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Performance and Emission Characteristics of Diesel Engine With Blends of Ethanol and Dual Bio-Diesel With Diesel

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ABSTRACT:

The recent research on biodiesel focused on performance and emission of single biodiesel, ethanol and its blends with diesel. Hence, the present work aims to investigate the possibilities of the application of mixtures of two biodiesel, ethanol and its blends with diesel as a fuel for diesel engines. The present investigations are planned after a thorough review of literature in this field. This paper enlightens the performance and emission analysis of the mixed fuels of pongamia pinnata biodiesel, jatropha biodiesel, ethanol and diesel fuel blends. The combinations of ethanol, jatropha biodiesel, pongamia biodiesel, along with diesel (EJPD) are taken for the experimental analysis. Experiments are conducted in a single cylinder direct-injection diesel engine with different loads at rated speed 1500 rpm.The performance & emission levels has been investigated under the various parameters like Brake Thermal efficiency, BSFC, Exhaust temperature, Smoke density, HC, CO & exhaust temperature. The results indicate that the calorific value of the blends decrease with an increase in concentration of dual biodiesel in the blends. The kinematic viscosity, density, cetane number, calorific value, flash point and fire point temperatures of the dual biodiesel and ethanol blends are augmented with an increase in concentration of dual biodiesel and ethanol in the blends. With an increase in temperature, the viscosity of dual blends are decreases and also nears the viscosity of diesel at higher temperatures. The specific fuel consumption (SFC) values of ethanol-dual biodiesel blends were comparable to diesel. The multi-blend biodiesel with ethanol are suitable alternative fuel for diesel in stationary/agricultural diesel engines.

Key words:

Alternate fuel; diesel engine; performance; emission; ethanol; jatropha and pongamia multi-blend biodiesel.

INTRODUCTION:

The petroleum fuel plays a vital role in the development of industries, transportation, and agricultural sector and to meet many other human requirements. As the fossil fuels are depleting at a very faster rate, there is a need to find out an alternative fuel to fulfill the energy demand of the world. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, the usages of fossil fuels are alarming the environmental problems to society. The scarcity of fossil fuel resources in the world enlightens the importance of new and renewable energy resources. Renewable energy has become a vital element of global energy policy to decrease greenhouse gas emissions caused by fossil fuels. Alternative transport fuels such as hydrogen, natural gas and biofuels are the options for the transport sector at the prospect of lack of oil availability and its environmental impact. Biodiesel has received ample consideration as a substitute for diesel fuel, since it is biodegradable, nontoxic and can considerably decrease exhaust emissions and overall life cycle emission of carbon oxides from the diesel engine when utilized as a fuel. Hence, available abundantly in India which can be there is a need of research for alternative fuels. There is a long list of trees, shrubs, and herbs exploited for the production of biodiesel. Biodiesel and ethanol are one of the best available sources to fulfill the energy demand of the world.

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MATERIALS AND METHODS:

Based on the availability of biodiesel, the properties like calorific value, kinematic viscosity, flash point and fire point of Jatropha biodiesel, Pongamia biodiesel, ethanol and diesel is estimated in the table 2.1 selected for bio-fuel preparation and experimental analysis. Various blending combinations of multi-blend biodiesel i.e. EJPD-1(Ethanol 5%, Jatropha biodiesel 5%, Pongamia biodiesel 5%, and Diesel 85% by volume), EJPD-2 (Ethanol 5%, Jatropha biodiesel 10% and Pongamia biodiesel 10%, Diesel 75% by volume), EJPD-3 (Ethanol 5%, Jatropha biodiesel 15% and Pongamia biodiesel 15%, and Diesel 65% by volume), EJPD-4 (Ethanol 5%, Jatropha biodiesel 20% and Pongamia biodiesel 20%, and Diesel 55% by volume), are prepared. The oils and blends (ethanol, Pongamia pinnata biodiesel and Jatrophabiodiesel) were selected on the basis of its physical and chemical properties described in the past literatures. Most of the researchers used the pongamia pinnata oil (Karanja oil) and jatropha oil as a single biodiesel fuel for conducting the experiments. The above said oils are available in India. The raw non edible vegetable oils were purchased from nearby oil plants. The biodiesels were produced separately in the laboratory environment by transesterification method. The combinations was prepared from the two different biodiesels (Pongamia pinnata biodiesel and Jatrophabiodiesel) and ethanol. EJPD(ethanol blended dual biodiesels) were tested with four different blending ratio's (EJPD 1 is 5:5:5:85, EJPD 2 is 5:10:10:75, EJPD 3 is 5:15:15:65, and EJPD 4 is 5:20:20:55).The experiments were conducted on a computerized single cylinder, four stroke, water cooled diesel engine and the performance and emission characteristics were compared with baseline data of diesel fuel. Tests were conducted at constant speed and at varying loads for all ethanol blended dual biodiesel blends. Three experiments for each load were carried out for accuracy. Experimental analysis was conducted at 0, 20, 40, 60, 80 and 100% of rated load using four different dual biodiesel mixtures (EJPD 1, EJPD 2, EJPD 3 and EJPD 4). Each experiment was carried out twice at different climatic conditions of a complete year for repeatability and accuracy.

Table.1.Estimated the properties of multi-ble nd biodiesel

Properties/ Fuel samples	Fuel density Kg/m^3	Kinematic viscosity@ 40^{0}C cSt	Flash point ^{0}C	Calorific value Kj/kg
Diesel	837.8	2.649	50	44.893
Pongamia Biodiesel	871	5.9	172	40.13
Jatropha Biodiesel	835	4.8	125	42.97
Ethanol	799.4	1.10	12	28.180
EJPD1	832	4.1	67	46.10
EJPD2	835	4.3	75	45.50
EJPD3	838	4.4	85	45.10
EJPD4	839	4.6	96	44.60

Biodiesel Production:

The biodiesel preparation flow chart is shown in Figure 1. The biodiesel can be extracted by the following process namely pretreatment of vegetable oil, transesterification of oils, washing and heating and biodiesel extraction. The vegetable seeds are dried and the vegetable oil is extracted. The vegetable oil is pretreated to remove the impurities from the extracted vegetable oil through primary filtration and secondary filtration. The primary filtration is done by mesh and then the secondary filtration is done by filter paper for removal of micro impurities. The filtered vegetable oil has small amount of moisture content which is removed by heating the oil to 110oC by an electrical heater. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called transesterification. In this method triglyceride reacts with ethyl alcohol in the presence of a catalyst (NaOH) producing a mixture of fatty acids, vegetable oil ester and glycerol. The vegetable oil ester is called biodiesel.

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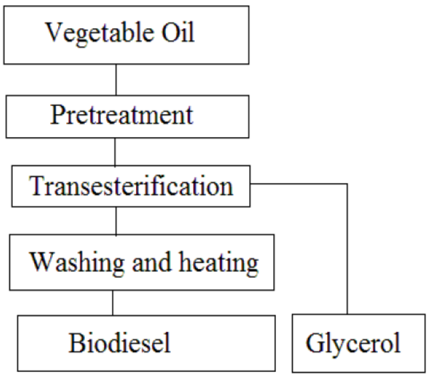

Fig. 2.1. Flow chart for biodiesel preparation.

The manufacturing process of biodiesel can be carried out in two ways, either batch or continuous flow process. The maximum ester yield of 98% is possible using 20% methanol and 1% of NaOH at 60oC reaction temperature after 90 min. The main product of transesterification is biodiesel and the by-products produced are glycerol, which can be refined and used in cosmetic industries, and oil cake that can be used as fertilizer. The esterified vegetable oil is then transferred to separating funnel and left for settling of 8 hours. The setup is not to be disturbed during settling process, because more time taken for settling the byproducts. The glycerol formed in the separating funnel is removed and the vegetable oil ester (biodiesel) is collected from the funnel. The vegetable oil ester is then washed by distilled water to remove the impurities. The distilled water is added to the separating funnel and this water settles all the impurities at the bottom of the funnel. Water with impurities is then removed and then the vegetable oil ester is collected from funnel and further heated to 110oC to remove water poured during washing. Thus after finishing the water washing and heating pure biodiesel is extracted.

Experimental Setup:

The various components of experimental set up are described below. Figure 3.1 shows Line diagram of the experimental set up. Figure 3.2 shows the actual setup.

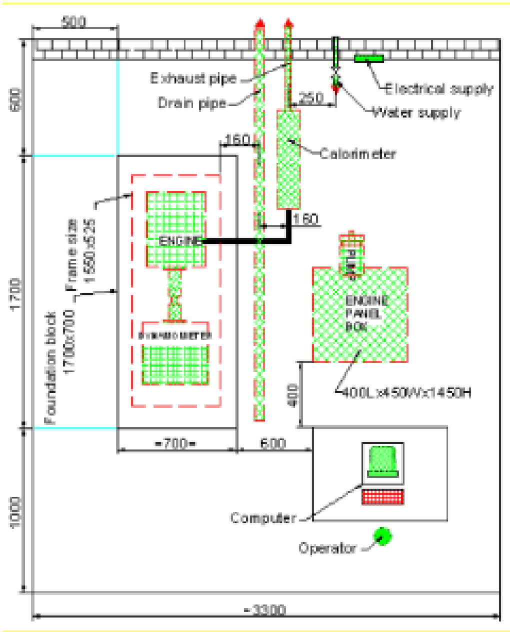

Figure 3.1

Figure 3.2

RESULTS AND DISCUSSION:

The performance analysis on brake thermal efficiency(BTE), specific fuel consumption(SFC) and exhaust gas temperature are described in the section 4.1. The exhaust gas emission analysis on hydro carbon(HC), carbon monoxide(CO), carbon dioxide (CO2) and nitrogen oxides are revealed in the Section 4.2.

Performance Characteristics:

Figure 4.1.1 shows the variations of load on brake thermal efficiency for different dual biodiesel blends. It can be also observed that, EJPD-1 gives the maximum thermal efficiency of 26.03%,

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EJPD-2 gives 25.24% whereas the diesel gives 26.53% at the same load. EJPD-1 gives the maximum thermal efficiency than other EJPD blends. This is due to the higher calorific value of EJPD-1 than that of other dual biodiesel. At low load conditions, the thermal efficiency of the diesel engine has enhanced with escalating concentration of the dual biodiesels in the fuel. This is due to the additional volatility provided by the dual biodiesels. The dual biodiesels have a quantity of oxygen, which is used for the complete combustion in the diesel engine.

The effect of load on specific fuel consumption is shown in Figure 4.1.2. As load increases the SFC reduces for all the multi blend biodiesel blends. For the maximum load, the value of SFC of EJPD-1 is 0.349 kg/kwh, the value of SFC of Blend EJPD-2 is 0.349 kg/kwh and EJPD-3 is 0.357 kg/kwh whereas diesel fuels have 0.360 kg/ kw h. The SFC is high for the increased value of dual biodiesel blends, due to the lower calorific value of it.

The changes in load with respect to exhaust gas temperature variation are shown in Figure 4.1.3. Exhaust temperature increases with increase in load in all cases. For the maximum load, the value of exhaust temperature of EJPD-1 is 212.5oC, Blend EJPD-2 is 232.5oC, EJPD-3 is 244.74oC whereas diesel fuels have 187.4oC. The increase in exhaust gas temperature with engine load is clear that, more amount of fuel is required by the engine to produce the required power to take up the additional loading.

Emission characteristics:

Figure 6 shows that, the relation between load and Hydro Carbon (HC) increased by increasing the load for each blend. All the Blends give lower HC than diesel. From the results, Blend EJPD-1 gives lesser HC than other blends. It gives 50% lower HC than diesel at the maximum load. At lower combinations of dual biodiesel blend, the oxygen present in the biodiesel assist for complete combustion. But, as the dual biodiesel combination increases, the negative result attained due to high viscosity and density which reduces the complete combustion and increases the hydro carbon emission. The dual biodiesels and blends generally exhibit lower HC emission at lower engine loads and higher HC emission at higher engine loads. This is because of relatively less oxygen available for the reaction when more fuel is injected into the engine cylinder at high engine load. The variations of carbon monoxide on load are shown in Figure 4.2.2. Carbon monoxide (CO) content is also increasing with increase in load. The dual biodiesel blends give lower CO than diesel.This is due to the oxygen contents in the biodiesel which makes easy burning at higher temperature in the cylinder. Higher the engine load, richer fuel-air mixture is burned and thus more CO is produced. The variations of carbon dioxide (CO_2) emission with different dual biodiesel blends is shown in Figure 4.2.3. The dual biodiesel blends give higher CO_2 than diesel. EJPD-1 gives the CO_2 value of 4.71 % volume whereas diesel gives 4.63% vol. It is an indication of efficient combustion. It is desirable in combustion process, to have higher CO_2 production and less HC and CO emissions since it is a measure of combustion efficiency. The effect of load on nitrogen oxides is shown in Figure 4.2.4. The nitrogen oxides (NO_x) increased by increasing the load for each blend. From the results, NO_x emission is higher for dual biodiesel blends than diesel. However, Blend EJPD-1 gives lesser NO_x than other dual biodiesel blends. The biodiesel extracted from vegetable oils contains a small amount of nitrogen. This contributes towards NO_x production. The high average gas temperature and the presence of oxygen in the fuel and residence time at higher load conditions with the blend combustion caused higher NO_x emissions.

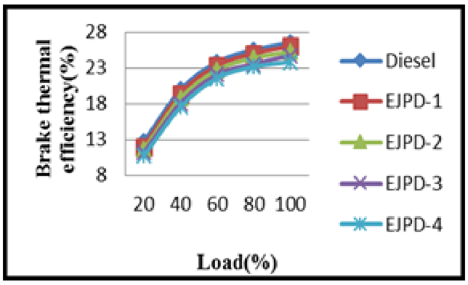

Fig. 4.1.1. Variations of load on brake thermal efficiency.

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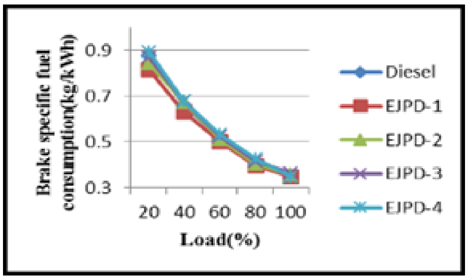

Fig. 4.1.2. Effect of load on brake specific fuel consumption.

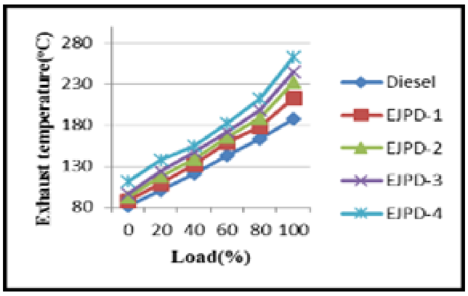

Fig. 4.1.3 Variations of load on exhaust gas temperature.

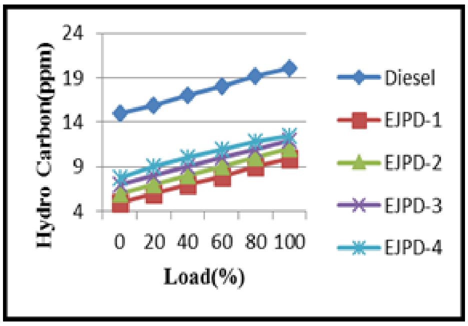

Fig. 4.2.1 Effect of brake power on hydro carbon emission.

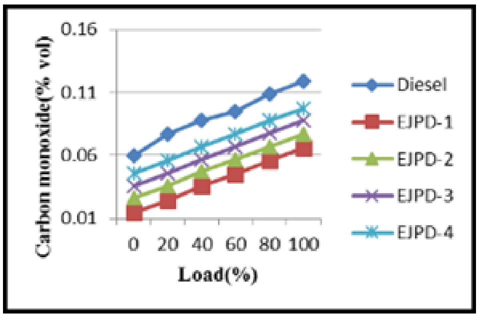

Fig. 4.2.2 Carbon monoxide variations with different dual biodiesel blends.

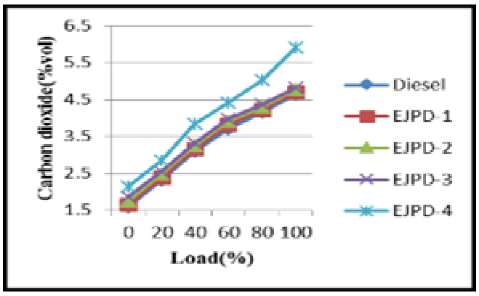

Fig. 4.2.3 Carbon dioxide variations with different dual biodiesel blends.

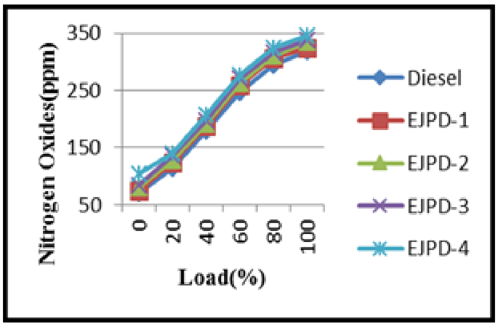

Fig. 4.2.4 Nitrogen Oxides variations with different dual biodiesel blend.

CONCLUSION:

The calorific value, kinematic viscosity, flash point temperatures and density for ethanol-jatropha biodiesel-*Pongamia pinnata* biodiesel–diesel (EJPD) were evaluated in this study. From this analysis, the calorific value and kinematic viscosity of EJPD-1 was closer to diesel values. The cetane number of EJPD blends was higher than those of diesel. The flashpoint temperature of EJPD blends was higher than that of diesel fuel, facilitating safe transport and storage. The dual biodiesel blend EJPD-1 has closer density value with the diesel; other blends were higher than that of diesel.From the performance analysis, the thermal efficiency of blend EJPD-1 and EJPD-2 were very closer to the diesel values. The specific fuel consumption(SFC) values of dual biodiesel blends were comparable to that of neat diesel. From the emission analysis, the EJPD blends were produced lower HC and CO than those of diesel. This was a considerable advantage over neat diesel while using the EJPD dual biodiesel blends.

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The EJPD blends gave higher NOx than those of diesel. Based on these results, EJPD-1 and EJPD-2 were closer to diesel. Hence ethanol blended dual biodiesel can be recommended as fuel for stationary agricultural purpose diesel engines.

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