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An Experimental Investigation of Prosopis Juliflora Biodiesel's Performance and Emission Characteristics

M. Nagappan[1]*, J.M. Babu[2], K. Karthik[3], PV Elumalai[4]

Abstract

Fossil fuels are currently in crisis due to their higher cost, their increasing use, and their scarcity. In view of the large number of cars on the road and the emission levels caused by combustion ignition engines, fuel substitutes are sought. Diesel is the most expensive fuel on the market, so biodiesel is a good alternative. Aside from its low toxicity, it reduces greenhouse gas emissions, does not emit sulphur, does not produce particulate pollutants, and is biodegradable. Prosopis juliflora and diesel were combined to create a biodiesel mix that was discovered and tested throughout the course of this investigation. Using an alkaline catalyst or a strong acid catalyst, Biodiesel can be produced from Prosopis juliflora seed oil and methanol. To find out about their different qualities, these mixes are compared to diesel. Various Prosopis juliflora blends are evaluated in terms of their thermal efficiency, fuel consumption, and emissions and A comparison is made between neat diesel and the results.

Keywords: Energy; Emission; Biodiesel; Prosopis Juliflora; Performance.

INTRODUCTION

In response to rising energy consumption, rigorous emission standards, and environmental concerns, Biodiesel plays an important role in internal combustion engines with considerable attention being paid to alternative fuels combustion engines[1]. Petroleum can be replaced environmentally-friendly with biodiesel, which is created from domestically available renewable resources[2]. The transport sector makes use of another variety of fuels such as alcohol, biodiesel, Liquified Natural Gas(LNG), and Compressed Natural Gas (CNG) [3]. The transportation sector needs help for the future in this industrialized society[4]. It is crucial to take into account our current reliance on these resources because petroleum and diesel require decades to replace[5].

***Author for Correspondence**
M. Nagappan

[1]Research Scholar, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.
[2]Professor, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.
[3]Assistant Professor, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.
[4]Associate Professor, Department of Mechanical Engineering, Aditya Engineering College, Andhra Pradesh, India.Telangana, India.

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In addition to having a higher fuel density than pure diesel, biodiesel also has a lower calorific value[6]. Biodiesel has shown to be a useful fuel by improving horsepower, thermal efficiency, torque, and particular fuel consumption.[7] In this study, different blends of fuel were characterized based on their combustion characteristics. Torque increases for all blends with varying compression ratios, but Brake Specific Fuel Consumption (BSFC) falls off as the proportion of biodiesel increases. BSFC then rises as the blend's biodiesel -content is increased.

The India arid and semi-arid zones can utilize Prosopis Julifora as a cheap feedstock for generating fuel, building protective fences, and increasing fertility[8]. As a result of its environmental impact, the state government of Tamil Nadu has condemned the plant[9]. Hence, these seeds can be used to create bio-oil, which can be used to generate energy from waste. Using this kind of technology Waste disposal is reduced as a result of production[10]. Hence, a sustainable economy and renewable energy can be achieved using an alternative fuel source.

EXPERIMENTAL SETUP FOR BIODIESEL PREPARATION AND TESTING

Prosopis Juliflora seeds are gathered from wastelands and dried in the sun as long as seed collection is done during the appropriate season. The dried seeds of Prosopis Juliflora are pulverized in this figure 1 to increase oil extraction. An extraction method was used to create Prosopis Juliflora biodiesel from the oil of the plant and Procedural steps involved in transesterification. For the creation of stable blends, diesel and bio-oil proportions were varied. B10, B20, and B30 are respective blends of 10%, 20%, and 30% trans-esterified oil and diesel.

Figure 1: Prosopis Juliflora Seeds

Stable blends were created by adjusting the ratio of bio-oil to diesel. Most stable blends were Prosopis Juliflora Biodiesel 10% and diesel 90%, Prosopis Juliflora Biodiesel 20% and diesel 80% and Prosopis Juliflora Biodiesel 30% and Diesel 70%. To determine whether they would be suitable as diesel fuel, their properties were examined. The characteristics of each blend are considered along with its flash point, density, calorific value, and viscosity. Bio-oil and diesel are compared in the following table. By mixing 10% neat diesel with the biodiesel obtained, comparisons were made. When the parameters have been established, computed, and blended with 20% and 30%, repeat the process with neat diesel. However, there are some distinctions between 10% mix and plain diesel.

Table 1: Properties of various blends of Juliflora Biodiesel with diesel comparison

Property	**Unit**	**Diesel**	**Neat Juliflora**	**B10 Fuel**	**B20 Fuel**	**B30 Fuel**
Density	kg/m3	850	960	862	880	890
Viscosity at 40ºC	cst	2.85	3.05	3.65	4.2	5
Flash point	ºC	64	55	60	66	73
Fire point	ºC	79	66	73	80	83
Calorific value	MJ/kg	44	41	40	38	36

Figure 2 shows a schematic of the Kirloskar TAF 1 engine, which is used to test biodiesel blends once they are created. There is one cylinder in the engine and two strokes in the alternator of this engine setup. At 1500 rpm for the engine speed and 1500 rpm for the fuel consumption, we timed how long it took for 10 cc to consume fuel. Load cells apply load by managing the load, much like alternators. An airflow sensor measures how much air is discharged from the airbox[11]. Fuel readings are measured with the help of the fuel sensor. Using a fuel sensor, fuel readings are taken. A gas analyzer and smoke meter measure the emissions from the exhaust pipe.

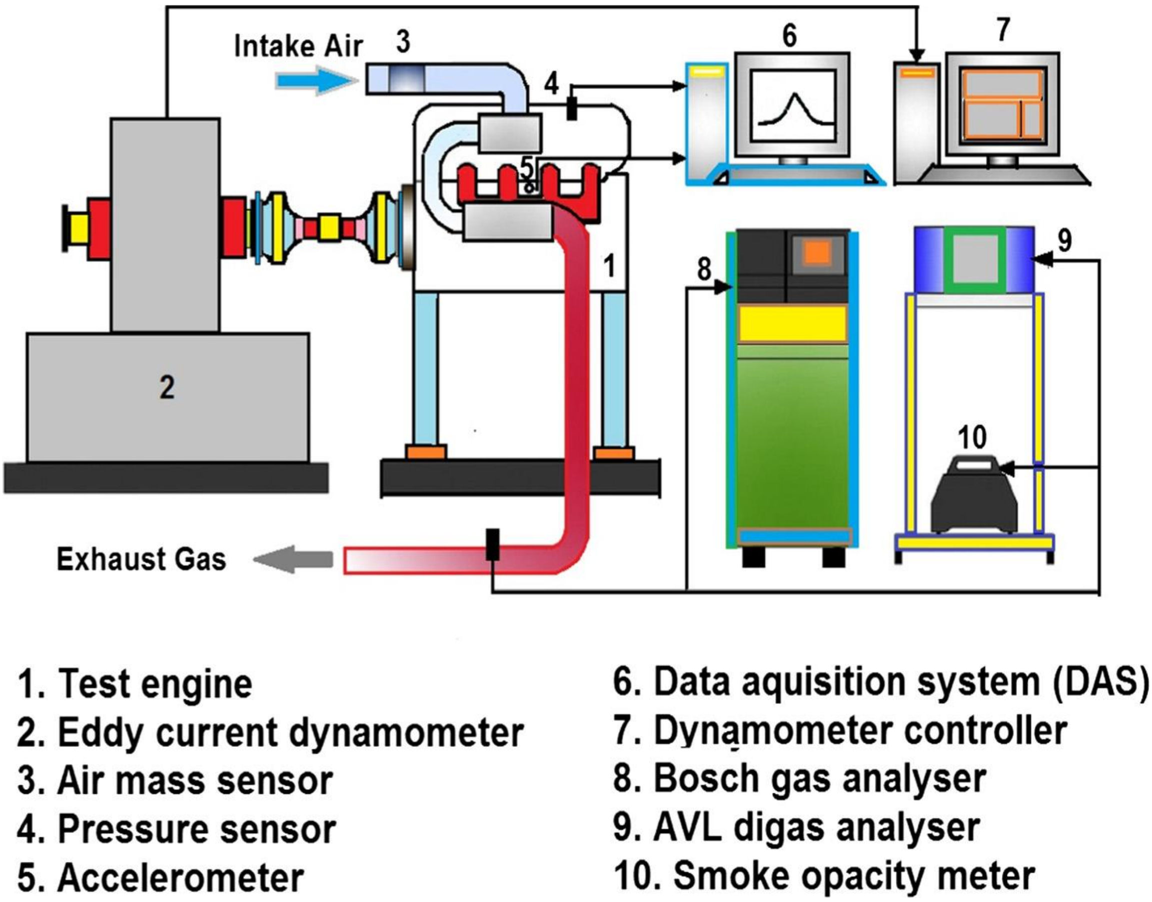

Figure 2. Experimental Diagram

RESULTS AND DISCUSSIONS

Brake Thermal Efficiency

In the Figure 3, various blends of fuel and diesel are shown in order of their brake thermal efficiency. Under full load, diesel provided 32.55% brake thermal efficiency. But among all Prosopis Juliflora Seed Oil (PJSO) blends, B20's BTE was 33.05% on a 100% load. Therefore, improved BTE outperforms regular diesel by a margin of 2.09%. Out of the PJSO blends, B10 had the second-best BTE at 30.95%, which is a decrease of 3.43% when compared to B20. In contrast to B10 after 3.51kW, which declines, the percentage of PJSO reduces as BTE rises in general. Biodiesel's higher viscosity decreases BTE in blends because they are poorly atomized due to their high biodiesel content.

Consumption of specific fuels by blends

Figure 4 displays the specific consumption of various fuels.. Fuel consumption on large loads was 0.25 kg/kWh for base diesel. The SFC for PJSO blends at full load was 0.27 kg/kWh. PJSO blends have a lower SFC than base diesel because the concentration of PJSO increases mainly with concentration. When compared to other blends, a B20 blend performed the best under all loads and was closest to base diesel. SFC is determined using the density and gross calorific value of biodiesel. With decreasing density, SFC also decreases. Biodiesel's lower gross calorific value (energy content) also results in lower fuel consumption[12] and power generation compared to diesel.

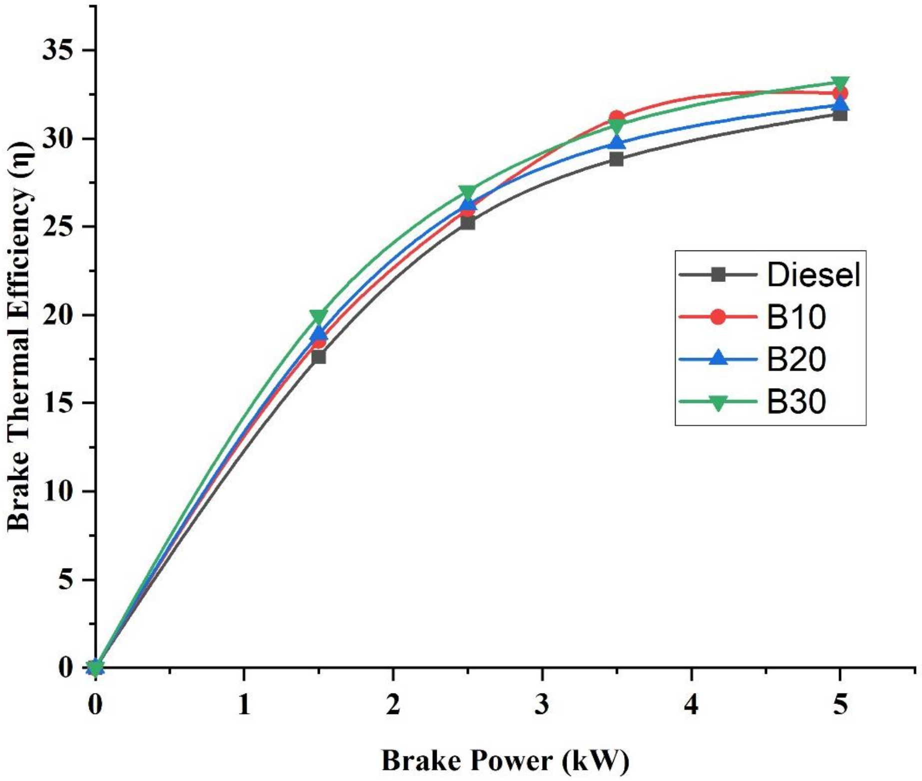

Figure 3. Brake Power vs Break Thermal Efficiency

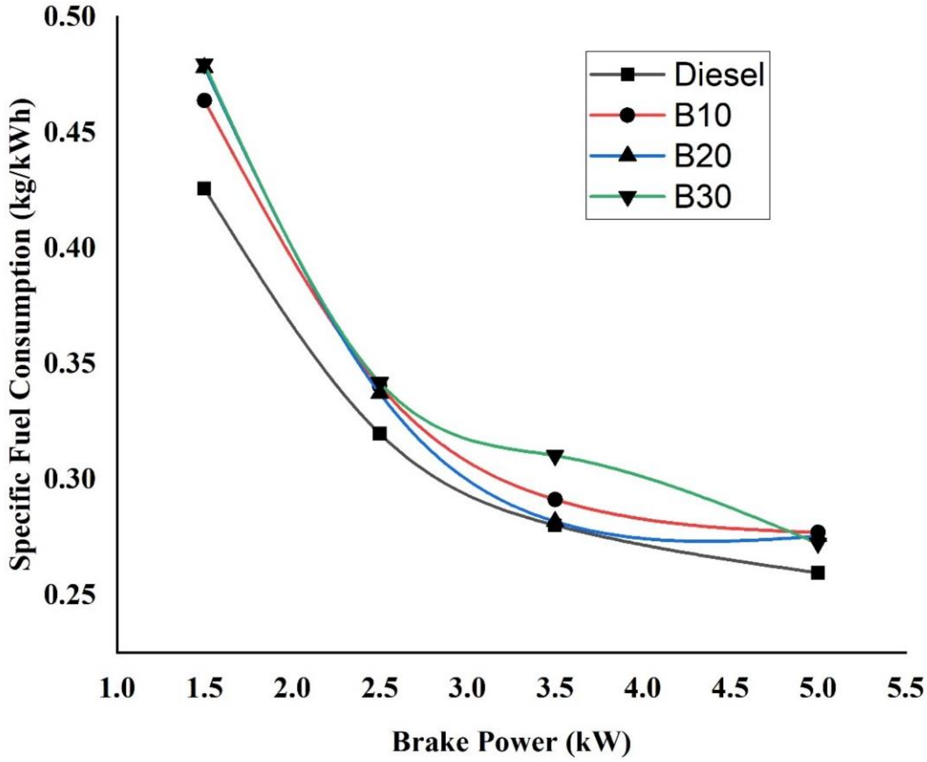

Figure 4. Specific Fuel Consumption vs Brake Power

Emissions of Carbon Monoxide

According to the figure 5, carbon monoxide emissions range widely. B20 emissions were much lower at 75% and full loads than diesel emissions. The B20 had the lowest CO emissions of all the outputs, with a full load CO emission of 0.025%. When oxygen is insufficient to completely oxidize fuel carbon, CO is a by-product produced[13]. Air-fuel ratios below stoichiometric ratios result in higher CO emissions[14]. High loads cause fuel and air to burn more quickly, which reduces oxygen availability, resulting in increasing CO emissions. Indirect effects on CO are promoted by various compositional differences in the mixture and/or late oxidation processes. In lower loads, biodiesel blends emit similar levels of CO as base diesel.

Emissions of Hydrocarbon

As shown in Figure 6, hydrocarbon emissions vary for different loads. Our analyses show that sample B20 emits merely 17 ppm of HC at full load, which is the least amount. On full load, diesel emits 20ppm of HC. Base diesel had HC emissions that were 17.64% greater than B20's. Mix B10 was the next-best blend; it had HC emissions of 22 ppm, which were 10% higher than diesel. In tests after B20, higher levels of Prosopis juliflora are associated with higher HC emissions. In the final stages of fuel insertion, fuel-air mixtures are caused by under mixture of fuel Insufficient combustion ratios result in HC emissions. Poorly atomized fuel at the conclusion of injection from the nozzle holes and nozzle sac volume is another cause of HC emissions[15]. Poor fuel ignition often results in high hydrocarbon emissions[16]. Diesel emissions were lower than those from B20 biodiesel blends. As a result, the biodiesel mixture burns better when oxygen is present.

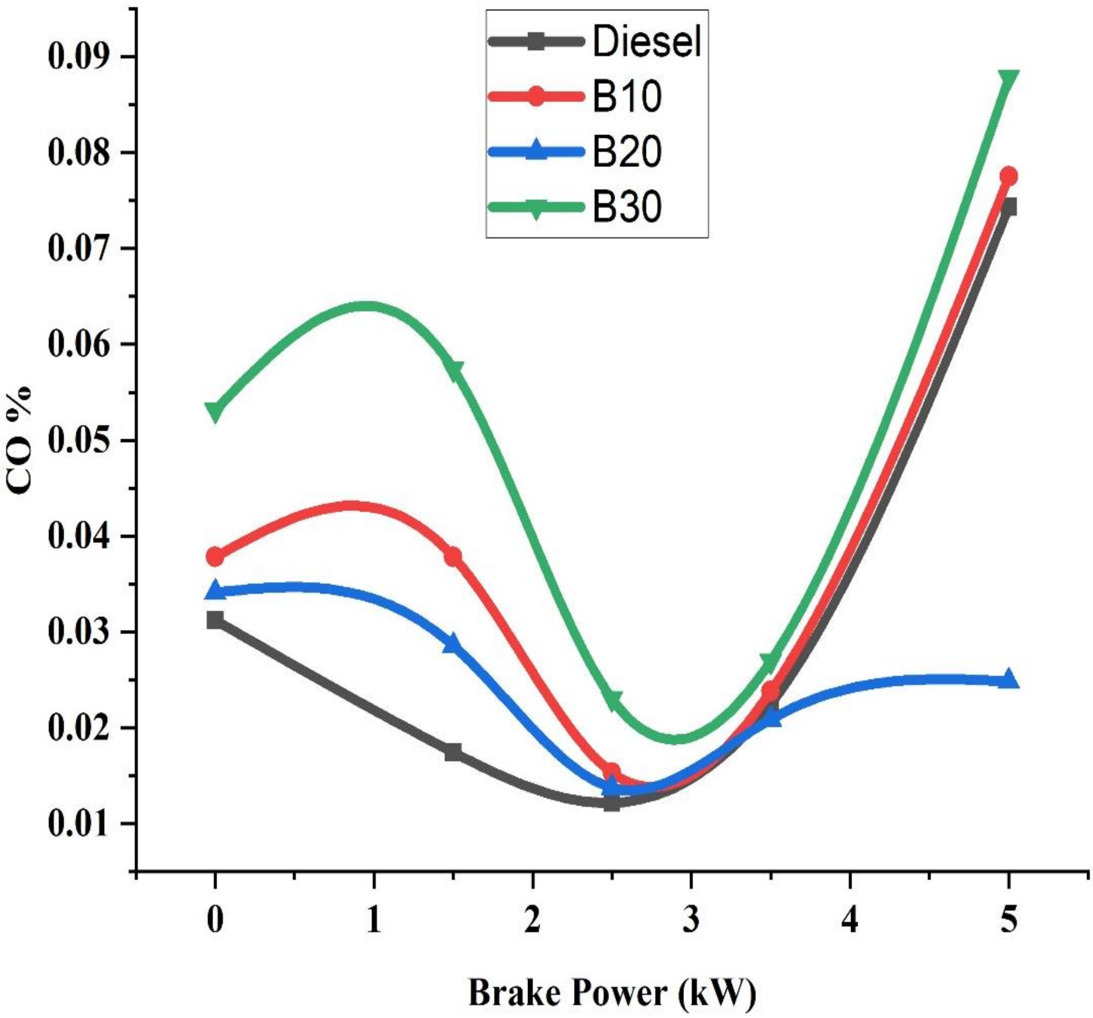

Figure 5. Brake Power vs Carbon Monoxide Emission

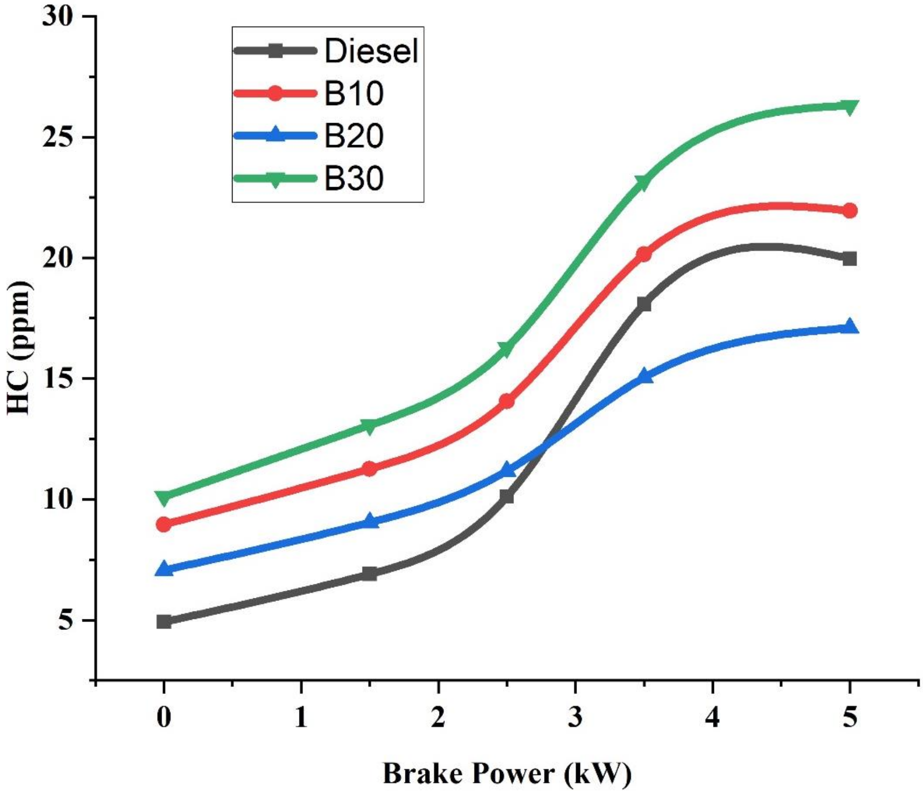

Figure 6. Brake Power vs Hydro Carbon Emissions

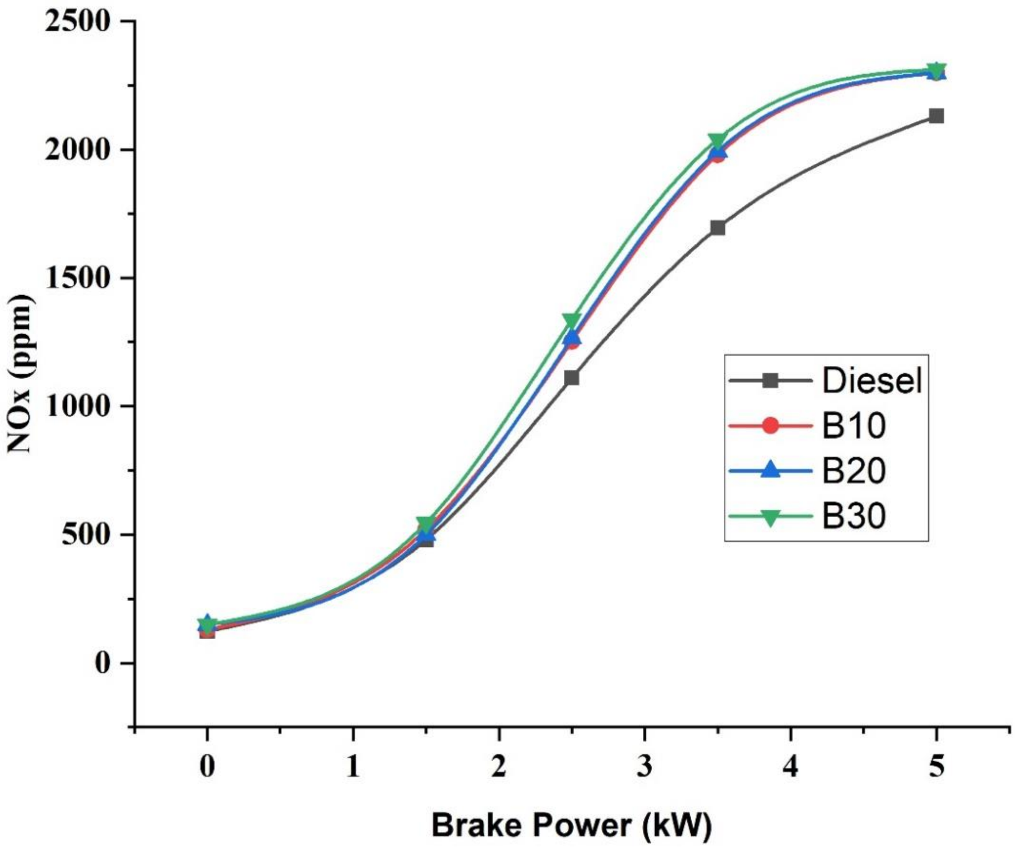

Figure 7. Brake Power vs Nitrogen Oxide Emissions.

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Emission of Oxides of Nitrogen

Nitrous oxide emissions vary with load as shown in Figure 7. The B20 blended biodiesel produced fewer NOx emissions than the other blends at full load, 2295 ppm. A maximum load of 2137 ppm of NOx was released by base diesel, while a maximum load of 2107 ppm was released by urea diesel. In this sense, B20 had an increased emission rate of 7.3% when compared to base diesel. There was no significant difference in NOx emissions between diesel and gasoline. Second, B20 is a superior biodiesel blend compared to other blends. Increases in PJSO percentage also increase NOx emissions. During combustion, NOx is created in the engine cylinders based on the temperature and the combustion rate. By comparing the stoichiometric air-fuel ratio and the flame temperature of diesel and biodiesel, it can be seen that NOx is produced more frequently when biodiesel is burned. According to reports, when powered by biodiesel, soybean, rapeseed, and soap stock fuels produce the greatest levels of NOx; these fuels contribute the most. According to reports, when powered by biodiesel, soybean, rapeseed, and soap stock fuels produce the greatest levels of NOx; these fuels contribute the most.

Opacity of Smoke

In Figure 8, the smoke opacity is shown. B20 had the lowest smoke emission at 60% opacity, while other samples had higher emissions. 58.6% of smoke was produced by base diesel in 5.16kW. There was a 1.2% increase in emissions from the B20 blend in this case compared with the base diesel. Smoke emissions from B20 were found to be lower than those from other fuels. A rise in PJSO percentage results in a rise in smoke emissions. As a result of higher concentrations of soot in exhaust gases, diesel engines produce visible black smoke emissions. The design and operating variables of diesel engines affect soot formation and oxidation, which also determine black smoke intensity. The reason why the engine is rated based on its maximum permissible smoke density to limit black smoke emissions is because smoke emissions are greater when the engine is loaded with more power since the fuel-air ratios are often larger. The reason why the engine is rated based on its maximum permissible smoke density to limit black smoke emissions is because smoke emissions are greater when the engine is loaded with more power since the fuel-air ratios are often larger[17]. Also referred to as smoke-limited power, it is the rated power. The fuel injection rate is also poorly controlled during acceleration, causing smoke to increase.

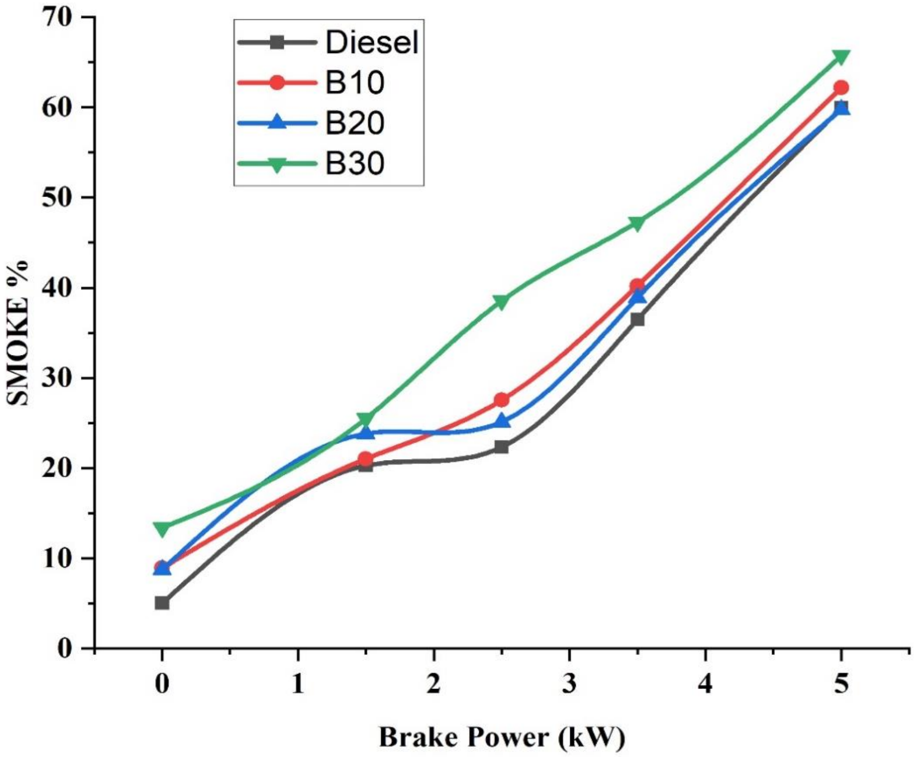

Figure 8. Brake Power vs Smoke

CONCLUSION

The inquiry led to the discovery that Prosopis Juliflora biodiesel is acceptable for direct use in diesel engines because of its distinctive chemical properties. Prosopis Juliflora biodiesel blends showed notable gains in thermal efficiency when compared to diesel, but alcohol energy has the drawback of having a high fuel consumption rate. Prosopis Juliflora blends perform significantly better than regular diesel at full loads in terms of HC, CO, and smoke emissions. Compared to blends using normal diesel, those including Prosopis Juliflora emit more NO_X and CO_2. In order to save significant amounts of HC, CO, and smoke, Prosopis Juliflora biofuel may be used in diesel engines at constant speeds without requiring changes.

REFERENCES

1. D. Deepa, T. Mythili, K. Anbalagan, M. B. Raja, and C. Kamal, “Production of Bio Diesel from Rice Bran Oil,” pp. 576–580, 2015, doi: 10.15680/IJIRSET.2017.0603235.
2. S. Savariraj, T. Ganapathy, and C. G. Saravanan, “Experimental Investigation of Performance and Emission Characteristics of Mahua Biodiesel in Diesel Engine,” ISRN Renewable Energy, vol. 2011, pp. 1–6, 2011, doi: 10.5402/2011/405182.
3. J. M. Babu, “Experimental Investigation on the Effect of Injection Pressure on Diesel Engine Performance when Operated with Electrolytically Generated Hydrogen Oxygen Mixture,” vol. 9, no. 2, pp. 83–88, 2017.
4. S. S. Anjum and Dr. O. Prakash, “Impact of Kerosene Oil Blend with Diesel Fuel on Engine Performance: An Experimental Investigation,” International Journal of Engineering and Technology, vol. 9, no. 3S, pp. 122–126, 2017, doi: 10.21817/ijet/2017/v9i3/170903s021.
5. J. M. Babu, M. Sarath Chandra, P. Ravi Chandra Ganesh, P. Jayaprakash, K. . Sunil Kumar, and M. Nagappan, “Experimental evaluation of direct injection diesel engine performance and emissions with acacia biodiesel,” International Journal of Ambient Energy, 2022, doi: 10.1080/01430750.2022.2058998.
6. M. Nagappan et al., “Emission characteristics study of biodiesel-alcohol blends in a compression ignition engine,” AIP Conference Proceedings, vol. 2311, no. December, 2020, doi: 10.1063/5.0034430.
7. A. Devaraj, N. Bharath, M. Nagappan, and D. Yogaraj, “Emission Trends on an Un-modified Research Engine Run with Alcohol and Cashew-Nut Blends,” International Journal of Vehicle Structures and Systems, vol. 14, no. 3, pp. 365–367, 2022, doi: 10.4273/ijvss.14.3.17.
8. M. A. Asokan, S. Senthur Prabu, P. K. K. Bade, V. M. Nekkanti, and S. S. G. Gutta, “Performance, combustion and emission characteristics of juliflora biodiesel fuelled DI diesel engine,” Energy, vol. 173, pp. 883–892, 2019, doi: 10.1016/j.energy.2019.02.075.
9. B. Duraisamy, K. Velmurugan, and V. S. K. Venkatachalapathy, “Analysis of Prosopis juliflora Methyl Ester as a Fuel in the CI Engine,” International Journal of Research and Review, vol. 9, no. 7, pp. 112–118, 2022, doi: 10.52403/ijrr.20220713.
10. E. Raja and M. Premjeyakumar, “Potent effect of prosopis juliflora (biodiesel + isopropanol + diesel) fueled with diesel engine and egr alteration,” Clean Eng Technol, vol. 4, p. 100205, 2021, doi: 10.1016/j.clet.2021.100205.
11. M. Nagappan et al., “Impact of additives on Combustion, performance and exhaust emission of biodiesel fueled direct injection diesel engine,” Mater Today Proc, vol. 62, no. xxxx, pp. 2326–2331, 2022, doi: 10.1016/j.matpr.2022.04.114.
12. A. Devaraj, M. Nagappan, D. Yogaraj, O. Prakash, Y. A. Rao, and A. Sharma, “Influence of nano-additives on engine behaviour using diesel-biodiesel blend,” Mater Today Proc, vol. 62, no. xxxx, pp. 2266–2270, 2022, doi: 10.1016/j.matpr.2022.03.598.
13. A. Devaraj, Y. Devarajan, and I. Vinoth Kanna, “Investigation on emission pattern of biodiesel and Nano-particles,” International Journal of Ambient Energy, vol. 42, no. 10, pp. 1103–1107, 2021, doi: 10.1080/01430750.2019.1586765.
14. O. A. Journal, N. C. Teja, and S. Raju, “Experimental Investigation On The Effect Of Injection

Pressure On Diesel Engine Performance And Emissions When Operated With Lotus Bio Diesel And Its Blending ," vol. 11, no. 4, pp. 418–427, 2017.
15. A. Prabhu, B. K. Reddy, M. Nagappan, and N. Bharath, "Effect of Al2O3 nano-additives on the performance and emission characteristics of jatropha and pongamia methyl esters in compression ignition engine," International Journal of Ambient Energy, vol. 41, no. 5, pp. 528–532, 2020, doi: 10.1080/01430750.2018.1477688.
16. N. Murugan, H. Venu, J. Jayaraman, and P. Appavu, "Emission and performance characteristics study on nanographene oxide additives doped palm oil methyl ester blend in a diesel engine," International Journal of Ambient Energy, vol. 0, no. 0, pp. 1–7, 2019, doi: 10.1080/01430750.2019.1697361.
17. A. Devaraj, M. Nagappan, and D. Yogaraj, "Emission pattern of higher alcohol-biodiesel blends in compression ignition engine," Materials Today: Proceedings, vol. 37, no. Part 2, pp. 1876–1879, 2020, doi: 10.1016/j.matpr.2020.07.455.

