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Comparative performance, combustion and emission evaluated di - diesel engine using methyl ester of *Jatropha* oil and animal fat oil (Pork fat oil)

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Abstract

Interest in use of biodiesel fuels derived from vegetable oils or animal fats as alternative fuels for petroleum-based diesels has increased due to biodiesels having similar properties of those of diesels and characteristics of renewability, biodegradability and potential beneficial effects on exhaust emissions. Reductions of particulate matter (PM), carbon monoxide (CO), and total hydrocarbon emissions (THC) can be achieved with biodiesel use. Based on life-cycle analysis, the use of biodiesel produces real reductions in petroleum product consumption and carbon dioxide (CO2) emissions. This experimental work was conducted to evaluate the performance, emission and combustion characteristics of a diesel engine and compare the use of biodiesel (*Jatropha* oil MEOJ, Animal fat oil AFO) at blend ratio B20, B40, B60, B80 and B100 in single cylinder four strokes DI diesel engine. In each test fuel consumption, break thermal efficiency, nitrogen oxides (NOx), carbon monoxide, cylinder pressure and heat release rate were measured. The experimental results showed that the engine brake thermal efficiency and fuel consumption were comparable to diesel when fueled with two different biodiesels and their blends. The emission of nitrogen oxides (NOx) from biodiesels and their blends were lower than that of diesel fuel.

Keywords: biodiesel, *Jatropha* oil, pork fat oil, thermal efficiency, vegetable oils

INTRODUCTION

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 underground based carbon resources (Narayana Reddy *et al.,* 2004). The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. For the developing countries of the world, fuels of bio-origin may be alcohol, vegetable oils, biomass, and bio-gas. Some of these fuels can be used directly while others need to be formulated to bring the relevant properties close to conventional fuels.

Vegetable oils have comparable energy density, Cetane number, heat of vaporization, and stoichiometric air/fuel ratio with mineral diesel fuel. The large molecular sizes of the component triglycerides result in the oils having higher viscosity compared with that of mineral diesel fuel. The viscosity of liquid fuels affects the flow properties of the fuel and 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 deposits in the upper piston ring groove of the piston ring. The piston ring gets stuck in the groove there by weakening and decreasing the engine performance, as the combustion becomes erratic. The deposits grow, and the efficiency decreases. Another problem is that the vegetable oil and gases escape through clearance into the engine crankcase as the sticking ring fails to reel adequately. 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 buildup 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 (Kalligeros *et al.,* 2002; Murugana *et al.,* 2007).

EXPERIMENTAL PROCEDURE

The performance tests were carried on a single cylinder, four strokes and water cooled, Kirloskar TV 1 diesel engine (Fig. 1). The engine always runs at 1500rpm. (Table 1) Experimental tests have been carried out to evaluate the performance, emission and combustion

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characteristics of a diesel engine when fueled with two different biodiesel (*Jatropha* oil, MEOJ, Animal fat oil (AFO) and its blends of 20%, 40%, 60%, 80% and 100% of biodiesel with diesel fuel separately. It is coupled with a swing field electrical dynamometer. The exhaust gas temperature was measured using thermo couple. AVL 444 Di - gas analyzer was used to measure the oxides of nitrogen. AVL 437 smoke meter was used to measure the density of exhaust gas. AVL combustion analyzer was used to analyze the combustion characteristics.

Table 1. Engine specification

Type	Vertical inline diesel engine, 4 stroke, water cooled
No of cylinder	Single cylinder
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5:1
Brake power	5.2 kW
Speed	1500 rpm
Dynamometer	Eddy current
Ignition system	Compression Ignition
Ignition timing	23° bTDC (rated)
Injection pressure	220 kgf/cm^2

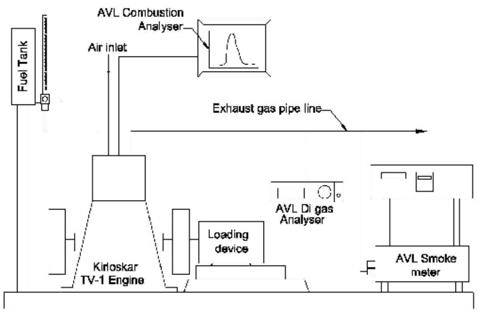

Figure 1. Test Engine

RESULTS AND DISCUSSION

Performance parameter

Fuel consumption

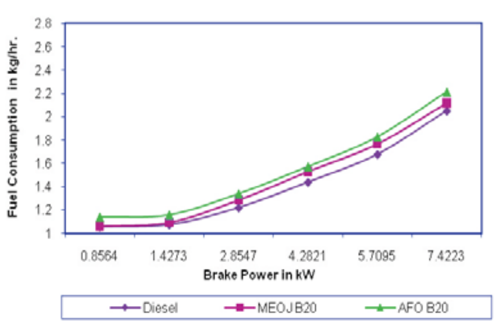

Figure 2. Comparison of fuel consumption *Vs* brake power of different fuels

The variation of fuel consumption with brake power is shown in Fig 2. The fuel consumption is slightly higher for all blends of biodiesel than the diesel. This is caused due to the combined effect of higher viscosity and lower calorific value of the bio diesel.

Brake thermal efficiency

The variations of the brake thermal efficiency with brake power of the engine with MEOJ B20 and AFO B20 in comparison with diesel is shown in Fig 3. It is seen that the thermal efficiency is slightly lower for MEOJ B20 and AFO B20 as compared to diesel. The higher viscosity and lower volatility of these lead to poor mixture formation and hence lower thermal efficiency.

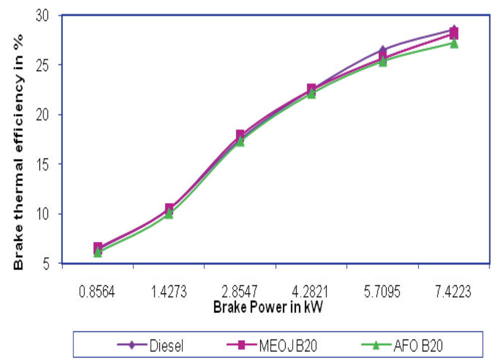

Figure 3. Comparison of brake thermal efficiency *Vs* brake power of different fuels

Exhaust gas temperature

The variation of exhaust gas temperature with respect to brake power is shown in the Fig 4. It is found that the exhaust gas temperature is lower for biodiesel than that of diesel, which indicates better combustion of diesel. Biodiesel dominates the diffusion combustion phase, which makes the heat release to proceed longer. The temperature of exhaust gas leaving the cylinder,

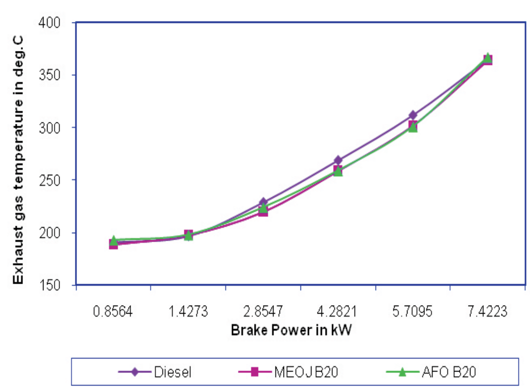

Figure 4. Comparison of exhaust gas temperature *Vs* brake power of different fuels

represent the extent of temperature reached in the cylinder during combustion. With increase in load, the cylinder pressure increase and more of the fuel is burnt leading to increase in temperature.

Emission parameter

Smoke density

Figure 5 represent smoke density with brake power for all fuels. The biodiesel blends MEOJ B20 and AFO B20 produced less smoke density than pure diesel. This is

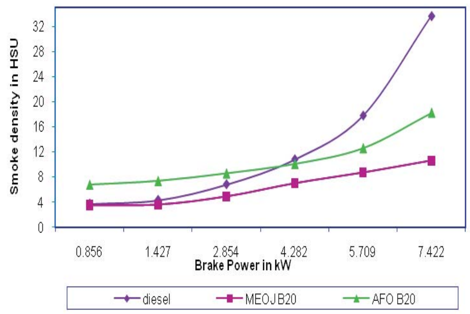

Figure 5. Comparison of smoke density *Vs* brake power of different fuels

due to the presence of oxygen in the molecule of the biodiesel. Sole diesel fuel displays the highest value in smoke density with nearly 33.7HSU at full load. The least observed value is for the blend MEOJ B20 at 10 HSU and AFO B20 18.7 HSU for full load condition.

Oxides of nitrogen

The variation of NOx with brake power for differernt fuels tested is presented in Fig 6. The AFO B20 is lower in NOx level compare to all other fuels. The nitrogen oxides emission formed in an engine highly depends on combustion temperature along with the

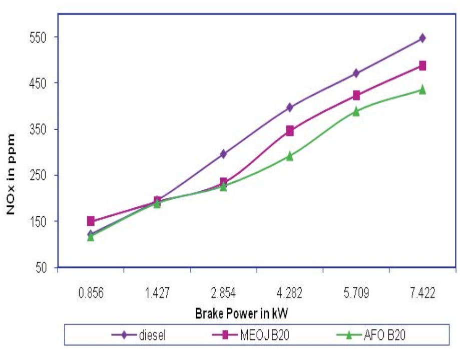

Figure 6. Comparison of oxides of nitrogen *Vs* brake power of different fuels

concentration of oxygen present in combustion products. In general the NOx concentration varies linearly with the load of the engine. As the load increases, the overall fuel air ratio increases resulting in an increase in combustion chamber gas temperature and hence the NOx formation .

Combustion Parameter

Heat release rate

Figure 7 shows the heat release rate with crank angle. The rate of heat release rate for the blended fuel shows short delay period. However the periods of premixed combustion of the two fuels show no difference. But rate of diffusion combustion of biodiesel blended engine was much faster than sole fuel operation. It can be seen that rapid diffusion combustion at AFO B20 by fast rate of burning process than other blends.

Maximum cylinder pressure

Figure 8 shows the maximum cylinder pressure with number of cycle. . It can be seen that for certain cycles the peak pressure is higher and for certain cycle it is lower. The variation in the cycles depends on the air

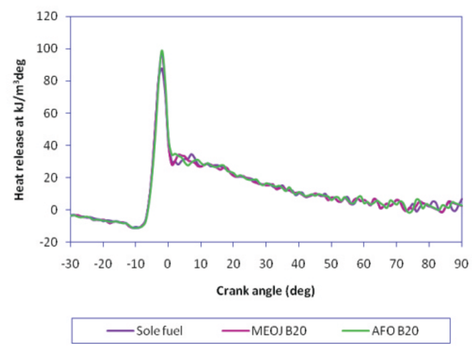

Figure 7. Comparison of heat release rate *Vs* crank angle of different fuels

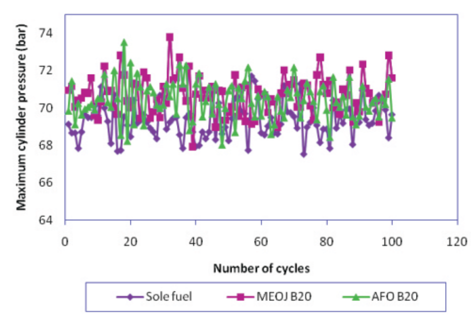

Figure 8. Comparison of maximum cylinder pressure *Vs* Crank angle of different fuels

fuel ratio. While the fuel is being burnt the energy release depends on the calorific value of the fuel. In compression ignition engines the peak pressure depends on combustion rate in the initial combustion period, which in turn depends on the amount of fuel taking part in the uncontrolled combustion phase. The optimum pressure is found in B20 MEOJ compared to all other fuels.

CONCLUSIONS

The engine develops maximum rate of pressure rise and maximum heat release rate for diesel compare to bio-diesel blends. The fuel consumption increases with increase in percentage of bio-diesel blends due to lower calorific value. Based on performance characteristics B20 MEOJ is found to be an optimum blend. NOx level is lower in AFO B20 compared to all other fuels. Heat release rate is higher for AFO B20 compared to diesel and MEOJ. The optimum pressure is found in B20 MEOJ compared to all other fuels.

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