Research Article

PERFORMANCE,VIBRATION AND EMISSION ANALYSIS OF DIESEL ENGINE FUELLED WITH FISH OIL BIO DIESEL BLENDS

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ABSTRACT

This paper presents the Performance, emission and vibration evaluation of four stroke single cylinder diesel engine fuelled with three fish oil biodiesel (FME) blends. FME in three different proportions viz.20%, 30% and 40% by volume is mixed with diesel to form bio diesel blends (B20, B30 and B40). Performance Parameters like fuel consumption, torque and brake thermal efficiency were measured at different loads for pure diesel and various blends of FME. Emission studies were also carried out to study the CO, NO_x and smoke emissions. The results demonstrate that the smoke and CO emissions from FME blends operated engine are comparatively less with that of pure diesel operation which is accompanied by an increase in NOx emissions.

KEYWORDS Brake power, Emissions, Fish oil, Specific fuel consumption, transesterification.FME: Fish oil Methyl Ester

1. INTRODUCTION

Bio-diesel, which is used as an alternative diesel fuel, is made up of renewable biological sources such as vegetable oil and animal fats. It is biodegradable, non-toxic and possesses low emission profiles. In addition the uses of bio-fuels are environmentally beneficial. Vegetable oils have comparable energy density, cetane number, heat of vaporization, and stoichiometric air/fuel ratio with mineral diesel. Vegetable oils and their derivatives in diesel engines lead to substantial reductions in emissions of sulfur oxides, carbon monoxide (CO), poly aromatic hydrocarbons (PAH), smoke, particulate matter (PM) and noise. The contribution of bio-fuels to greenhouse effect is insignificant, since carbon dioxide (CO_2) emitted during combustion is recycled in the photosynthesis process in the plants. F. Halek et.al [1] reported that Diesel engines operated on biodiesel have lower emissions of carbon monoxide, unburned hydrocarbons, particulate matter, and air toxics than when operated on petroleum-based diesel fuel. G. Amba Prasad Rao et.al [2] studied the Performance of DI and IDI engines with Jatropha oil based biodiesel and concluded that DI engine operation with biodiesel under supercharged condition the performance very close to diesel fuel operation. They also showed that transesterification reduces the viscosity by about 88% and density by 4.34%. Cherng-Yuan Lin et.al [3] transesterified Fish oil to produce biodiesel. They used discarded parts of mixed marine fish species as the raw material to produce biodiesel. They reported that, commercial biodiesel from waste cooking oil, when compared with marine fish-oil biodiesel had a larger gross heating value, elemental carbon and hydrogen content, cetane index, exhaust gas temperature, NO_x and O_2 emissions, and black smoke opacity and a lower elemental oxygen content, fuel consumption rate, brake-specific fuel consumption rate, equivalence ratio, and CO emission. T.Hari Prasad et.al used artificial neural network (ANN) modeling of a diesel engine to predict the exhaust emissions of the engine [4]. To acquire data for training and testing the proposed ANN, they conducted experiments on a single cylinder, four-stroke test engine fuelled with biodiesel (fish oil) blended with diesel at different loads. They compared ANN predictions with the experimental results. From the experimental results, they found significant reduction in the CO, CO_2 and HC emission levels accompanied by an increase in NOx level. A. Karthikeyan et.al[5] studied the diesel engine performance with fish oil biodiesel and its blends with diesel in proportions of 20:80, 40:60, 60:40 and 100% (by volume), on a single cylinder, water cooled, four stroke diesel engine and reported that Brake thermal efficiency of B60 blend and B-100 was close to the brake thermal efficiency of diesel at all loads. They concluded that volumetric efficiency values of fish oil biodiesel and its diesel blends were higher than the volumetric efficiency values of diesel at all loads. Smoke, CO and particulate matter emissions were shown to increase with increase in percentage of fish oil biodiesel in the fuel. However NOx emissions of fish oil blends are slightly higher than that of diesel. J. A. Steigers [6] also showed decreases in CO, PM, and SO2 in exhaust gas emissions as fish oil content of the fuel blend increases, with an offsetting increase in NOx. Dilip Kumar Bora[7] studied the performance of single cylinder diesel engine using blends of karabi seed biodiesel by using Potassium hydroxide as catalyst to facilitate estarification process. He concluded B20 fuel showed better BTE than B100 fuel, B100 also showed maximum NOx emissions however B100 emitted least CO emissions in comparison with B20 and diesel. This present investigation aims at performance, emission evaluation of FME (B20, B30 and B40) fuelled diesel engine with an emphasis on vibration analysis.

2. EXPERIMENTATION

The engine used (as shown in Fig.1) for investigations on FME blends to evaluate the performance and emission characteristics was a computerized single cylinder four stroke, naturally aspirated direct injection and water cooled diesel engine. The specifications of the test engine are shown in table 2. It was directly coupled to an eddy current dynamometer that permitted engine motoring either fully or partially. The engine and the dynamometer were interfaced to a control panel which is connected to a digital computer. The computer software Engine soft version 2.4 supplied by the test rig supplier was used for recording the test parameters such as fuel flow rate, temperatures, air flow rate, load etc and for calculating the engine performance characteristics such as brake thermal efficiency, brake specific fuel consumption and volumetric efficiency. The calorific value and the density of the particular fuels were fed to the software. The injection timing was set to 27 before TDC. The exhaust gas temperature, water inlet and outlet temperatures, airflow rate, fuel consumption, brake power, brake specific fuel consumption, torque etc were measured through the computer by using the software 'ENGINE SOFT'.

Table 1: Specifications of the engine

Make	Kirloskar
Rated Power	3.7 kw(5hp)
Bore	80 mm
Stroke Length	110 mm
Swept volume	562 cc
Compression ratio	16.5:1
Rated Speed	1500 rpm

Fig. 1 Experimental Setup

Properties of FME and its blends B10, B20 B30 were found experimentally in the laboratory and shown in Table 2.

Table 2 Properties of FME

Properties	B10	B20	B30	B100	DIESEL
Carbon % (w/w)	0.2325	0.2083	0.1666	0.1369	0.2439
Flash Point (°C)	58	62	64	141	60
Fire Point(°C)	68	70	72	173	62
Density (g/cm^3)	0.822	0.826	0.829	0.896	0.830
Kinematic Viscosity (Centi Stokes) at 30°C	3.575	3.96	4.3877	10.1551	3.15
Specific Gravity	0.8225	0.826	0.829	0.896	0.830

3. RESULTS AND DISCUSSION

Brake power (as shown in fig.2) is high for the blends when compared to diesel. *Volumetric Efficiency* of the engine (as shown in fig.3) with blends is high. *Brake thermal efficiency* (η_{bth}) (as shown in fig.4) of FME blends is greater than the diesel. *bmep* for FME (as shown in fig.5) is comparable with that of diesel. *isfc* increases with the load and the ISFC of FME blends is slightly higher than that of diesel. With the increase in percentage of fish oil in the blend the NO_X emissions will increase (as shown in fig.7).The flue gas Analyzer used for this experiment is shown in Fig (7) The smoke produced (as shown in fig.9) decreases when the blend percent increases for all loads and with B40 the smoke produced is very less when compared to diesel. CO emission (as shown in fig.10) decreases with increase in the percentage of fish oil.

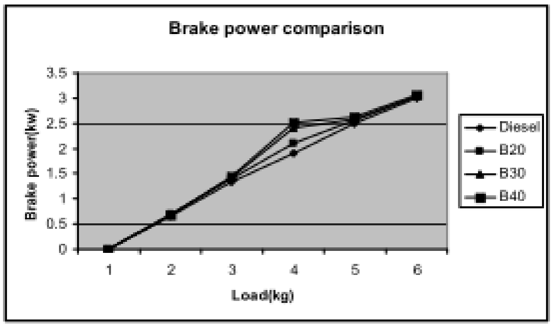


Fig. 2 Brake power Comparison

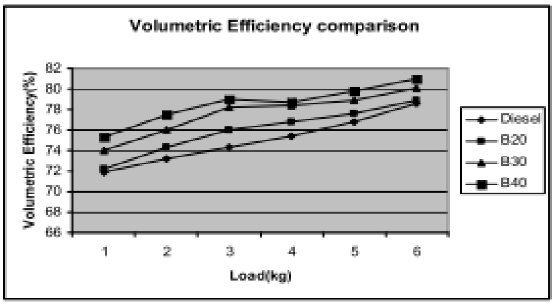


Fig.3 Volumetric Efficiency Comparison

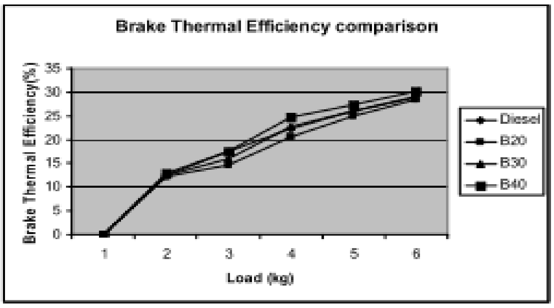


Fig. 4 Brake Thermal efficiency comparison

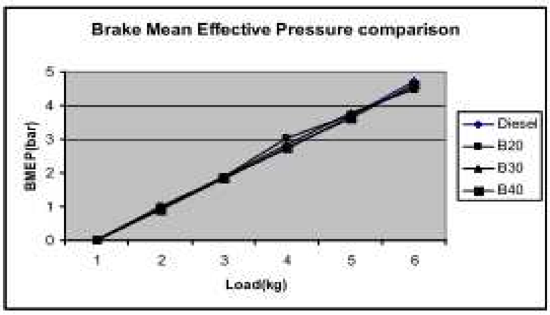


Fig.5 BMEP Comparison

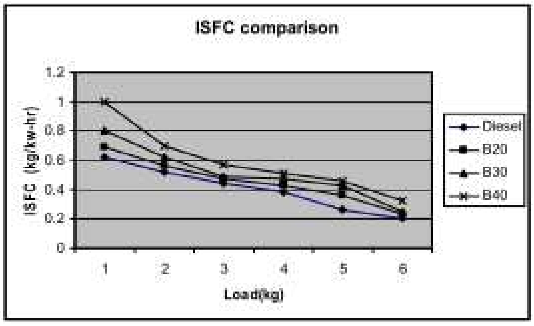


Fig.6 ISFC Comparison

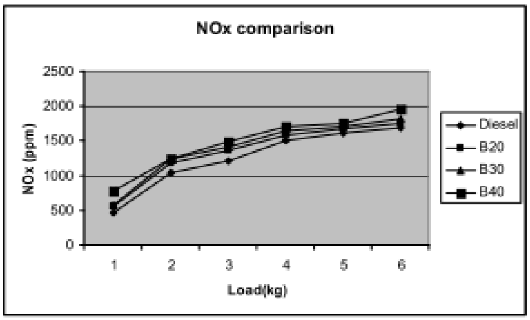


Fig. 7 NOx comparison

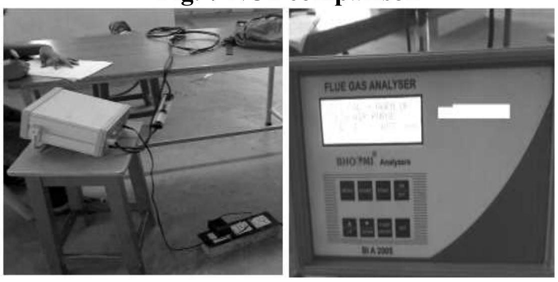


Fig. 8 Flue gas analyzer

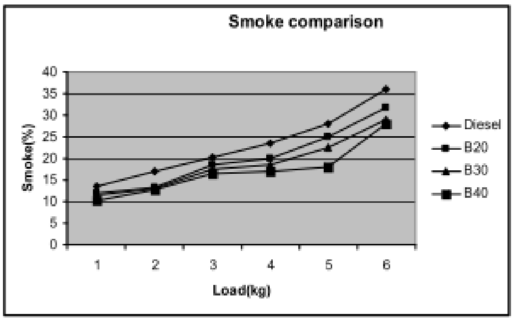


Fig. 9 Smoke comparison

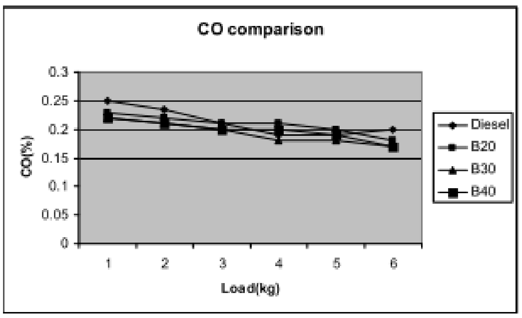


Fig. 10 CO comparison

Engine Vibration comparison

The overall values of vibration on the cylinder in two directions are measured [8], One in the radial direction perpendicular to the crankshaft and the second on the cylinder head in vertical direction.

With B20, the engine generated the minimum overall vibration when compared with other oils including diesel but with an exception that it generates slightly higher value on the cylinder head in vertical direction as shown in Fig.11

The vibration signatures obtained on the cylinder in vertical direction indicate lesser high frequency amplitudes in the case of B20 (Fig 13) indicating supporting lesser overall levels as indicated above. The observation is same for B20 in the signatures obtained in the other two radial directions on the cylinder.

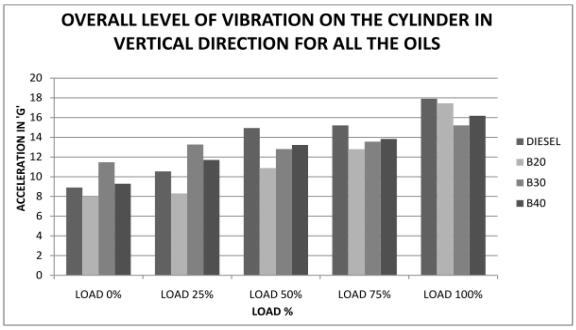


Fig. 11 Overall values of vibration in acceleration amplitude Vs the load percentage

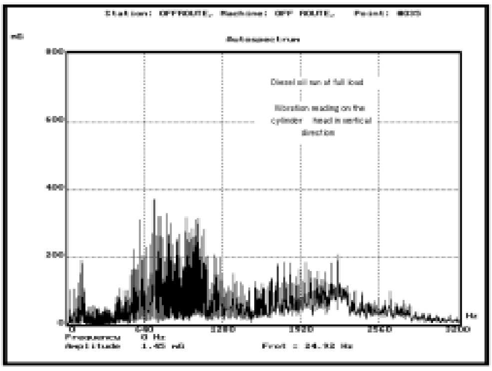


Fig.12 Cylinder vibration in vertical

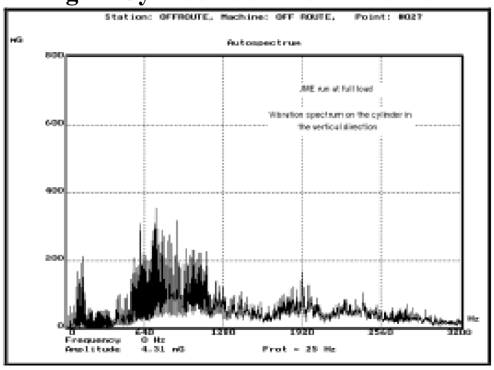


Fig.13 Cylinder vibration in vertical direction direction the diesel oil with the B20 run at full load run at full load

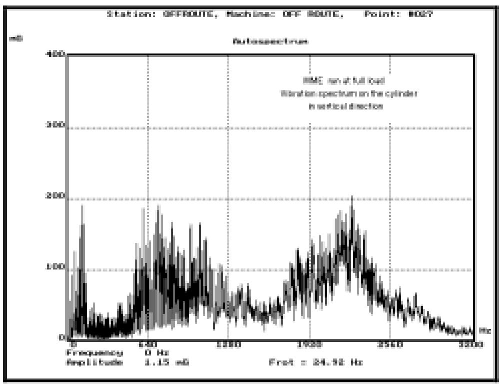


Fig.14 Cylinder vibration in vertical direction with the B30 run at full load

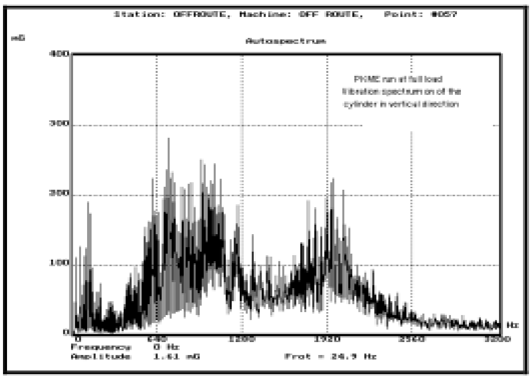


Fig.15 Cylinder vibration in vertical direction with the B40 run at full load

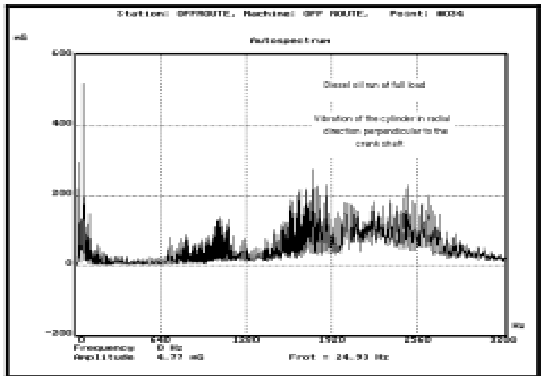


Fig.16 Cylinder vibration in radial direction perpendicular to the crankshaft with the diesel oil run at full load

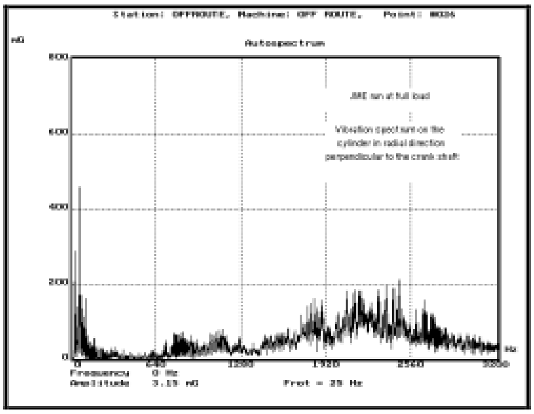


Fig.17 Cylinder vibration in radial direction perpendicular to the crankshaft with the B20 run at full load

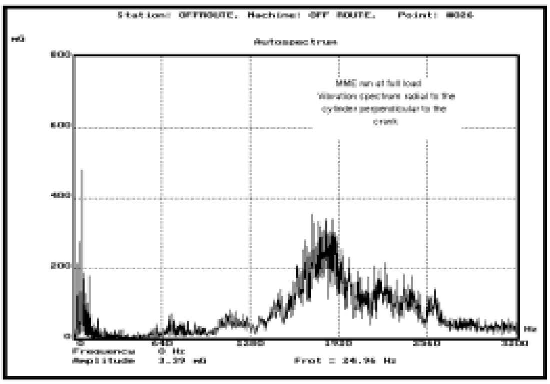
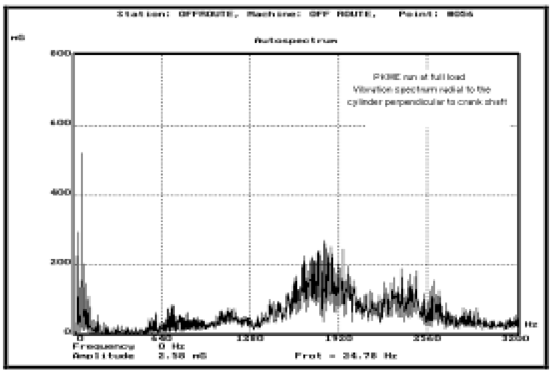


Fig.18 Cylinder vibration in radial direction perpendicular to the crankshaft with the B30 run at full load



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ig.19 Cylinder vibration in radial direction direction perpendicular to the crankshaft with the B40 run at full load

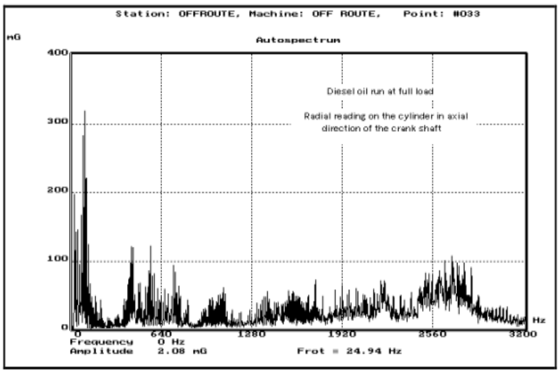

Fig.20 Cylinder vibration in radial direction axial to the crankshaft with the diesel oil run at full load

CONCLUSIONS

Fuel consumption in the case of diesel run is comparatively lower than the ester tested on the same Engine. Except in the case of mechanical efficiency, diesel excelled in almost all parameters for which graphic evaluation is made. The reason can be assigned to the structure of the esters because of which the frictional power wastage might have been reduced. The brake specific fuel consumption is an important parameter that is rated whenever engine performance is adjudicated. In our observation diesel fuel's *bsfc* is comparatively lowest. The reason can be assigned to the inferior calorific value of the ester. There is an increased vibrational severity of the engine with the usage of the *diesel* fuel when compared to the ester tested. This may be due to relatively higher power development in the case of diesel fuel. Vibration phase measurements indicate that there is a phase difference for the first order which exceeds even 550.This will give an additional support to the conclusion that the diesel fuel gives higher vibratory trend than FME. The emissions are also less for the esters .In the light of the above said conclusions, the esters can be recommended to be implemented to run the engine without changing the basic design of the engine because of the reason that the esters are affordable because of the ong oing trend in the increase of prices of petro-diesel.

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