Evaluating Performance And Emission Characteristics Of C.I. Engine Run By Cashew Nut Shell Liquid (Cnsl) As A Fuel

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ABSTRACT: The CI engine is used more than any other type of engine for transportation, thermal power generation and many miscellaneous Industrial applications. It has been established as the most efficient of all engines, the exhaust pollutants from combustion in CI engine are not different from those of other combustion processes, the difference being only the use of fuel and concentration of individual pollutants. The use of non-conventional energy source has greatly influenced the CI engine. Bio-mass in the form of cashew nut shell represents a renewable and abundant source of energy in India. The Cashew nut shell oils are found to be a renewable natural resource of unsaturated phenols with long linear chain and marked absence of anacaridic acid. The oil is completely miscible in diesel and is found to have low corrosive effect and this promise to be a potential fuel. The oil has low ash, and water content. The properties of CNS oil have been found to be amazingly near to that of petroleum fuels.

Keywords: CashewNut Shell Liquid (CNSL), Before Top Dead Centre (bTDC), Hatridge Smoke Unit (HSU), Hydro Carbon (HC), Nitrates of Oxides (NOx), Blend 20% (B20)

INTRODUCTION

The use of alternative fuels as source of energy mainly in the sector of transport will not only contribute to the environmental quality but also has several positive socio-economic effects. By the last century most of the scientists suggested that bio-fuels, would become an alternative to fossil fuels. India is the largest producer, processor and exporter of cashew nut in the world. In India cashew cultivation covers around a total area of 0.70 million hectares of land. Presently cashew nut shell liquid (CNSL) is obtained as a byproduct of cashew industry. The cashew nut has a shell of about 1/8 inch thickness with soft honey comb structure inside [2]. It contains a dark brown liquid, called CNSL. The CNSL is extracted by various methods like roasting nuts and collecting liquids, super heated steam treatment method, solvent extraction method etc., The traditional method of removing CNSL involves roasting the nut in drums. This method results in the loss of most of CNSL. To extract the retained CNSL fully and to dispel the unpleasant fumes the nuts are roasted in baths at a temperature of 180° - 185°C [1]. The major pollutants from automobiles are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx), lead compounds, sulphur compounds and particulates.

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Large engines emit large quantities of pollutants compared to smaller engines and the quantity of pollutants dumped into the atmosphere depends on the vehicle population.Due to growing number of engines the oil consumption has been increasing rapidly. But the world reserves of crude oil are depleting very fast. Hence scientists and technologists all over the world are looking for an alternative fuel. The increase in prices of petroleum based fuels, a strict governmental regulation on exhaust emissions and future depletion of worldwide petroleum reserves encourage studies to search for alternative fuels. One of the viable alternative renewable sources is bio-fuel. The main advantage of bio-fuel is renewable nature. It can be used as substitute fuel in internal combustion engine with appropriate engine alteration and its use as fuel does not cause much environmental pollution. Hence its efficient utilization in engines can go a long way to meet the growing problems of fuel oil scarcity and exhaust pollution. In present work the single cylinder air cooled engine is used to run with B20, B40, B60, B80, B100 substitution of CNSL produced from cashew nut shell. The performance and emission tests are carried out.

Table 1.1 Properties of Diesel Vs CNSL oil in the study

Properties	Diesel	CNSL
Density at (g/cc)	0.8/0.84	0.9326
Kinematic Viscosity @ 40 °C (cSt)	2.0 to 4.5	17.2
Calorific value (kJ/kg)	42000	42090
Flash Point (°C)	80	198
Fire Point (°C)	86	206
Ash content (%)	0.01 to 0.1	0.01

(Source: Laboratory evaluation at Italab – Chennai,India)

COMPOSITION OF CNSL

Compounds	Composition of CNSL (%)	
	Natural	Technical
Anacardic acid	71.0 – 82.0	1.1 – 1.8
Cardanol	1.2 – 9.2	60.0 – 68.0
Cardol	3.8 – 20.1	15.0 – 18.1
2-methylcardol	1.6 – 3.9	1.0 – 3.3
Other	0 – 2.0	0 – 7.4

Source: adapted from Gedam and Sampathkumaran (1986); Kumar et al (2002)

MISCIBILITY STUDY OF CNSL OIL WITH DIESEL

The oils CNSL have been found completely miscible in diesel.This behavior is unlike any other paralysis' oil [1]. The oils have been mixed with diesel in different ratio and the physical property.

Miscibility in %

Hexane	100
Methanol	100
Acetone	100
Diesel	100

PHYSICAL PROPERTIES OF CNSL OIL

Properties	
Ash	0.01
Moisture	3.5
Absolute viscosity (cSt) at 30°C	33
Flash point °C	180
Pour point °C	-5
Solid content (%)	Nil
Calorific value (kJ/kg)	40,000

EXPERIMENTAL SETUP AND EXPERIMENTS

A single cylinder water-cooled, four-stroke direct injection compression ignition engine with a compression ratio of 17.5: 1, developing 3.7 kW at 1500 rpm was used for this study. The engine was always run at its rated speed. The operating pressure of the nozzle was set at the rated value of 200 kg/cm2. The cooling of the engine was accomplished by supplying water through the jackets on the engine block and cylinder head. The engine is coupled with electrical swing field dynamometer.

Specifications of the Test Engine

Type	:	Vertical, Water cooled, Four stroke
Number of cylinder	:	One
Bore	:	87.5 mm
Stroke	:	110 mm
Compression ratio	:	17.5:1
Maximum power	:	3.7 kW
Speed	:	1500 rpm
Dynamometer	:	Electrical swing field DC generator type
Injection timing	:	23° before TDC
Injector opening pressure	:	200 kg/cm2

The engine was coupled to an electrical swing field dynamometer. A photo sensor along with a digital rpm indicator was used to measure the speed of the engine. The voltage pulses from the sensor are sent to the digital rpm meter for pulse conversion and display of the engine speed with an accuracy of 1 rpm. Fuel flow rate was measured on the weight basis using a weighing balance. The fuel was supplied to the engine from the diesel tank, placed in the weighing balance. The fuel rates were obtained by noting the time taken for 40gm of fuel consumption. Temperature of the exhaust gas was measured with Chromel Alumel(K-Type) thermocouples. A digital indicator with automatic room temperature compensation facility was used. The temperature indicator was calibrated periodically. The AVL smoke meter works on light extinction principle. It consists of a flexible sampling hose with appropriate exhaust gas probe. The sampling probe is inserted in the exhaust pipe approximately 200 mm from the engine. A continuous exhaust sample is passed through the tube of about 46 cm length, which has a light source at one end the other end fitted with a photo cell. The amount of the light passing through the smoke column is sensed as an indication of smoke level. The smoke meter consists of display unit. The smoke density in HSU is displayed Exhaust emissions of hydrocarbons (HC), carbon monoxide (CO) and oxides of Nitrogen (NOx)were measured by AVL – di gas analyzer. The exhaust sample to be evaluated was passed through a cold trap (moisture separator) and filter element to prevent water vapour and periodiacally calibrated with standard gas, according to the instruction of the manufacturer. Hydrocarbons and oxides of nitrogen were measured in parts per million (ppm) and carbon monoxide emissions were measured in terms of percentage volume

RESULTS

The experiments were done at different static injection timing 18°, 19°, 21°, 23°, 26°, and 28°bTDC at the rated injector opening pressure 200 kg/cm2. Hence injection opening pressure was set at 200 kg/cm2 which was specify the manufacture for the diesel operation. The results are shown in figures 7.1 to 7.5. The brake thermal efficiency is seen in figure 7.1 increasing when the injection timing is advance from 18° to 19°bTDC. This is because starting the combustion earlier has complete combustion. The retardation of injection timing leads to incomplete mixture of air and diesel leads to the incomplete combustion. The maximum brake thermal efficiency at the static injection timing of 19°bTDC which is selected as a optimized value. We find that the variation of smoke density (figure 7.5) also decrease with the advancing the injection timing. HC emission is lowest with the best injection timing namely 19°bTDC seen in figure 7.2. This injection timing lower the HC level at all loads due to improved combustion and use of over leaner fuel air mixtures compared to the other timing an account improved brake thermal efficiency. The reduction of HC emission is also due to more amount fuel taking part in the premixed phase of combustion as that injection timing advance due to an increase in ignition delay period. However very high advance timings the effect of reduced brake thermal efficiency dominates and HC rises. Smoke level decrease as the injection timing is advance as normal in diesel engine because of dominance of the premixed combustion phase. When the injection timing advance the ignition delay period rises and premixed fraction increases. This leads to greater fraction of the fuel burns in the well mixed condition and lower smoke level. NOx emission level increase as the advance that injection timing 19°bTDC expect due to increase cylinder gas temperature seen in figure 7.3. We find the variation of exhausts gas temperature seen in figure 7.4.Advanced the injection timing increase the temperature of the combustion gas by making the combustion occur earlier.

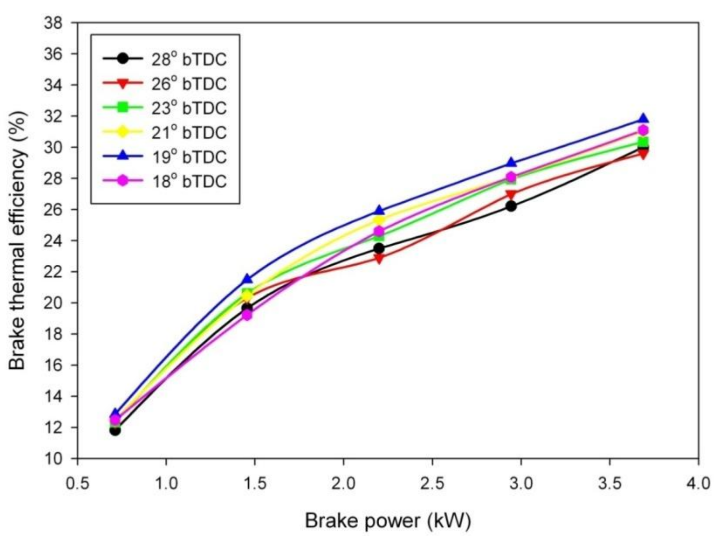

Figure 7.1 Comparison of brake thermal efficiency

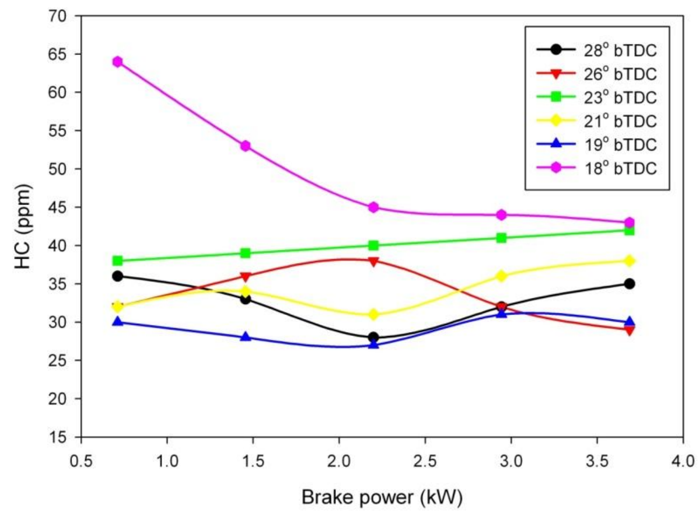

Figure 7.2 Comparison of HC

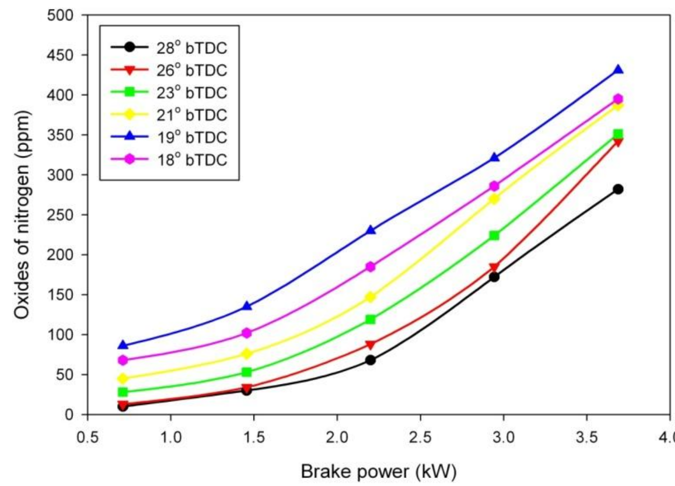

Figure 7.3 Comparison of oxides of nitrogen

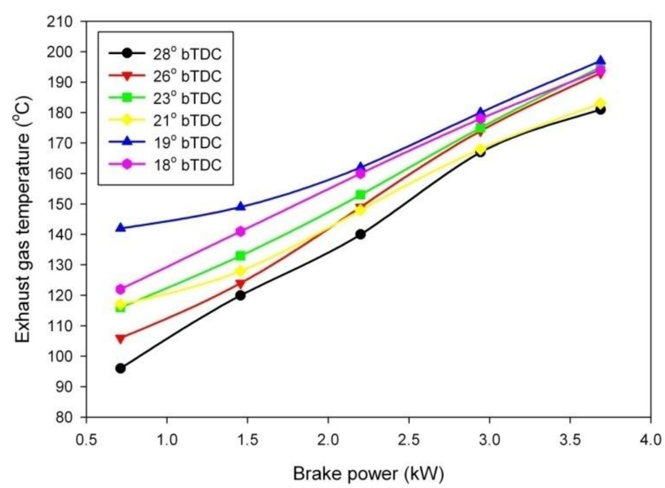

Figure 7.4 Comparison of Exhaust gas temperature

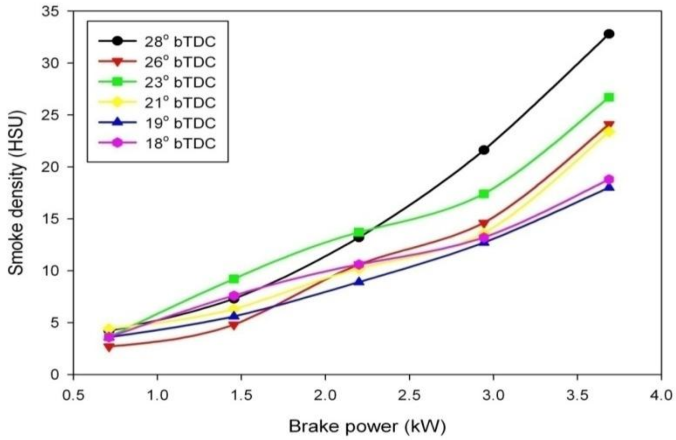

Figure 7.5 Comparison of smoke density

COMPARISON OF CNSL OIL BLENDS AND NEAT DIESEL

The test were conducted with blends of CNS oil and compared with neat diesel results.The variation of brake thermal efficiency with respect to load for different blends of CNS oil were considered for the present analysis and presented in figure 7.11. In all cases, brake thermal efficiency has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load. The thermal efficiency of all blends of CNSL oil is lower than that of neat diesel. This is due to poor mixture formation as a result of low volatility, higher viscosity and higher density of CNSL oil. The thermal efficiency of B20 blends gives the higher efficiency compared to other blends namely B40, B60, B80 this is because of more blends gives the high viscosity of fuel and poor atomization and hence poor combustion. Lower brake thermal efficiency obtained for B100 could be due to the poor mixture formation as compared to B20. While running the engine with neat CNSL oil, brake thermal efficiency is always lower than the blends of CNSL oil as well as diesel. The variation of specific fuel consumption with load for different fuels is presented in Figure 7.12. The specific fuel consumption of CNSL oil is higher than that of diesel for all loads. This is caused due to the effect of higher viscosity and poor mixture formation of CNSL oil. For all fuels tested, specific fuel consumption is found to decrease with increase in the load. This is due to more blended fuel is used to produce same power as compared to diesel. Hence the mixture formation is very poor if we increase the amount of CNSL oil with diesel. This is proved from the graph that the B20 blend gives less fuel consumption compared to B100 blends.

Hydrocarbon emission

The hydrocarbon emission is seen in figure 7.13. The unburned hydrocarbon emission of blends of CNSL oil is more compared to that for neat diesel for all loads. This is because of poor mixture formation tendency of blends of CNSL oil. In addition to the other factors, the lower thermal efficiency with these blends also is responsible for this trend. It may be noted that a lower thermal efficiency with these blends will lead to injection of higher quantities for the same load condition.

Carbon monoxide emission

Figure 7.14shows the plots of carbon monoxide emissions of the CNSL oil and various blends of biodiesel operation at the rated engine speed of 1500 rpm at various load conditions. The CO emissions increase as the air fuel ratio becomes greater than the stoichiometric value. CO concentration in the exhaust emission is negligibly small when a homogeneous mixture is burned at stoichiometric air–fuel ratio mixture or on the lean side stoichiometric. With increasing CNSL oil percentage, CO emission level increases. In the case of, 100% CNSL oil, the carbon monoxide emission is higher than that of diesel blends. This is due higher viscosity and poor atomization tendency of CNSL oil leads to poor combustion and higher carbon monoxide emission.

Oxides of nitrogen

Figure 7.15indicates that blends of CNSL oil shows lowerNOx emission compared to neat diesel fuel. This is due to poor atomization of CNS oil leads to poor combustion and lead lower NOX emission.

Exhaust gas temperature

The variation of exhaust gas temperature with respect to applied load for different fuels tested is shown in figure 7.16. It is seen that the exhaust temperature of CNS oil is decreased because of poor combustion takes place compare to neat diesel.

Smoke density

The variation of smoke density with respect to different fuels is considered and depicted in figure 7.17. Smoke density for CNSL oil blends is noticed to be generally higher than that of the diesel oil. This is due to the heavier molecular structure, poor atomization, presence of high carbon residue. The viscosity of blends is comparatively lower than neat CNSL oil tested. Due to this, the spray pattern and fuel penetration are improved. The smoke density of neat diesel and B20 blend is almost same compared to neat CNSL oil .This is because of less viscosity and improved atomization of fuel.

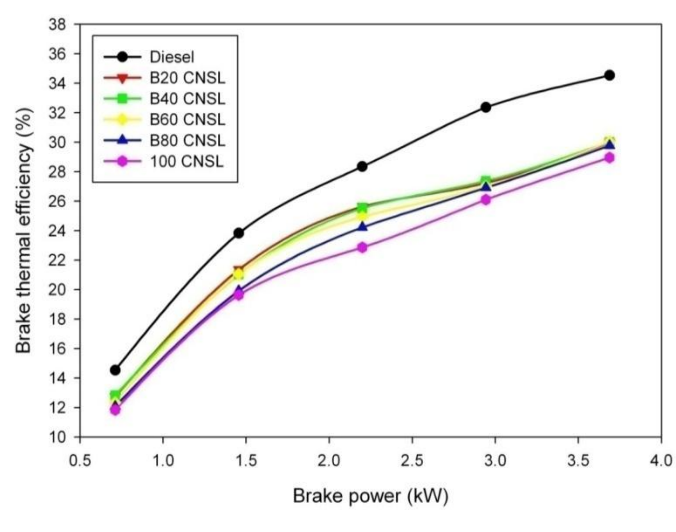

Figure 7.11 Comparison of brake thermal efficiency

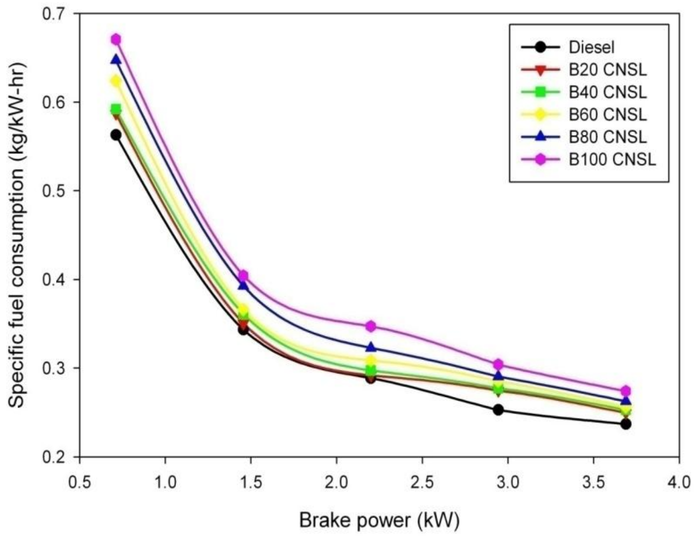

Figure 7.12 Comparison of specific fuel consumption

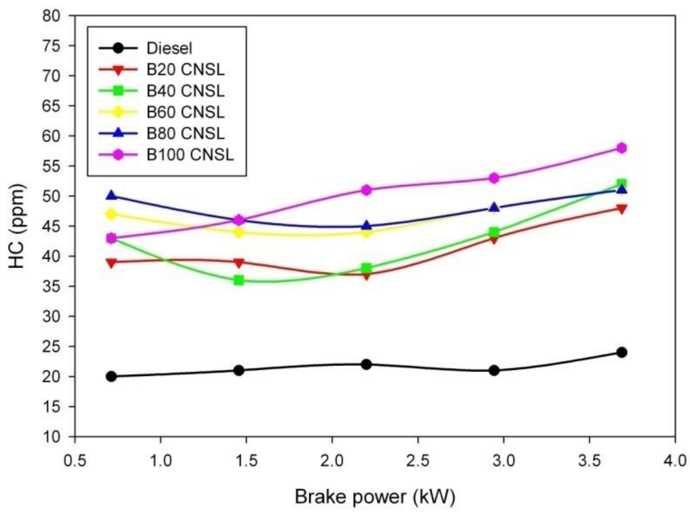

Figure 7.13 Comparison of HC

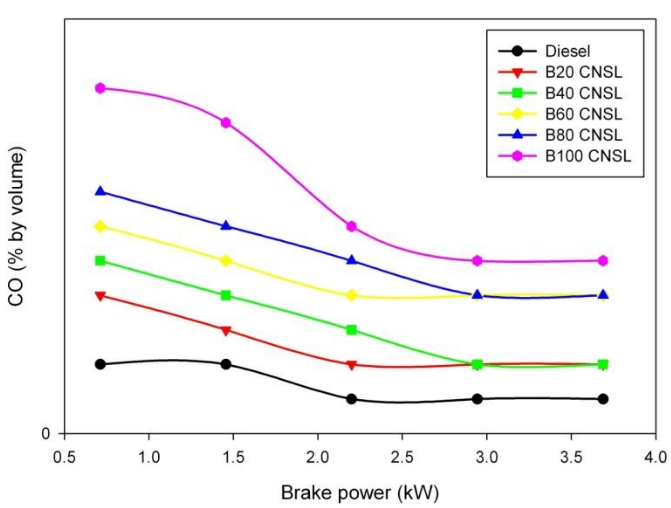

Figure 7.14 Comparison of CO

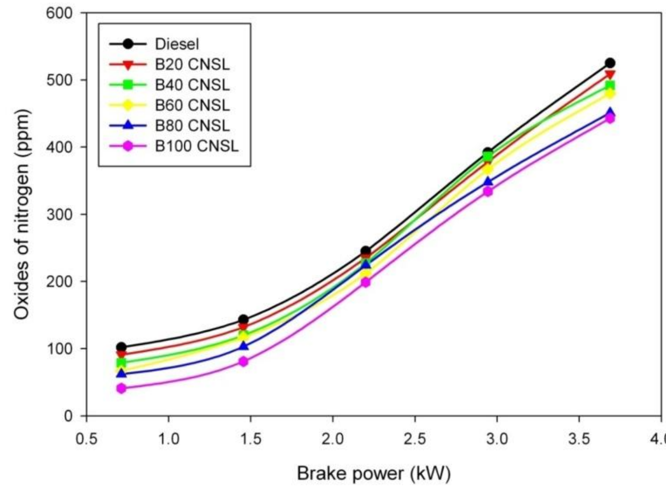

Figure 7.15 Comparison of oxides of nitrogen

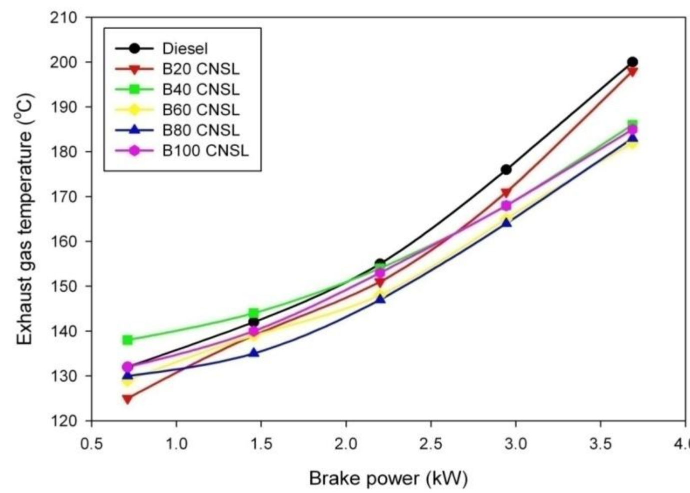

Figure 7.16 Comparison of exhaust gas temperature

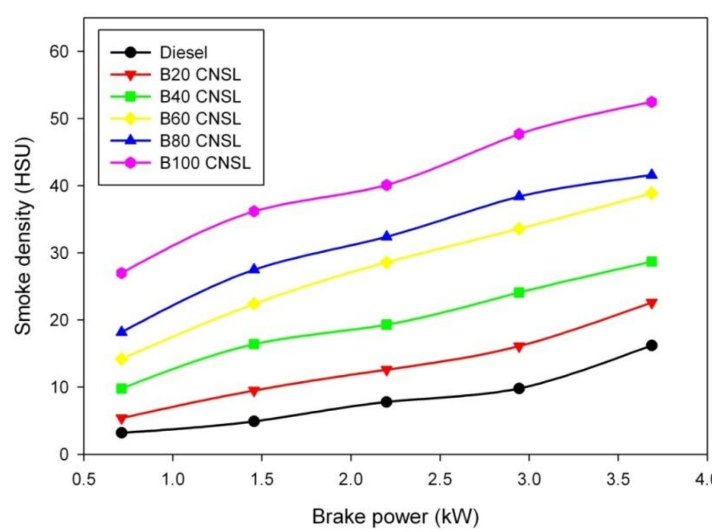

Figure 7.17 Comparison of smoke density

CONCLUSIONS

The CNSL oil is chosen as potential non-edible oil for the production of biodiesel. The cardanol oil which is extracted from raw CNSL oil is used to run the diesel engine. Based on the experimental investigations carried out on the single cylinder diesel engine with neat diesel CNSL oil blends can be used as alternative fuels in diesel engine and with further experiments of adding additives emissions can be reduced.

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