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Performance characteristics of direct injection diesel engine running on Mackerel fish oil biodiesel / diesel fuel blend

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Abstract— Triglycerides and their derivatives are considered as viable alternatives for diesel fuel. Highly viscous Mackerel fish oil biodiesel can be reduced by blending with diesel fuel. The present research work is aimed to investigate experimentally the performance characteristics of direct injection (DI) diesel engine, over entire load range when fueled with Mackerel fish oil biodiesel (FOB) and diesel fuel (DF) blends (B20, B40, B60, B80, B100; example: B20: 20% FOB + 80% DF by volume).The performance parameters such as brake specific fuel consumption, brake specific energy consumption, brake thermal efficiency, air fuel ratio were analysed. Results showed that all blends follow the same trend as that of DF. There was no much difference between the performance of DF and FOB. At higher loads both specific energy and specific fuel consumptions were low for FOB (B100). FOB can be used in the DI diesel engine as an alternative fuel without any engine modifications.

Index Terms— Blends, diesel engine, fish oil biodiesel, load, performance, triglycerides

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1 INTRODUCTION

THE continuous rise in the global prices of crude oil, ever increasing threat to environment due to exhaust emissions, the problem of global warming and the threat of supply fuel oil instabilities have adversely impacted the developing countries like India [1]. The consumption of fossil fuels can be minimized by exploring alternative fuel sources. From the point of view of long-term energy security, it is necessary to develop new alternative fuels with properties comparable to petroleum-based fuels [1], [2]. Vegetable oils are one such alternative source. The major limitation of vegitable oils is their viscosity. The magnitude of which is higher than the diesel fuel. Vegetable oil and diesel fuel blending (dilution) is one of the methods to reduce their viscosity [1], [2], [3], [4], [5], [6].

It was reported that usage of raw vegetable oil as an alternative diesel engine fuel has resulted in higher specific fuel consumption and emissions such as CO, HC and smoke opacity compared to diesel fuel [7], [8], [9], [13]. This was attributed to the lower heating value, higher viscosity, poor atomization, low volatility and polyunsaturated characteristics of neat vegetable oils [1].

Another potential source is animal fat. Marine fish oil biodiesel has a larger gross heating value, elemental carbon and hydrogen content, cetane index, exhaust gas temperature, brake fuel conversion efficiency, and a lower elemental oxygen content [8].

Cetane index of Mackerel fish oil biodiesel is higher than the raw oil and the viscosity of the blend decreases with increase in the quantity of diesel fuel in the blend [10].

Investigator [11] made a comparative analysis of performance, emission and combustion parameters of DI diesel engine with ethyl ester of fish oil and its diesel blends and concluded that the mean brake thermal efficiency decreases with increase in the blend ratio by 1.8%, 6.4%, 11.3% and 12.4% compared to diesel. Higher smoke emissions of blends compared to diesel.

The present research work is aimed to investigate experimentally the performance characteristics by exploring the technical feasibility of FOB and DF blends in the DI compression ignition engine.

2 MATERIALS AND METHODS

2.1 Oil characterization

The properties of FOB (B100; pure biodiesel) and blends of FOB and DF were determined [10] as per the methods approved by Bureau of Indian Standards. The properties of DF and FOB (B100) are given in the table 1 [10].

2.2 Experimental setup and plan

Experimental tests were conducted on a DI diesel engine. The specifications of the engine are given in table 2. The fuel tanks were used in the present investigation with switch over arrangement, so that supply of fuel can be changed without stopping the engine operation. The engine was started with DF and data was collected after attaining the steady state then the experiment was switched over to blend of FOB and DF. The engine tests were conducted for the entire load range (0 to 100%; steps of 25%) at constant spped of 1500 rpm. The cooling water temperature was maintained constant (70 to 75^0 C). The engine parameters such as fuel consumption, air con-

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TABLE 1
PROPERTIES OF DF AND FOB

Properties	Method IS:1448	DF	FOB [10]
Cetane number	--	45 - 55	59
Density (Kg/m^3)	P:32	820 - 880	882.3
Kinematic viscosity at 40^0C (cst)	P:26	3.0	5.0
Calorific value (KJ/Kg)	P:6	43000	37668.63
Flash point (^0C)	P:21	56	162

sumption, speed were measured.

Exhaust gas temperature, cooling water temperature were measured with digital indicator. Figure 1 shows the photograph of engine setup.

Fig. 1. Photograph of the experimental setup showing the test rig and the twin cylinder DI diesel engine.

3 RESULTS AND DISCUSSION

The performance parameters such as specific fuel consumption, energy consumption, brake thermal efficiency, air-fuel ratio are presented in the figures 2 to 5 for different blends including pure biodiesel (B100) and DF.

3.1 Brake specific fuel consumption (bsfc)

Figure 2 shows the variation of brake specific fuel consumption (bsfc) aginst the load. Specific fuel consumption is initially high due to pumping work. Increase in the magnitude of friction and the relative heat transfer reduces the fuel conversion efficiency.

TABLE 2
ENGINE SPECIFICATIONS

Make	Kirloskar
Number of cylinders	Two
Bore	80 mm
Stroke	110 mm
Speed	1500 rpm
Power	10 hp
Compression ratio	16:1
Injection advance	27^0 bTDC
Injection pressure	200 kgf/cm^2
Type of starting	By hand cranking
Governor	Mecahanical governing (centrifugal type)

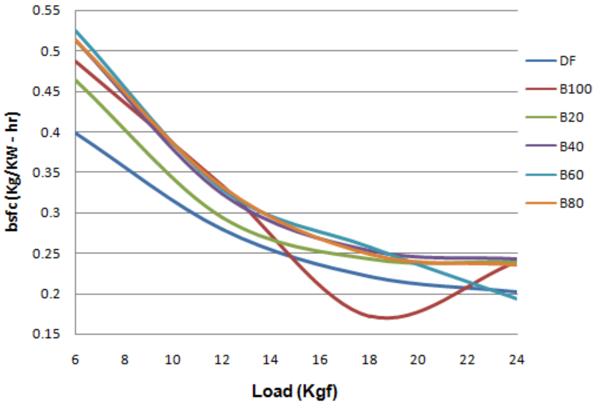

Fig. 2. The effect of quantity of FOB in the blend on bsfc.

As the load on the engine increases the fuel consumption decreases. The bsfc for FOB (B100; pure biodiesel) is less compared to the DF in the range between medium and higher loads. At lower loads B20, B40, B60, B80 blends show higher bsfc and decreases with increase in the loads, but higher than DF over entire load range. B20 shows the lower bsfc compared to B40, B60, B80, and B100 at lower loads and also near to the DF.

3.2 Brake specific energy consumption (bsec)

Generally bsfc is not used to compare two different fuels, because their calorific value, density, chemical and physical parameters are different [12]. Performance parameter bsec is used to compare two different fuels by normalizing bsec in-terms of the amount of energy released with the given amount of the fuel. The variation of bsec against the load is shown in the figure 3

The bsec for the blends B20, B40, B60, and B80 is higher than DF over entire load range this may due to poor atomization and decrease in the percentage of oleic acid [10] present in the pure biodiesel due to blending. FOB from medium loads to higher loads show lower bsec than DF this may due to combustion of volatile fats [10] present in the FOB.

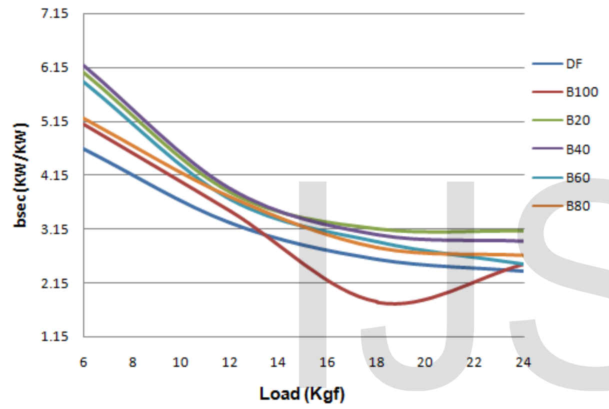

Fig. 3. The effect of quantity of FOB in the blend on bsec.

3.3 Brake thermal efficiency

Figure 4 shows the variation of brake thermal efficiency for different blends over entire load range. For all blends brake thermal efficiency increases with increase in the load. This may due to reduction in heat loss and increase in the power output. Owning to the poor mixture formation as a result of higher viscosity the thermal efficiency of blends are lower compared to pure biodiesel (FOB).

At 50% loading condition FOB shows nearly same brake thermal efficiency as that of DF and the magnitude of thermal efficiency of FOB is near to the DF over the entire load range.

3.4 Air fuel ratio

In diesel engines for given speed irrespective of load an approximately constant fuel enters the cylinder. Figure 5 shows the variation of the air fuel ratio of different blends as function of load on the engine. All blends follow the same trend as that of DF. At lower loading condition (between 25 to 50% loading) air fuel ratio for FOB is near to the DF and approximately between 30% to 75% loading condition the air fuel rato for B20 is near to the DF.

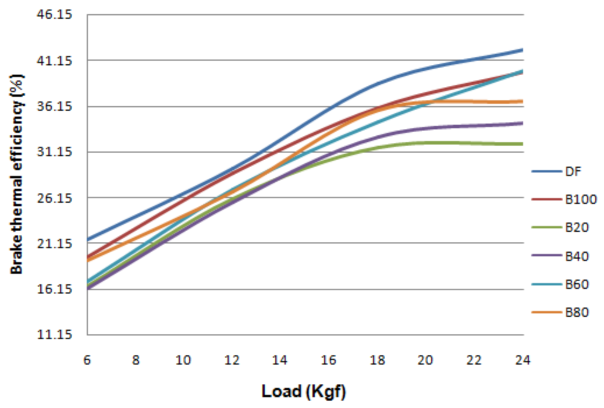

Fig. 4. The effect of quantity of FOB in the blend on brake thermal efficincy.

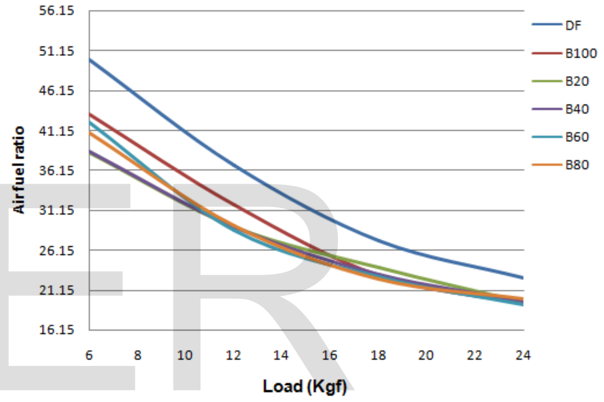

Fig. 5. The effect of quantity of FOB in the blend on air fuel ratio.

5 CONCLUSIONS

Based on the experimental results of the work the following conclusions are drawn.

No problem was faced at the time of starting of the engine and ran smoothly over the range of FOB present in fuel blend.

There is no much difference between the performance parameters of FOB and DF. FOB, consumes less fuel compared to DF, at higher loading conditions and the same result replicates for the energy consumption too.

Higher cetane number of the FOB ensures the complete combustion with lesser emissions compared to DF.

Brake thermal efficiency for FOB, is nearer to the DF over entire load range.

Pure biodiesel (B100) can be used as an alternate fuel in the DI diesel engine without any engine modifications.

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