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An Experimental Investigation of Diesel Engine Fuelled with MgO Nano Additive Biodiesel - Diesel Blends

C. Vijayakumar [a, *], A. Murugesan [a], D. Subramaniam [a], N. Panneerselvam [a]

[a] Department of Mechatronics Engineering, K.S.Rangasamy College of Technology, Tiruchengode-637215, Tamil Nadu, India.

*Corresponding Author:vijecvk@gmail.com DOI: https://doi.org/10.34256/bsr1924

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Abstract: In this experimental investigation compacts the performance and emissions of compression ignition engines fuelled with MgO nano additive, maducaindica bio diesel blends were examined. Based upon the previous literatures only 20% mahuca methyl ester fuel blends without nano additives is suitable for compression ignition engine without affecting engine efficiency and its characteristics. In this paper magnesium oxide nano additives are added into the 40% Mahucaindica biodiesel- diesel blends at the rate of 50ppm for developing the test fuels. In this nano additives improve the properties of diesel fuel like viscosity, calorific value and decreased the flash point and fire point. Then compared the performance and emissions differences of all blended fuels used as a fuel in a diesel engine. The observation of results, 40MgO + 50ppm blended fuels brake thermal efficiency is improved then CO, HC, CO2and smoke decreased compared to other fuel blends. The results are taken into account, a blend of 40MgO+ Mgo50ppm is the best blend ratio compared than other blends with nano additives.

Keywords: Diesel engine, engine emissions, nano additives, diesel, biodiesel

1. Introduction

The world's energy demand in the last two decades has encouraged the world towards searching for the alternative energy source. Bio diesel acts as a promising alternative fuel to diesel oil. Vegetable oils are a very promising alternative to diesel oil since they are renewable and have similar properties. Many researchers have studied the use of vegetable oils in diesel engines. Vegetable oils offer almost the same power output with a slightly lower there-mal efficiency when used in diesel engines Diesel engines have a negative effect on environment since they include high amounts of sulphur and aromatics. The dashed increase in the demand for diesel and other petroleum products India's addiction on oil import is probable to rise to 92% by the year of 2030 [1]. Due to contemporary energy crises and dwindling reserves of crude oil the demand for alternate liquid fuels, particularly the diesel is increasing [2]. There are many advantages in using bio-diesel as an alternate liquid fuel such as they are easily available, environmentally friendly potential, biodegradable and contribute to sustainability [3].

Biodiesel can be extracted from various edible and non-edible vegetable oils. Many researchers have recommended non-edible oils to be a better sustainable alternative for biodiesel production. They have identified several non-edible crops that can be used for biodiesel production, which include Jatropa oil, Karanji or Pongamia oil, Neem oil, Jojoba oil, Cottonseed oil, Linseed oil, Maducaindica oil, Deccan hemp oil, Kusum oil, Orange oil and Rubber seed oil, etc. [4, 5]. In this study, we took Maducaindica oil biodiesel as an alternate fuel for diesel engine. Because, the chemical composition of Maducaindica oil is almost similar to that of other non-edible oils. It is the prime reason behind selecting Maducaindica oil as the raw material for biodiesel production [6]. Apart from that, many numbers of publications in jatropa, Karanja and neem esters. Maducaindica oil is obtained from the seeds of Maducaindica, a deciduous tree which can grow in semi-arid, tropical and sub-tropical areas [7]. It has an approximate annual production possible of 181 thousand metric tons in India [8]. The drying and decortications yield 70% kernel on the weight of seed. The kernel of seed contains about 50 % oil. The oil yield in an expeller is nearly 34 - 37% [9, 10]. To reduce the viscosity of Maducaindica oil we may go for several conversion methods such as blending of oils, micro emulsification, cracking / pyrolysis and transesterification. Among these, transesterification is widely used for industrial biodiesel production. It gives better yield than other transesterified non edible oil [11]. In our experimental study results proved that 20% Maducaindica methyl ester fuel blends without nano additives is suitable for CI engine without affecting engine characteristics [12] Biodiesel with metal based additives, fuel used in diesel engine it showed the lower emission characteristics compared to without additives diesel fuel. The nano additives as additive in neat diesel and diesel-biodiesel-ethanol blends used in diesel engines. The carbon monoxide, NOx and HC emissions decrease with the role of nano blends and neat diesel [13].

Based on literature review and knowledge of authors no research yet studied Maducaindica methyl ester blends with nano additives as a fuel for diesel engine. The objective of the present study aims to analysis the suitable fuel ratio of the Maducaindica oil biodiesel blend with use copper nano additives on the performance, emission and combustion characteristics of a compression ignition single cylinder diesel engine.

2. Materials and Methods

Maducaindica is known as Illupaimaram in Tamil and Hippi in Kannada. It's grown up from the badlands and dry lands. The seeds from the tree are known as an Indian butter tree. The Figure 1. shows the Maducaindica fruit with tree and Maducaindica seeds.

Figure. 1 Mahucaindica fruit with tree and seeds

The Mahucaindica oil is purchased from local shops nearby hosur, Tamil Nadu, india and it is utilized as a fuel for diesel engine with some chemical modifications.

2.1 Nano Materials

Selection of nano materials is based on the dissolving ability of the nano additives with the Maducaindica methyl ester- diesel blends and the characters of nano powder like purity, atmospheric changes and toxic to human beings. Based on these characters we have selected the MgOnano particles for the experimental investigations [14]. Nano additives was purchased from M/s sigmaaldrich, USA with the purity of 99.9% and the size of <50nm. Nano MgO powder mixed with Maducaindica methyl ester blend (40MEOM) through Magnetic strewing process for 1 hour and indorsed to cool down the temperature of oil mixture engendered while strewing through hydrolysis and polymerization process (sol-gel process) of nano additive sols are distributed in the Maducaindica methyl ester. After precipitation process the nano powders are homogenously distributed in the Maducaindica methyl ester. The fuel sample of nanoMgO in the mass fraction of 50ppm blended with Maducaindica methyl ester

blends (40MEOM+ 50 ppm).

2.2 Fuel Properties

The fuel properties of diesel, 20MEOM, 40MEOM and nano additive fuel blends are compared with ASTM Standards in the Table 1. It was observed that nano additive Maducaindica methyl ester close to properties of without additive Maducaindica methyl ester. Fuel properties of 40MEOM+50ppm almost closer than diesel. The viscosity and density has decreases as the nano additive content in the 40MEOM biodiesel blends.

3. Experimental Setup and Procedure

The engine tests were carried out using a single-cylinder, four-stroke, naturally aspirated, constant speed direct injection compression ignition engine. The schematic diagram of the engine setup is shown in Figure 2.

Table 1. **Properties comparison of Diesel, 20MEOM,40MEOM and nano additive fuel blends**

Properties	Diesel	20 MEOM	40 MEOM	40MEOM+50ppm	ASTM standards for biodiesel
Kinematic viscosity at 40 ^{0}C (cSt)	4.2	4.6	4.9	4.7	1.9- 6.0
Calorific value (MJ/kg)	43.4	42.5	41.1	42	> 40
Density (kg/m3)	830	849	865	855	875-900
Flash point (^{o}C)	56	62	71	64	>130
Fire point (^{o}C)	68	70	79	73	>65

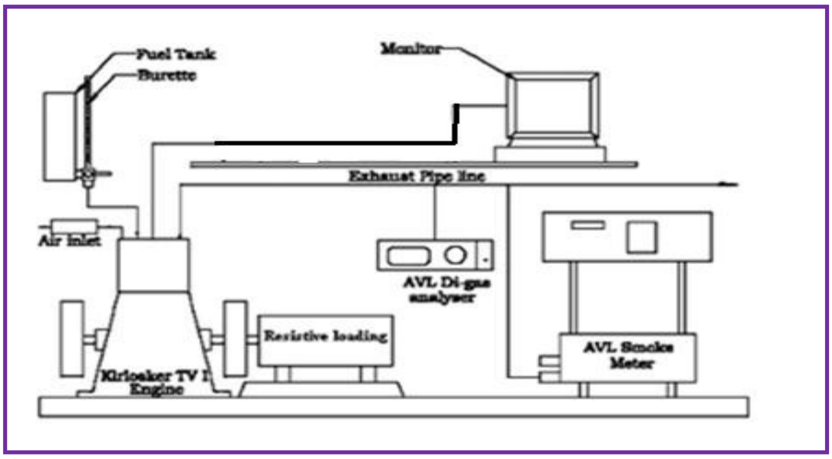

Figure 2. **Schematic diagram of experimental setup**

The engine had a bore diameter of 80 mm, stroke length of 110 mm and a maximum Power of 3.7 kW. The tests were carried out at a constant speed of 1500 rpm. Each test was repeated three times to ensure the reproducibility of data.

The engine was first operated on diesel fuel with no loads for few minutes at rate speed of 1500rpm. The same temperature were maintained throughout the experiment with all the fuel modes. The basic line parameters were obtained at 0%, 25%, 50%, 75%, and 100% of load on the engine with the diesel fuel. The diesel fuel was replaced with the different Maducaindica methyl ester-diesel blends with nano additives and the test is conducted by varying the loads in the same manner. The nano blended fuel does not require any modification to the diesel engines. Hence directly blended nano additive is used for the test. The mass of the fuel consumption was measured by using a fuel tank fitted with the burette and a stop watch.

The performance parameters of brake thermal efficiency were calculated from observed values. The AVL 437 standard smoke meter and AVL 444 di gas analyzer (AVL India Private Limited, Gurgaon, India) were used for the measurement of the engine exhaust emission. The combustion pressure sensor (Optrand make pressure range 0-200 bar), and software (Engine test express, make legion brothers, written in "visual C"), Crank Angle Encoder (Make Kubler, 360PPR coupled to crankshaft) are used to analyze the combustion characteristics.

4. Result and Discussions

4.1 Brake Thermal Efficiency

Figure 3 shows the variation of brake thermal efficiency with different engine load of fuel blends. It indicates the ability of assessing how efficient the energy in the fuel can be converted into mechanical output. Among the fuel blends with nano additives, brake thermal efficiency of 40MEOM+50ppm is 30.6%. The brake thermal efficiency was increased by 1% with the addition of 50ppm copper oxide nano additive additives compared than 40MEOM (30.7%) fuel blends. This is due to the high surface area and, subsequently, great chemical reactivity of the nano particles lead to increase the combustion efficiency of the nanoparticle blended fuel blends.

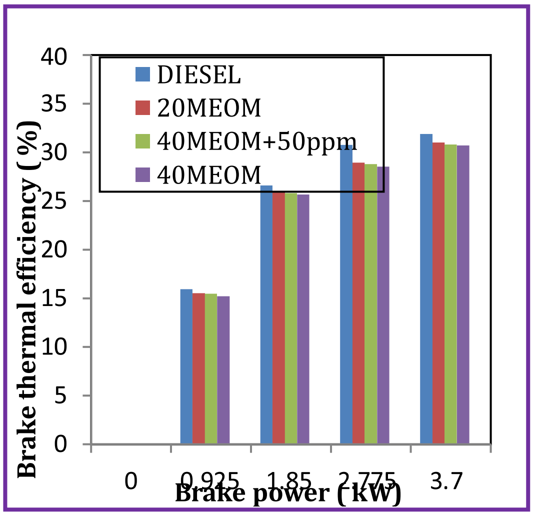

Figure 3. Variation of brake thermal efficiency with engine load of fuel blends

4.2 Carbon Monoxide

The variation of carbon monoxide with different engine load of fuel blends is shown in Figure 4.

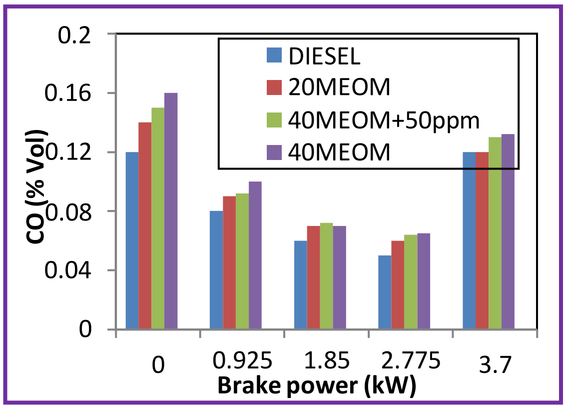

Figure 4. Variation of CO emissions with engine load of fuel blends

CO is the transitional product of incomplete combustion of fuel. The carbon monoxide emission decreases with the addition of copper nano additives with 40MEOM fuel blends. Whereas the CO emissions of 40MEOM+ 50ppm is 0.12%. The CO emission is decreased with adding of nano additive additives in Maducaindica methyl ester fuel blends compare than 40MEOM fuel blends. It is due to the nano additives gives high catalytic activity and its higher surface to volume ratio. In addition Nano additives improving the mixing rate of fuel and air.

4.3 Hydro Carbon

The variation of hydrocarbon emission with different engine load of fuel blends is shown in Figure 5. The addition of nano additives in fuel blends to reduces the HC emission when compared with the without addition of nano additives. The HC emissions of 40MEOM+ 50ppm are 72ppm. Its 3% less than diesel. The HC emission is observed as 40MEOM+ 50ppm is due to the higher cetane number, and high oxygen content present in the nano additive blended fuels. Another reason is due to perfect mixing of fuel with air and increasing the oxidation process.

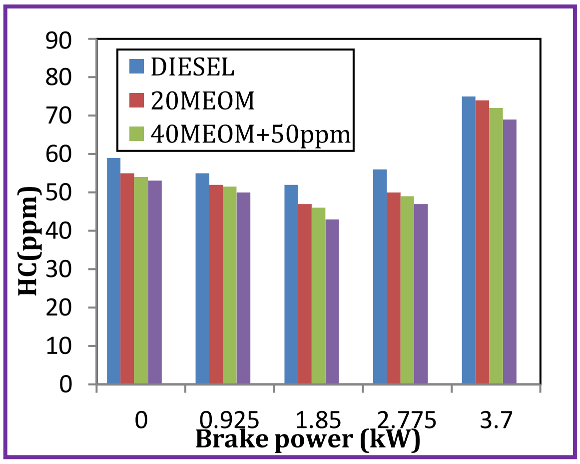

Figure 5. Variation of hydrocarbon emissions with engine load of fuel blends

4.4 Nitrogen Oxide

The variation of NOx emissions with different engine load of fuel blends is shown in figure 6. NOx emissions is mainly depends upon combustion temperature and the amount of oxygen. It is clear that, the NOx emission dramatically increases, by adding nano additives in the methyl ester fuel blends. The NOx emissions of 40MEOM+50ppm are 912ppm.

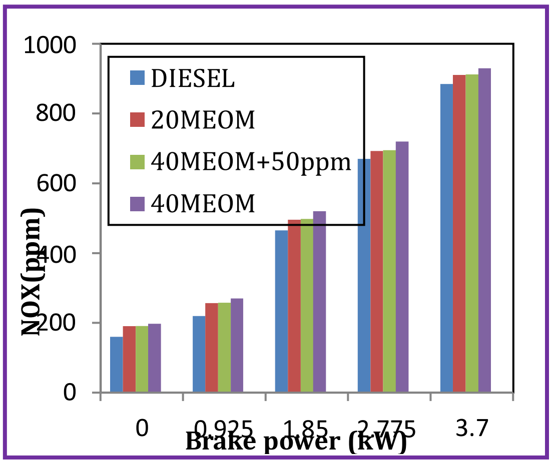

Figure 6. Variation of NOX emissions with engine load of fuel blends

It's closer to 20MEOM (910ppm). It is due to complete combustion fuel and higher combustion temperature. Its leads to higher NOx emission.

4.5 Smoke

Figure 7 shows the variation of smoke emissions with engine load of fuel blends. The smoke emissions of 40MEOM+50ppm are 84.5HSU. Reduced smoke opacity is observed in the case of 40MEOM+50ppm fuel blends. It's closer to 20MEOM (85HSU) fuel blends.

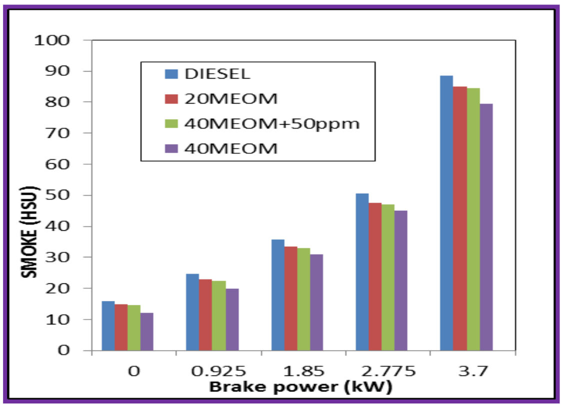

Figure 7. Variation of smoke emissions with engine load of fuel blends

This could be attributed due to shorter ignition delay and better combustion characteristics of nano additive fuel blends.

5. Conclusions

Diesel is the most using fuel in the automobiles. If the emissions from diesel engine controlled means the world will protect from greenhouse effect. So only we used Nano technology for control emission in diesel engine. The performance and emission characteristics of neat diesel, 40MEOM with MgO nano additive fuel blends are investigated. The conclusion of this investigation is as follows.

- The brake thermal efficiency of 40MEOM+50ppm fuel blend is increased 1% compared than the fuel blends.
- The HC emission of 40MEOM+50ppm is (71ppm) 3% which is lower than diesel and closer to 20MEOM fuel blends.
- The NO_X emission of 40MEOM+50ppm is closer to 20MEOM fuel blends.
- The overall combustion characteristics of 40MEOM+50ppm are closer to 20MEOM and higher than 40MEOM fuel blends.
- From the experimental investigation results proved that 40MEOM+ 50ppm additive fuel bends is the best blend ratio for compression ignition engine compared than other fuel blends with nano additive fuel blends.

References

[1] M. Varathavijayan, T.P. Murugan, S. Mohanamurugan, Experimental Investication of DI Diesel Engine Using Biodiesel Blends with Different Injection Pressures, *International Journal of Engineering Sciences & Research Technology*, 2 (2013) 3134-3137.

[2] S.Naramsetty, V. RanjithKumar, Y.V.H. Rao Performance and Emission Characteristics of Diesel Engine Fuelled with Biodiesel of Maducaindica Oil & Diesel Blends with Additives, *International Journal of Engineering Research and Applications*, 3 (2013) 936-941.

[3] A. Demirbas, Progress and recent trends in biofuels, *Progress in Energy and Combustion Science*, 33(2007) 1-18.

[4] A.M. Ashraful, H.H Masjuki, M.A. Kalam, I.M. Rizwanul Fattah, S. Imtenan, S.A. Shahir, H.M. Mobarak, Production and comparison of fuel properties, engine performance, and emission characteristics of biodiesel from various non-edible vegetable oils: A review, *Energy Conversion and Management*, 80 (2014) 202-228.

[5] A.K. Hossain, P.A. Davies Plant oils as fuels for compression ignition engines: A technical review and life-cycle analysis, *Renewable Energy*, 35(2010) 1-13.

[6] S.H. Heroor, S.D.R. Bharadwaj, Performance and Emission Charecteristics of CI-engine using Maducaindica (MadhucaLongifolia) Biodiesel under Varying Operating Conditions, *International Journal of Applied Engineering Research*, 8(2013) 2005-2010.

[7] H. Mulimani, O.D. Hebbal, M.C. Navindgi, Extraction of biodiesel from vegetable oils and their comparisons, *International journal of advanced scientific research and technology*, 2 (2012) 242-250.

[8] S. Puhan, N. Vedaraman, G. Sankaranarayanan, B.V.B. Rama, Performance and emission study of Maducaindica oil(maducaindica oil) ethyl ester in a 4-stroke natural aspirated direct injection diesel engine, *Renewable Energy*, 30(2005) 1269-1278.

[9] K.P. Shadangi, K. Mohanty, Comparison of yield and fuel properties of thermal and catalytic Mahua seed pyrolytic oil, *Fuel*, 117 (2014) 372-380.

[10] N. Kapilan, T.P. Ashok Babu, R.P. Reddy, Characterization and effect of using Mahua oil biodiesel as fuel in compression ignition engine, *Journal of Thermal Science*, 18 (2009) 382–384.

[11] M.K. Ghosal, D.K. Das, S.C. Pradhan, N. Sahoo, Performance Study of Diesel Engine by using Mahua Methyl Ester (biodiesel) and its Blends with Diesel Fuel, *Agricultural Engineering International: CIGR Journal*, 10 (2008).

[12] C. Vijayakumar, A. Murugesan, B. Aishwarya, A. Jeyaram, G. Gogul, P. Abinash Nayak, (2015) Experimental Investigation of Mahucaindica Methyl Ester as an Alternative Fuel for Diesel Engine, *International Journal of PharmTech Research*, 8 (2015) 193-199.

[13] J.S. basha, R.B. Anand, An experimental investigation in a diesel engine using alumina nanoparticles blended water-diesel emulsion fuel, (2009).

[14] V. Chandrasekaran, M. Arthanarisamy, P. Nachiappan, S.Dhanakotti, B. Moorthy, The role of nano additives for biodiesel and diesel blended transportation fuels, *Transportation Research Part D: Transport and Environment*, 46 (2016) 145-156.

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