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PERFORMANCE AND EMISSION CHARACTERISTICS ON METHYL ESTERS OF SARDINE OIL FUELLED IN DIESEL ENGINE

V. NARASIMAN[*], S. JEYAKUMAR[a], M. MANI[b] and S. SIVALAKSHMI[c]

Department of Mechanical Engineering, Vinayaka Mission University, SALEM (T.N.) INDIA
[a]Department of Mechanical Engineering, Kalasalingam University, SRIVILIPUTHUR (T.N.) INDIA
[b]Department of Mechanical Engineering, Rajalakshmi Engineering College, (T.N.) INDIA
[c]Department of Mechanical Engineering, Government College of Engineering, SALEM (T.N.) INDIA

ABSTRACT

Engine tests were carried out with several mixing ratios of fuel between sardine oil and diesel in a diesel engine. The high viscosity of sardine oil leads to problem in pumping and spray characteristics. The improper mixing of sardine oil with air leads to incomplete combustion. The best way to use sardine oil as fuel in diesel engines is to convert it into biodiesel. It can be used in diesel engines with out any engine modifications. This is because it has properties similar to mineral diesel. Combustion tests for methyl ester of sardine oil and its blends with diesel fuel were performed in a kirloskar TAF1 DI diesel engine, to evaluate sardine biodiesel as an alternative fuel for diesel engine, at constant speed of 1500 rpm under variable load conditions. The tests showed that break thermal efficiency is slightly increased and HC, CO in the exhaust are reduced when fuelled with methyl esters compared to diesel except NO_x emission.

Key word: Biodiesel, Diesel engine, Sardine oil, Emission, Performance.

INTRODUCTION

Biodiesel is produced by the combination of alcohol, which is usually alcohol with vegetable or animal oil/fats. In order to lesson harmful vehicle emission, it can be utilized on its pure form as a renewable substitute for diesel engine. Biodiesel and ethanol are clean, which can produced on site in local villages and in renewable resources. Another gain is that many alternative fuels can be generated, while oil is a non renewable resource. Present estimates predict that world oil production will reach its peak some time in the next 10 to 15

[*]Author for correspondence; E-mail: narasiman_1979@rediffmail.com, ssjk2013@yahoo.com, mmanimemba2003@yahoo.com, s_sivalakshmi@yahoo.com; Mo.: +91 9952665632, +91 9600136655, +91 9884647061, +91 9842888202

years. Even low concentration of biodiesel reduces PM emission and provides significant health and compliance benefits wherever human receives higher levels of exposure to diesel engine. Ali and Hanna[1] alternate fuels like ethanol, biodiesel, LPG, CNG, etc have been commercialized in transport sector. Ken et al.[2] converted sunflower and fish oil to their methyl esters, tested in a single cylinder diesel engine and concluded that, the maximum output with both methyl esters was higher (0.11 kW, 3%) than the diesel fuel. Hulya[3] analyzed qualitatively and quantitatively, the crude commercial fish oil, by gas liquid chromatography. The major fatty acids detected in this oil were as follows: 24.8% stearic, 23.6% palmitic, 9.84% myristic, and 6.56% octadecatetraenoic acids. The physical and chemical properties of crude commercial fish oil were established. Steigers[4] demonstrated the use of fish oil as fuel in a large stationary diesel engine. Rao and Mohan[5] studied the performance of DI and IDI engines with jatropia oil based biodiesel and concluded that DI engine operation with biodiesel under supercharged condition the performance are very close to diesel fuel operation. Lin and Li[6] trasesterified fish oil to produce biodiesel and 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 large gross heating value elemental carbon and hydrogen content, cetane index, exhaust gas temperature, NO_x, and O_2 emission and black smoke opacity with lower elemental oxygen content. Karthikeyan et al.[7] studied the diesel performance with fish oil biodiesel and its blends with diesel in proportion of 20 : 80, 40 : 40, 60 : 40 and 100% by volume on single cylinder water cooled four stroke diesel engines and reported that break thermal efficiency of B60 blend and B100 was close to break thermal efficiency of diesel at all loads. Bora[8] studied the performance of single cylinder diesel engine using blends of karabi seed biodiesel by using potassium hydroxide as catalyst to facilitate estarification process and concluded B20 fuel showed better break thermal efficiency than B100 fuel, B100 also showed maximum NO_x emission however B100 emitted least CO emission in comparison with B20 and diesel. More research work on the engine performance, combustion and emission characteristics is required for complete evaluation of using fish oil as an alternative diesel engine fuel. The specific objective of the present work is to evaluate the performance and emission characteristics of a diesel engine using sardine oil and its methyl ester, prepared by a method of transesterification process.

EXPERIMENTAL

Fuel properties

The sardine oil methyl ester contained no suspended matter but had an undesirable smell peculiar to fish oil. The colour was trans-parent, light yellow. The physical characteristics of fish oil methyl ester are closer to diesel oil. The fuel properties were tested and listed in Table 1, for sardine biodiesel and diesel fuel.

Table 1: Fuel properties of Sardine biodiesel

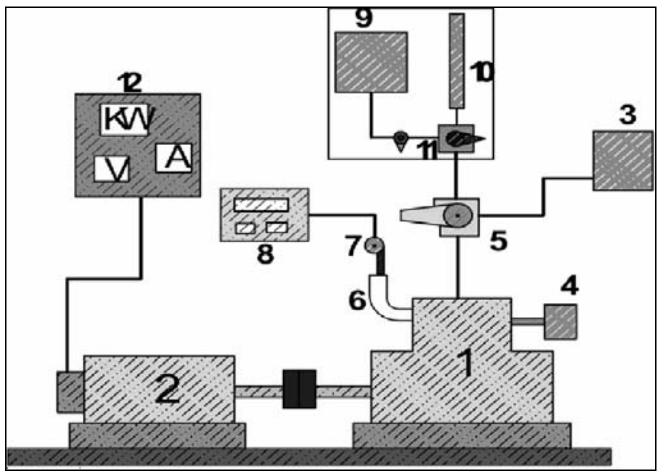
S. No.	Properties	Sardine biodiesel
1	Density (Kg/m^3)	890
2	Specific gravity	0.89
3	Kinematic viscosity at 40 C (Cst)	4.5
4	Calorific value (KJ/Kg)	37,405
5	Flash point (C)	58
6	Fire point (C)	68
7	Oxygen contents	0.72
8	Iodine value	142
9	Moisture	0.02
10	Carbon	90.02
11	Hydrogen	9.19
12	Sulphur	0.01
13	Nitrogen	0.03

Experimental setup

Tests have been conducted on a Kirloskar Engine TAF1, four strokes, single cylinders, air-cooled direct injection, and naturally aspirated diesel engine with displacement of 2826 cc, bore 87.5 mm, stroke 110 mm, rated power 4.4 KW, compression ratio of 17.5 : 1 and runs at constant speed of 1500 rpm. The engine was coupled to a generator set and loaded by electrical resistance to apply different loads on the engine. The voltage, current and power developed by engine were directly displayed on control panel. The layout of experimental test rig and its instrumentation is shown in Fig. 1.

Experimental procedure

The series of exhaustive engine tests was carried out on Kiroskar TAF1 diesel engine using diesel and sardine oil biodiesel blends separately as fuels at 1500 rpm. Performance and emission tests were conducted on various biodiesel blends in order to optimize the blends concentration for long-term usage in CI engines. To achieve this, several blends of varying concentration were prepared ranging from 0 percent (Neat diesel oil) to 100 percent through 10 percent, 20 percent, 40 percent 60 percent and 80 percent and 100 percent by volume. The performance data was then analyzed from the graphs recording power output, fuel consumption, specific fuel consumption, thermal efficiency for all blends of biodiesel. The optimum blend was found out from the graphs based on maximum thermal efficiency. The major pollutants in the exhaust of a diesel engine are carbon monoxide, hydrocarbon and oxides of nitrogen. For measuring exhaust emissions, AVL digas 444 five gas analyzer was used. The brake specific fuel consumption is not a very reliable parameter to compare the two fuels as the calorific value and the density of the blend fallow a slightly different trend. Hence, brake specific energy consumption is a more reliable parameter for comparison.



1. Kirloskar engine; 2. Alternator; 3. Diesel tank; 4. Air filter; 5. Three way valve; 6. Exhaust pipe; 7. Probe; 8. Exhaust gas analyzer; 9. Biodiesel tank; 10. Burette; 11. Three way valve; 12. Control panel.

Fig. 1: Layout of experimental setup with instrumentation

RESULTS AND DISCUSSION

Break specific fuel consumption

The BSFC of Kirlosker engine obtained for different fuels is shown in Fig. 2 as a function of load for compression ratio of 17.5 : 1. The BSFC in general, was found to increase with increasing proportion of B100 in the fuel blends with diesel, where as it decreases sharply with increase in load for all fuels. The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. As the BSFC was calculated on weight basis obviously higher densities resulted in higher values for BSFC. As density of sardine biodiesel was higher than that of diesel, which means, the same fuel consumption on volume basis resulted in higher BSFC in case of 100% biodiesel. The higher densities of biodiesel blends caused higher mass injection for the same volume at the same injection pressure. The calorific value of biodiesel is less than diesel. Due to these reasons, the BSFC for other blends were higher than that of diesel. Similar trends of BSFC with increasing load in different biodiesel blends were also reported by other researchers[9] while testing biodiesel obtained from karanja, mahua and honge oils.

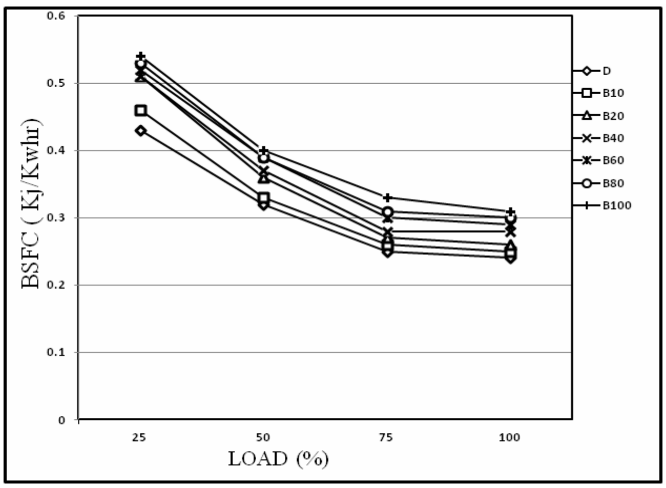


Fig. 2: Comparison of break specific fuel consumption with load for diesel, methyl ester of sardine oil and its blends

Break thermal efficiency

The variation of break thermal efficiency with load for different fuels is presented in Fig. 3. In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. The brake thermal efficiency obtained for B20, B40, B60, B80 and B100 were less than that of diesel. This lower brake thermal efficiency obtained could be due to reduction in calorific value and increase in fuel consumption compared to B10. Based on the results it can be concluded that the performance of the engine with biodiesel blends is comparable to that with diesel, in terms of brake thermal efficiency.

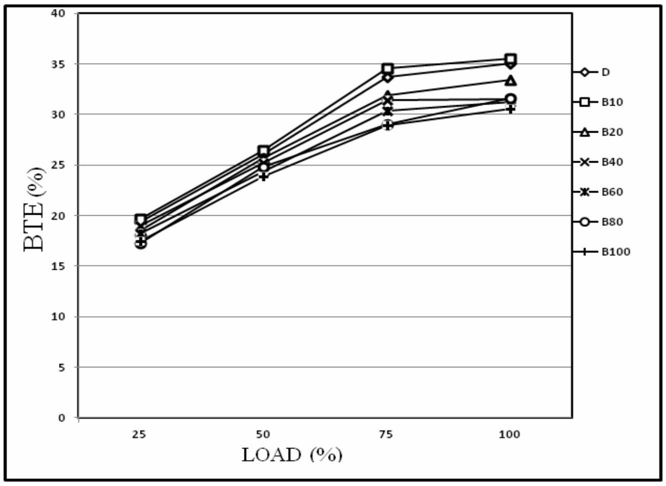


Fig. 3: Comparison of break thermal efficiency with load for diesel, methyl ester of sardine oil and its blends

Exhaust gas temperature

The variations of EGT with respect to engine loading are presented in Fig. 4. In general, the EGT increased with increase in engine loading for all the fuel tested. The mean temperature increased linearly from 213^{o}C for diesel at no load to 384^{o}C for B100 at full load condition. This increase in exhaust gas temperature with load is obvious from the simple fact that more amount of fuel was required in the engine to generate that extra power needed to take up the additional loading.

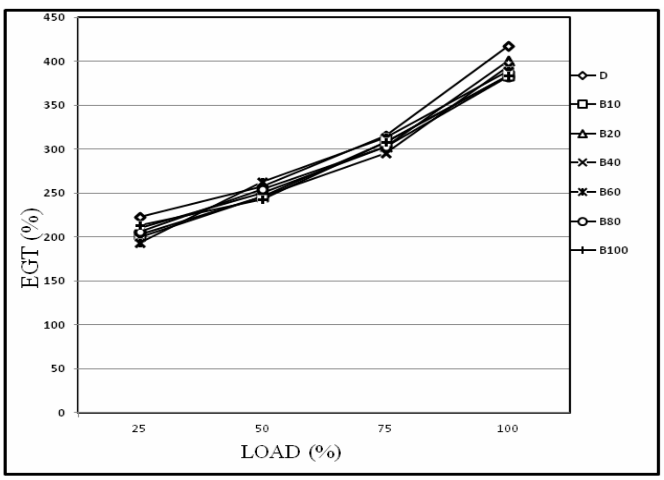


Fig. 4: Comparison of exhaust gas temperature with load for diesel, methyl ester of sardine oil and its blends

The exhaust gas temperature was found to increase with the increasing concentration of biodiesel in the blends. This could be due to the increased heat loss of the higher blends, which are also evident from, their lower brake thermal efficiencies as compared to diesel.

Carbon monoxide

Variation of CO emissions with engine loading for different fuel is compared in Fig. 5. The minimum and maximum CO produced was 0.04-0.14% for B100. These lower CO emissions of biodiesel blends may be due to their more complete oxidation as compared to diesel. Some of the CO produced during combustion of biodiesel might have converted into CO_2 by taking up the extra oxygen molecule present in the biodiesel chain and thus reduced CO formation. It can be observed from Fig. 5 that the CO initially decreased with load and latter increased sharply up to full load. This trend was observed for all the fuel blends tested.

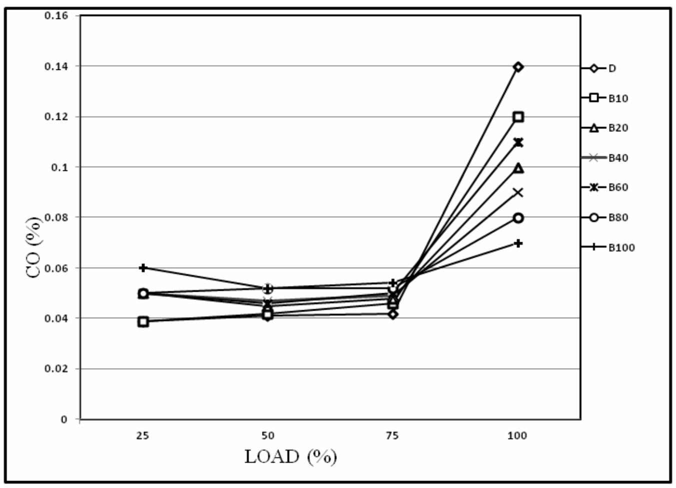


Fig. 5: Comparison of carbon monoxide with load for diesel, methyl ester of sardine oil and its blends

Hydrocarbon

The variation of HC emission with load for various blends of methyl ester are shown in Fig. 6. It can be seen that there is an increase in HC emission for all test fuel as the load increases. This is due to the presence of fuel rich mixture at higher load. There is a significant reduction in HC emission for methyl ester and their blends at all loads compare to diesel. Increasing the percentage of methyl ester in the fuel drastically reduces HC emission.

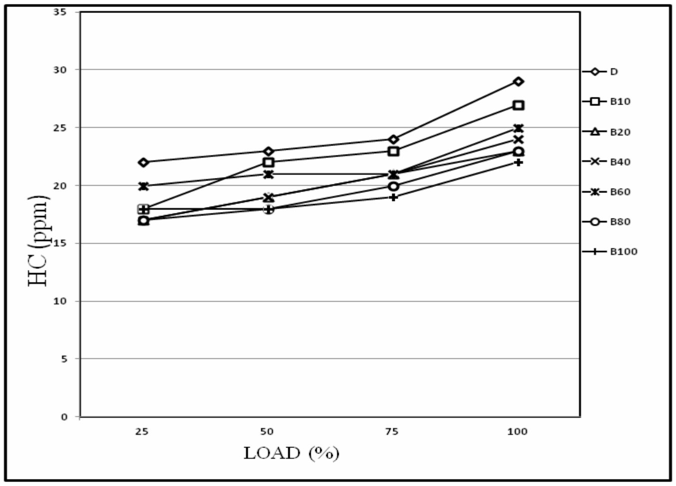


Fig. 6: Comparison of hydrocarbon with load for diesel, methyl ester of sardine oil and its blends

Nitrogen oxides

The NO_x values as parts per million for different fuel blends of diesel and B100 in exhaust emissions of Kirlosker TAF1 are plotted as a function of load in Fig. 7. The amount of NO_x produced for B10 to B100 varied between 390 and 1395 ppm as compared to 408-1110 ppm for diesel. It can be seen that the increasing proportion of biodiesel in the blends was found to increase NO_x emissions, when compared with that of pure diesel.

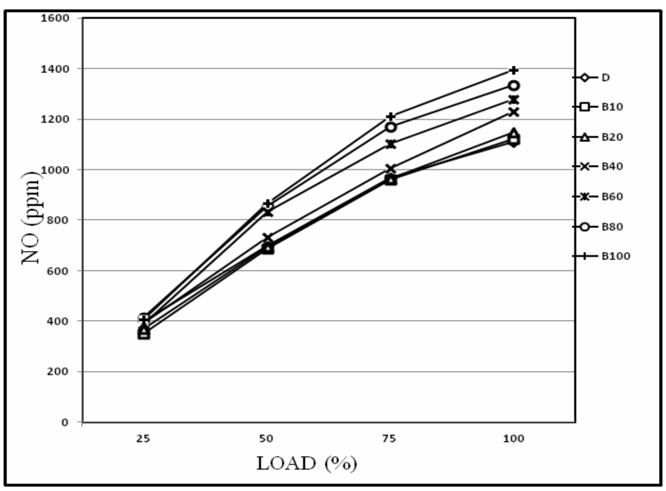


Fig. 7: Comparison of nitrogen oxide with load for diesel, methyl ester of sardine oil and its blends

This could be attributed to the increased exhaust gas temperatures and the fact that biodiesel had some oxygen content in it which facilitated NO_x formation. In general, the NO_x concentration varies linearly with the load of the engine. As the load increases, the overall fuel-air ratio increases resulting in an increase in the average gas temperature in the combustion chamber and hence NO_x formation, which is sensitive to temperature increase.

CONCLUSION

Based on the results, the some conclusions are derived. In terms of fuel properties and exhaust emission characteristics, Sardine oil can be regarded as an alternative to diesel fuel. Break specific fuel consumption for B100 is higher than the diesel fuel and it is decreased in blended fuels. The Break thermal efficiency for B10 (31.74%) was higher than that of diesel. The brake thermal efficiency obtained for B20, B40, B60, B80 and B100 were less than that of diesel. The exhaust temperature increased as a function of the concentration of biodiesel blend i.e. higher the percentage of Sardine oil methyl ester. Increase in the exhaust temperature of a biodiesel-fuelled engine led to increase in NO_x emissions for B100. This is due to the higher temperatures and presence of oxygen molecules present in biodiesel. The reduction in CO and HC was linear with the addition of biodiesel for the blends tested. These reductions indicate the complete combustion of the fuel.

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