Performance and Emission Characteristics of Single-Cylinder Diesel Engine Fueled with Biodiesel Derived from Cashew Nut Shell

M. Karthick, K. Logesh, S. Baskar, and Abhishek Sharma

1 Introduction

Diesel vehicles are the primary means of transport in today's world. Its key appeal is sturdy architecture, simple service, and easy maintenance. Due to the fossil fuel shortage, maybe we cannot use its facilities for a long time. Efforts to manufacture unconventional fuels for use in diesel engines are therefore being produced around the world. Likewise, how fuel demand decreased has emphasized automotive and pressured it to manufacture modern technical engines. This led to new combustion systems being developed. Many research investigations have been done toward resolving the above problems [1–3]. The diesel engine pollution characteristics were investigated with diesel and cassava shell oil blends in different loads at constant rpm. In all the mixtures, 20% CNS was higher than all the other mixtures. It has also been found that CNS mixtures can be used without alteration in the diesel engine [4].

The liquid biodiesel CNS is mixed with this diesel fuel which acts as a biodiesel mixture. CNB20, CNB40, and CNB60 are the blends used for testing. Output testing determined the effects of the combustible fuel on the engine capacity, brake heat quality, and gas exhaustion. Emission studies tested the effect of mixtures on carbon oxides and hydrocarbon emissions. The work focuses on connection

M. Karthick · K. Logesh
Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R and D Institute of Science and Technology, Avadi, Chennai, Tamil Nadu, India

S. Baskar
Department of Automobile Engineering, VELS Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, Tamil Nadu 600117, India

A. Sharma (✉)
Department of Mechanical Engineering, Manipal University Jaipur, Jaipur, Rajasthan 303007, India

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with pure diesel and the impact of doping pentanol combined with cashew nut biodiesel [5]. Cashew nut biodiesel was derived from cashew nutshell oil, and pentanol is an oxygenated product by a transesterification process. The test was done with diesel, cashew nut biodiesel, 10% pentanol, and biodiesel 20%. Researcher explores the effects of aluminum nanoparticles on the emissions and performance of the CSN fueled engine. The biodiesel nutcase of cashew prepared with the inclusion of aluminum nanoparticles is prepared through traditional and biodiesel transesterification changed [6].

The efficiency and emission properties of diesel engines depend on a range of variables, such as fuel injection, combustion chamber type, injection nozzle hole location and duration, fuel spray patterns, and air bucking. Several laboratory experiments of diesel engines have also been carried out to improve operational performance and reduce emissions [7–10]. There are two substitutes, gasoline, bioethanol, and modern adapted diesohol, which use the liquid/biodiesel-distilled cashew nutshell. The four main pollutants from diesel engines are carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM), and nitrogen oxides (NO_x), and their control strategist are diesel oxidation catalyst, diesel particulate filter, and selective catalytic reduction. Biodiesel and distilled cashew noodles can be used as emulsifiers for the stabilization of diesohol and marginally for a decrease in the portion of diesel in the blend due to their molecular structure. In the last years, significant global interest was seen in the development of sustainable, waste-to-energy, and low-cost raw materials technology for diesel engine fuel and hydrocarbon bio-jet fuel [11–13]. This modern and renewable route is exciting because it requires conversion to green diesel with moderate experimental conditions with low-value residues. CNS processing of biofuels facilitates the complete use and future industrial uses in many countries of the residues of the agro-industry castaway-neutral chain. Many studies were carried out on the use of biodiesel study to determine the effects of the study and emission properties of oxygen-additive nanoparticles, followed by a comparison of experimental results with base pure diesel. Several researchers have shown to have used a variety of biodiesel to evaluate emission characteristics and to study the quality of a wide range of diesel engines with or without modification. In this study, biofuel combinations of CNS oil of its three blends B20, B40, and B60 explored and its performance analysis and emissions characteristics in a single-cylinder diesel engine are discussed in this paper.

2 Experimental Details

Cashew nut oil is a viscous reddish-brown dark liquid which is collected within the cashew from a soft structure. It is a biomaterial that is natural and organic and gives a synthetic benefit. CNS oil is also viewed as cost-effective and more advanced phenol ingredients. Cardanol oil, a commonly used commodity in the industry, has the main purpose of CNS extraction. Physically processed CNS produces 70% anacardic acid, 18% cardol, and 5% cardanol. In essence, cardanol is a single-hydroxy phenol with

Table 1 Properties of cashew nutshell blends

Property	Diesel	B20	B40	B60
Density (kg/m^3)	845	870	878	885
Calorific value (kJ/kg)	4300	41,912	41,325	40,758

a long meta-position carbon chain. It can replace phenol in phenolic resin base chemicals. Blending is characterized by the blending, to create a commodity of the desired nature of the different forms of the same material together. Biodiesel in varying amounts is mixed with renewable diesel, the names of which are B20, B40, and B60. For instance, 200 ml biodiesel is mixed with 800 ml diesel in the preparation of 1 L of B20 (20% biodiesel and 80% diesel) and is well mixed with magnet stirrer, similarly in B40 and B60 proportions. The properties of blends are given in Table 1.

To test engine investigation and CNS oil emission requirements, the air-cooled direct injection diesel engine was used at 2.5 kW in the 1200-rpm speed rating. A dynamometer may be used manually for loading an engine from zero to maximum load, ranging from an increment of 25% based on generated engine capacity. The test rig was linked to the critical combustion pressure, diesel line pressure, and crank angle measurements computing instruments. AVL gas analyzer has observed the exhaust emission characteristics. The engine needs to start at no loading and was allowed to idle for a while. During the usage of the stopwatch and a fuel calculation desk, the time needed for 10 cc fuel consumption is noted. Now the motor is loaded steadily to the target value. The time required for fuel consumption and speed of the engine is noted after the engine has been operating at no load for some time to reach a steady state. For no loading of 25, 50, 75, and 100% of graded load, the procedure has been repeated. The reading is presented and outcomes measured. The results are current. Both mixtures are maintained with the same injection strength. For multiple loads and biodiesel blends (B20, B40, B60, and renewable diesel), the process is repeated. The results are estimated and tabled. The limitations are as the engine load increases, relative contribution of premixed combustion phase to the total heat release decreases due to the reduction in ignition delay and mixing controlled combustion phase starts to control the engine combustion and heat release process and the future work to be carried out in different blend with respect to various proportions.

3 Results and Discussion

3.1 Brake Thermal Efficiency

The transformed heat energy is called power as indicated, and the power indicated often exceeds the brake power and is used to push the piston [14]. The brake power is the engine's driving shaft's power output without loss of engine power, transfer, etc. The biodiesel also includes a quantity of the ester oxygen molecule. It also

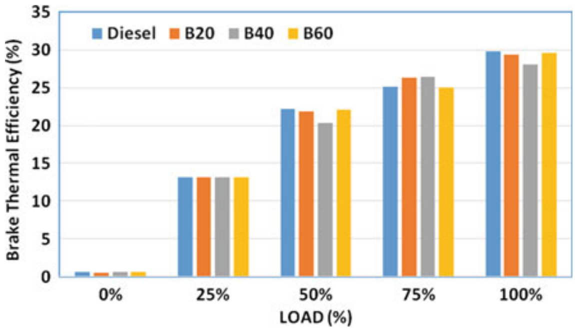


Fig. 1 Variation of brake thermal efficiency on engine load

participates in the burning process. The brake thermal efficiency (BTE) is the brake power-to-fuel energy ratio [15]. It is found that BTE as shown in Fig. 1 is steadily decreased as the applied load is increased and brake thermal efficiency improves as the load is increased. This shows for B20 that efficient combustion exists, and energy loss reductions are made about exhaust gas [16]. The B40 and B60 also reflect this fact.

3.2 *Mechanical Efficiency*

The torque tests the power of a motor to spin the wheels at a certain rpm. The ratio of the brake power to the indicated power is mechanically specified [17]. Volumetric efficiency is defined as the air volume flow rate at which the device transfers volume. The efficiency, mechanical for a combination B20, B40, and B60, from the study of Fig. 2, is greater than the diesel due to the higher volumetric air flux for mixing, the volumetric efficiency is greater, and due to a rise in the specified heat power and the thermal brake efficiency is greater.

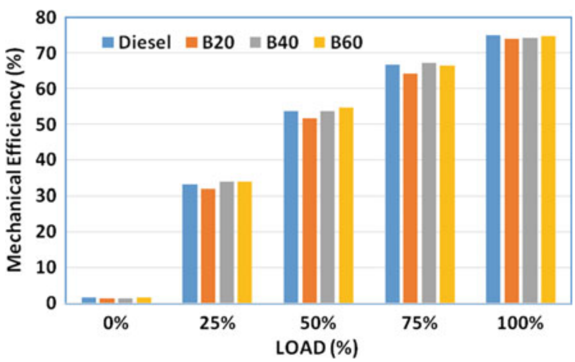


Fig. 2 Variation of mechanical efficiency on engine load

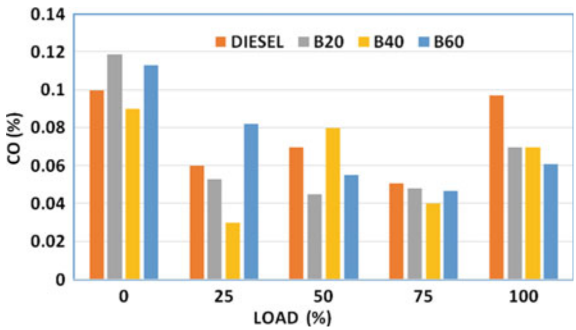


Fig. 3 Variation of carbon monoxide emission on engine load

3.3 Carbon Monoxide

The difference between carbon monoxide load and combustion is as shown in Fig. 3. The formation of CO emissions depends primarily on the physical and chemical characteristics of the fuel [18]. The CO emission of CNS biodiesel is less than the CO emission of diesel. The reduction in CO emissions for blends is due to a large amount of cetane and oxygen in the cashew nutshell's molecular structure. The lack of oxygen primarily allows carbon monoxide to be formed. Since mixtures are oxygenated, fuel combustion increases and decreases emissions of carbon monoxide.

3.4 Unburnt Hydrocarbon

As seen in Fig. 4, hydrocarbon differences for all fuels and their mixtures have been greatly decreased by unburnt carbon emissions, but higher unburnt carbon emissions are found for the mix at low load conditions. Their emissions are substantially reduced. Under low load conditions, the fuel-injected is less and the effect is that the mixture is slight, the flame has darkened, and gas has fallen, and that the combustion is insufficient, and the hydrocarbon emissions are higher. Because of the higher

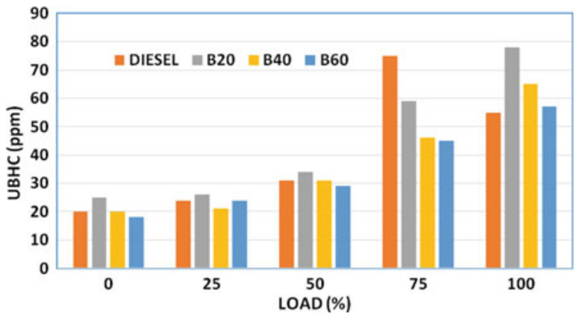


Fig. 4 Variation of unburnt hydrocarbon emission on engine load

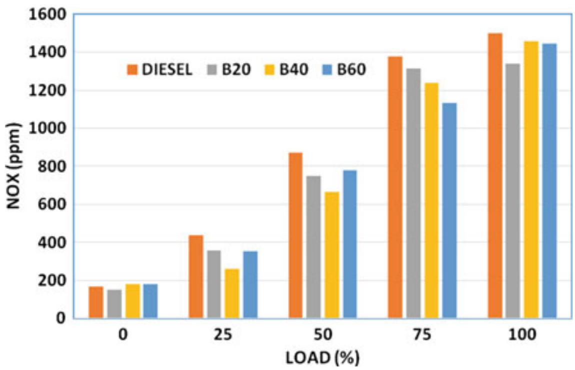


Fig. 5 Variation of nitrogen oxides emission on engine load

cetane amount and oxygen inherent in the molecular structure of CNS biodiesel, hydrocarbon pollution of the biodiesel cashew shell is less than that of diesel fuel [19].

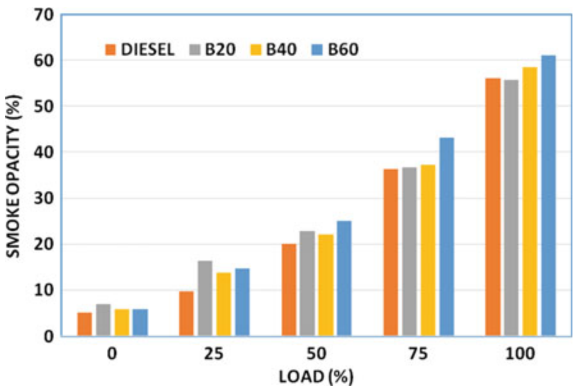
3.5 Nitrogen Oxide

As seen in Fig. 5 and the bar diagram, the shift in nitrogen oxide in comparison with both gasoline and their mixture is seen below. Results show that the engine load that encourages NO_x emissions has risen for both fuels. As the forming of NO_x is susceptible to temperature, this increased load promotes the temperature of the cylinder's loading, which is responsible for the formation of Zeldovich NO_x thermal [20]. The biodiesel CNS contains a little more NO_x than diesel [21]. The growth in NO_x is the presence of mono-unsaturated and poly-unsaturated fatty acids contained in biodiesel in the cashew nutshell. With the rise in the proportion of fuel mixtures, NO_x increases steadily. The NO_x rise can be related to the oxygen content of mixtures, and the oxygen in the gasoline can be used to generate extra NO_x oxygen.

3.6 Smoke Formation

Opacity generated from diesel engine can be explained as soot particles which are the results of unburnt fuel [22]. Opacity constitutes the degree to which smoke blocks light, and the basis on which the smoke in the diesel-powered car is measured. The opacity of smoke is somewhat equal to B20, B40, and B60 petrol, and variations are shown in Fig. 6. The smoke opacity of the B20 and B40 mixtures is similar, with the diesel fuel lower at 0–30% in addition of biodiesel, but NO_x increases. The increase in the residence time and the temperature of the mixture in the cylinder may lead

Fig. 6 Variation of smoke emission on engine load



to raise in NO_x emission [23]. In the future, the biodiesel will play a major role in terms of improvement in the behavior of the diesel engine.

4 Conclusion

Efforts to produce unconventional fuels for use in diesel engines are therefore being produced around the world. Emission and engine characteristics were studied and compared with simple diesel-driven diesel fuel for a single cylinder's direct injection diesel engine fueled with cashew nutshell biodiesel–diesel blends. With a growth in the proportion of mixtures due to lower calorific value for CNS biodiesel, the basic fuel consumption increases. The thermal efficiency of CNS oil is significantly higher than that of diesel. For engines operating on biodiesel, the fuel consumption values are higher by 10% than the engine running on conventional diesel. CO emissions are low as compared to diesel at higher loads for cashew nutshell esters. The raised NO_x emissions of the biodiesel cassava nutshell are the result of unsaturated fatty acids of mono- and polyester. Cashew nutshell biodiesel with copper oxide nanoparticle meets the essential properties of fuel in compliance with the requirements for biodiesel.

5 Limitation and Future Scope

One of the most common problems associated with biodiesel is higher viscosity than diesel. The same issues were faced with cashew nutshell biodiesel. This problem can be solved by blending CNS with fuel of lower viscosity. Also, preheating can be done to reduce the viscosity.

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