

Effect of Fuel Injection Timing on Performance of CI Engine Using (Simarouba) Biodiesel as Fuel

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Abstract

In the present work, the biodiesel is prepared from simarouba and used as fuel in CI engine. This study investigates the influence of injection timing of blended simarouba biodiesel on performance and emission parameters. The effect of varying fuel injection timing such as 23°bTDC Normal, 26°bTDC Advanced, 23°bTDC Retarded is evaluated in terms of Brake thermal efficiency, Brake specific fuel consumption, Mechanical Efficiency, Exhaust gas temperature, CO, HC, CO₂, NO_x and smoke density. Transesterification of vegetable oils is carried out by using methanol and sodium hydroxide. The Simarouba Oil Methyl Ester (SOME) has been tested in a single cylinder four stroke diesel engine coupled with an eddy current dynamometer. Experiments are conducted on the engine at different loads and different injection timing. It is found that at 23°bTDC injection timing and at 220 bar fuel injection pressure & blend S20 has given better results than other blends and it is also observed that, the emission are also less as compared to diesel.

Keywords: *Simarouba oil methyl ester, performance, exhaust emissions, injection timing.*

1. INTRODUCTION

Alternative fuels have received much attention due to the depletion of world

petroleum reserves and increased environmental concerns. Thus processed form of vegetable oil (Biodiesel) offers

attractive alternative fuels to Compression Ignition (CI) engines. In literature the work has been carried out with biodiesel in verity of engines with and without modifications. The different methods of producing biodiesel for its compatibility as fuel for CI engine are also studied. In addition to this amount of pollutants produced are also noticed along with performance parameters using for variety of tree borne oil seeds.

The simarouba biodiesel is considered as best alternative fuels to diesel because of its superiority over many other vegetable oils in terms of performance, emissions, ease of availability and the review has been taken up to identify the performance and emissions using simarouba biodiesel. In this study an effort is made to address the following objectives:

- To investigate the properties of the biodiesel as well as blends of biodiesel with diesel.
- To evaluate the effect of injection timing on the performance of CI
- Engine using biodiesel (Simarouba) oil as fuel.
- To evaluate the optimum injection timing for maximum efficiency and minimum pollution.

2. EXPERIMENTAL SETUP AND METHODOLOGY

Experimental setup used in this work consists of single cylinder four stroke diesel engine coupled with an eddy current dynamometer. The schematic of test rig and its instruments are shown in Fig. 1. Further, the Table 1 shows the specifications of engine. The test rig is also equipped with exhaust gas analyzer, smoke meter, pressure sensor to measure the cylinder pressure, TDC sensor which records the pressure for every two degrees of crank rotation, with which P- θ curve is plotted. A rotameter is placed for engine cooling water flow measurement. The calorimeter cooling water flow is measured and adjusted by the rotameter.

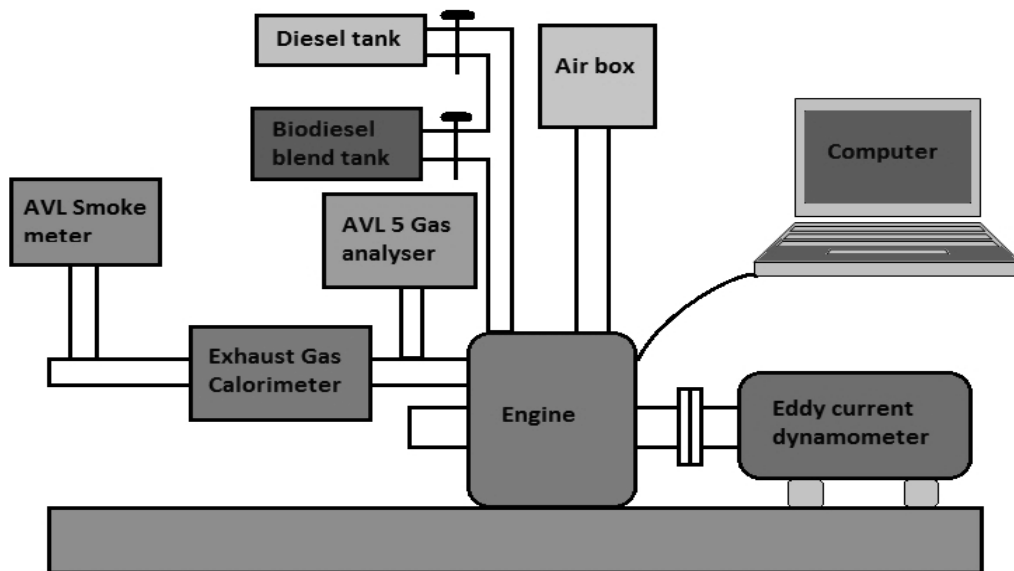


Fig 1: Schematic of experimental set up.

Table 1: Specifications of engine

Make	Kirloskar Engine
Bore & stroke	87.5mm x110mm
Type of cooling	Water cooled
Speed	1500 rpm
Compression ratio	17.5:1
Number of cylinder	1
Rated power	5.2 kW
Start of injection	23° bTDC
Injection pressure	220 bar

The temperature sensors are fitted at the inlet and outlet of the calorimeter for temperature measurement. A fuel tank is fitted inside control panel along with fuel measuring unit. An air box is powered for damping pulsation in airflow line. An orifice meter with manometer is fitted at the inlet of air box for flow measurement.

The PCI 1050 IC card is connected to COM port of CPU. Engine soft is the software used to control the entire engine readings. The engine is tested at constant rated speed of 1500 rpm at different loads. Three different tests are carried at ± 3 degree injection timing (advance, normal and retarded injection timing).

3. RESULTS AND DISCUSSION

In this work, the blends of S0, S20, S40 and S100 are tested for 26°bTDC, 23°bTDC and 20°bTDC (advance, normal and retarded) injection timing, respectively. Thereafter, the performance and emissions are studied. The experiments are conducted on a single cylinder four stroke diesel engine, in this test, the engine is loaded from 0 to 18.3 kg and the readings are noted and again unloaded from 18.3 to 0 kg. Observations are made at constant injection pressure of 220 bar, to evaluate various performance parameters and

emissions which will be discussed in the following sections.

Influence of injection timing on brake thermal efficiency at rated load:

The variations of the brake thermal efficiency (BTE) with injection timing for diesel and SOME blends are shown in Fig.2. It is seen from Fig 2 that for all blend tested, the highest BTE is achieved with blend S0 (Diesel) at 23°bTDC. The BTE is found to be lower for SOME blends than diesel. This drop in BTE is attributed to poor atomization of the blends due to higher viscosity, higher density and lower heat value of the fuel. It is also observed from Fig 2. that at normal injection 23°bTDC, maximum BTE is for S0. BTE for S100, S40, S20 decreases by 2.58%, 3.33%, 4.89%, respectively.

At advanced injection timing, more of the fuel is injected and injection starts early in the cycle leading to earlier pressure rise before the piston reaches TDC position. Greater pressure rise in the compression stroke increases the negative work and consumes the momentum of flywheel, with reduction in net work output and increased fuel consumption, the BTE will be drop down. S Jindal, also reported an increase in thermal efficiency and corresponding decrease in fuel consumption on retarding the injection timing upto a point after which the trend reversed and

also stated that, there is an optimum timing at which engine delivers best efficiency which depends on the combustion properties of the fuel.

See Figure 2.

Influence of injection timing on brake specific fuel consumption at rated load:

The variation of the brake specific fuel consumption (BSFC) with injection timing

for diesel and SOME blends are shown in Fig 3.

It is seen that for all the fuels tested. It is seen from fig, the BSFC of blend S20 is best amongst all blends and it also indicates that at normal injection timing 23°btdc blend S20 is having higher BSFC compared to S40 and S100 at rated load. At 23°bTDC, Compared to S0, BSFC for S20, S40, and S100 increases by 6.66%, 9.67%, 15.15%, respectively.

See Figure 3.

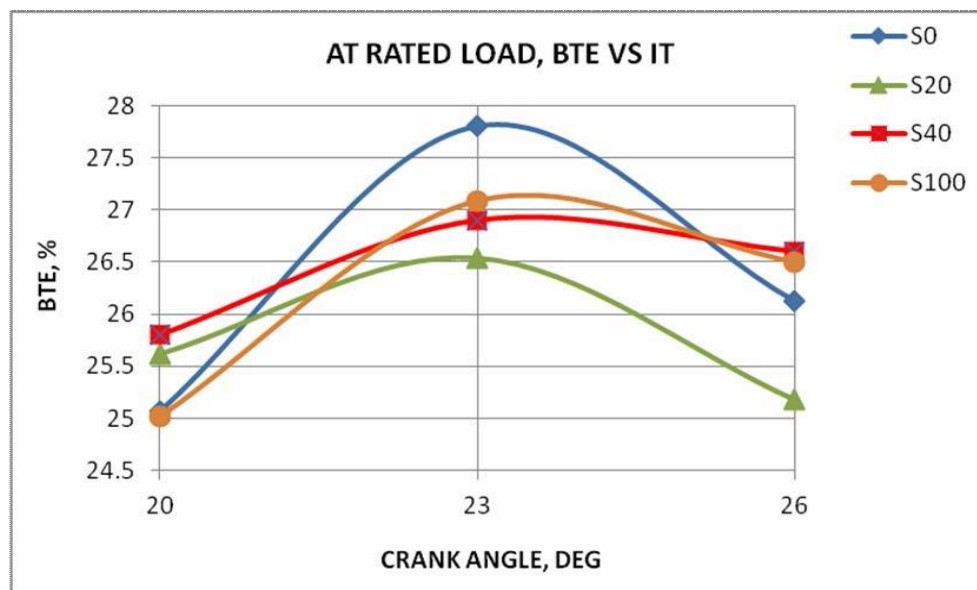


Fig 2: Influence of injection timing on brake thermal efficiency at rated load.

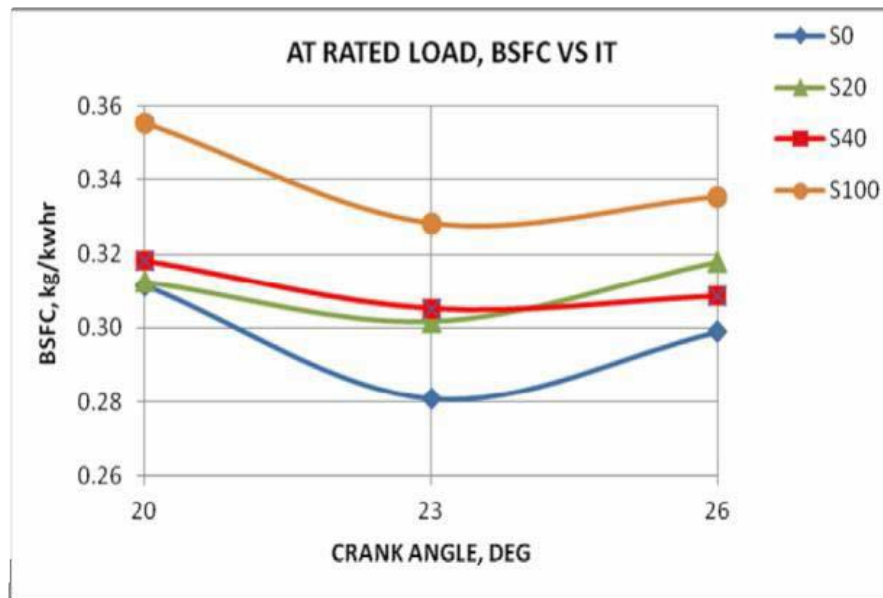


Fig 3: Influence of injection timing on brake specific fuel consumption at rated load.

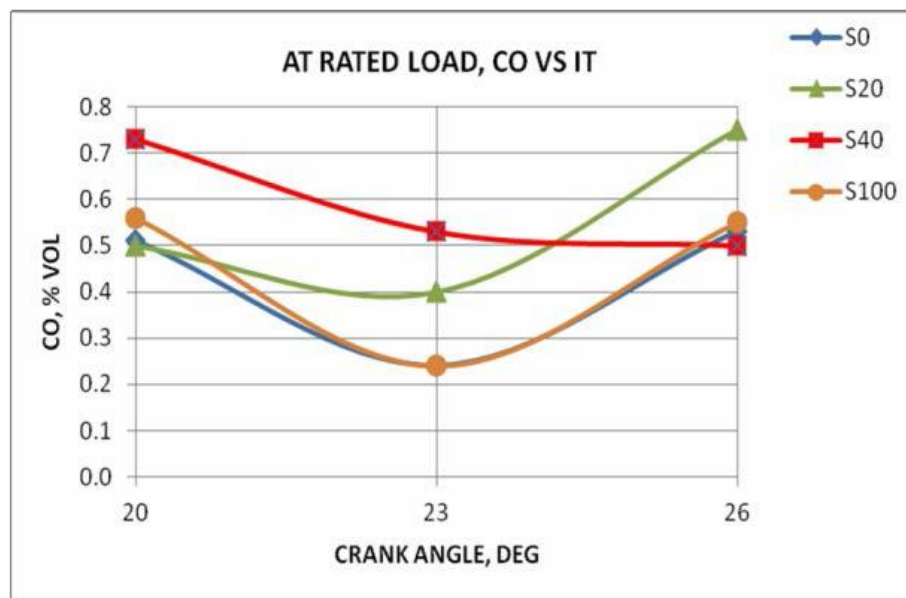


Fig 4: Influence of injection timing on CO at rated load.

Influence of injection timing on CO at rated load:

The variation of the carbon monoxide emission with injection timing for diesel and SOME blends are shown in Fig 4. . CO is formed due to incomplete combustion of fuel, which may be due to lack of air. At rated load, CO emissions in SOME blends are higher than that of diesel fuel. This is due to incomplete combustion. It can be observed from fig 4, at 20° bTDC and 26° bTDC CO emissions are more than 23° bTDC injection timing. At 20° bTDC CO emission are more because of incomplete combustion, lack of oxygen and incomplete oxidation of CO to CO₂ .which leads to incomplete combustion. At 23° bTDC, CO for S20, S40 increases by 50% and 60%, respectively. This is because at 26° bTDC (advanced injection timing), longer delay period is achieved, leads to early combustion process which results in higher emissions of CO.

Early combustion which results in higher BSFC. At 20° bTDC (retarded injection timing), there is shorter delay period, which results in incomplete combustion and lower combustion pressure which results in higher emissions of CO. Early combustion which results in higher BSFC. With the

advancement of injection timing, BSFC increases where as retarding the injection timing the delay period increases, but fuel delivery to cylinder reduces with cylinder mean effective pressure in the cycle maintaining the power there by reducing the SFC.

Influence of injection timing on EGT at rated load:

The variation of the exhaust gas temperature (EGT) with injection timing for diesel and SOME blends are shown in Fig. 5. It is observed from Fig. 5 that at 23° bTDC, compared to S0, EGT increases for S20 by 1.19% and decreases for S40, S100 by 1.21% and 0.86%, respectively. The trend line for exhaust temperature with different injection timings indicates increase in temperature of exhaust gases with retarded injection (Fig 5). As the combustion is delayed and more of the heat is released in mixing controlled combustion regime, greater amount of heat goes with exhaust gases. With advanced injection, wall heat transfer is more due to earlier combustion in the cycle leading to lower exhaust temperature.

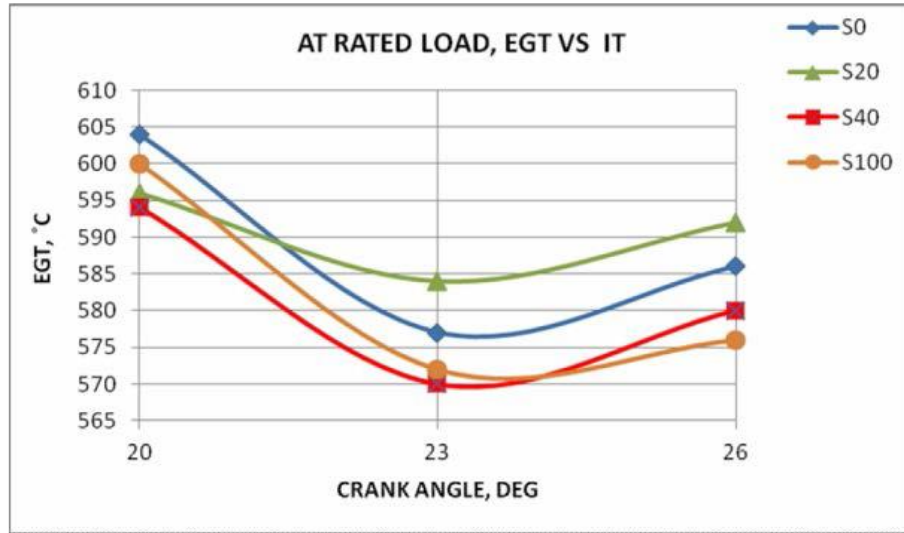


Fig 5. Influence of injection timing on EGT at rated load.

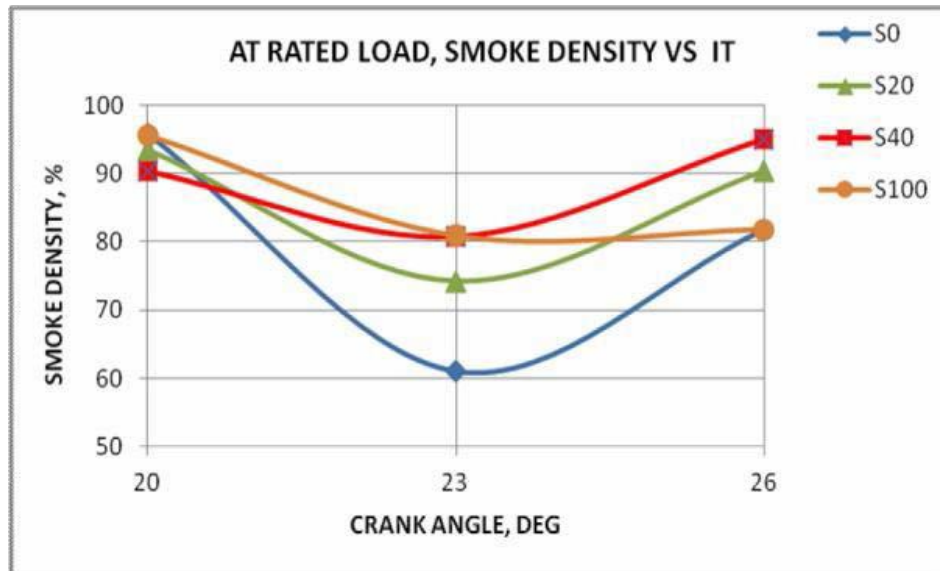


Fig 6: Influence of injection timing on smoke density at rated load.

Influence of injection timing on smoke density at rated load:

Smoke is an indication of incomplete Combustion and it limits the output of the engine. The variation of the smoke density

(SD) with injection timing for diesel and SOME blends are shown in Fig. 6. It is seen from the fig that the smoke density increases with increase in concentration in simarouba blends. Further at rated load, 23°

bTDC smoke density for S20 is higher than that of diesel. This is caused due to the poor atomization, improper mixing of the fuel droplets with air and incomplete combustion because of the higher viscosity of the blends. For S100 at 26° bTDC there is reduction in smoke density as there is no diesel. When compared to S0 At 23°bTDC, SD for S20, S40, S100 increases by 17.65%, 24.28%, 24.47%, respectively.

Influence of injection timing on NOx at rated load:

The variation of the NOx with injection timing for diesel and SOME blends are shown in Fig 7. For rated load NOx emission is higher for S100 at 23° bTDC injection timing when compared to that of diesel. At rated load overall air-fuel ratio increases resulting in increase in combustion temperature in the combustion chamber and oxygen content in biodiesel facilitates for NOx emission.

The NOx emission is affected by injection system, injection time along with variation in fuel characteristics such as cetane number, viscosity, rate of burning etc. For S20 and S40 at 23°bTDC injection timing NOx emission is low higher when compared to that of diesel because of lower

combustion temperature. At 20° bTDC and 26° bTDC NOx emissions are less than 23° bTDC injection timing for all blends.

At 23°bTDC, Compared to S0, Nox increases for S100 by 5.07% respectively because of higher combustion temperature and presence of extra oxygen in biodiesel respectively and decreases for S20, S40 by 5.76% and 12.96% respectively because of lower combustion temperature.

See Figure 7.

Influence of injection timing on HC at rated load:

The variation of the HC with injection timing for diesel and SOME blends are shown in Fig 8. It can be observed that the HC emissions are least for S40 and S100 at full load. For blends S0 and S20 at 23° bTDC injection timing HC emissions are high. For S20 at 26° bTDC HC emissions are minimum. For S100 at 20° bTDC HC emissions are minimum. At 23° bTDC, maximum HC is for S0. Compared to S0, HC for S20, S40, S100 decreases by 27.02%, 43.24%, 43.24%, respectively.

See Figure 8.

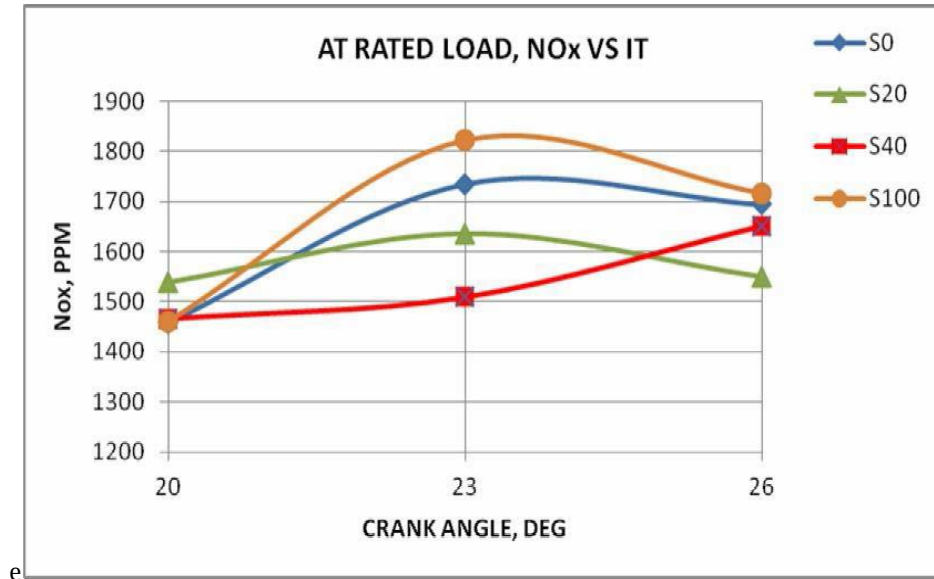


Fig 7: Influence of injection timing on Nox at rated load.

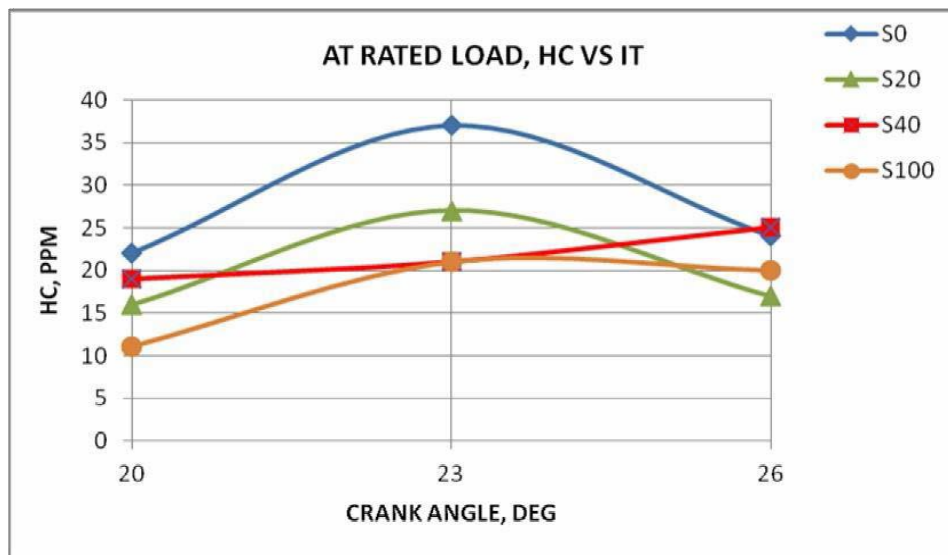


Fig 8: Influence of injection timing on HC at rated load.

4. CONCLUSIONS

Blend S20 with injection timing 23° bTDC (Normal injection timing) and at 220 bar injection pressure shows higher performance

and fewer emissions for all blends at rated load. BSFC is more for blends. S20 matches nearly to that of diesel.

1. BTE is low for S20 blend by 2.58%

compared to S0.

2. CO and smoke emission are less for blend S20.
3. NO_x and HC emissions are marginally high for blend S20.
4. Without engine modification (at normal injection timing) blend S20 can be used as alternate fuel.

Blends had better emission properties when compared to diesel. At rated load CO, HC and smoke emissions are less. In Simarouba oil methyl ester (SOME) blends CO emission is lower than that of diesel, as SOME contains extra oxygen content which results in complete combustion of fuel. At rated load diesel had the highest HC emission.

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