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An Experimental Study of Fuel Properties of Diesel Blends With Sunflower/Soybean Oil and Ethanol

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Abstract

Biodiesel, a renewable alternative fuel manufactured by transesterifying vegetable oil with ethanol, is becoming more widely available for use in transportation blends with traditional diesel fuel. The higher density and viscosity of these biodiesel mixes than diesel is a substantial hurdle to commercial biodiesel use. Varied fuel sources, such as sunflower oil and soybean oil, were used to make biodiesel in various amounts in this study. The effects of different biodiesel mix concentrations on efficiency, NOx, CO, and smoke opacity characteristics were studied experimentally. The addition of ethanol to balm/sunflower oil biodiesel improves efficiency due to the good combustion process, according to the findings. For all load circumstances, the Su5Sb5D85E10 bio diesel performed better with reduced emissions. Overall, adding ethanol to soybean/biodiesel fuel reduced emissions of NOx, CO, and smoke opacity. The findings indicate to a method for improving diesel fuel performance in terms of environmental effect.

Keywords: Diesel, Biodiesel, Oilseeds, Ethanol, Emissions, Engine performance

1. Introduction

Fuel with specified characteristics is required for efficient conversion as well as having proper engine operating conditions. Researchers discovered that with only minor engine modifications, biodiesel meets these standards. Biodiesel is a fuel manufactured from animal fats and vegetable oils. When compared to diesel fuel, it has the same amount of thermal energy. It also doesn't include sulphur minerals and emits low levels of engine emissions as a result, owing to a high oxygen concentration [1-3]. The unmanageable rate of fossil fuel use and large-scale emissions resulting from traditional energy sources are directly responsible for global environmental damage. Internal Combustion Engines (ICE) have been a key contributor to the development of modern societies while also serving as the principal source of energy in isolated places. The high biodiesel intensity aids in self-lubrication [4, 5]. Among the mechanical components of the engine, biodiesel is made up of mono-alkyl esters. Acyl-glycerol can be used to make long-chain fatty acids discovered in vegetable oils. It can be done with the help of a catalyst. In the presence of a catalyst, a transesterification process with short-chain alcohols is performed. The most common approach is homogeneous transesterification to make biodiesel [6].

Biofuels, which are obtained from a wide range of natural resources, such as sunflower oil, soybeans, palm oil, karanja oil, canola oil, safflower oil, canola oil, coconut oil, rapeseed oil, waste cooking oil, and so on, have recently emerged as a viable alternative natural source. It is also comparable lower emissions and better engine efficiency [7-9]. Numerous studies have focused on the efficiency and emissions of various sunflower biodiesel blends. Uyarglu et al. [10] studied on engine performance and emissions of sunflower, edible hazelnut, soybean, canola biodiesel, and corn, each of which is a 30% blend with diesel. The results revealed that engine efficiency was reduced by the blending of all biodiesel. However, less emissions were found in the biodiesel combination compared to diesel. The maximum percentage reduction of NOx emissions was obtained for sunflower diesel. Hemanandh and Narayanan [11] An emission study of sunflower oil biodiesel was attempted in an experimental investigation in a DI diesel engine. The use of hydrotreated refined sunflower oil B25 and B100 reduced NOx by 10% and 18.18%, HC by 42%, and CO by 9% and 37%, respectively.

Hybridization of natural oil blends has been found to help enhance engine efficiency in addition to increasing engine performance. On the other hand, biodiesel blends with ethanol, alcohol, and butanol fuel, have been shown in multiple experiments to improve fuel properties [12, 13]. Vergel-Ortega et al. [14] explored an emission study of sunflower/palm oil/ethanol biodiesel with various blend concentrations. They found that the 4% of ethanol concentration with sunflower/palm oil blend biodiesel showed the minimum emissions of NOx, CO, HC, CO2, and smoke opacity compared to other biodiesel blends. Da Silva et al. [15] overall efficiency for biodiesel fuels made from soybeans, chicken fat, sunflower oil, and cow tallow increased by up to 2%. This is due biodiesel blended with ethanol to reduce the viscosity. Another study showed that as the cold flow and volatility increase, ethanol has a higher oxygen content than biodiesel. Combining the two minimises PM emissions when compared to using biodiesel alone [16, 17]. Leite et al. [18] investigated the effects of bio diesel concentration on emissions and performance in diesel engine. They revealed that the minimum concentration of biodiesel level showed the better results for both emissions and performance.

Numerous studies have been conducted to determine the efficiency and emissions of various biodiesel composition. The major goal of this study is to propose an alternative fuel approach that incorporates biodiesel blends made from sunflower, soybean and ethanol as an additional agent to investigate the impact on a diesel engine's overall performance and emissions. Specifically, the performance evaluation addresses fuel metrics, thermal efficiency, as well as pollutant emissions of CO, NOx, CO_2, HC, and smoke opacity. Therefore, this work contributes to reducing the knowledge gap immersed in the implementation of biodiesel blends from sunflower oil, and soybean and subsequent characterization of performance metrics.

2. Materials and experimental procedure

For varying proportionalities of this work, sunflower with soybean oil blend fuels are processed into biodiesel. A quantity of methanol and sodium hydroxide solution is added to the sample oils. Filtration was done in a three-necked glass flask with a condenser and a thermometer. After two hours of processing, the methanol was removed using the condenser. The reactant was heated to 50°C, the boiling point of methanol, and then cooled slowly to room temperature. Filtration is accomplished in two layers: upper and bottom. Glycerin was present in the lowest layer, which sank to the bottom. The process layer separation for the settling took a total of six hours. The ester was then rinsed with water at room temperature to remove any remaining methanol and sodium hydroxide.

A heating technique was used to remove leftover water and particulates from the residual fuels at first. The particulate matter was removed from residual fuel using a funnel and filtration procedure after it was heated to 90°C. The remaining fuel is then mixed with methanol and sodium hydroxide in the next stage. This gasoline was placed in a glass bowl and stirred with a motorised stirrer at 500-600 rpm to dissolve it and temperature is constantly maintained at 60°C for this process. Following the mixing process, a chromatographic column was used to separate glycerin from biodiesel, which was then washed with water. To establish the emission and engine performance parameters, four different biofuels were examined. Table 1 displays the various biofuels ratio. A bio-diesel reactor, which is a tank that can hold biooil, base catalyst, and methanol. Because it is a basic machine with minimal moving components, mixing can be done with just a motor and a baffle.

Table 1 Blended biodiesel concertation

	Blend proportional (%)			
Fuel	Sunflower oil	Soybean	Diesel	Ethanol

Su5Sb5D90	5	5	90	-
Su5Sb5D85E5	5	5	85	5
Su5Sb5D85E10	5	5	80	10
100D	-	-	100	-

For this experimental investigation, four-stroke single-acting cylinder specifications like connecting rod length of 230 mm, stroke length of 110 mm, cylinder bore of 87 mm, injection pressure of 200 bar, maximum power of 4 kW, and water-cooling system were used for this experimental investigation. A sun diagnostic fuel analyzer was used to determine the emissions of CO and NOx. A type-K thermocouple was originally used to measure the temperature of the exhaust fuel. Ethanol is added to the B25 mix in amounts ranging from 5% to 10%. The kinematic viscosity, flash point, and density of sunflower oil and soybean oil fuel are shown in Table 2. One significant difference between biodiesel and oil diesel is the high oxygen content (between 10 and 11%), which improves burning and execution characteristics. The properties of biofuels are shown in Table 2.

Table 2 Properties of biodiesel and diesel fuels [9, 20]

Types of fuel/Property	Density kg/m^3	Flash point °C	Kinematic viscosity at 40^{0}C mm^2/s
Soybean oil	940	270	43
Soybean oil Bio diesel	877	150	6.098
Sunflower oil	918	274	33.9
Sunflower oil Biodiesel	880	176	4.3
Diesel fuel	850	56	2.7

3. Results and discussions

3.1 Brake thermal efficiency

Figure 1 depicts the thermal efficiency of soybean/sunflower biodiesel fuels. Chemical energy is used to convert mechanical energy. The BTE is the maximum for neat diesel fuel, as seen in the graph. The 10% addition of ethanol improved the thermal efficiency when compared to biodiesel. When compared to other ethanol blended fuels, soybean/sunflower mixed biodiesel had the lowest thermal efficiency. Su5Sb5D85E10 showed moderate efficiency compared to Su5Sb5D90 biodiesel at maximum loaded condition. Furthermore, efficiency improves as the engine load increases since less power is lost as the engine load increases. The BTE, on the other hand, decreases as the percentage of ethanol in fuel mixtures increases due to the decreased calorific value of the gasoline blend. Furthermore, the findings demonstrated that increasing the amount of ethanol in the gasoline mixture improved fuel efficiency. The use of ethanol improves efficiency because of the good combustion process that occurs, resulting in an oxygenated environment. In prior literatures, similar efficiency results were reported [21].

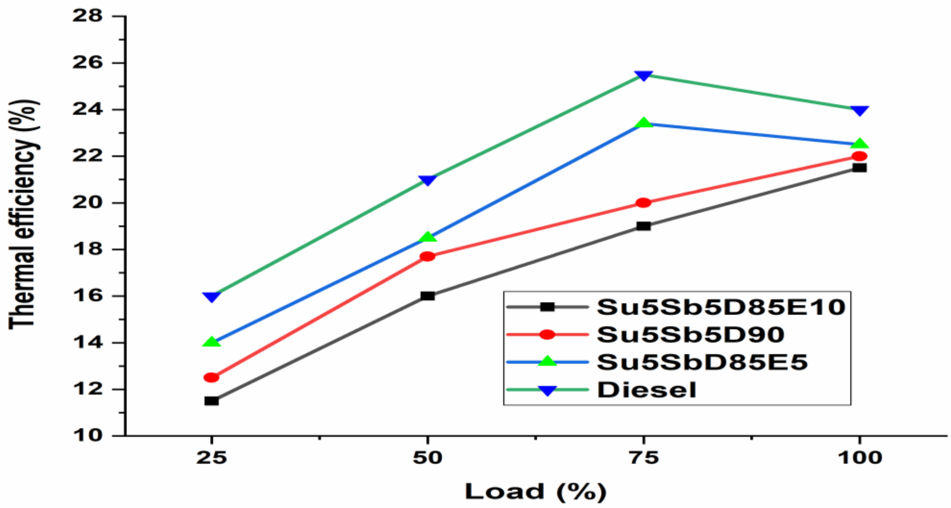

Figure 1 Brake thermal efficiency of soybean/sunflower biodiesel

3.2 NO_x emissions

Figure 2 depicts the level of NOx emissions from soybean/sunflower/diesel and soybean/sunflower/ethanol/diesel biodiesel fuels at various loads. CO and NOx emissions show a similar pattern, as can be seen in the graph. The biodiesel fuel lowered carbon monoxide emissions, according to the findings. For all load settings, the Su5Sb5D85E10 bio diesel produced the least amount of NOx. Su5Sb5D85E10 biodiesel emits less NOx than Su5Sb5D90 and Su5Sb5D85 biodiesels. This is due to the cooling action of ethanal, which lowers NOx emissions. NOx emissions (maximum load) for increment level of Su5Sb5D90<Su5Sb5D85E5<Su5Sb5D85E10 biodiesel were reduced, when compared to clean diesel. NOx emissions are reduced by the higher oxygen content of ethanol blend gasoline [13, 22]. The addition of the loading level raised the combustion temperature, resulting in a higher NOx emission level for all biodiesel. As ethanol is added to biodiesel, it lowers NOx emissions when compared to straight diesel, which could be due to ethanol's cooling impact [22].

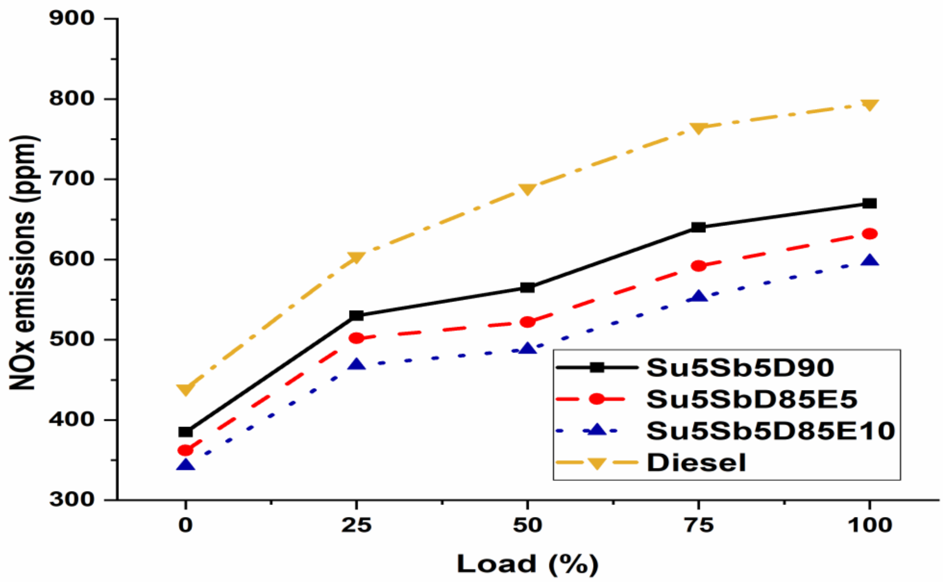

Figure 2 NOx emissions of soybean/sunflower biodiesel blends

3.3 Smoke opacity

In Figure 3, the smoke opacity levels of neat diesel and soybean/sunflower biodiesel fuels are shown. In general, the level of smoke opacity is determined by the incompleteness of combustion. The figure clearly shows that the ethanol blended bio diesel improved the smoking quality of the fluid gases. The Su5Sb5D85E10 bio diesel showed a low-level smoke opacity for all the load conditions. Su5Sb5D85E10 has a lower smoke opacity than all other fuels due to the addition of ethanol to improve oxygen content, which aids in complete combustion, resulting in a lower smoke opacity. When compared to Su5Sb5D90 and Su5Sb5D85 biodiesels, Su5Sb5D85E10 biodiesel emits less smoke opacity level. When compared to neat diesel, smoke opacity at maximum load condition for Su5Sb5D90, Su5Sb5D85E5, and Su5Sb5D85E10 biodiesel was reduced. The higher oxygen content of ethanol blend fuel reduces the smoke opacity. On the other hand, the addition of the loading level increased the combustion temperature, and the resulting smoke level has been increased for all biodiesel. Overall, results showed that smoke emissions quality improved with ethanol addition. Similar smoke opacity levels of biodiesel were observed by Vergel et al. [14].

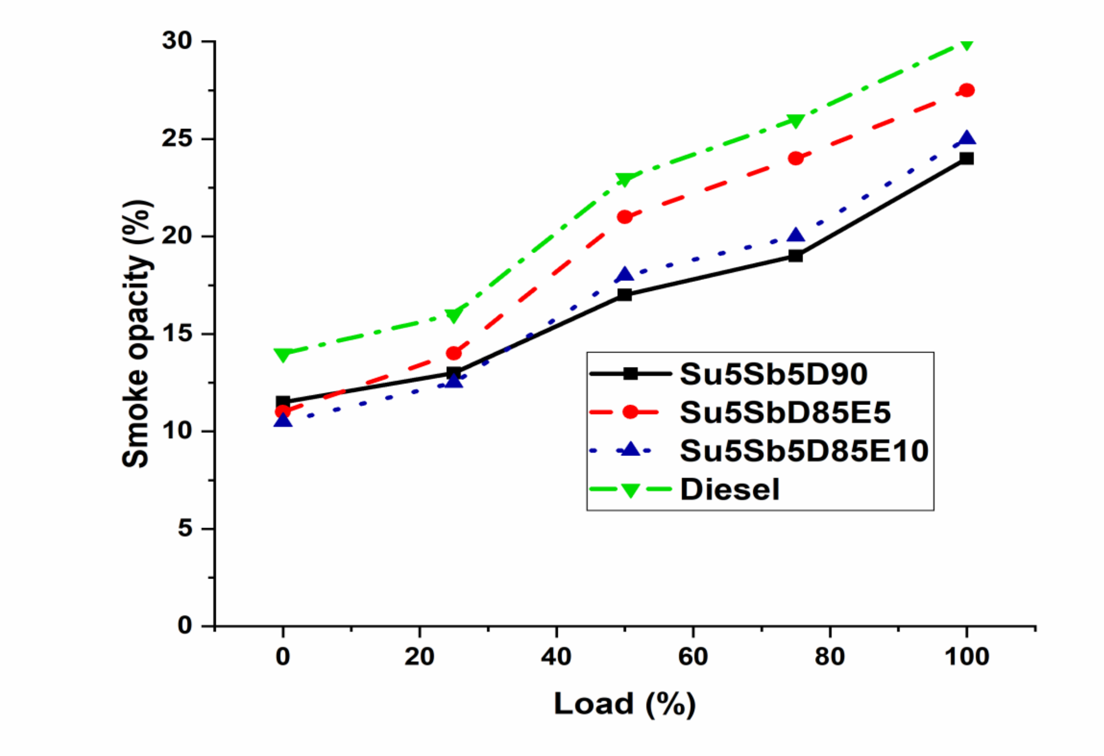

Figure 3 Smoke opacity of soybean/sunflower biodiesel blend

3.4 Carbon monoxide emissions

The carbon monoxide (CO) emissions of diesel and soybean/sunflower biodiesel as a function of various loading conditions are shown in Figure 4. The biodiesel fuel lowered carbon monoxide emissions, according to the findings. The soybean/sunflower biodiesel blended ethanol 10% fuel (Su5Sb5D85E10) showed a minimum CO emission for all the load conditions. Su5Sb5D85E10 biodiesel emits less CO than soybean/sunflower oil blended (Su5Sb5D90) and soybean/sunflower/ethanol blended biodiesel (Su5Sb5D90). This is because ethanal lowers the carbon content of biodiesel. When compared to clean diesel at maximum load condition, CO emissions from Su5SbD90, Su5Sb5D85E5, and Su5Sb5D85E10 biodiesel. Other research studies revealed a similar observation: adding ethanol reduced carbon content, which resulted in lower CO emissions [22].

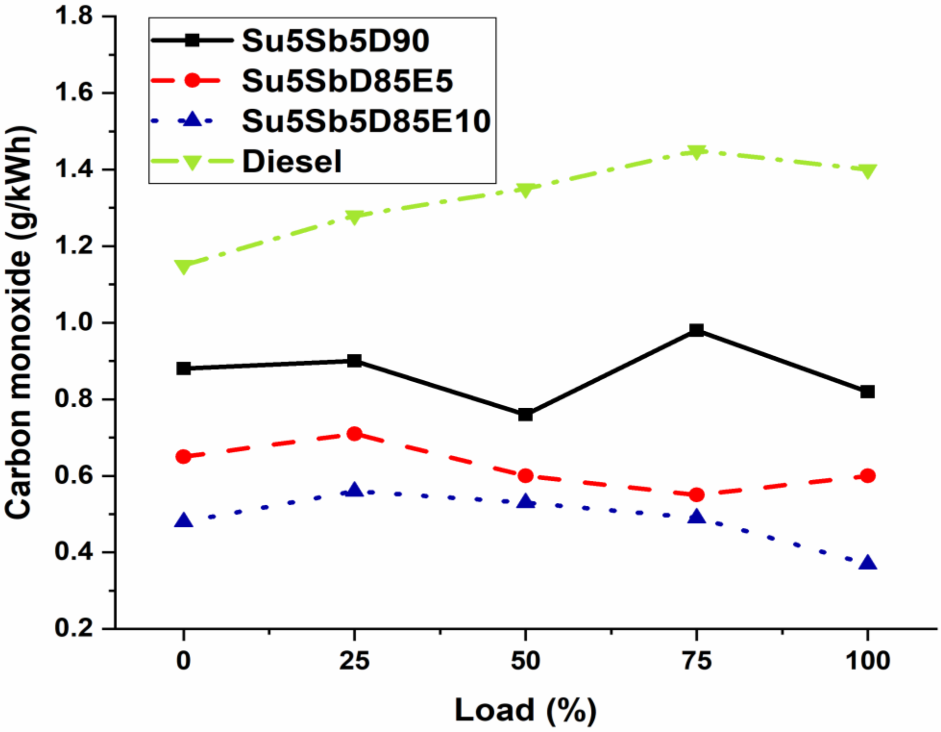

Figure 4 Carbon monoxide emissions of soybean/sunflower biodiesel blends

4.Conclusions

Experimental research was conducted on the efficiency and emission characteristics of soybean-sunflower biodiesel with ethanol-diesel fuels. The results of the tests revealed that soybean/sunflower biodiesel fuels had a substantial impact on brake thermal efficiency and emissions. The thermal efficiency of soybean/sunflower biodiesel with a higher ethanol addition was enhanced. Soybean palm/sunflower blended biodiesel has the lowest thermal efficiency when compared to ethanol blended fuels. Biodiesel fuel reduced carbon monoxide emissions, according to the results of the trials. Under all load conditions, the soybean-sunflower biodiesel blended ethanol fuel (Su5Sb5D85E10) emitted the least quantity of carbon. This is because ethanal lowers the carbon content of biodiesel. NOx emissions were found to be similar for soybean/sunflower blended fuels. The lower opacity of the smoke is due to the higher oxygen content of ethanol blend biofuel. Overall, the Su5Sb5D85E10 biodiesel performed better in terms of fuel properties like emissions and economy.

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