EXPERIMENTAL INVESTIGATION ON EXHAUST EMISSION OF A VARIABLE COMPRESSION RATIO DIESEL ENGINE USING METHYL ESTERS OF PONGAMIA PINNATA OIL BLENDS AND DIESEL

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ABSTRACT

In this paper emission characteristics of a single cylinder, four stroke, variable compression ratio Diesel engine when fueled with Pongamia pinnata oil methyl ester and its 5%, 10% and 15% blends with diesel (on a volume basis) were analyzed and compared with diesel fuel. Bio diesel produced from Pongamia pinnata oil methyl ester by transesterification process has been used in this study. Experimental studies has been conducted on a single cylinder, constant speed, vertical, variable compression ratio, water cooled Diesel engine with 0%, 50% and full load and at compression ratios of 18:1 and 15:1.The result shows that the blends when used as fuel results in reduction of different emission characteristics like carbon monoxide (CO), Unburnt hydrocarbons (UBHCs), carbon-di-oxide (CO_2) and increase in nitrogen oxides (NO_X) compared with pure diesel fuel.

Keyword: - *Variable compression ratio Diesel engine; Pongamia Pinnata oil methyl ester; emission characteristics.*

1. INTRODUCTION

Transport vehicles significantly spoil the environment over and done with emissions such as CO, CO2, NO*x*, SO*x*, unburnt or moderately burnt HC and particulate emissions. Fossil fuels are the foremost sponsors to metropolitan air fumes and most important foundation of greenhouse gases (GHGs) and considered to be the prime cause behind the global climate change. Biofuels are renewable, can supplement fossil fuels, reduce GHGs and mitigate their adverse effects on the climate resulting from global warming [1].Fuel crisis because of dramatic increase in vehicular population and environmental concerns have renewed interest of scientific community to look for alternative fuels of bio-origin such as vegetable oils. Vegetable oils can be produced from forests, vegetable oil crops, and oil bearing biomass materials. Non-edible vegetable oils such as linseed oil, mahua oil, rice bran oil, etc. are potentially effective diesel substitute. Vegetable oils have high-energy content [2].Oil content in the Jatropha and Pongamia seed is around 30- 40 %. India has about 80-100 million hectares of wasteland, which can be used for Jatropha and Pongamia plantation. [3].The various alternative fuel options tried in place of hydrocarbon oils are mainly biogas, producer gas, ethanol, methanol and vegetable oils. Out of all these, vegetable oil offers an advantage because of their comparable fuel properties with that of diesel [4]. The idea of using vegetable oil as fuel has been around from the birth of diesel engine. Rudolph diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil [5].Biodiesel is produced from renewable vegetable oils/animal fats and hence improves the fuel or energy security and economy independence [6].The different studies have been reviewed the results of engine tests carried out by earlier researchers using vegetable oil based fuels. Most of them have utilized sun- flower oil, rapeseed oil, cottonseed oil, soybean oil, palm oil and peanut oil as fuel for diesel engines in different modes. They concluded that coking is a major problem for unmodified vegetable oils in diesel engine [7]. The feedstock price of vegetable oils, homogeneity and material compatibility are the major challenges. Engine durability, popularization of environmental benefits of vegetable oils, and effects of glycerol on engine life are the primary technical difficulties of biodiesel [8].Use of biodiesel in a conventional diesel engine results in substantial reduction in unburned hydrocarbon (UBHC), carbon monoxide (CO), particulate matters (PM) emission and oxide of nitrogen [9].Many researchers have also found slight increase in nitrogen oxide (NOx) emissions and few others found slight increase in aldehyde emissions [10, 11]. It is also found increased NOx emissions for a 3.5% increase in fuel density. It was also found that the number of double bonds, quantified as iodine number, correlated with NOx emissions [12].In this context, the main objective of this study was to examine the effect of different Pongammia Pinnata methyl ester oil blends with respect to the different emissions aspect of the variable compression ratio diesel engine running on this biodiesel.

2. MATERIALS AND METHODS

2.1 Pongamia pinnata oil methyl ester production

The pongamia pinnata methyl ester is obtained from pongamia pinnata oil by transesterification process. It is the process by which the fatty acid present in the raw pongamia pinnata oil is converted into its corresponding methyl ester. The mixture of pongamia oil methyl ester, methanol (molar ratio of8:1) and sodium hydroxide (NaOH) (1% w/w) as catalyst is taken in the reaction chamber. The complete above said mixture is heated at an elevated temperature of60^{o}C for 3hours and then slowly cooled down to the room temperature. After the slow cooling process, there are two layers are observed with upper layer recognized as methyl ester and lower layer as since it has high density. Then the top layer is washed with distilled water and shattered out. Finally, pongamia oil methyl ester (PME) is obtained as final product and is used in the present investigation.

2.2 Experimental set-up

The complete experimental analysis has been carried out on a variable compression ratio, single cylinder, four stroke, constant speed, water cooled, electrically loaded, vertical configuration diesel engine. The complete experimental setup is shown in fig.1. Engine is combined with an air cooled eddy current dynamometer alongside with load cell. The different loads on the engine are varied with the help of the controller provided on the dynamometer. Standard burette device along with stop watch is used for fuel flow amount on volumetric basis. Exhaust gas emissions such as CO, UBHCs, CO_2 and NO_x are measured by using QRO-402exhaust gas analyzer. Engine is started under no load condition and then hit it off with at the rated speed of 1500 rpm and all the readings are taken under steady state conditions. Engine is run at 1500 rpm and data are gathered with respect to the different emission parameters at various loads of0%, 50%, and 100%.

Fig-1: Experimental setup

3. RESULTS AND DISCUSSIONS

Diesel engine emission characteristics are analyzed for all blends of Pongamia Pinnata Methyl Ester oil blends like D95/P5, D90/P10 and D85/P15 fuels and compared with petroleum diesel. All the emission results are presented and discussed in this section.

3.1 Unburned hydrocarbon emissions

Unburned hydrocarbon (UBHC) emissions are produced due to the in complete combustion of the fuel inside the combustion chamber. It is also one of the important parameters for decisive the emission manners of diesel engine. Comparison of UBHC of all the PME blends and diesel at various load conditions is shown in Fig. 2. It is shown that the variation in UBHC drops with the impact of PME percentage in bio-diesel blends. It is detected that UBHC contents are reduced due to the extra availability of oxygen content in the biodiesel that leads to earlier the burning chemical reaction inside the combustion chamber.

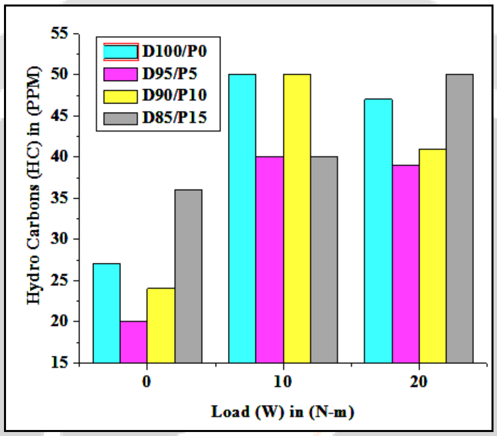

Fig-2: Variation in unburned hydrocarbon emission with different loads

3.2 Carbon monoxide emissions

Carbon monoxide (CO) is the most common type of disastrous air poisoning in many countries. It is colorless, odorless and tasteless, but highly toxic gas. Fig.3 shows the variant in carbon monoxide of all the tested fuels with respect to unlike loads. It is learned that the CO emissions for all biodiesel blends are very small compared with diesel fuel. It is also acknowledged that CO concentration of D95/P5, D90/P10 and D85/P15 blends are lower than conventional diesel at all load conditions. This may be due to the oxygen content and less C/H ratio of biodiesel that causes complete combustion. However, it is discovered that the decreasing tendency of CO emission depend on the biodiesel percentage in the blends.

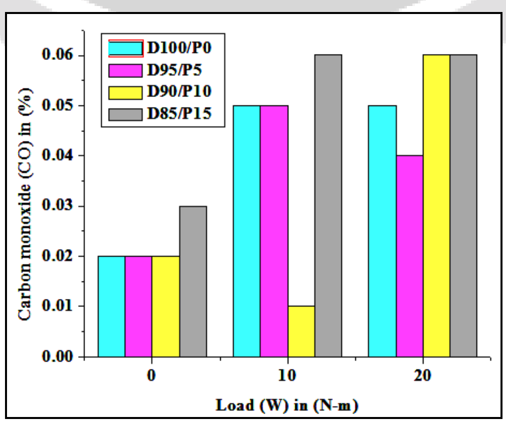

Fig-3: Variation in carbon monoxide emission with different loads

3.3 Oxides of nitrogen emissions

NOx emission is produced from the reaction of nitrogen and oxygen gases in the air through burning process. The concentrated burned gas temperature, the absolute concentration of oxygen and the reaction time are the dangerous variables for NOx formation. The variation in NOx concentration with dissimilar loads for D95/P5, D90/P10 and D85/P15 and petroleum diesel is shown in Fig.4. NOx emissions of all biodiesel blends are greater than that of pure diesel. The greater burning temperature and the being there of extra oxygen are the focal parameters for more NOx emissions.

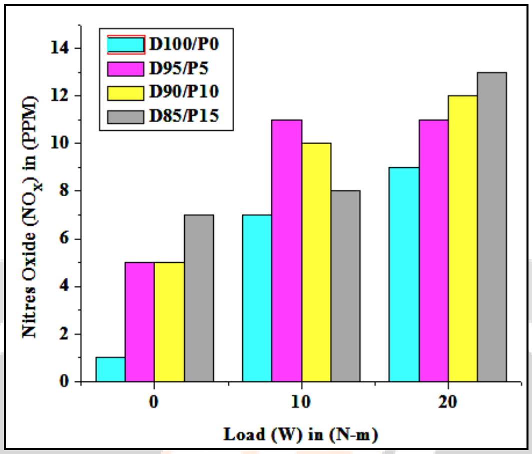

Fig-4: Variation in oxides of Nitrogen with different loads

3.4 Carbon-di-oxide emissions

CO_2 emission is another type of diesel engine exhaust gas emissions which is produced from the reaction of carbon and oxygen gases in the diesel and air during combustion process. The amount of carbon contents present in the diesel fuel, concentration of oxygen present in the air and combustion timings are variables for CO_2 formation. The variation in CO_2 concentration with unrelated loads for D95/P5, D90/P10 and D85/P15 and petroleum diesel is shown in Fig.5.CO_2 emissions of all biodiesel blends are lower than that of conventional diesel.

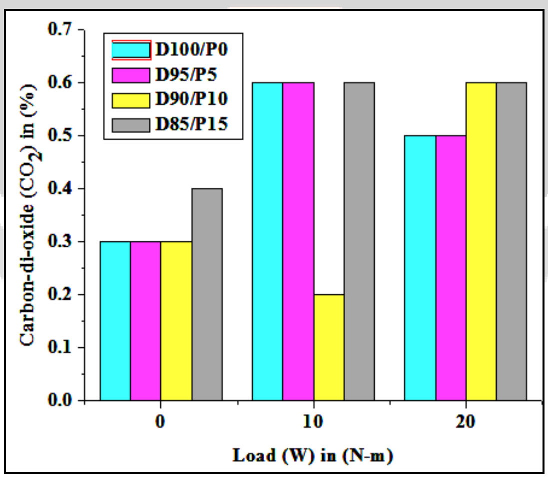

Fig-5: Variation in carbon-di-oxide emission with different loads

4. SUMMARY

The emission characteristics of an unmodified variable compression ratio diesel engine which was operated with different Pongamia Pinnata Methyl Ester oil and its blends are compared with the conventional diesel fuel. Results are summarized as follows: It is also observed that there is significant reduction in carbon monoxide (CO), Unburnt hydrocarbons (UBHCs), carbon-di-oxide (CO_2) for all biodiesel blends like D95/P5, D90/P10 and D85/P15 when compared to pure diesel fuel. On the other hand the NOx emission of Pongammia Pinnata Methyl Ester biodiesel is little bit higher than that of petroleum diesel. The experimental results show that the pongamia oil methyl ester would be used as an environment friendly fuel for a diesel engine.

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