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Performance and pollutant analysis of diesel engine with cashew shell oil as bio-material

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ABSTRACT

The aim is to identify the substitute fuel using Cashew Nut Shell Liquid as bio-diesel and to lessen the difficulties pretended by the environmental degradation. Cashew nut shell is pulverized and the oil is extracted. The bio-diesel thus obtained is blended with neat diesel in the ratios 20:80, 40:60 and 60:40 per litre. The blended mixture is then tested for emission characteristics using computerized AVL Smoke Metre. Based on several studies, it is commonly noticed that CNSL biodiesel is utilized as posing numerous benefits, with sustainability, reduction of CO, HC and NO_x and several detrimental pollutants.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science.

1. Introduction

The most leading source of transport in current world is Diesel Engines. Its main attraction is ruggedness in construction, simplicity in operation and ease of maintenance. Hence efforts are being made all over the world, to bring out nonconventional fuels for use in diesel engines. Similarly, how to decreases fuel intake has put attention on the motor trade and enforced them to develop engines with new expertise [1]. This has directed to improvement of different combustions arrangements. A number of untried tests have been carried out in diesel engines to increase the operating efficiency and also to reduce the pollution out of it. In present work injection pressure is varied to study the outcome in the direct injection diesel engine. Different ratios of biodiesel blended with diesel were used as fuel. This is an effort to find the optimum working condition injection pressure in terms of output power, efficiency and specific fuel consumption [2]. The deprivation of the atmosphere owing to the burning of fossil fuels has initiated a lot of awareness in finding substitute fuel.

2. Sources of biodiesel

Plant oil based fuel is non-toxic, bio-degradable and considerably reduces pollution. Report on the usage of biodiesel in CI engines indicates a considerable decline in PM, Noise and Smoke. Biodiesel in overseas have been established from peanut, scaffold, sunflower, grape seed, linseed, etc., which could be grownup in the waste land of the nation to yield biodiesel [6]. The thickness of plant oil being 10–20 times higher and has low viscosity index, the spray features of the oils are dissimilar, which clue to the unlike heat release and emission features. Higher viscosity may source poor atomization, larger droplets and higher spray jet dispersion [9,10]. These fallouts in deprived burning can be accomplished by loss. Pure plant oils are totally harmless to the atmosphere, especially the ground water. Conversely esterification of plant oil raises its water hazards.

3. Cashew nut shell liquid biodiesel

Cashew nut shell oil is a dark reddish-brown sticky liquid, obtained from a soft honeycomb structure of cashew shell. It is a regular and renewable bio-material. Hence, it bids advantage over synthetic. CNSL is habitually deliberated as cost-effective and improved modern supplies of unsaturated phenols [3–5]. Trials have exposed that the practice of nonedible oil in straight form is probable but not desirable. The higher viscosity of nonedible oil and lower volatility disturbs the atomization and fuel spray pattern, leading to imperfect burning and more carbon deposit, injector choke and piston-ring stick. Among these, the transesterification is commonly used commercial process to produce clean

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and environment friendly fuel, Combination of several fatty acid chains dependent on the definite oil in usage. Clean oils are not appropriate for CI engines since they may source the carbon deposit and also root the glitches like injector plugging, engine deposit and lube-oil gelling [7,8]. So to usage the oil in the CI engines, they are treated chemically and that practice is recognised as transesterification.

Blending is defined as the mixture of different type of the same substance together so as to make a product of the desired quality. Bio diesel is mixed with neat diesel in dissimilar concentrations and they are named as B20, B40 and B60 in Fig. 3.1. For example, in order to prepare 1 L of B20 [20% biodiesel and 80% diesel], 200 ml biodiesel is mixed with 800 ml diesel is added and mixed well with magnetic stirrer.

1. B20: 80% Neat Diesel and 20% Biodiesel
2. B40: 60% Neat Diesel and 40% Biodiesel
3. B60: 40% Neat Diesel and 60% Biodiesel

Each type of blends has a different density and calorific value due to variation in their viscosity for each type of blends. The colour variation of B20, B40 and B60 blends is due to the facts that change in the concentration of each type of blends.

4. Experimental procedure

The engine turned with no load and permitted to run at idle for some time. Time engaged for 10 cc fuel ingesting is noted with the stop watch and burette. Now the engine is steadily loaded to chosen value (K600W, 1200W, 1800W and 2400W). Subsequently permitting the engine to run at no load in order to attain steady state circumstance, time engaged for fuel consumption and the engine speed is noted. The practice is continual from no loading, 1/4th, 1/2th, 3/4th and maximum of the rated load. The reading is tabulated as shown and results are calculated. The same injection pressure is maintained for all the blends. The procedure is repeated for dissimilar loads and for dissimilar bio-diesel mixtures (B20, B40, B60 and nea Diesel). The readings are tabulated and results are calculated (Fig. 4.1).

5. Result & discussions

5.1. Emission characteristics

Biodiesel is deliberated to be instantaneous substitute energy by providing a key to aid lessening the effect of dangerous greenhouse gases, as it is derived from the plant oil offering safer, cleaner and renewable alternative to petroleum diesel.

5.1.1. Carbon monoxide (CO)

The disparity of carbon monoxide against the load for both fuel and their mixtures is as presented in the Fig. 5.1. The development of carbon monoxide emission largely depends on the physical/chemical assets of the fuel. It is perceived that the carbon monoxide emission of cashew nut shell biodiesel is lower than diesel at lower load conditions.

The reduction in carbon monoxide discharge for blends is accredited to the higher cetane number and the existence of O_2 in the molecular arrangement of the cashew nut shell biodiesel. Carbon monoxide is largely formed owing to the lack of O_2. Subsequently blends are an oxygenated fuel; it clues to improve burning of fuel, ensuing in the decline in carbon monoxide emission.

5.1.2. Un-burnt hydrocarbon (UBHC)

The disparity of hydrocarbons against the load for both fuel and their mixtures is as revealed in the Fig. 5.2. Hydrocarbon emissions were less at full load, but the high hydrocarbon emissions are detected for the mixture at lesser load. At lower load, the amount of fuel injected is lesser causing in a lean mixture, flame quenching and lesser gas temperature effects in imperfect burning leading to greater hydrocarbon pollutants.

The hydrocarbon emission of the cashew nut shell biodiesel is lower than diesel owing to high cetane number and intrinsic existence of O_2 (9%) in the molecular arrangement of the cashew nut shell biodiesel.

5.1.3. Carbon dioxide (CO_2)

Fig. 5.3 displays that, for all the fuel, the growing tendency of carbon dioxide (CO_2) emission is witnessed with power output.

1. B20: 80% Neat Diesel and 20% Biodiesel
2. B40: 60% Neat Diesel and 40% Biodiesel
3. B60: 40% Neat Diesel and 60% Biodiesel

Fig. 3.1. Diesel & blends of bio diesel.

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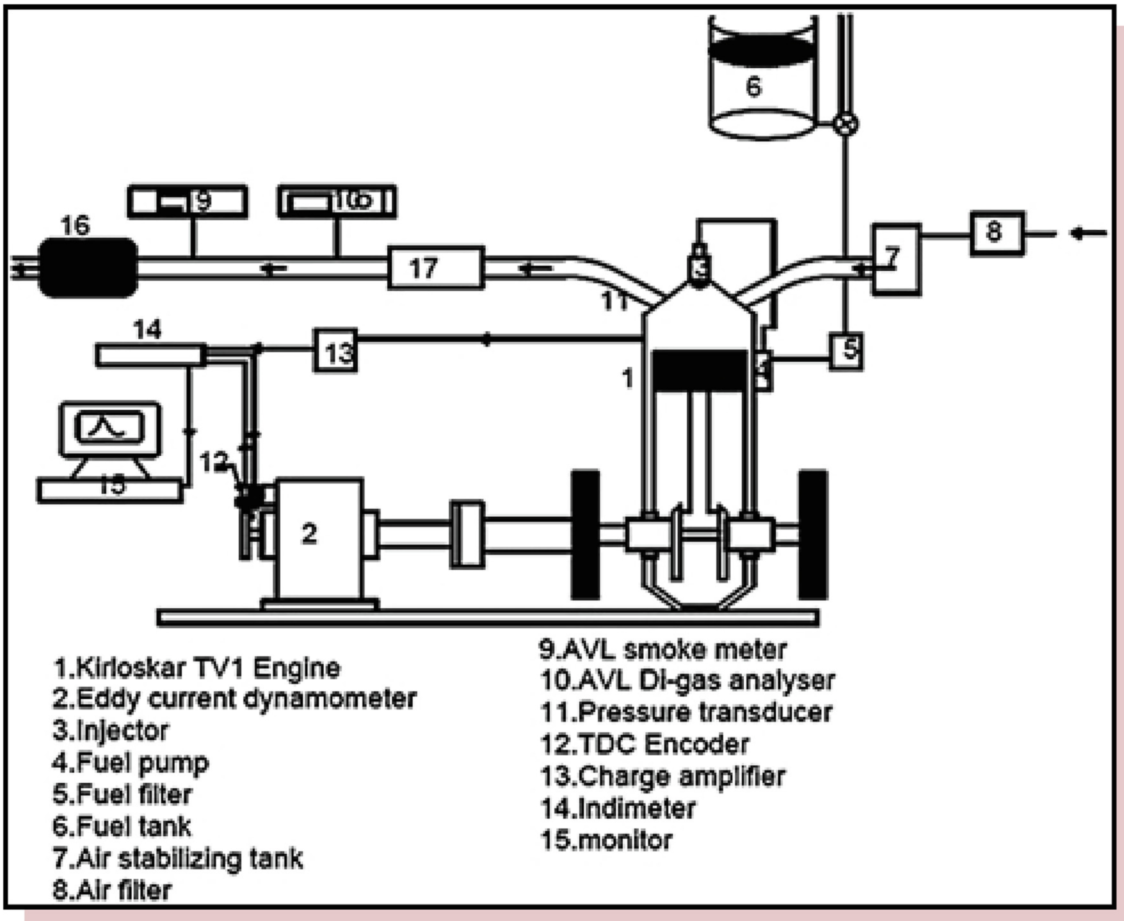

Fig. 4.1. Experimental setup.

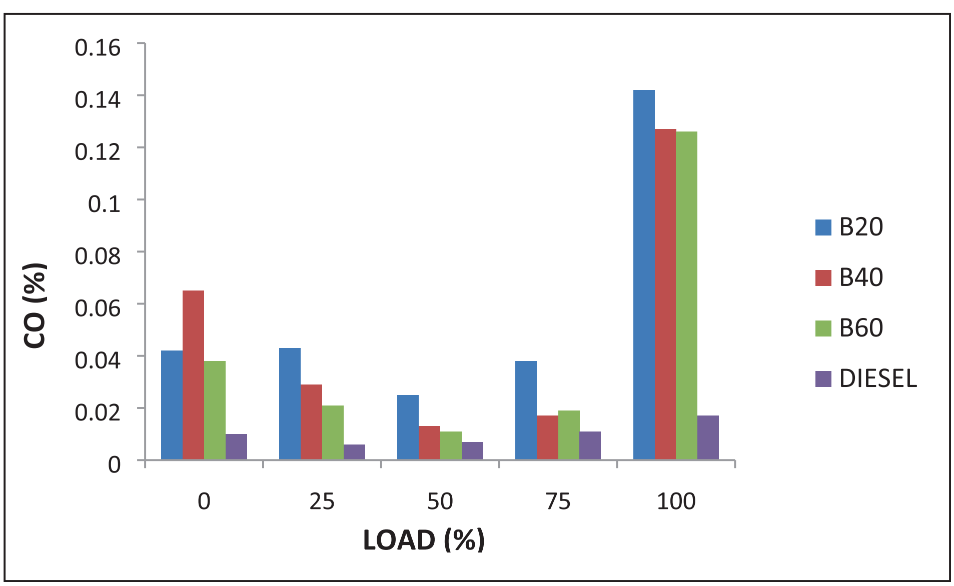

Fig. 5.1. Load vs CO emission.

This growing tendency of carbon dioxide is owing to the rise in volumetric fuel ingestion. It is detected that the carbon dioxide emission of cashew nut shell biodiesel is higher than diesel at the entire load except no load and partial load. This is accredited to the existence of O_2 and higher cetane number of cashew nut shell biodiesel.

5.1.4. Nitrogen oxide (NO_X)

The disparity of NO_X against the load for both fuel and their mixtures is as presented in the Fig. 5.4. Outcomes displays for all the fuel, the augmented engine load encouraging NO_X pollutant. Meanwhile the development of NO_X is very sensitive to temperature; these high load support cylinder temperature, which is

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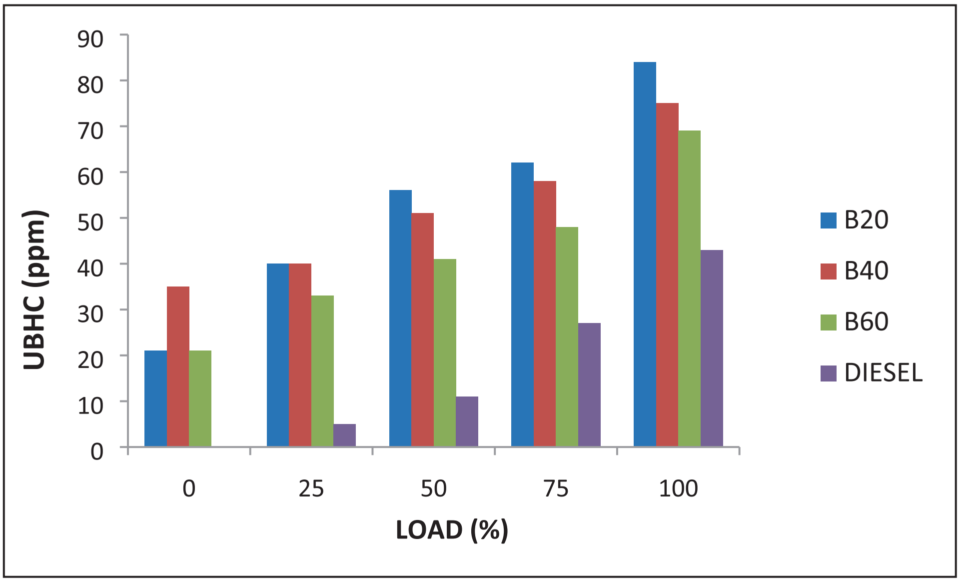

Fig. 5.2. Load vs UBHC emission.

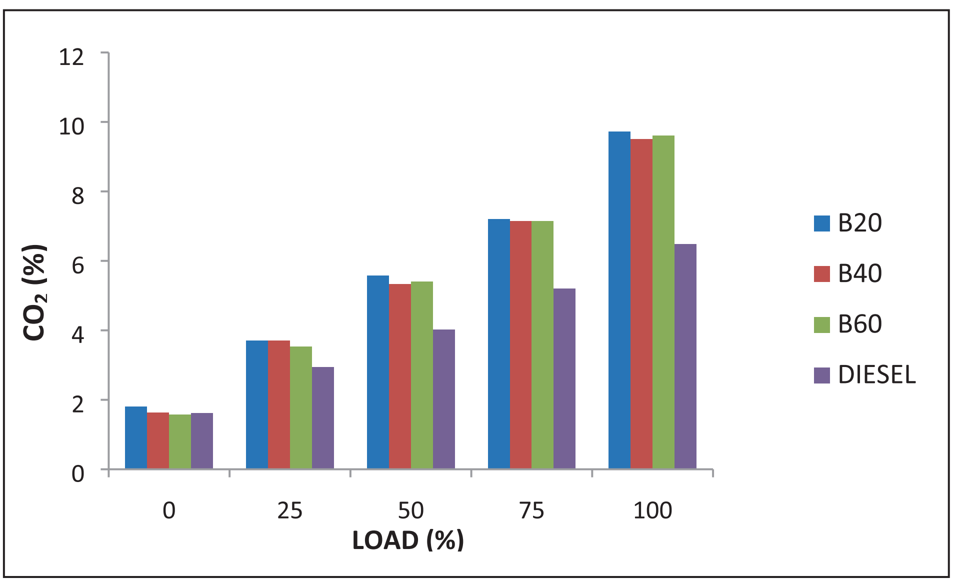

Fig. 5.3. Load vs CO_2 emission.

accountable for NO_X development. The cashew nut shell biodiesel yields marginally more NO_X than diesel. The rise in NO_X is endorsed to the existence of mono unsaturated and poly unsaturated fatty acids existing in the cashew nut shell biodiesel. NO_X progressively rises with the upsurge in ratio of mixtures in the fuel. The NO_X rise for mixtures may be related with the O_2 content of mixtures, since the O_2 existing in the fuel may deliver additional O_2 for NO_X formation.

5.1.5. Smoke opacity

The phenomenon of not permitting the passage of electromagnetic radiation is known as opacity. The smoke opacity is slightly equal to the fuels of diesel and blends of B20, B40 and B60 at all the loads. The smoke opacity of blend B60 is closer to the diesel is lower at all the loads (Fig. 5.5).

6. Conclusion

It is witnessed that the carbon monoxide pollutant of cashew nut shell biodiesel is lower than diesel at lower load conditions. Hydrocarbon emissions were less at full load, but the high hydrocarbon pollutants are detected for the mixture at lower load. It is perceived that the carbon dioxide pollutant of cashew nut shell biodiesel is higher than diesel at the entire load except no load and partial load. Outcomes displays for all the fuel, the augmented engine load encouraging NO_X pollutant. Subsequently the development of NO_X is very profound to temperature; these high loads encourage cylinder temperature, which is accountable for NO_X creation. The smoke opacity is marginally equal to the diesel and blends of B20, B40 and B60 at all the loads.

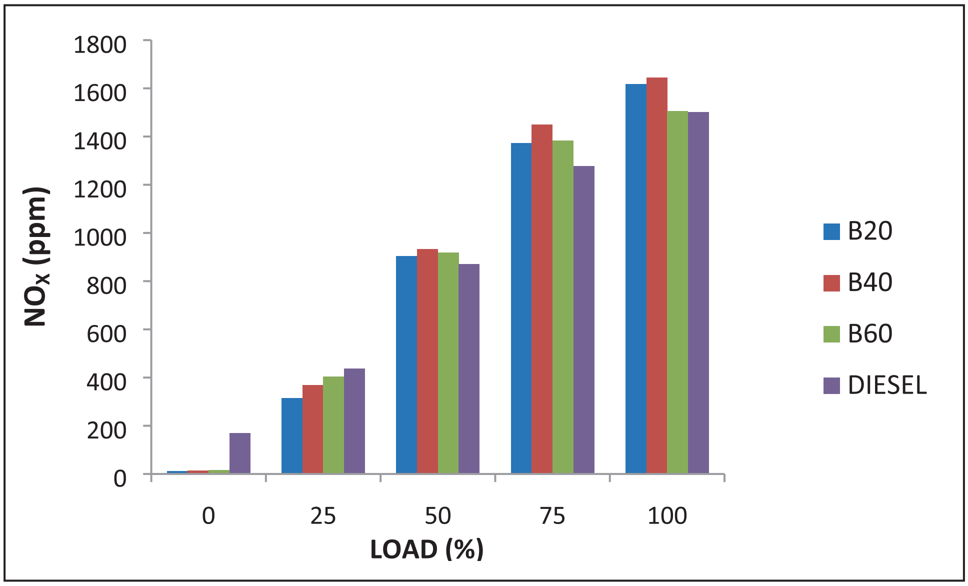

Fig. 5.4. Load vs NO_X emission.

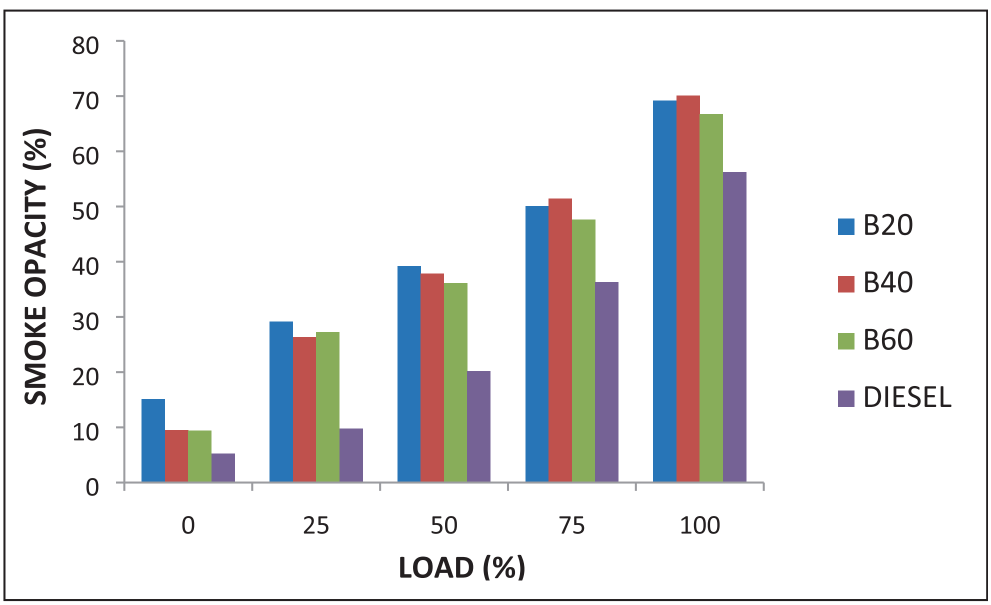

Fig. 5.5. Load vs. smoke opacity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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