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Research Paper

Performance and Emission Characteristics of Neem (Azadiracta Indica) Biodiesel in A Diesel Engine

Biofuel

KEYWORDS : Neem biodiesel, exhaust emissions, diesel engine performance

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ABSTRACT

A 3.7 kW diesel engine was fuelled with diesel and neem biodiesel blends and its performance and emission characteristics were studied. The parameters such as specific fuel consumption (SFC), brake thermal efficiency (BTE) and exhaust emissions of carbon dioxide (CO2), carbon monoxide (CO), oxides of nitrogen (NOx) and oxygen were measured and compared with diesel. With 100% biodiesel, the SFC was 352, 323 and 299 g/kWh at 1.5, 2.0 and 2.5 kW load conditions. The increase in BTE of engine with neem biodiesel blends (B20 to B80) ranged from 0.16 to 2.3% higher than diesel fuel. The exhaust gas temperature increased with increase in loads and quantity of biodiesel in its blends. The CO2 emission from 100% biodiesel was slightly higher than that of diesel. The CO reduction and increase in NOx emission by biodiesel were 14 to 16% and 18 to 28% respectively as compared to diesel at tested load conditions.

Biodiesel contains oxygen, which leads to complete combustion in internal combustion (IC) engines. Biodiesel can be used in the existing diesel engines without any modification and can mix readily with diesel at any blending level (Srivastava & Prasad, 2000). Certain edible oils such as cottonseed, palm, sunflower, rapeseed, and safflower can be used in diesel engines. For longer life of the engines these oils cannot be used straightway. These oils are not cost effective to be used as an alternate fuel in diesel engines at present. Some of the non-edible oils such as castor, rice bran, linseed, karanja, jatropha, neem, madhuca, rubber, etc. can be used in diesel engines after some chemical treatment. The viscosity and volatility of these vegetable oils is higher, and these can be brought down by a process known as "transesterification".

Many researchers have used biodiesel of madhua oil (Puhan et al., 2005), linseed oil (Deepa et al., 2007), cottonseed (Ali et al., 2008), Hazelnut oil (Ceviz et al., 2011) and reported the performance and emission characteristics in diesel engines. The objective of this paper is to investigate the performance and emission characteristics of a single cylinder, 4 stroke, constant speed, water cooled diesel engine with neem biodiesel and four different blends of neem biodiesel with diesel (B_{20}, $B_{40,}$ B_{60} and B_{80}) and compared with diesel fuel.

EXPERIMENTAL SET-UP

A 3.7 kW diesel engine (4-stroke, constant speed, water cooled, direct injection) was selected to evaluate the performance and emissions with selected fuels. The engine was coupled with a DC compound generator. Experiments were conducted using diesel and biodiesel blends at 1.5, 2.0 and 2.5 kW generator output at the rated speed of 1500 rpm. The parameters selected for the study were specific fuel consumption (SFC), brake thermal efficiency (BTE) and exhaust emissions like carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x) and oxygen (O_2) and results compared with diesel fuel. A KM900 exhaust gas analyzer was used to determine the composition of exhaust gases. The ambient and exhaust gas temperatures were recorded using a k-type thermocouple attached with KM900 exhaust gas analyzer.

RESULTS AND DISCUSSIONS

i. Specific fuel consumption

The SFC for neem biodiesel alone (B_{100}) were found to be 352, 323 and 299 g/kWh at 1.5, 2.0 and 2.5 kW load conditions respectively. The increase in SFC of biodiesel blends (B_{20} to B_{80}) ranged from 3 to 11, 2 to 12 and 2 to 15 % higher than that of diesel at 1.5, 2.0 and 2.5 kW loads (Figure 1). The percent increase in SFC increased with decreased quantity of diesel in the blended fuels. The reason for increase in fuel consumption is due to higher density and lower heating value of the biodiesel as compared with diesel fuel.

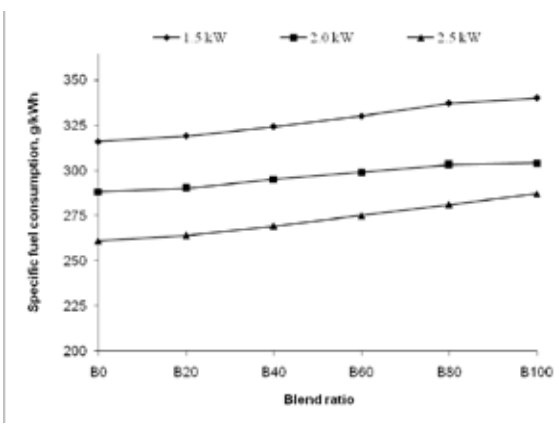

Figure 1. Specific fuel consumption for biodiesel blended fuels at different loads

ii. Brake thermal efficiency

The BTE of the engine when operating with neem biodiesel alone (B_{100}) were 26.84, 29.23 and 31.57 % at three load conditions tested (Figure 2). Maximum BTE of 31.57% was noted for biodiesel, which was 31.05% for diesel. The BTE of biodiesels was found to be 1 to 5% higher than that of diesel and there was no significant difference between the biodiesel and its blended fuel efficiencies.

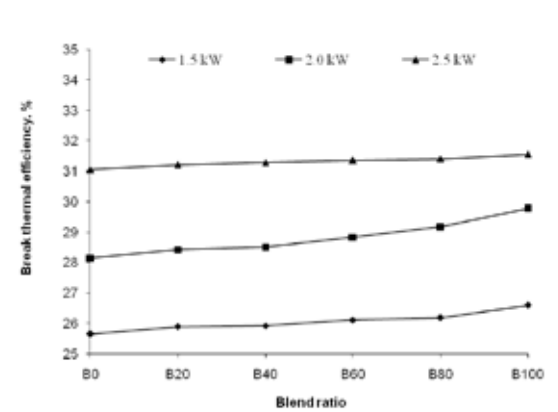

Figure 2. Brake thermal efficiency for biodiesel blended fuels at different loads

iii. Emission profile

The exhaust emission of diesel engine with different blends of neem biodiesel was monitored with exhaust gas analyzer and re-

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sults are presented in the table 1.

Table 1. The exhaust emission of diesel engine with different blends of neem biodiesel and loads

Fuel type	Exhaust gas temperature, °C			Carbon dioxide (CO_2) emission, %			Carbon monoxide (CO) emission, ppm			NOx emission, ppm			Oxygen (O_2) emission, %		
	1.5 kW	2.0 kW	2.5 kW	1.5 kW	2.0 kW	2.5 kW	1.5 kW	2.0 kW	2.5 kW	1.5 kW	2.0 kW	2.5 kW	1.5 kW	2.0 kW	2.5 kW
B_0	184	220	280	8.5	7.7	6.3	748	701	514	1850	1888	1935	14.8	13.1	11.5
B_{20}	195	255	305	8.9	8	6.5	666	652	483	1907	1922	2011	14.9	13.3	11.7
B_{40}	197	268	306	8.9	8.1	6.6	656	631	479	2023	2064	2157	14.9	13.4	11.7
B_{60}	197	296	334	9.2	8.3	6.7	653	624	457	2129	2179	2217	14.9	13.4	11.8
B_{80}	198	308	344	9.4	8.5	6.9	649	615	448	2172	2250	2267	15.0	13.5	11.9
B_{100}	209	318	361	9.9	8.8	7.4	641	599	432	2187	2306	2482	15.1	13.6	12.0

From the table 1, the exhaust gas temperature was observed to be higher in neem biodiesel fuel mode by 25, 98 and 81°C as compared with diesel fuel mode and rise in temperature found with increase in quantity of biodiesel in blends. The exhaust gas temperature varied between 195 and 209, 255 and 318 and 305 and 361°C for neem biodiesel blends (B_{20} to B_{80}) at 1.5, 2.0 and 2.5 kW loads. The exhaust gas temperature increased with increase in load and quantity of biodiesel in blended fuels. This may due to higher ignition delay, which may results in delayed combustion of the fuels.

The CO_2 emission at 1.5, 2.0 and 2.5 kW loads was noted as 9.9, 8.8 and 7.4% for biodiesel whereas that of diesel fuel was 8.5, 7.7 and 6.3 %. For the biodiesel blended (B_{20} to B_{80}) fuels, CO_2 emission increased from 5 to 16, 4 to 14 and 3 to 17% at 1.5, 2.0 and 2.5 kW load conditions.

For 1.5, 2.0 and 2.5 kW loading conditions, the CO emission was noted as 641, 599 and 432 ppm for biodiesel whereas it was 748, 701 and 514 ppm for diesel fuel. For the biodiesel blended (B_{20} to B_{80}) fuels, CO emission decreased from 666 to 641, 652 to 599 and 483 to 432 ppm at 1.5, 2.0 and 2.5 kW load conditions.

The NO_x emissions increased with increase in biodiesel quantity in the blends and also the NO_x emission from the biodiesel alone was found to be higher than diesel. NO_x emissions under selected tested load conditions were noted as 2187, 2310 and 2485 ppm for neem biodiesel, whereas it was 1850, 1888 and 1935 ppm for diesel fuel. For the biodiesel blended (B_{20} to B_{80}) fuels, the NO_x emission increased from 1907 to 2187, 1922 to 2310 and 2011 to 2285 ppm at 1.5, 2.0 and 2.5 kW load conditions. It is seen that with increase in the quantity of biodiesel in the blends, there was an increase in NO_x emission. Several reasons associated for the increased NO_x emission from biodiesel, i) formation of NO_x depends upon the oxygen availability and combustion temperatures (Heywood, 1988 and Sharma et al., 2009) and ii) During combustion of biodiesel in the engine, the oxygen present in fuel oxidizes the nitrogen, which led increasing NO_x emissions (Serdari et al., 2000). Therefore, it is concluded that higher combustion temperature of biodiesel and oxygen presence may cause for higher NOx emissions from diesel engines.

The O_2 emissions from the diesel engine were reduced with increase in load. Maximum O_2 emission was noted as 15.1% for neem biodiesels alone (B_{100}) at 1.5 kW whereas that of diesel fuel was 14.8%. For the biodiesel blends (B_{20} to B_{80}), the O_2 emission increased from 14.9 to 15.1, 13.3 to 13.6 and 11.7 to 12.0% at 1.5, 2.0 and 2.5 kW load conditions.

CONCLUSIONS

Performance and emission characteristics were conducted on neem biodiesel fuelled diesel engine at an injection pressure 240 bar, the following conclusions are drawn based on the test results:

- Neem biodiesel alone, the SFC was 11, 12 and 15% higher than that of diesel at 1.5, 2.0 and 2.5 kW loads. The corresponding BTE were found to be slightly higher than that of diesel fuel at tested load conditions and there was no significant difference between the biodiesel and its blended fuels efficiencies.
- For neem biodiesel and its blended fuels, the exhaust gas temperature increased with increase in loads and biodiesel quantity. The highest exhaust gas temperature was observed as 209, 318 and 361°C for neem biodiesel alone at 1.5, 2.0 and 2.5 kW loads.
- The CO_2 emission from the biodiesel fuelled engine was slightly higher than that of diesel fuel. The carbon monoxide reduction by neem biodiesel was 14, 15 and 16% respectively at 1.5, 2.0 and 2.5 kW load conditions.
- The NOx emission from biodiesel was 18 to 28 % higher than that of the diesel fuel at the tested three load conditions.

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