IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Experimental Study On Performance And Emission Characteristics Of Nmo-Diesel Blend With Nano Particles

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Abstract

The purpose of this study is to see how two Nano particles, Zirconium oxide and Manganese oxide, affect the NEEM OILMETHY ESTER (NOME)-diesel blend. Many academics have proposed various techniques for lowering pollutant emissions from direct injection (DI) diesel engines, particularly nitrogen oxides (NOx). Diesel, mixes of 75 percent diesel and 25 percent NO (i.e., NMO25), and additional blends such as NMO25 ZO and NMO25 MNO were evaluated in a direct injection (DI) diesel engine. The NO biodiesel engine characteristics were compared to those achieved with diesel fuel. For the experiment, a single cylinder water-cooled CI diesel engine was used.Smoke, NOx, CO, HC, and CO2 emissions were measured, as well as several engine performance characteristics. The effects of the EGR system on NMO25 engine performance and emission characteristics, as well as the effect of Nanoparticles of NMO25 ZO, NMO25 MNO, are researched and compared to regular diesel and NMO25 blend results.

Keywords ---Diesel, neem oil, biodiesel, NOx emissions, zirconium oxide, manganese oxide

1. INTRODUCTION

Diesel engines have long been utilised in heavy-duty applications; however, due to their superior fuel efficiency, they have only recently become popular in light-duty applications. High compression ratios and a relatively high oxygen concentration in the combustion chamber help diesel engines achieve higher fuel efficiency. However, with diesel engines, these same characteristics result in excessive NOx emissions. Strict emission standards have been a major driving force in the development of more environmentally friendly internal combustion engines.NOx and particulate matter are the major pollutants produced by diesel engines (PM). Furthermore, their combustion products contribute to global issues such as the greenhouse effect, ozone layer depletion, acid rain, and pollution, all of which pose a serious threat to our environment and, ultimately, to all life on our planet [1-3]. Biodiesel is made from vegetable oils and animal fats, and there are fears that the feedstock for biodiesel could compete with food supplies in the long run. As a result, the search for oil bearing plants that produce non-edible oils as a feedstock for biodiesel production has recently intensified. Lemon grass (Cymbopogan flexuosus) is explored as a newer source of oil for biodiesel production in this research. Biodiesel made from neem oil is native to India and tropical Asia [4-6]. It is grown in India around the Western Ghats (Maharashtra, Kerala), Karnataka, and Tamil Nadu states, as well as the foothills of Arunachal Pradesh and Sikkim, indicating that it may be grown throughout a large area in India and may favour easy supply [7-10].

1.3 NANO PARTICLES:

a.Zirconium Oxide

Zirconium Oxide is a white powder with a high thermal expansion and insulating properties. Ceramic colours, porcelain glaze, artificial jewellery, abrasive, insulting, and fire-resistant materials are all possible applications. Optical storage, light shutters, and stereo television glasses can all benefit from zirconium oxide powder. Zirconium oxide ($ZrO2$ – commonly known as zirconia) is a substance that, unlike other ceramic materials, has a great resistance to crack propagation. Because zirconium oxide ceramics have a relatively high thermal expansion, they are frequently used for connecting and steel [11-15].

b.Manganese Oxide

Manganese oxide nanoparticles ($MnO2$) can be used to improve efficiency; however, these materials require particles of a specific size and must be environmentally friendly. We used a bio mineralization technique to make NPs and tested their antibacterial properties. Biodiesel is a sustainable fuel that is devoid of sulphur and aromatic chemicals, according to H.E. Saleh. Because CO2 from the atmosphere is absorbed by the vegetable oil crop during the photosynthesis process when the plant is growing, biodiesel does not pollute the environment. As a result, biodiesel has a net CO2 benefit over traditional fuels. Using biodiesel in diesel engines does not necessitate any hardware changes,Sharma,Y.C et al., [2] studied on biodiesel preparation.In the United States, soybean oil is widely used, while rapeseed oil is widely used in several European countries for biodiesel manufacturing, however in Malaysia, coconut oil and palm oils are often used. In India and Africa, jatropha is a common feedstock for biodiesel production. The procedures that convert vegetable oils to corresponding ethyl or methyl esters are known as transesterfication.To yield three moles of fatty acid ester and one mole of glycerol, transesterfication required at least three moles of alcohol per mole of vegetable oil. Ethanol, methanol, and butanol are the most often used alcohols as transesterfication reactants. NaOH, NaOCH 3, and KOH are some of the catalysts employed. The molar ratio of the reactants and the presence of free fatty acids influence the catalyst choice [16-20].

K. Rajan et al., [3] did an experiment using diesel blended with sunflower oil methyl ester, which reduced NOx emissions by 25% and other unburned HC and CO emissions by a similar amount in different percentages of biodiesel blends in the range of 5%, 10%, and 20%. Because this biodiesel has a lower calorific value, it improves brake thermal efficiency by 4% and increases BSFC by 10%.

Pooja Ghodasara et al. [4] found that increasing EGR rates reduces NOx emissions while increasing HC emissions, smoke opacity, and lowering brake thermal efficiency at lower loads. At greater loads, lowering EGR rates improves brake thermal efficiency. Experiments have shown that 15% EGR is the most effective for reducing NOx emissions

Achuthanunni et al. [5] conducted an experiment with 10% EGR for diesel blended with sunflower oil and methanol (B20) and found that NOx emissions were reduced by 40%. At all loads, this B20 biodiesel blend performed better than other blends and was comparable to diesel.

EGR rate change causes favourable results in NOx emission reduction, whereas CO emission causes negative results in HC emission reduction, according to Donepudi Jagadish et al., [6]. As a result, 10-15% EGR was discovered to be the best rate for reducing NOx emissions while also reducing significant increases in HC and CO emissions.

EGR, according to Abd-Alla.G.H et al., [7], is a simple and effective way to reduce NOx emissions by lowering combustion temperature and reducing oxygen concentrations in the intake air. EGR replaces the oxygen and nitrogen in the fresh air that enters the combustion chamber with carbon dioxide and water vapour from the exhaust. EGR, on the other hand, causes an increase in PM, UHC, and CO emissions, with a consequent reduction in NO emissions.

D. Agarwal et al., [8] tested rice bran methyl ester (RBME) and its blends as fuel with an EGR system on a single cylinder DI diesel engine and assessed performance and emission characteristics. They optimised and found that combining 20% biodiesel with 15% EGR reduces NOx, CO, and HC emissions while simultaneously improving thermal efficiency and lowering BSFC.

Ken Satoh et al. [9] investigated how various combinations of EGR, fuel injection pressures, injection timing, and intake gas temperatures affect exhaust emissions on a naturally aspirated single cylinder DI diesel engine, and discovered that regardless of injection pressure or timing, NOx reduction ratio has a strong correlation with oxygen concentration. The NOx reduction ratio is proportional to the temperature of the intake gas.EGR can have a negative impact on smoke emissions because it decreases typical combustion temperatures and oxygen intake gases, preventing soot from oxidising. They also claimed that, at a given amount of oxygen concentration, cooled EGR decreases NOx more effectively with lower EGR rates than hot EGR.

Sharma et al. [10] investigated the performance of a single cylinder DI diesel engine with hot EGR and Jatropha oil methyl ester biodiesel (JBD). They found that a 15% EGR provided acceptable NOx reduction with the least amount of smoke, CO, and UBHC emissions. Increased EGR rates resulted in higher NOx emissions.

2.TEST FUEL :

NEEM OIL:

The cellular matrix of the seeds contains 40–45 percent of the oil in neem seeds. The oil is brownish yellow in colour, non-drying, and has an acerbic flavour and odour. Neem oil contains several useful bioactive compounds from the limonoids class of triterpenoids. The primary nonvolatile chemicals include Azadirachtin (Azadirachtin A), Nimbidiol, 3-tigloylazadirachtol (Azadirachtin B), Salannol, Salannin, Nimbinin, Nimbin, Nimbidin, and 1-tigloyl-3- acetyl-11-hydroxymeliacarpin (Azadirachtin D).In addition, neem seed oil contains sulfur-modified fatty substances such as loeic acid (50–60%), palmitic acid (13–15%), stearic acid (14–19%), linoleic acid (8–16%), and arachidic acid (1–3) .

Oil of neem (Family: Meliaceae, Genus: Azadirachta, Species: Indian lilac, Parts used: Seeds).

Neem seed is a high-biomass seed that might be used to make biofuel. The cost of producing biomass for biofuel may be cheap due to the high amount of its high-value essential oil, as biomass would be a by-product of essential oil manufacturing. India, Southeast Asia, and Oceania are all home to neem oil biodiesel [24-26].

Fig.1 Neem seeds

The most common and best method for using plain vegetable oils is transesterification [16]. It was carried out by scientists E. Duffy and J. Patrick as early as 1853, several years before the first diesel engine became operational [16]. This procedure was developed in the 1940s to increase the separation of glycerin for soap manufacture [17]. The esterification process is catalysed by an acid catalyst, while the transesterification reaction is catalysed by an alkali catalyst (KOH or NaOH).On a mass basis, raw oil, 15% methanol, and 5% sodium hydroxide are required for the synthesis of methyl esters via transesterification of vegetable oil. In the presence of a catalyst (KOH or NaOH), one mol glyceride combines with three mol methanols to form methyl esters. A temperature of 55-65°C is required for the reaction to reach equilibrium [27-30].

The interaction of a fat or oil with an alcohol to produce esters and glycerol is known as transesterification. Glycerol and esters are formed when alcohol reacts with triglycerides. To boost the reaction rate and yield, a catalyst is frequently utilised. Excess alcohol is required to move the equilibrium to the product side since the reaction is reversible. Methanol, ethanol, propanol, butanol, and amyl alcohol are some of the alcohols that can be utilised in the transesterification process.The most often used commercially is alkali-catalyzed transesterification, which is substantially quicker than acid-catalyzed transesterification. Various alkyl groups are represented by R1, R2, R3, and R'. The transesterification process causes a significant shift in the viscosity of vegetable oil. This procedure produces biodiesel that is completely miscible with mineral diesel in any proportion [31-35].

2.1 Test fuel preparation

Using a mechanical stirrer, test fuels were created for diesel with 25% NMO mixed in. Both NMO 25 ZO and NMO 25 MNO were tested using the same test fuel.

Preparation Process :

Biodiesel is a biodiesel-based alternative to conventional or fossil diesel. It is made from organic goods and wastes that are renewable and biodegradable, such as vegetable oil and animal fats. Transesterification is the process of converting these oils into biodiesel. The triglyceride reacts with alcohol in the presence of a catalyst, generally a strong alkaline like sodium hydroxide, during the transesterification process.The mono-alkyl ester or biodiesel and crude glycerol are formed when the alcohol interacts with the fatty acids. Biodiesel has a higher cetane number than diesel fuel, has no aromatics or sulphur, and includes 10-11% oxygen by volume [36].

Because it contains more oxygen, it emits less pollutants than diesel. Biodiesel is compatible with all Compression Ignition (CI)

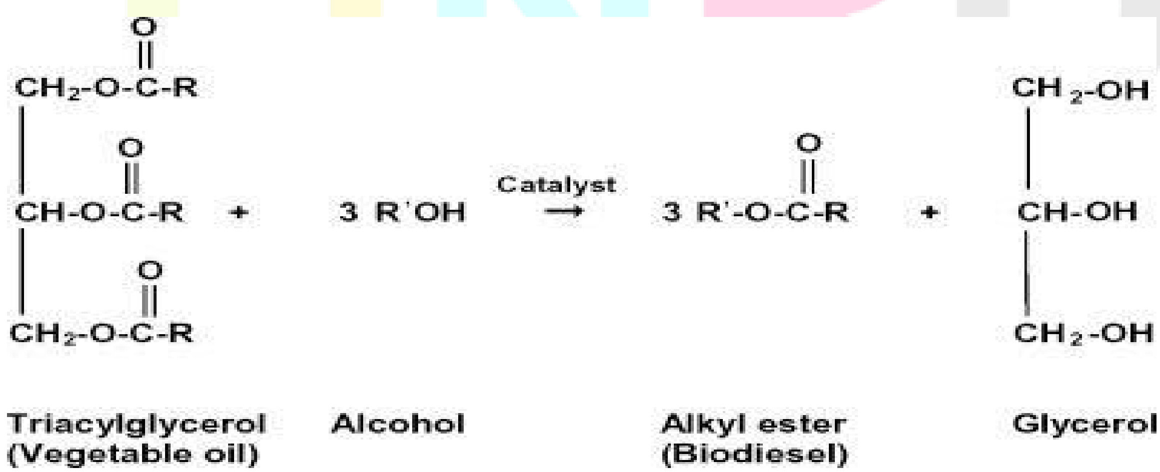

Fig . 2

engines that were intended to run on diesel fuel. Because biodiesel contains no sulphur, it does not contribute to the creation of acid rain. When compared to pure diesel fuel, biodiesel emits a negligible amount of contaminants. Biodiesel has two drawbacks: it is not widely available in large amounts and it raises NOx emissions by 15% [37]

Neem Oil BioDiesel :

Neem oil is a vegetable oil made from the fruits and seeds of the neem plant. The hue of neem oil ranges from pale to dark brown. Pressing and solvent extraction are used to obtain neem oil. The seed kernel is pressed under cold pressure or by a temperature-controlled procedure in pressing. It may also be produced via solvent extraction of neem seed, fruit, oil cake, and other plant materials. When opposed to cold pressing, the oil produced via the solvent extraction process is of inferior quality [38].

Table 1 : Properties of BioDiesel:

Name of Property	Diesel	Neem Seed Biodiesel	Diesel-Biodiesel blend (B10)	Diesel-Biodiesel blend (B15)
Calorific value (kJ/kg)	44100	33000	43050	42000
Density (kg/m^3)	830	890	845	855
Viscosity (cSt)	4.2	6.2	5.3	5.9
Specific Gravity	0.83	0.89	0.845	0.855
Flash Point (^{0}C)	53	110	65	67
Cloud Point (^{0}C)	-12	9	-2	1
Pour Point (^{0}C)	-16	2	-6	-4

3.Experimental set up and Procedure

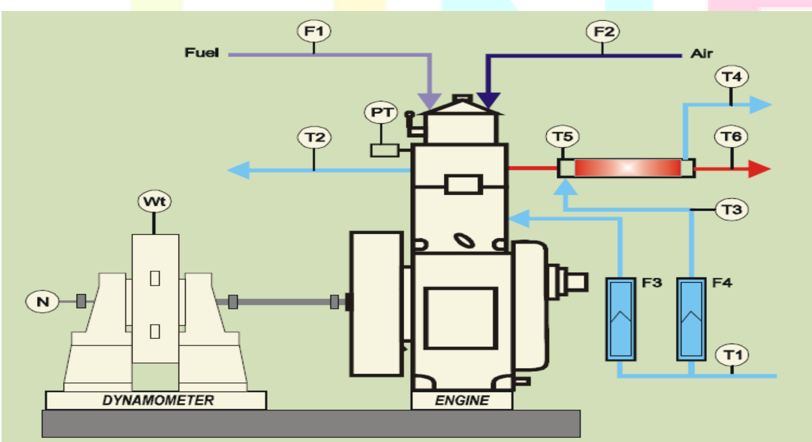

Fig . 3

The engine utilised in this experiment was a single cylinder, water cooled, NA, 4-stroke DI diesel engine with a load cell that was connected to an eddy current dynamometer. The engine's parameters are listed in Table 4.1. All of the tests were carried out at the same temperature and pressure. To save data for off-line processing, the engine is linked to a data capture system. The AVL smoke metre is used to detect smoke intensity, while the gas analyzer is used to monitor NOx, CO, and HC emissions [39].

At no load to full load, the engine runs on diesel in baseline mode at a constant speed of 1500 rpm. The engine was loaded using an eddy current dynamometer, with loads applied in increments of 0, 25, 50, 75, and 100% of full load. The engine performance characteristics and emissions were recorded for each load, and the dynamic fuel injection timing was set to 23° BTDC.

A burette attached to the engine was used to measure fuel consumption, and a stop watch was used to record the time it took to consume 10 cm3 of gasoline. Wahun Cubic Gas Analyzer was used to analyse carbon monoxide, unburned hydrocarbon, and NOx emissions. A Bosch smoke metre was used to monitor smoke emissions (GASBOARD-5020H). The temperature of the exhaust gas was measured using a chromium-alumel (k-type) thermocouple. The engine is started by using standard diesel and the engine operating temperature was reached and then loads are applied.The engine is started with ordinary diesel, and when the engine has attained working temperature, loads are applied. When the cooling water temperature reaches 60°C, the warm-up phase is over. The tests are run at 1500 rpm, which is the rated speed. Every test measures volumetric fuel consumption as well as exhaust gas emissions such carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx), carbon dioxide (CO2), and oxygen (O2).Braking thermal efficiency (BTE), specific fuel consumption (SFC), brake power (BP), indicated mean effective pressure (IMEP), mechanical efficiency, and exhaust gas temperature for varied water ratios (2.5 percent and 5%) are computed and recorded based on the original measurement.

2. Results and discussion

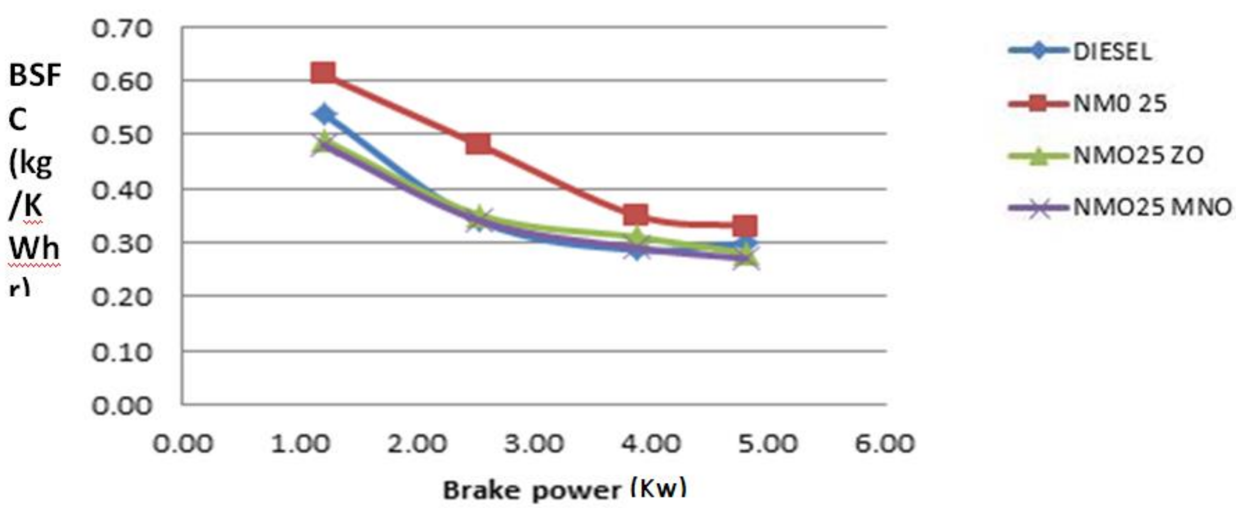

Fig . 4

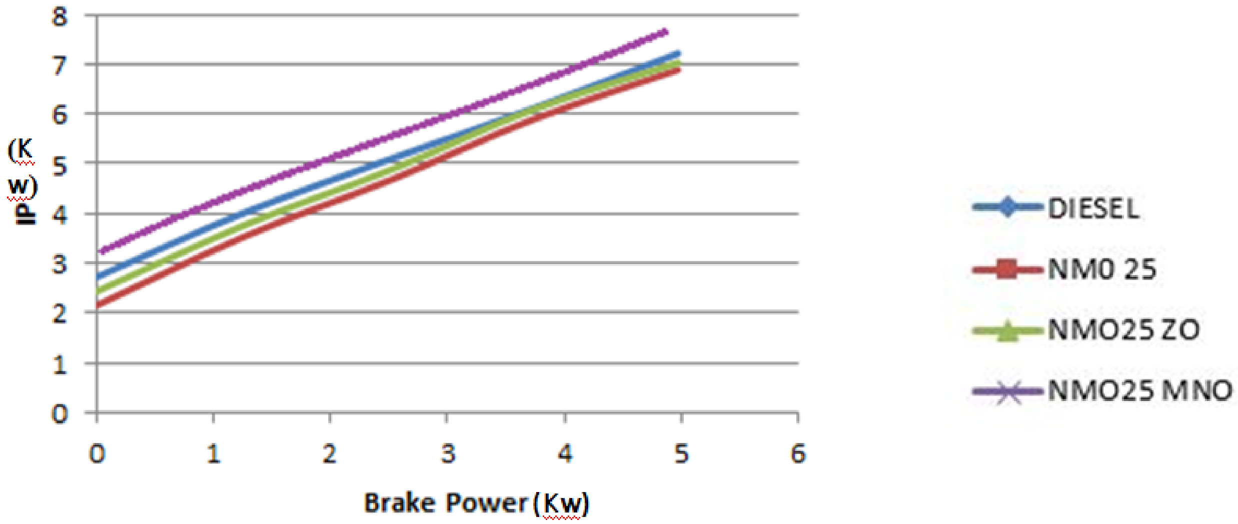

Fig . 5

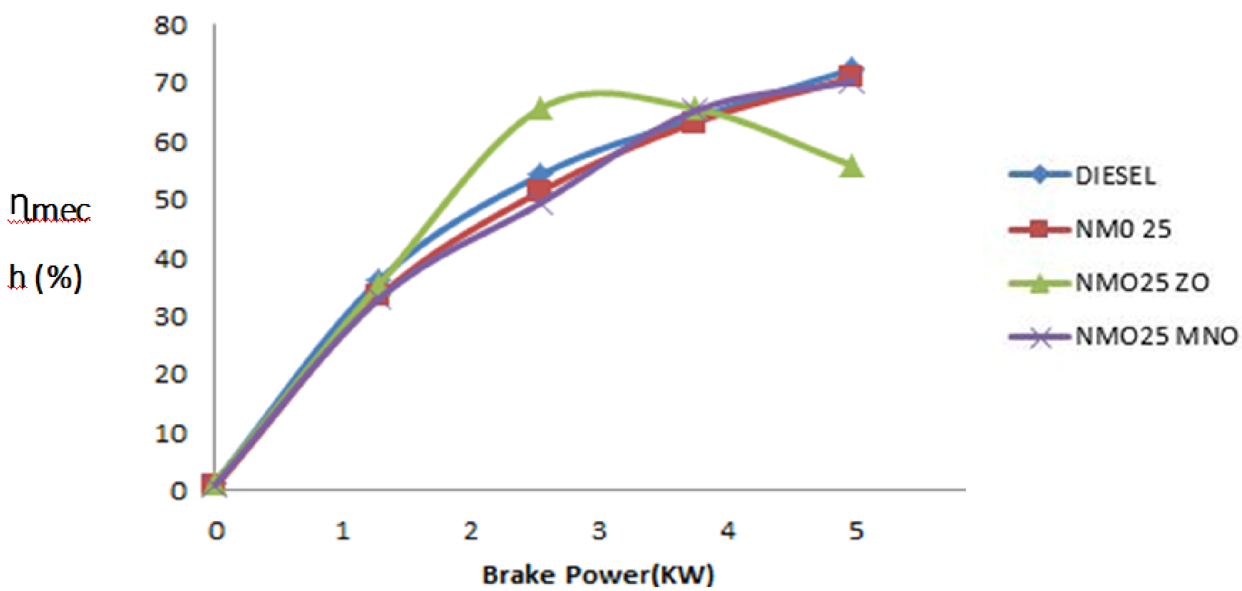

Fig . 6

In fig. 7.1, the braking power and indicated power of diesel, NMO25, NMO25ZO, and NMO25MNO blends are compared.

It demonstrates that the stated power for nano particle biofuel rises. This is related to the increased production of CO2.

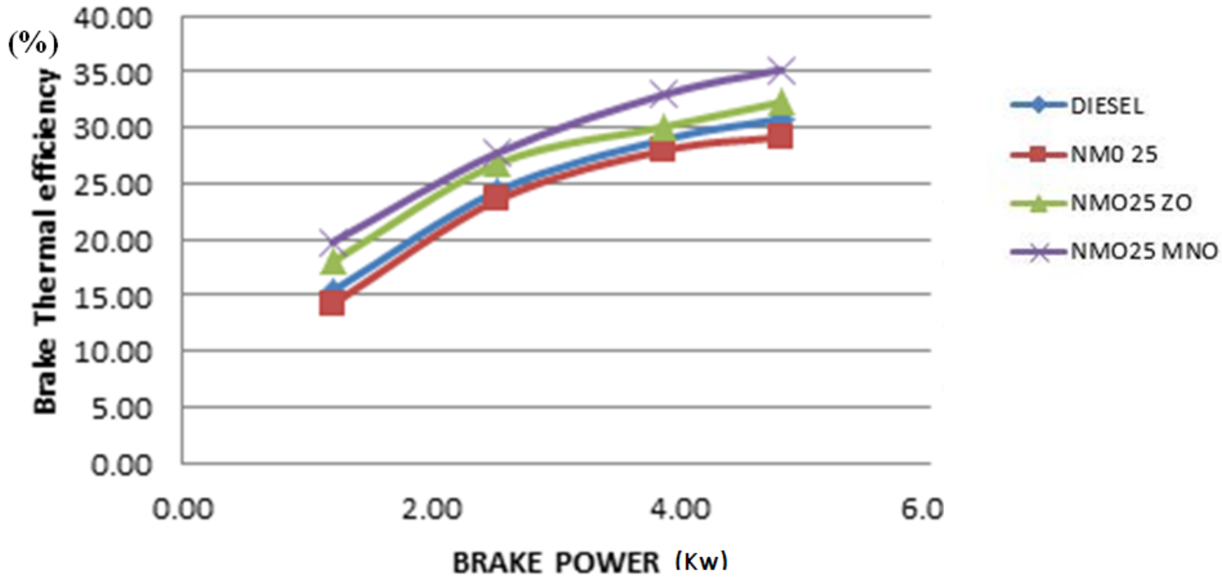

Fig . 7

Figure 7.4 compares the brake thermal efficiency of diesel, NMO25, NMO25 ZO, and NMO25 MNO. It reveals that the thermal efficiency of biofuel brakes is lower than that of diesel brakes. However, the values of both nanoparticle blends are similar. The quantity of fresh oxygen available for combustion reduces, lowering brake thermal efficiency.

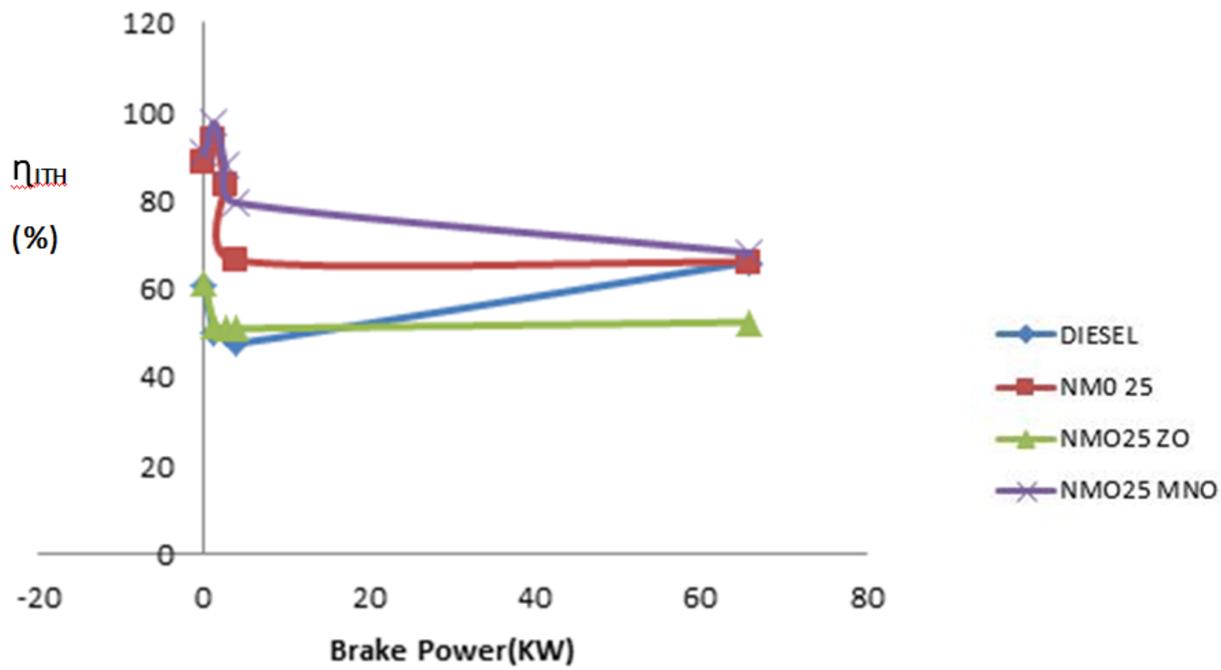

Fig . 8

Figure 7.5 compares the suggested thermal efficiency of diesel, NMO25, NMO25 ZO, and NMO25 MNO. It can be seen that the indicated thermal efficiency for biofuel is somewhat lower than for diesel.

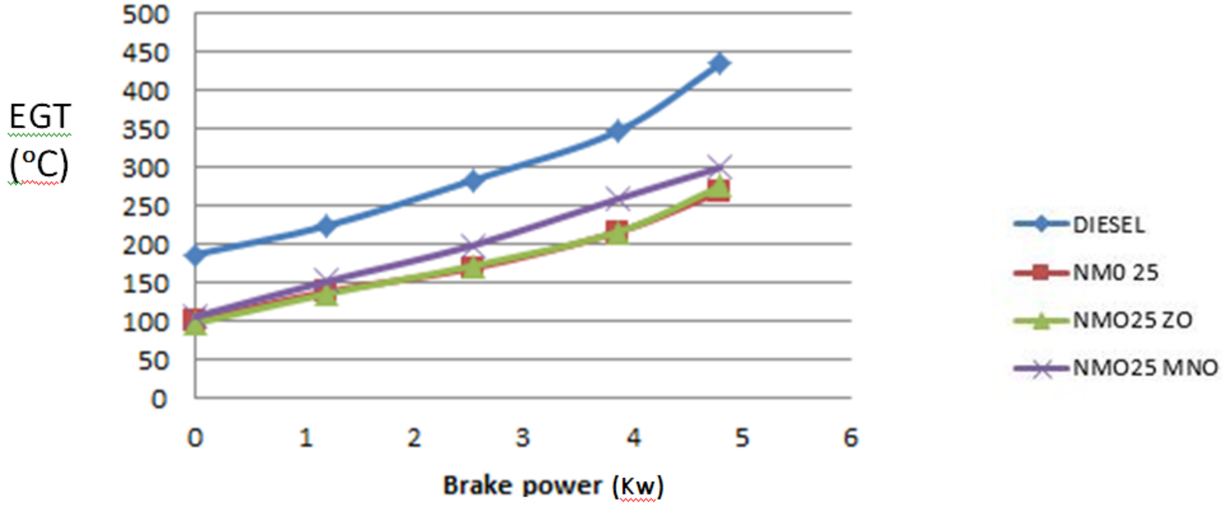

Fig . 9

In fig. 7.6, the exhaust gas temperatures of diesel, NMO25, NMO25 ZO, and NMO25 MNO are compared. It indicates that the temperature of the exhaust gas increases for diesel over NMO25, NMO25 ZO, and NMO25 MNO. However, the compositions of both nanoparticles are similar.

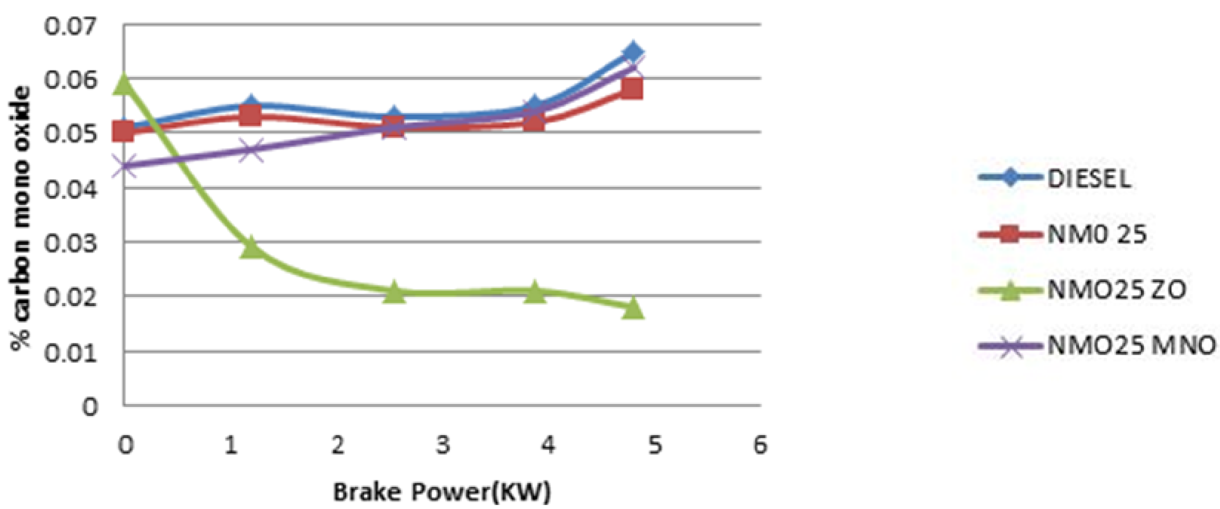

Fig . 10

Figure 7.7 compares the CO emissions of diesel, NMO25, NMO25 ZO, and NMO25 MNO. CO levels are lower in NMO25ZO than in diesel, NM025MNO, and NMO25. The use of nano-additives reduces CO emissions because the nano particles help in the conversion of CO into CO2 elements owing to their high oxygencontent.

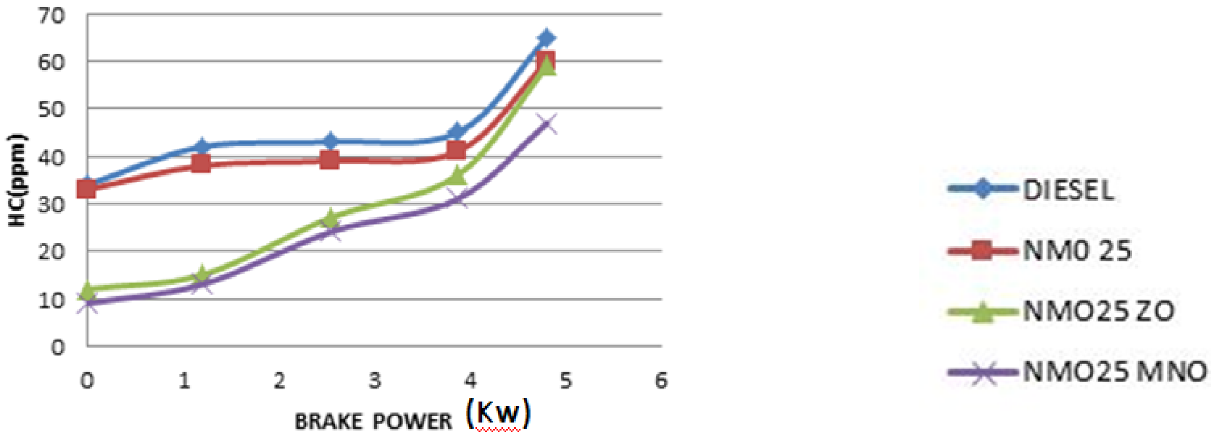

Fig . 11

Figure 7.8 compares the HC emissions of diesel, NMO25, NMO25 ZO, and NMO25 MNO. It can be shown that HC levels are lower in NMO25 ZO and NMO25 MNO than in diesel and LGO25. Because there is less oxygen available for combustion, the mixture becomes richer, resulting in incomplete combustion and increased hydrocarbon emissions. The oxygenated additives, as well as the O2 molecules in the biodiesel chemical structure, aid in the oxidation of unburned hydrocarbons into H2O particles.As a result, as compared to other test fuel mixes, HC emissions dropped.

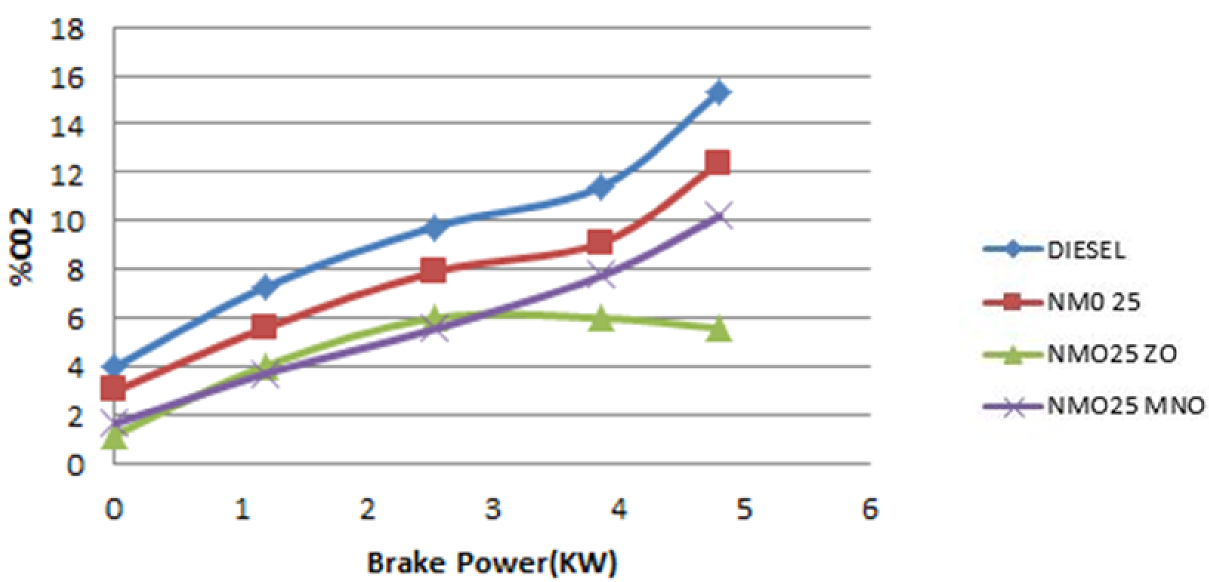

Fig . 12

In Figure 7.9, the CO2 emissions of diesel, NMO25, NMO25 ZO, and NMO25 MNO are compared. CO2 levels rise for diesel and NMO25, but not for NMO25 ZO or NMO25 MNO. Both proportions, however, have similar values.

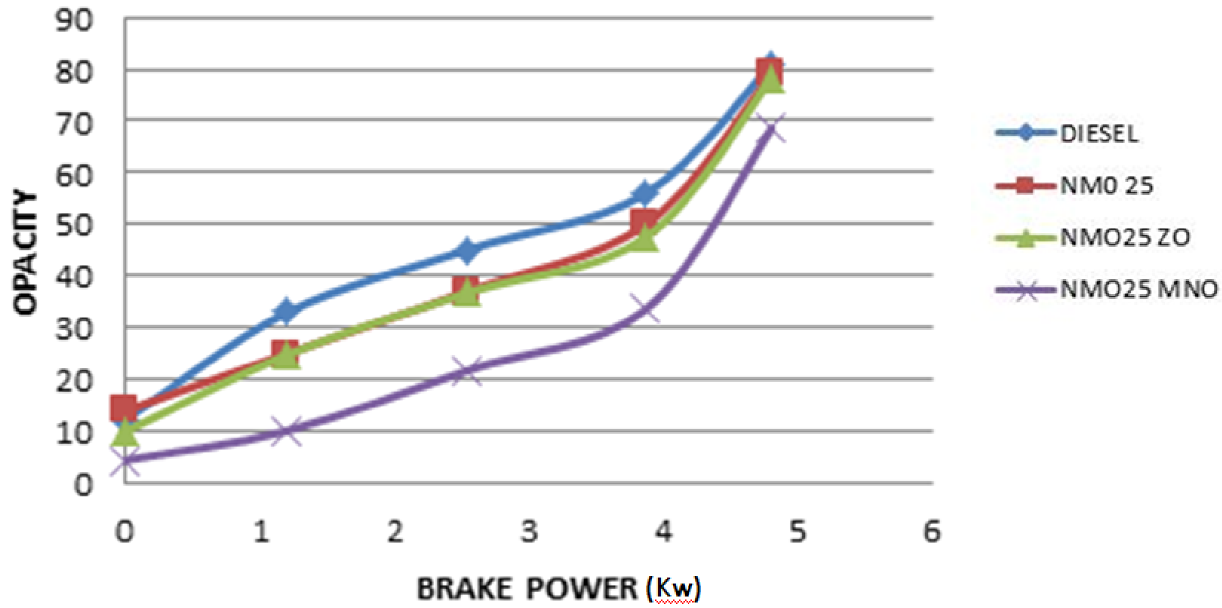

Fig . 13

Figure 7.10 compares the smoke emissions of diesel, NMO25, NMO25 ZO, and NMO25 MNO. It indicates that NMO25 ZO and NMO25 MNO produce less smoke than diesel and NMO25. Nano-added gasoline mixes resulted in lower smoke emissions. It is because of the presence of oxygen molecules in the blend that smoke emissions are reduced.

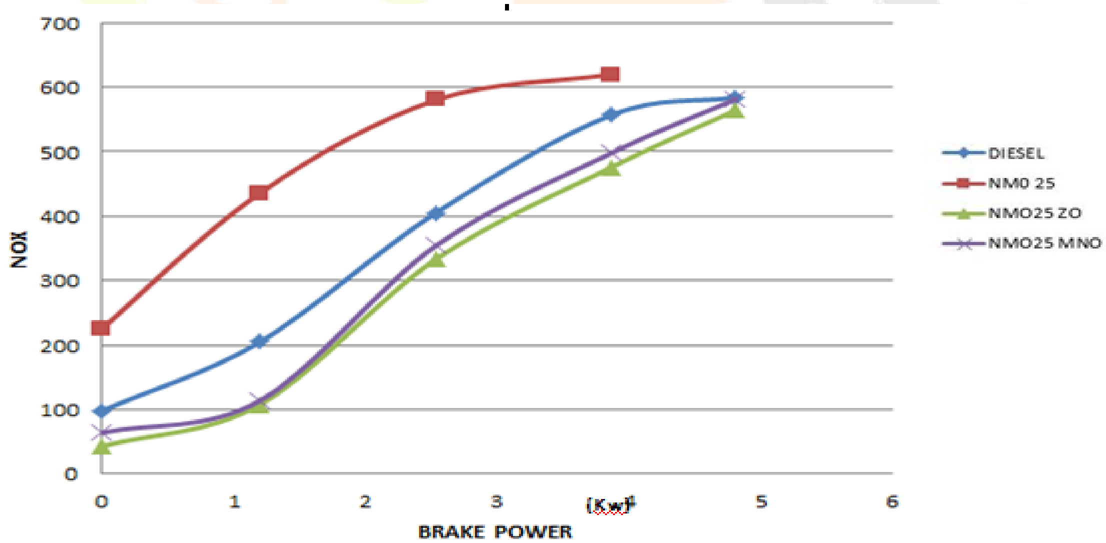

Fig . 14

In Figure 7.11, the NOx emissions of diesel, NMO25, NMO25 ZO, and NMO25 MNO are compared. NOx levels are lower in NMO25 ZO and NMO25 MNO than in diesel and NMO25. Both proportions, however, have similar values. It's because of the lower temperature in the combustion chamber. The absorption of heat energy during the combustion process was altered by the addition of nano-additives to Biodiesel-diesel mixtures.

3. CONCLUSION

The effects of neem oil biodiesel (NMO), diesel, and their mixtures are studied. The findings suggest that NOx emissions and smoke levels have decreased. There is a minor decrease in efficiency (brake thermal, indicated thermal, and mechanical) when utilising certain biofuel mixes, although it is minimal or has little influence. Emissions are reduced when biofuel is used as an alternative fuel. The drop in NOx and smoke in the cylinder is due to a lower peak temperature, while the decrease in NOx and smoke in the EGR is due to a lower oxygen concentration and lower flame temperatures in the combustion chamber.Neem Oil (NMO)-Diesel blends can be successfully used as an alternative fuel, and adding Zirconium oxide and Manganese oxide to the biofuel blend reduces NOx emissions and smoke even more than the biofuel blend. With these Nano particles in biofuel, we can use it as an alternative fuel in the future for low pollutant emissions in the environment.

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