher NOx emission for blended fuels as compared to baseline data.

4. CO emission were to be higher at low load during dual fuel operations is due to the lower combustion temperature which results in the incomplete combustion of fuel.

This is due to accumulation of fuel at part load which burns out with increase in load. At 75% load, the CO emission of diesel and CNG-JOME operations were found almost same i.e. 0.82 ppm. The lower CO emission of CNG-JOME fuel at higher load was due to the lower carbon content in CNG and also due to increases of oxygen.

5. Variation in smoke opacity was substantial at lower loads for all the test fuels. However, at higher loads, CNG-JOME blends showed reduction in smoke opacity as compared to neat diesel operation.

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