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Performance Evaluation of a Diesel Engine Run on Biodiesel Produced from Coconut Oil and Its Blends

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Authors' contributions

This work was carried out in collaboration between all authors. Author GMT designed the study, wrote the protocol and wrote the first draft of the manuscript. Author NAM managed the literature searches and analyses of the study performed. Author SAY managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

This paper presents the evaluation of performance parameters viz a viz Brake Specific Fuel Consumptions (BSFC), brake powers and mechanical efficiencies of a diesel engine run on biodiesel, its blends and diesel. The results of the evaluation showed that all the parameters exhibit similar variations. Mechanical efficiencies of the diesel engine run on the blends of biodiesel with diesel containing 30%, 40% and 50% biodiesel denoted by B30, B40 and B50 respectively were found to be higher than when it was run on diesel and a blend of biodiesel with diesel containing 20% biodiesel denoted by B20. Mechanical efficiencies of the diesel engine run on the blend of biodiesel with diesel containing 10% biodiesel and solely biodiesel denoted by B10 and B100 respectively were found to be lesser than when it was run on diesel denoted by B0, with increase in brake powers. The mechanical efficiencies of the diesel engine run on B10, B30, B40, B50 and B100 were found to be lesser with increase in engine loads in comparison to when it was run on diesel. BSFC of the diesel engine that was run on biodiesel and its blend were found to be higher

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than when it was run on diesel only. They increased with increase in percentage of biodiesel added to diesel as the engine load increased. However they were found to increase with increase in brake power in the order of B10, B20, B30, B40, B50 and B100.

Keywords: Biodiesel; BSFC; diesel; diesel engine; engine load; mechanical efficiency.

1. INTRODUCTION

Diesel fuels have an essential function in the industrial economy of developing and developed countries [1] and it is used in most types of transportation. Diesel engines are the power behind our machines- trucks, train, ships and submarine. They generate more power more efficiently as compared to petrol engines. Diesel engines are the most efficient prime movers, from the point of view of protecting global environment and concerns for long term energy security; it has become necessary to develop alternative fuels with properties comparable to petroleum based fuels [2]. Beg et al. [3] opined that the source of crude oil of which diesel is a product, would be completely consumed in future as the demand of petroleum products is growing at faster rate day by day. In the quest for finding alternatives, biodiesel has gained a lot of attention. As it is known that the use of biodiesel (B100), instead of diesel oil (B0), has environmental benefits, even though for economic reasons, today a complete replacement of fossil fuel is not possible [4]. Shetye [5] stated that biodiesel is an alternate fuel that can be produced from renewable feedstock such as edible and non edible vegetable oils, wasted frying oils and animal fats. It is oxygenated sulphur free, non toxic biodegradable and renewable fuel. Savarirag et al. [6], stated that many technical papers revealed that the application of biodiesel in diesel engine is suitable for better performance, combustion and emission properties. A lot of work has been done partly or wholly on emissions and performance of diesel engine running on biodiesel from edible and non edible plants and its blends. This is in line with Teran and Yaman [7], who asserted that some notable researchers have produced biodiesel from different types of vegetable oils and animal fats. Remarkable sources of the aforementioned biodiesel which have been used to run diesel engine, whose emissions and performance parameters have been studied are fish oil [8], sunflower and olive oil [9], palm oil [10], cotton seed oil [11,12], castor oil [13], almond [14], rapseed [15], pongamia [16], jathropha oil [2], waste oil, rapeseed oil and corn oil [17]. Mahua oil [18,19], ricebran [20], mustard oil [21], safflower oil and milk scum oil [22]. The results of their studies of the emission from biodiesel and its blends in comparison with diesel when they were used to run diesel engine revealed that emissions from biodiesel are lower than that from diesel, except in case of NO_X and the emissions decrease with increase in the concentration of the blend of the biodiesel. The results of the performance evaluation varied from one researcher`s work to another because of different sources of biodiesel, performance parameters and the variation between them they individually considered. Biodiesel has been produced from coconut oil, characterized and the emissions were studied by Teran and Yaman [7]. Transesterification process with Sodium hydroxide (caustic soda) as catalyst was used to produce the biodiesel with a yield of 49.9%. Dias et al. [23] asserted that biodiesel can be produced over calcium oxide catalyst from low value raw material without significant deterioration of the catalytic performance. However a higher yield would have been obtained if heterogeneous catalyst, calcium oxide was used, in line with the work of Puna et al. [24] where biodiesel yields of 97-98% were obtained from soybean and rapeseed. The results of the emission test obtained from the biodiesel and its blend by Teran and Yaman [7], revealed the potentials of being used to run diesel engine. So the aim of this research is to use the biodiesel, its blends, and diesel to run a diesel engine and evaluate its performance in terms of operational parameters.

2. MATERIALS AND METHODS

The fuel materials used for this study include diesel fuel, biodiesel produced from coconut oil and characterized by Teran and Yaman [7] and the blends of the biodiesel. The test rig shown in Plate 1 was used for this study. It includes GD411 diesel Honda 9.0 an air cooled, 4-cycles, single cylinder and 9 horse power engine manufactured by Honda Motor Company, Japan, coupled to dynamometer, equipped with sensors, data acquisition and digital display systems.

The specifications of the engine in the test rig are shown in Table 1.

Table 1. Engine specifications

Parameters	Specifications
Engine model	GD411
Engine type	Air cooled, 4 stroke, direct injection diesel engine.
Number of cylinders	1
Bore(mm)x Stroke(mm)	82x78
Displacement(cm^3)	411
Compression ratio	18.2:1
Maximum power	9HP(6.6 Kw) at 3600 rpm
output	4.6 l
Fuel Tank capacity	440 mmx405 mmx490 mm
Engine dimensions	

Plate 1. Test Rig

2.1 Experimental Procedure

Blends of biodiesel and diesel fuel were produced in the ratio of 10:90, 20:80, 30:70, 40:60 and 50:50 by volume, denoted by B10, B20, B30, B40 and B50 respectively.

The engine was made to run for 30 minutes in line with the work of Savariraj et al. [8] with 100% diesel fuel denoted by B0 as base fuel or reference fuel at constant speed of 1000 rpm which was measured by digital Tachometer. The engine load was applied by employing dynamometer that was coupled to it. The fuel consumption rate was measured using a glass burette and stopwatch. After completing the experiment with 100% diesel, the engine was allowed to run with 100% biodiesel denoted by B100 and biodiesel blends that is B10, B20, B30, B40, and B50 respectively. Each test was repeated five times and the arithmetic mean of the readings or observations was used for calculation and analysis. The performance parameters determined, include engine load, brake specific fuel consumption (BSFC), brake power and mechanical efficiency.

3. RESULTS AND DISCUSSION

The results of the determined performance parameters of the diesel engine run on coconut oil biodiesel, its blends and diesel are presented in this section.

The variation of mechanical efficiency with brake power is shown in Fig. 1.

It can be seen from Fig. 1 that mechanical efficiency increased with increase in brake power. The mechanical efficiency of the diesel engine when it was run on the blends B50 is higher than when the diesel engine was run on diesel (B0) and the same when the diesel engine was run on B20. It is evident in Fig. 1, that the mechanical efficiency of diesel engine when it is run on diesel is higher than when it is run on other blends and this is in line with the findings of Srithar et al. [25] in their work.

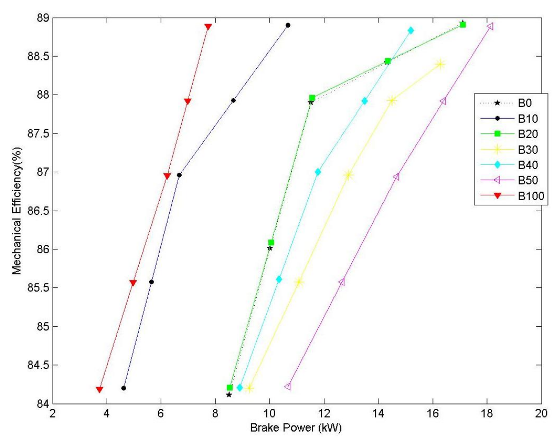

Fig. 1. Variation of mechanical efficiency with brake power

The variation of brake specific fuel consumption with brake power is shown in Fig. 2.

It can be seen from Fig. 2, that the diesel engine has higher BSFC when it was run on B100 or on others and has the least BSFC when it was run on B0. However BSFC increased with increase in brake power except when the diesel engine was run on B50 where the BSFC initially decreased from 441g/kWhr at 10kW brake power to 422g/kWhr at 13kW brake power and finally increased with increase in brake power. The reason for initial decrease in BSFC could be that percentage increase in fuel to run the engine was less than the percentage increase in brake power output [8]. As BSFC increases, smokiness lowers down to 50% [4]. The fuel flow problems such as higher density and higher viscosity of biodiesel and decreasing combustion efficiency have certain effect, such as reduction in brake power as discussed by Shirneshan et al. [26].

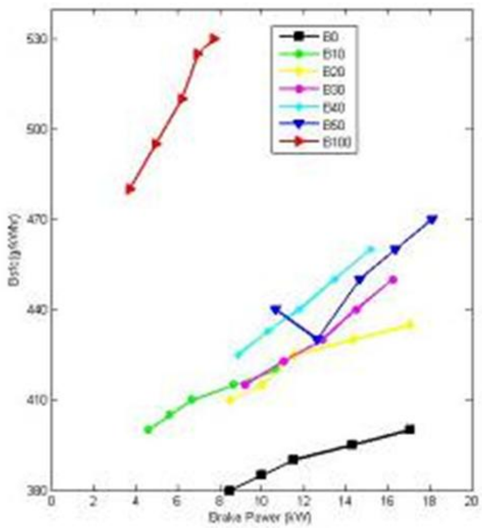

Fig. 2. Variation of brake specific fuel consumption with brake power

The variation of brake specific fuel consumption with engine load is depicted in Fig. 3.

It can be seen in Fig. 3, that BSFC of the diesel engine when run on B0, B10, B20, B30, B40 and B100 increased with increase in engine load, while when run on B50, decreased with increase in engine load to about 25 Kw and increased with increase in engine load. The decrease in BSFC with increase in engine load as experienced by the diesel engine when it was run on B50, might be due to the fact that percentage increase in fuel required to operate the engine was less than the percentage increase in brake power as relatively less portion of the heat losses occurred at higher engine loads [27]. BSFC of the diesel engine run on the coconut oil biodiesel and its blends are higher than those of diesel engine run on diesel at all loads. This is as a result of lower calorific value [8,28] of coconut oil biodiesel and its blends compare to diesel. BSFC increases with biodiesel blend ratio [29] and this is evident in Fig. 3.

The variation of mechanical efficiency with engine load is shown in Fig. 4.

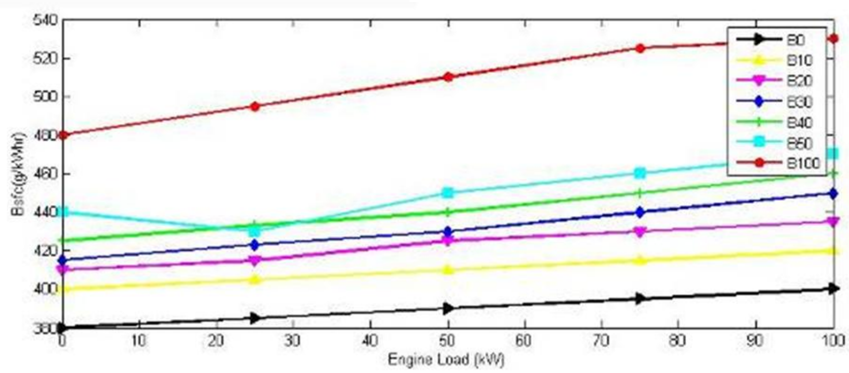

Fig. 3. Variation of brake specific fuel consumption with engine load

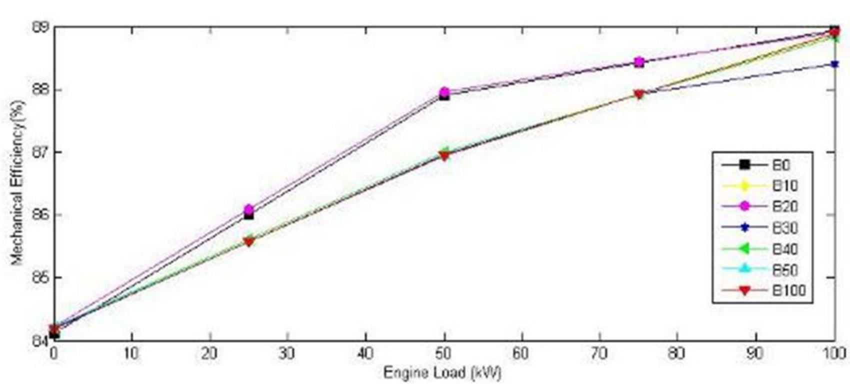

Fig. 4. Variation of mechanical efficiency with engine load

It can be seen from Fig. 4 that mechanical efficiency increased with increase in engine load for the diesel engine when it was run on diesel (B0), biodiesel (B100) and all the blends of the biodiesel. This could be attributed to minimal power that was lost as the load increased. It is evident in figure 4 that the diesel engine has the highest mechanical efficiency when it was run on B20 compared to when it was run on diesel and others, although they are close to each other.

4. CONCLUSION

Performance analysis of a diesel engine run on coconut oil biodiesel, its blends and diesel has been carried out. From the results obtained, the following conclusions can be made. The mechanical efficiency of the diesel engine run on coconut oil biodiesel, its blends increased with increase in brake power. The BSFC of the diesel engine run on B100 is higher than when it is run on diesel irrespective of the load. Mechanical efficiency increases with increase in engine load, regardless of the type of fuel it is run on. Biodiesel produced from coconut oil and its blend can be used in running diesel engine quite effectively. Engine parameters evaluated, are similar to those with diesel from fossil fuel, which makes biodiesel an alternative fuel to mitigate the present energy and environmental crises.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Awolu OA, Layokun SK. Optimization of two-step transesterification production of biodiesel from neem seed (*Azadirachta indica*) oil. International Journal of Energy and Environmental Engineering. 2013;4: 39.
2. Rao YVH, Voleti RS, Hariharan VS, Raju AVS, Redd PN. Use of Jatropha oil methyl ester and its blends as alternative fuel in diesel engine. Journal of the Brazilian Society of Mechanical Sciences and Engineering. 2009;31(3):253-60.
3. Beg RA, Sarker MRI, Pervez MR. Production of diesel fuel from used engine oil. International Journal of Mechanical and Mechatronics Engineering. 2010;10(2):1-6.
4. Friso D. Brake thermal efficiency and BSFC of diesel engines: Mathematical modeling and comparison between diesel oil and biodiesel fueling. Applied Mathematical Sciences. 2014;8(130):6515 – 28.
5. Shetye AM, Ganguly A, Simha S, Acharjee S. Experimental investigation of tribological properties of lubricating oils for biodiesel fuelled single cylinder diesel engine. International Journal of Engineering Research and Technology. 2013;2(7):212-20.
6. Savariraj S, Ganapathy T, Saravanan CG. Characterization of the DI diesel engine powered by mango seed oil methyl ester with fuel additive. European Journal of Applied Engineering and Scientific Research. 2013a;2(4):44-50
7. Teran GM, Yaman SA. Production of biodiesel from coconut oil to power a diesel engine. Postgraduate Diploma project submitted to postgraduate school, Federal University of Technology Minna, Nigeria; 2015.
8. Savariraj S, Ganapathy T, Saravanan CG. Performance, emission and combustion characteristics of fish-oil biodiesel engine. European Journal of Applied Engineering and Scientific Research. 2013b;2(3):26-32.
9. Kalligeros S, Zannikos F, Stournas S, Lois E, Anastopoulos G, Teas Ch, Sakellaropoulos F. An investigation of using biodiesel/marine diesel blends on the performance of a stationary diesel engine. Biomass and Bioenergy. 2003;24:141–9.
10. Wirawan SS, Tambunan AH, Djamin M, Nabetani H. The effect of palm biodiesel fuel on the performance and emission of the automotive diesel engine. Agricultural Engineering International: The CIGR Ejournal; 2008. Manuscript EE 07 005. X :1-13
11. Nabi MN, Rahman MM, Akhter MS. Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions. Applied Thermal Engineering. 2009;29:2265–70.
12. Gowthaman S, Velmurugan K. Performance and emission characteristics of direct injection diesel engine using bio-diesel with Scr technology. International Journal of Engineering Research and Applications. 2012;2(5):1083-9.
13. Islam MS, Ahmed AS, Islam A, Abdul Aziz S, Xain LC, Mridha M. Study on emission and performance of diesel engine using castor biodiesel. Journal of Chemistry. 2014;2014:1-7.

14. Nadal HA, Khaled A. A comparative study of almond biodiesel-diesel blends for diesel engine in terms of performance and emissions. BioMed Research International. 2015;2015:1-8.
15. Oberweis S, Al-Shemmeri TT. Effects of biodiesel blending on emissions and efficiency in a stationary diesel engine. Being full length of paper presented at International Conference on Renewable Energies and Power Quality (ICREPQ'10) Granada Spain; 2010.
16. Gopal KN, Karupparaj RT. Effects of pongamia biodiesel on emission and combustion characteristics of Di compression ignition engine. Ain Shams Engineering Journal. 2015;6(1):297-305.
17. Tesfa B, Gu F, Mishra R, Ball A. Emission characteristics of a CI engine running with a range of biodiesel feedstocks. Energies. 2014;7:334-350.
18. Lenin AH, Ravi R, Thyagarajan K. Performance characteristics of a diesel engine using Mahua biodiesel as alternate fuel. Iranica Journal of Energy & Environment. 2013;4(2):136-141.
19. Brahma HS, Babu AV. An experimental investigation on emissions of neat Mahua biodiesel using Urea-SCR. International Journal of Scientific & Technology Research. 2013;2(8):39-44.
20. Umesh T, Manjunath HN, Rukmangadha P, Madhu D. Experimental study of performance and emission analysis of rice bran oil as an alternative fuel for an I.C engine. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). 2014; 11(4):130-4.
21. Sharma G, Dandotiya D, Agrawal SK. Experimental investigation of performance parameters of single cylinder ic engine using mustard oil. International Journal of Modern Engineering Research (IJMER). 2013;3(2):832-8.
22. Kotil RV, Prakash SB, Kiran K, Ravikumar T. An investigation on the performance and emission characteristics of a direct injection diesel engine using safflower oil and milk scum oil as a biodiesel. International Refereed Journal of Engineering and Science (IRJES). 2014;3(4):19-27.
23. Dias APS, Puna J, Correia MJN, Nogueira I, Bordado J. Effect of the oil acidity on the methanolysis performances of lime catalyst biodiesel from waste frying oils. Fuel Processing Technology. 2013;116:94-100.
24. Puna Jf, Correia MJN, Dias APS, Gomes J, Bordado J. Biodiesel production from waste frying oils over lime catalysts. Reac. Kinet. Mech; 2013. Cat.
DOI: 10.1007/s11144-013-0557-2
25. Srithar K, Balasubramaman KA, Pavendan V, Kumar BA. Experimental investigations of mixing of two biodiesels blended with diesel as alternative fuel for diesel for diesel engines. Journal of King Saud University- Engineering Sciences; 2014. In Press.
26. Shirneshan AR, Almassi M, Gbobadian B, Najafi GH. Investigating the effects of biodiesel from waste cooking oil and engine operating conditions on the diesel engine performance by response surface methodology. Transactions of Mechanical Engineering. 2014;38(M2):289-301.
27. Raheman R, Jena PC, Jodav SS. Performance of a diesel engine with blends of biodiesel (from a mixture of oils) and high-speed diesel. International Journal of Energy and Environmental Engineering. 2013;4:6.
28. Singh Y, Singla A. Comparative analysis of Jatropha and Karanja-based biodiesel properties, performance and exhaust emission characteristics in an unmodified diesel engine. Pollution. 2015;1(1):23-30.
29. Prajapati JB, Panchal PR, Patel TM. Performance and emission characteristics of CI engine fueled with diesel-biodiesel blends. IOSR Journal of Mechanical and Civil Engineering. 2014;11(3):114-121.

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