Experimental Investigation on the Effect of Thermal Cracked Carbon Filtered Fatty Acid Biodiesel on Engine Performance and Exhaust Emission

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Abstract *- The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in fossil resources. The search for an alternative fuel, which promises a harmonious correlation amongst sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. In this paper an attempt has been made to analyze the effect of thermal cracked carbon filtered fatty acid oil biodiesel (TCFAO) at different proportions with diesel (B20, B40, B60, B80 and B100) in a single cylinder, four stroke water-cooled, and diesel engine at 1500 rpm. The measured performance parameters are brake thermal efficiency, specific fuel consumption and engine exhaust emission of CO, HC, NOx and smoke density. Significant improvements in performance parameters and exhaust emissions have observed by the addition of TCFAO blends with diesel.*

Keywords — *Biodiesel; Fatty acid oil; Thermal cracking; Emission*

I. Introduction

In recent years, there has been a significant increase in research on the use of bio-fuels as a substitute for mineral fuels. This has been spurred on by the fact that the world's current crude oil reserves are set to run out in the next 50 to 60 years, and since bio-fuels are derived from renewable resources they are not likely to run out as long as plants can continue to grow on earth. Bio-fuels can be split into two main groups, namely bio-diesel and bio-alcohols. Bio-diesels are made by processing vegetable oil into a form that can be used as a direct replacement for mineral diesel with the minimum amount of fuss, the most significant problem being that bio-diesels generally have poorer low temperature properties than mineral diesel. They can also dissolve some polymers, and therefore it is necessary to check that the fuel system of any vehicle in which they are used does not contain any elements that may be dissolved by bio-diesel.

Vegetable oils have comparable values of energy density, cetane number, heat of vaporization, and stoichiometric air/fuel ratio with mineral diesel fuel. The large molecular sizes of the component triglyceride results in higher viscosity of other oils compared with that of mineral diesel fuel. The viscosity of liquid fuels affects the flow properties of the fuel mixing. The problem of viscosity has an adverse effect on the combustion of vegetable oils in the existing diesel engine. A major problem using vegetable oil in engine operation is the carbon deposits in the upper piston ring groove and piston ring. The piston ring gets stuck in the groove there by weakening and decreasing the engine performance, the combustion becomes erratic. The deposits grow, and the efficiency decreases. Another problem is that the vegetable oil and gases escapes through the clearance into the engine crankcase. As a result it contaminates the lubrication oils, which leads tough, rubber like coating on the engine part and the walls of the care the fuel pump, and cam shaft and push rods. The build up of carbon deposit is generally attributed to the large molecular size and resulting high viscosity of the medium-chain and long chain triglycerides that constitute most commercial vegetable oils.

II. Experimental Investigation

The experiments diesel with bio-diesel mixture was carried out in DI diesel engine. The test engine is a single cylinder, direct injection, water cooled Compression Ignition engine. The experimental setup is shown in figure 1. Diesel engine was directly coupled to an eddy current dynamometer. The engine was always run at its rated speed 1500rpm. The governor of the engine was used to control the engine speed. The dynamometer was interfaced to a control panel. Experimental tests have been carried out to evaluate the performance and emission characteristics of a diesel engine when fuelled thermal cracked carbon filtered fatty acid oil biodiesel (TCFAO) in various percentages B20, B40, B60, B80, B100 and diesel at different load. The emission like HC, CO, and NOx, were measured in the exhaust gas analyzer and smoke density was measured in the smoke meter. The specification of the engine mention in table 1.

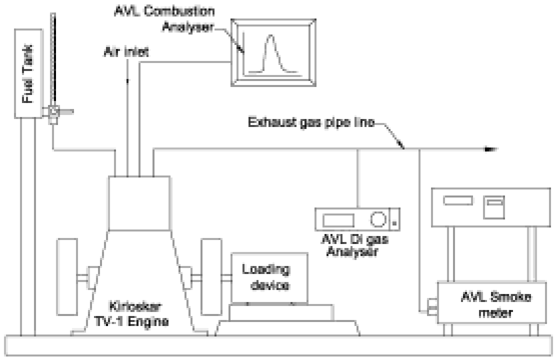

Figure 1 Experimental setup

Table.1.Engine Specifications

Type	:	Single cylinder vertical water cooled, 4 stroke Diesel Engine
Bore	:	87.5 mm
Stroke	:	110 mm
Cylinder diameter	:	0.0875 m
Stroke length	:	0.1m
Compression ratio	:	17.5 : 1
Power	:	5.2 kW (7HP)
Speed	:	1500 rpm
Loading device	:	Eddy current dynamometer

III.RESULT AND DISCUSSION

The optimal blend ratio for Thermal Cracked Carbon Filtered Biodiesel TCFAO was determined on the basis of performance and emission characteristic. For optimization, experiments were conducted using diesel and the various ester blends.

3.1 Performance Characteristics – TCFAO

The variation of Specific fuel consumption at different load and with the diesel and TCFAO blends is shown in Figure 2. For all cases SFC reduces with increase in load. The reverse trend in the SFC may be due to increase in TCFAO blends percentage ensuring lower calorific value of fuel. Another reason for the change in SFC in TCFAO blends in comparison to petroleum diesel may be due to change in the combustion delay caused by the TCFAO blends higher cetane number as well as delay period. It can be observed that the SFC decreases with an increase in the load for both the fuels. The SFC for diesel, B20TCFAO, B40TCFAO, B60TCFAO, B80TCFAO, and B100TCFAO are 0.252 kg/kWh, 0.274 kg/kWh, 0.285 kg/kWh 0.297 kg/kWh, 0.307 kg/kWh and 0.321 kg/kWh respectively, at full load. It is observed that the SFC is higher for all TCFAO blends compared to that of diesel. This may be due to the consumption of more fuel with TCFAO than diesel fuel, to gain the same power output owing to the lower heating value of TCFAO.

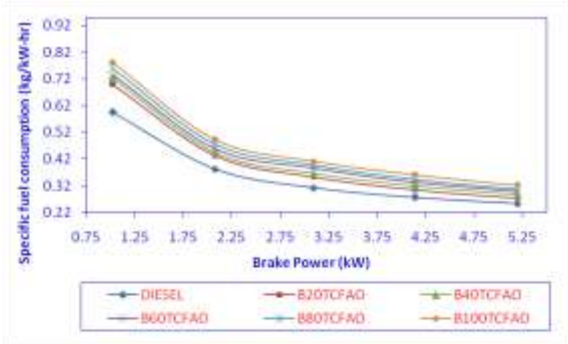

Figure 2 Specific fuel consumption Vs Brake power

The brake thermal efficiency variations of various test fuels are shown in Figures 3. It was observed that brake thermal efficiencies of all the blends of TCFAO were found to be lower than diesel at all load levels. For instance, at full load the brake thermal efficiency of diesel, B20TCFAO, B40TCFAO, B60TCFAO, B80TCFAO and B100TCFAO are 31.23%, 29.44%, 28.52%, 27.92%, 27.54% and 27.09 respectively. The Figures in show the decrease in brake thermal efficiency of all blends of TCFAO compared to diesel. For B20TCFAO the efficiency is closer to diesel since better spray characteristics in the combustion chamber resulted in complete combustion of the fuel. The decrease in brake thermal efficiency with increase in concentration is due to their higher viscosity and poor spray characteristics. The lower brake thermal efficiency is also due to lower calorific value of the fuel.

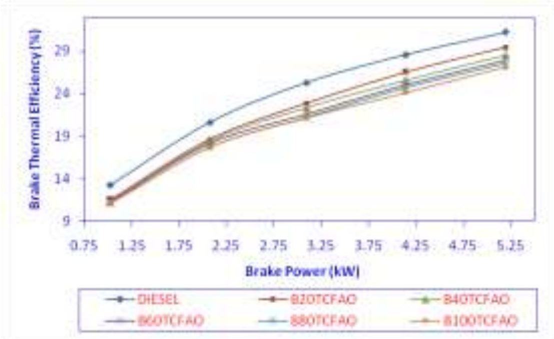

Figure 3 Brake thermal efficiency Vs Brake power

3.2 Emission Characteristics – TCFAO

The variation of smoke emissions at different engine load are presented in Figure 3. The exhaust of the CI engines contains solid carbon particles that are generated in the fuel-rich zones within the cylinder during combustion. These are seen as exhaust smoke and cause an undesirable odorous pollution. The smoke emission increases with an increase in the load for all fuels. The smoke density for diesel is 43 HSU at full load, whereas for B20 and B100 it is 41.2 HSU and 67.4 HSU at full load. The reduction in smoke for biodiesel blends may be due to more oxygen atom present in the biodiesel, resulting in better combustion of biodiesel.

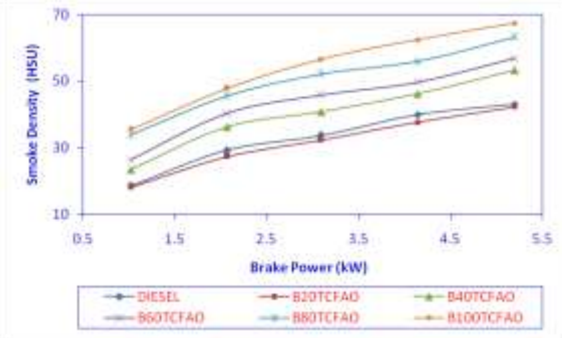

Figure 4 Smoke density Vs Brake power

Figure 5 shows the variation of oxides of Nitrogen emission with brake power for TCFAO biodiesel blends comparison with diesel. The NOx emissions for biodiesel blends B20TCFAO, B40TCFAO, B60TCFAO, B80TCFAO, B100TCFAO and diesel are 743 ppm, 755 ppm, 772 ppm, 786 ppm, 802 ppm, and 720 ppm at full load. NOx emissions are known to increase at high temperatures. It is noticed that NOx emissions are increasing with increasing blend percentage of biodiesel. B20TCFAO blend NOx emissions are slightly higher compared to diesel and lesser than other blends.

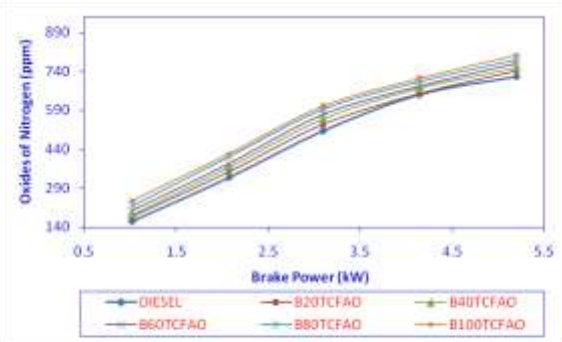

Figure 5 Oxides of nitrogen Vs Brake Power

The variations of un-burnt hydrocarbon emissions at different engine load for different diesel blends are shown in Figure 6. The shorter ignition delay associated with B20TCFAO blends higher cetane number could also reduce the over mixed fuel which is the primary source of un-burnt hydrocarbons. For B20TCFAO blends the minimum HC produced is 68 ppm and for B100 is 89 ppm at full load. The HC emission for diesel is almost equal to that of B20TCFAO which is 69 ppm at full load. Hydrocarbon emissions are mainly due to the presence of gaseous hydrocarbons in the relatively stagnant low temperature, boundary layer along the cylinder wall and in the cervices. Hydrocarbon remains unburned in these areas because the flame does not wholly propagate into these areas.

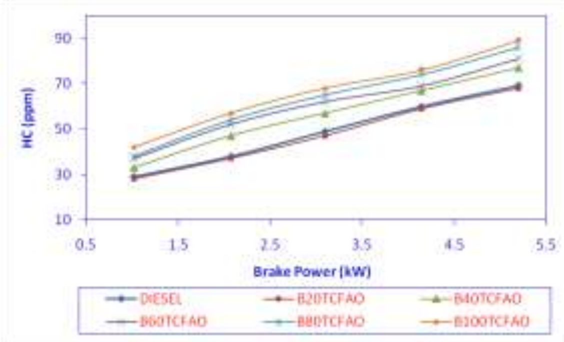

Figure 6 Hydrocarbon Vs Brake power

The variation of carbon monoxide produced with diesel and TCFAO blends are presented in Figure 7. The CO emission is higher for B40TCFAO and B100TCFAO blends compare to diesel and B20TCFAO. It is a product of incomplete combustion due to the insufficient amount of air in the air-fuel mixture or insufficient time in the cycle for the completion of combustion. The decrease in carbon monoxide emission for B20TCFAO blends is due to more oxygen molecule present in the fuel as compared to that of diesel. This may be due to the lower viscosity and more oxygen molecules present in the B20TCFAO, which results in low CO emissions.

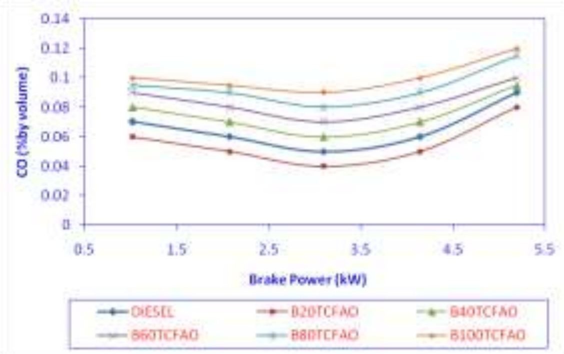

Figure 7 Carbon monoxide Vs Brake power

From figures 8 shows the exhaust gas temperature variations for TCFAO blends with brake power. It is observed that the exhaust gas temperature increases with brake power as more fuel is burnt at higher loads to meet the power requirement. It is also observed that the exhaust gas temperature increases with percentage of TCFAO in the fuel for all the loads. This may be due to the oxygen content of the TCFAO, which improves combustion.

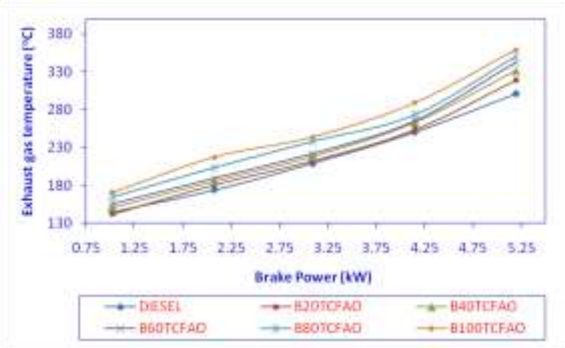

Figure 8 Exhaust gas temperature Vs Brake power

IV. CONCLUSION

- Brake thermal efficiency with B20TCFAO was found to be comparable with diesel at all loads.
- NOx emission for B20TCFAO was found to be comparatively higher than the diesel.
- HC emission levels were more for diesel compare with B20TCFAO. This reduction in HC emissions was due to the availability of molecular oxygen and increase in HC emissions is due to bad flame diffusion in combustion.
- Smoke density for B20TCFAO was found to be lower than diesel.
- CO emission B20TCFAO nearly closer to diesel.

B20TCFAO was found to be environmental friendly as far as carbon monoxide and unburned hydrocarbons were considered.

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