

Experimental Investigation of the Effect of Esterified Karanja Oil Biodiesel on Lubricating Oil and Wear of a 780 hp Military CIDI Engine

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ABSTRACT

Global warming due to exhaust pollution and rapid depletion of petroleum reserves, has given us opportunity to find bio fuels. Bio diesel is an alternative diesel fuel that can be produced from renewable feedstock such as edible and non-edible vegetable oils, wasted frying oils and animal fats. Bio diesel is an oxygenated, sulphur free, non-toxic, biogradable and renewable fuel. Use of karanja oil methyl ester (KOME) biodiesel in a compression ignition engine was found highly compatible with engine performance along with low emission characteristics. A Military 780 hp, CIDI engine was operated using biodiesel (KOME) and diesel fuel respectively. These were subjected to 100 hours long term endurance tests. Lubricating oil samples drawn from engine after a fixed interval (20 hours), were subjected to elemental analysis. Metal debris concentration analysis was done by atomic absorption spectroscopy. Wear of metals were found to be about 30% lower for biodiesel operated engine. The additional lubricating property of biodiesel fuel due to higher viscosity as compared to diesel fuel resulted in lower wear of moving parts and thus improved the engine durability with a biodiesel fuel.

INTRODUCTION

It is essential to evaluate engine wear and lubricating oil characteristics, especially when the engine is to be operated on alternative biodiesel. The biodiesel have emerged as attractive alternative for diesel fuel (1,2,3), considering their renewable nature, better ignition quality, comparable energy content, higher density, higher safety due to higher flash point, non toxic character of its exhaust emission (4,5,6,7,8), almost zero sulphur content, cleaner burning and acceptability in diesel engine without any hardware modification. The properties of karanja oil biodiesel and

diesel were tested in the laboratory. Out of different vegetable oils, karanja oil is having properties nearer to diesel (Table 1). Karanja plant can be grown in the wasteland and does not require too much care. It can be cultivated in all available wasteland to meet the total fuel requirement in future and for countries without petroleum reserves. The use of biodiesel can lead to reduced imports of energy supply, thus resulting in foreign exchange savings (9,10,11).

In the present study, pure karanja biodiesel fuel has been used for 100 hours endurance test. This investigation will evaluate the effect of additional oxygen content in biodiesel on engine component wears, and lubricating oil performance with used lubricant debris analysis.

The objectives of this study are:

- (a). To measure engine brake power.
- (b). To measure the metals wear carried by the lubricant away from the wear and frictional surfaces.
- (c). To measure the lubricating oil performance based on the total basic number (TBN), viscosity results, and lubricant additive results.

Transesterification of karanja oil

The karanja oil was used for making karanja oil methyl ester in this study. Karanja oil was converted into methyl ester by the transesterification process. This involves making the triglycerides of karanja oil to react with methyl alcohol in the presence of a catalyst (NaOH/KOH) to produce glycerol and fatty acid ester (12,13). The schematic diagram of the chemical reaction of transesterification is illustrated in Figure 1.

(See [Figure 1](#) after last section of paper.)

EXPERIMENTAL SET-UP AND PROCEDURES

A 780 hp, 12-cylinders, four stroke, variable speed, and supercharged CIDI diesel engine was tested for this study. The engine was couple to a 2000kW, SAJ hydraulic dynamometer as shown in [Figure 2](#). The basic specifications of the engine are given in [Table 2](#). Cylinder pressure has been measured using a piezo electric pressure transducer and charge amplifier. The viscosity and TBN of all lubricating oil samples were measured using Setavis Kinematic viscometer and TBN measurement apparatus (model: DIGI cell, Make: Kittiwake, UK) respectively. All the engine measurements have been collected and recorded by the data acquisition system. All measurements were taken three times and the average results were recorded.

A variable speed range from 1200-2000 engine rpm with full load condition was selected for performance test. Whereas a constant speed 1600 engine rpm with 50per cent load condition was maintained throughout the wear and lubricating oil test period for both the test fuels

(See [Figure 2](#) after last section of paper.)

The first sample was collected immediately after the engine had warmed up and subsequently oil samples (400ml) were drawn at the intervals of every 20 hours from engine oil sump through one-way valve. The test was carried out with diesel fuel using new lubricating oil first. After 100h operation, the fuel and lubricating oil were replaced with karanja biodiesel and fresh lubricating oil and the same procedure was followed for both the test fuels. Immediately after collection, test samples were analyzed to obtain wear, additive, viscosity and TBN results. Atomic absorption spectroscopy (model: GBC, Avanta, Australia) with dry ash technique was used for extracting metals wear from the lubricating oil samples (10 ml).

Table 1. Properties of fuels selected for engine experiments

Fuel Properties	Diesel	Biodiesel (KOME)	Test Method
Relative Density at 15°	829.6	922	ASTM D-4052
Kinematic Viscosity (cst) at 40°	2.49	5.57	ASTM D-445
Calorific Value (MJ/Kg)	43080	39800	ASTM D-240
Flash Point (° C)	59	168	ASTM D-93
Cloud Point (° C)	-1	23	ASTM D-2500
Cetane No.	48	51	ASTM D-613
Carbon Content (wt%)	87	78	ASTM D-5291
Hydrogen Content (wt%)	12.4	11.5	ASTM D-5291
Sulfur Content (wt%)	0.0022	<0.01	ASTM D-4394
Water Content (wt%)	< 0.01	< 0.01	ASTM D-1796
Free glycerin	-	0.00	ASTM D-6584
Total glycerin	-	0.02	ASTM D-6584

Table 2. Engine specifications

Make	B-460-6
Rated Brake Power (kW/ hp)	585 /780
At 2000 Engine rpm	
Rated Torque (N-m)	3188
at 1400 Engine rpm	
Number of cylinder	12
Bore x Stroke (mm)	150 x 180
Displacement volume (cc)	38886
Compression ratio	14:1
Lubrication System	Forced Feed
Cooling System	Water cooled
Breathing	Super charged
Engine oil Capacity	65 Litres

RESULTS AND DISCUSSION

The engine performances of diesel and karanja biodiesel fuel are compared at maximum operating speed at full load conditions. Whereas wear and lubricating oil characteristics were tested at constant operating speed of 1600 engine rpm. The performances were studied and compared with diesel baseline fuel.

ENGINE PERFORMANCE

The performance of engine was evaluated in terms of brake power. Pure biodiesel (KOME) has a significantly higher cetane rating, slightly lower heating value, slightly higher viscosity, as well as density than diesel fuel, and also contains approximately 10% oxygen. The lower heating value will cause a small loss in maximum power if engine fuel system is not recalibrated (Figure 3, and 4).

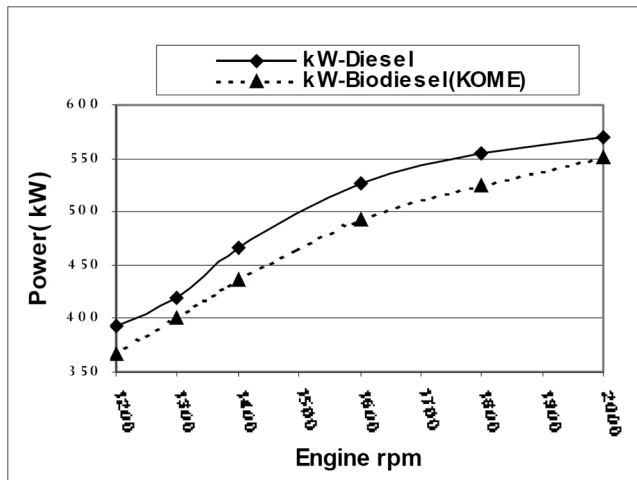


Figure 3. Brake power output for diesel - karanja biodiesel fuel.

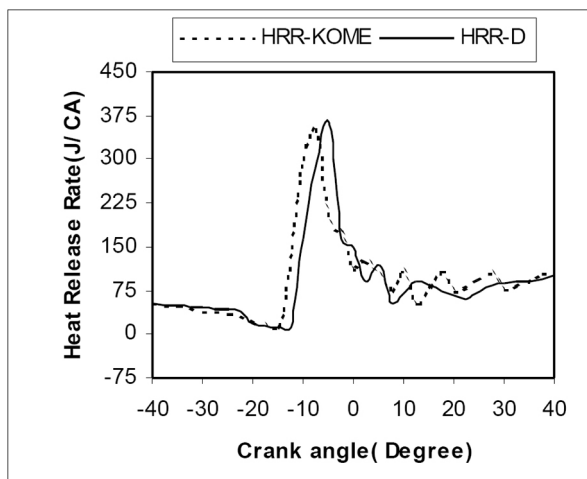


Figure 4. Heat release rate of diesel-karanja biodiesel at full load condition.

Engine Wear

Wear debris originate from various sliding and rotating component in engine, are washed away by lubricants and finally get accumulated in the engine oil sump. The metallic wear debris, which originates from different parts, may have different composition depending on the origin. Hence metal analysis of lubricating oil gives a fair idea of wear of vital

components of the engine. Various metals such as Fe, Cu, Cr, Al, Ni, Zn, Mg, and Pb were analysed.

Wear Of Metals And Additive Depletion

It has been observed that the wear debris of metals such as Fe, Cu, Cr, Al and Pb (Fig. 5,6,7,8,9) decrease up to 30% with biodiesel. One of the possible reasons for lower concentration may be the improved lubricating efficiency due to improved combustion and lower soot formation with biodiesel fuel.

The depletion of lubricant additives such as Zn, Mg, and Ni (Fig 10,11,12) was found lesser in biodiesel fuelled engine as compared to diesel fuelled engine. Other researchers (14,15) have also found lower wear with biodiesel.

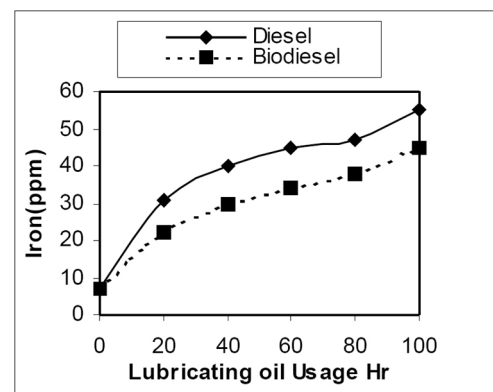


Fig.5. Fe concentration vs. usage hr

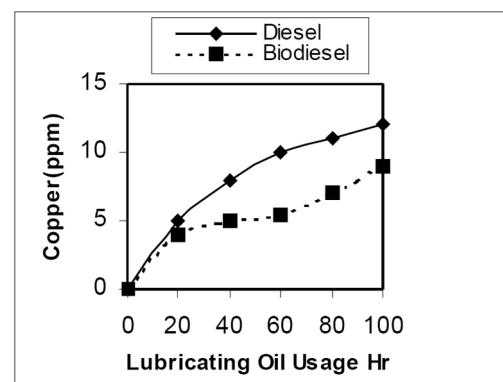


Fig.6. Cu concentration vs. usage hr