Effect of Compression Ratio on Performance and Exhaust Emission Characteristics of Diesel Powered by Jatropha Curcas Oil

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Abstract

During this investigation, an effort has been made to review the effect of compression ratio on the performance and emission characteristics of an insulated piston head diesel fueled by M.E.J.O (Methyl Esters of Jatropha Curcas Oil). The principle involved is variation in compression ratio is inversely proportional to the clearance volume of the engine. Thus the piston head of the engine was unanimously coated with ceramic, a bond of Alumina – Titania by Detonation firing process. The change within the piston head design directly affects the compression ratio of the engine. The engine performance also as emission characteristics of insulated piston head diesel is compared. Results show that for the coated piston head diesel the brake thermal efficiency, exhaust gas temperature, and smoke density, NO are increased, while BSFC, CO, and HC are reduced when compression ratio is increased. Under normal conditions MEJO has given out less amount of NO, HC while CO and smoke density has increased

Key words: *Performance, Emission, Ceramic Coating, Compression Ratio, M.E.J.O (Methyl Esters of Jatropha Curcas Oil), Eco – friendly fuel.*

1. Introduction

Vegetable oils deliver a very promising alternative to diesel fuel, as they are renewable and are produced easily in rural areas where there is an acute need for modern forms of energy. Vegetable oils have always had their advocates ever since the advent of the internal combustion engine. The inventor of the diesel engine, Dr. Rudolf Diesel, Confidently predicted that plant – based oils would be widely used to operate his engine. In fact he used peanut oil as fuel for demonstrating his engine, which made the utilization of vegetable oil as fuel in engine. This is obviously because of the problem of fast dwindling resources of petroleum fuels, the economic and political factors associated with their procurement and environmental pollution caused by the combustion of these fuels in the engines.

In diesel engines, normal structure of fuel is preferred for better ignition quality. But due to the larger molecular mass and different chemical, structure, Jatropha Curcas oil is not directly suitable for diesel engine operations. So the oil needs to be modified for attaining closer properties of diesel. The oil processed from Etherification process can mitigate these problems and becomes suitable for diesel engine.

In ceramic Coated Piston Head Diesel Engine, the combustion chamber temperature and pressure is higher compared to an aluminum piston engine and due to this quality, these engines have a multifuel capability. The characteristic feature of the combustion process on the ceramic coated engine is the decrease in the proportion of pre mixed combustion due to the effect of ignition delay with increase of wall temperature and an increase in the proportion of diffusion combustion and late burning.

By increasing the compression ratio, the engine operating temperature can be increased. The increased operating temperature can change the ignition delay period, deteriorate the injection characteristics and increase the emission characteristics. The results pose to be encouraging for vegetable oils with coated piston head, while proves to be a contrast for a diesel fueled engine.

So, an attempt has been made to examine the effect of compression ratio on the performance and exhaust emission of a diesel engine with ceramic coated piston head fueled by MEJO. Tests were conducted with esterified Jataropha Curcas oil, blends of Jatropha oil with diesel at a constant rpm and at varying loads by varying compression ratios.

2. EXPERIMENTAL SETUP

Single cylinder 4 stroke water cooled diesel engine developing about 7.4 KW at 1500 rpm was coated with ceramic oxides by detonation spray coating. A rope brake dynamometer was used for loading the engine. A diaphragm like unit was attached to the engine to make air flow measurements. The fuel flow rate was measured on volumetric basis using a burette and a stopwatch. The exhaust gas temperature was measured using a high range thermometer. The peak pressure was found using a compressor tester gauge. For measurement of exhaust emissions (NO, HC, CO, CO2) DELTA 1600S on line gas analyzer was used

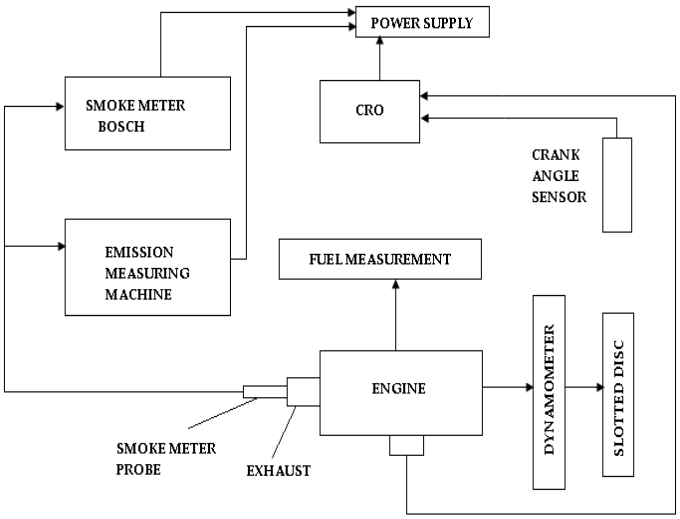

Figure 1. Experimental set up

3. RESULTS AND DISCUSSIONS

The performance and exhaust emission parameters of the engine with diesel and methyl ester of Jatropha oil at different compression ratios are presented and discussed below.

A higher compression ratio, the temperature and pressure of air at beginning of injection are higher. At that higher temperature, effect of proportion of esterified jatropha – diesel blends and esterified jatropha oil on brake specific fuel consumption (BSFC) are shown in figures 1&2. From the figure it's clear that 100% diesel fuel has low BSFC than esterified jatropha oil in both the compression ratio. The probable reasons behind the results are that the dissimilar relative density and heating value among the blends. So with the lower energy value fuels (Blends of Jatropha oil and MEJO), the engine responds to the load by increasing in fuel flow. The opposite reason is that ceramic coated engine responds well give to raised combustion behavior with MEJO.

Figure 3 shows the variation of brake thermal efficiency with reference to proportion of Jatropha-Diesel oil blends and MEJO at different compression ratios. The brake thermal efficiency decreases because the proportion of Jatropha oil increases within the blends in both the compression ratios. In pre combustion chamber the injector cannot hack the fuel properly during injection, because the compression ratio increases, the wall temperature of the chamber increases and thereby decreasing the volumetric efficiency. The decrease in volumetric efficiency and therefore the effect of ignition delay are the most reasons for the deterioration of fuel combustion leading to increased fuel consumption in subsequent reduction in brake thermal efficiency. In CR-166 the wall temperature is relatively less than CR- 18 thanks to the very fact that, the reduction of brake thermal efficiency in CR-16 is slightly less than CR- 18 for MEJO. The efficiency obtained from ceramic coated piston for MEJO is nearly closer to ordinary engine fueled by diesel

Brake thermal Efficiency

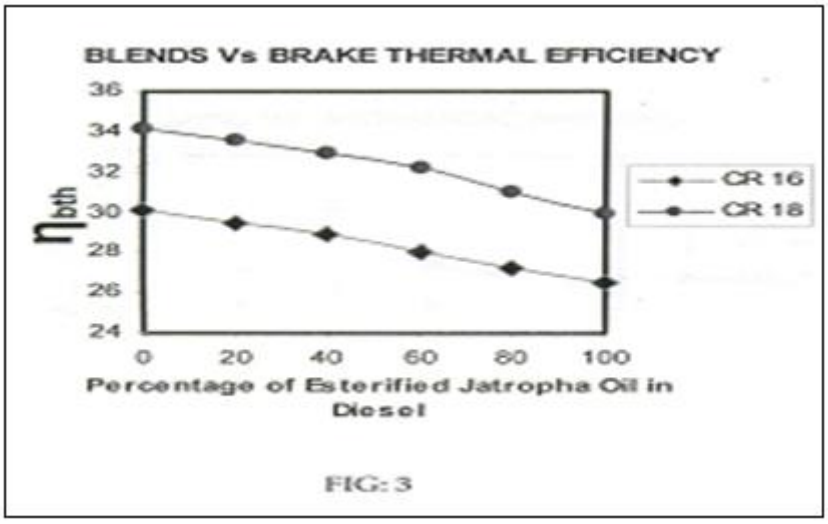

Figure 2.Brake thermal efficiency

Hydrocarbon emissions

Unburnt hydrocarbon emissions are the direct result of incomplete combustion. There is the drastic reduce in the HC level at higher compression ratio, this is due to diffused combustion, increased temperature and after burning phenomenon.

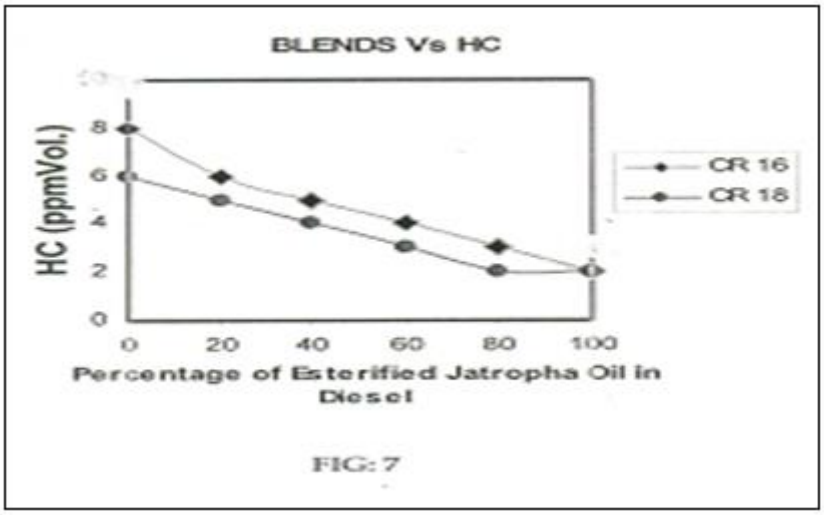

Figure 3 Hydrocarbon emission

Carbon monoxide

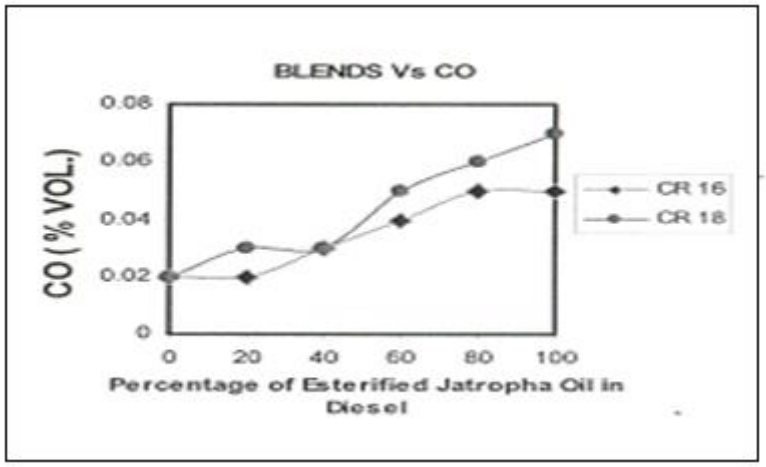

Figure 4 Carbon monoxide Emission

The variation in exhaust gas temperature with respect to proportion of Jatropha- Diesel oil blends and MEJO at different compression ratios are shown in figures 5. It is observed from the figure that as the proportion of diesel oil decreases in the blends, the exhaust gas temperature increases in both the compression ratios. In ceramic coated engine, higher wall temperature due to coating changes the ignition delay. When the engine switches over from diesel oil to blends, it suddenly changes the ignition delay which is different form diesel oil. The combustion process is shifted in the later stroke of the cycle, and more of the fuel energy may be retained in the expanding gases, resulting higher exhaust gas temperature. The ceramic coated engine with MEJO shows lower exhaust gas temperature than the blends of higher jatropha oil. This is due to the fact that, esterification of jatropha oil mitigates some of the problems associated with the high viscosity and poor flow characteristics of the oil. Moreover esterified jatropha oil has a cetane index of 50 which is almost equal to diesel, which helps to burn the fuel comparatively better. In CR-18 the exhaust gas temperature is slightly higher than CR-16.

Exhaust Temperature

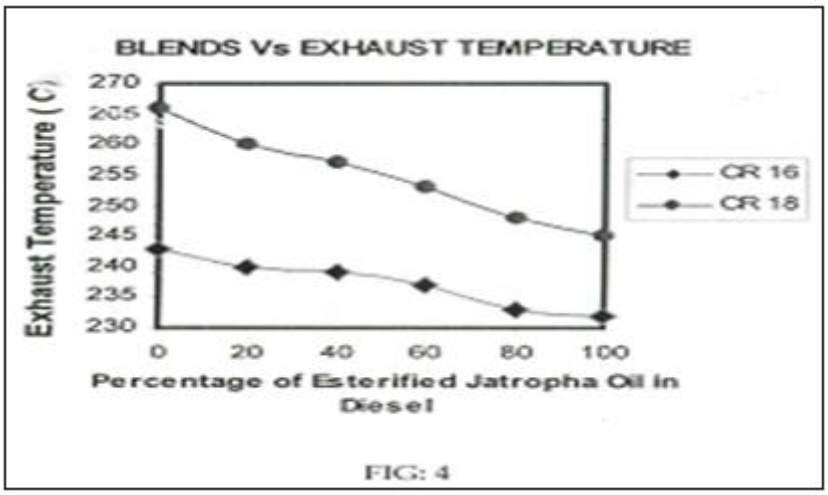

Figure 5. Exhaust Temperature

Figures 3 & 4 shows the variation of CO and HC level with respect to proportion of Jatropha – Diesel oil blends and MEJO at different compression ratios. From the graphs it is clear that the CO level decreases as the proportion of jatropha oil decreases in the blends. 100% diesel oil operation has the lowest CO level than the esterified Jatropha oil at all compression ratios. This is due to the fact that the esterified Jatropha oil at all compression ratios. This is due to the fact that the engine is not optimized to run with the diesel oil blends or esterified jatropha oil, so there is a large possibility of run rich fuel – air mixture in the cylinder and the higher brake specific fuel consumption resulting in a higher CO level. At higher compression ratio (CR-18). CO level is lower than CR-16 as the gas temperature is comparatively high for oxidation.

NOx Emission

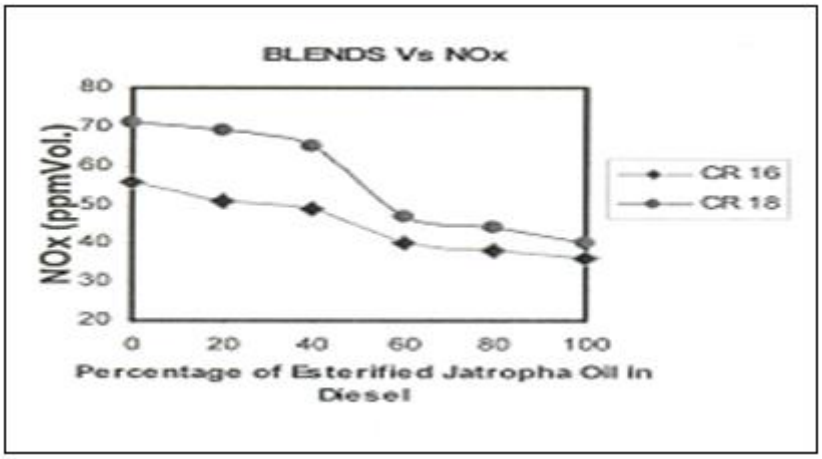

Figure 6 NOx Emission

Figure 6 shows the variation of NOx level with respect to proportion of Jatropha-Diesel oil blends and MEJO at different compression ratios. Results show that NOx level is comparatively higher with CR-18 than CR-16. It is found that NOx emission increases with increase in load. 100% diesel has the higher NOx level when compared to blends of jatropha oil and MEJO for a ceramic coated piston. This is due to the fact that in ceramic coated engine; heat release profile is shifted from premixed to diffusion combustion. The ceramic coated engine when fueled with esterified jatropha oil shows very jess amount of NOx when compared to ordinary engine fueled by Diesel.

CONCLUSION

A single cylinder compression ignition engine was operated successfully using MEJO as sole fuel at different compression ratios. The following conclusions are made based on the experimental result.

- Engine works smoothly on MEJO with performance comparable to diesel operation.

- Brake specific fuel consumption is increased in Jatropha-diesel oil blends and MEJO. BSFC varies according to the respective compression ratios.

- MEJO results in a slightly reduced thermal efficiency as compared to that of diesel and is almost equal to the efficiency of diesel when the compression ratio is increased.

- HC and CO emission decreases with increase in compression ratio and is also low with MEJO compared to diesel.

- The increase of NOx level is higher with higher thickness of coating. With 300 microns coated piston, NOx level is increased. This level is even low when compared to an ordinary engine using diesel.

  On the whole it is concluded that MEJO (Methyl Esters of Jatropha Oil) when used with increased compression ratio will be a good alternative fuel with closer performance and better emission characteristics to that of a diesel engine.

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