

Experimental Investigation on the Influence of Nano Additives on Engine Behavior of a Biofuel Based Diesel Engine

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ABSTRACT: Fossil fuels are depleted very rapidly in this decade because of increasing automobile and human population. So there has been huge demand for alternate energy source but due to more number of presence of diesel engines we are in need of an alternate fuel for diesel engines. Because Diesel engine plays an important role in automotive, transport and power production industries. Diesel engine is more efficient when compared to gasoline engines. But the major problem in diesel engine is its high emission rate of nitric oxide and smoke. To overcome the emission and fuel depletion problems in this project mahua oil is used as fuel for diesel engine. It is extracted from madhucaindica seeds. In addition with mahua oil some nano additives (titanium oxide and aluminium oxide) are added to it by sonication process. Mahua oil with various proportions of nanoparticles (25, 50, 75, & 100 ppm) and mahua oil emulsion with 100 ppm of nano particles are tested in single cylinder diesel engine and the performance and emission characteristics are noted down and compared the neat diesel fuel. Raw mahua oil and mahua oil emulsion with 100 ppm of TiO₂ has BTE of 28% and 31%. And mahua oil and mahua oil emulsion with 100 ppm of TiO₂ reduces the NO emission about to 18% and 40% compared to neat diesel fuel. From the results that mahua oil and mahua oil emulsion with 100 ppm of TiO₂ gives a better result than other proportions of nano particles.

KEYWORDS: Diesel Engine, Mahua oil, mahua oil emulsion, nano additives.

I. INTRODUCTION

In transportation and industrial sector, fossil fuels have become important resource for power production. But, fossil fuels produce enormous amount of emissions which is harmful to human as well as environment. The consequence of using cerium oxide (CeO₂) nanoparticle as additive in Lemongrass Oil (LGO) emulsion fuel was experimentally investigated in a single cylinder, constant speed diesel engine. A novel biofuel plant was introduced in this project, namely lemongrass whose binomial name is *Cymbopogon flexuosus*. The ceria nanoparticle was dispersed with the LGO emulsion fuel in the dosage of 30 ppm (ppm). The diesel engine performance, combustion behavior and emission magnitude were compared with diesel and LGO as the base fuels. The LGO emulsion fuel could reduce smoke and NO_x emissions and could improve Brake Thermal Efficiency (BTE), Brake Specific Energy Consumption (BSEC) compared with neat LGO despite the marginal increase in HC and CO emissions. For ceria nanoparticle blended test fuel, the drastic reduction of carbon monoxide (CO), unburned hydrocarbon (HC), oxides of nitrogen (NO_x) and marginal decrease of smoke opacity emission could be achieved compared with the LGO emulsion and diesel fuel at various power outputs [1]. Improvement in BTE was also observed for LGO nano emulsion test fuel compared to neat LGO and LGO emulsion fuels due to improved atomization and rapid evaporation rate of fuel owing to large surface area to volume ratio of CeO₂ nanoparticle. M. Annamalai et al. [3] (2016) experimental study, CI engine is made to run on 100% CalophyllumInophyllumMethly Ester (CIME) biodiesel and the same dozed with fuel additives [2]. The study mainly focuses on the influence of two types of fuel additives namely Zinc oxide (ZnO) which is a metal oxide nanoparticle and Ethanox which is an antioxidant. ZnO was added to CIME in the form of nanofluid at different constituent levels of 50 ppm and 10 ppm while Ethanox was added at concentration levels of 200 ppm and 500 ppm. Addition of 100 ppm of ZnO improves the efficiency by 4.7% and 12.6% reduction of NO_x at full load [3]. Ethanox was found to be better fuel additives in terms of NO_x reduction and 500 ppm of Ethanox results in maximum

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decrease of 17.8%. B. Ashok et al. [1] (2017) In order to evaluate the effect of nano particles such as Alumina (Al_2O_3) and Cerium oxide (CeO_2) as additives in Jatropha biodiesel, an experimental investigation is carried out to study the performance and emission characteristics in a single cylinder, four stroke DI diesel engine. Alumina and Cerium oxide nanoparticles are added with Jatropha biodiesel at mixed proportions forming 10, 30 and 60 parts per million. Hence JBD30A30C test fuel, higher brake thermal efficiency of 31% is observed, which is almost near to the brake thermal efficiency of neat diesel by 32% [4]. A significant percentage reduction of NO by 13%, CO by 60%, Unburned HC by 33% and smoke emission by 32% are observed for JBD30A30C test fuel compared to neat biodiesel Prabu et al. [6] (2016) experimentation was carried out to investigate the effects of nano-metallic oxide fuel additives on the major physicochemical properties and performance of jatropha biodiesel blends in a DI diesel engine in dual fuel mode. Jatropha methyl ester (JME) biodiesel is produced from degummed crude jatropha oil after reducing the free fatty acid (FFA) content to less than 2% and performing transesterification using a 20 kHz frequency ultrasonicator with a sodium hydroxide (NaOH) catalyst. Zinc oxide (ZnO) nanoparticles at 100 ppm with a size of 20 and 40 nm were suspended in primary fuel of JME biodiesel. H₂ as a secondary fuel with flowrates of 0.5 and 1.5 L/min was maintained during the experiments. NO_x emissions are reduced with the inclusion of nanoparticles. HC emissions mainly depend on nanoparticle size and H₂ flowrates [5]. With the presence of ZnO nanoparticles in blends of pure JME, the CO emission increased, and higher H₂ flowrate supplemented the CO emission. Hence, blending ZnO nanoparticles with JME blends along with H₂ as a dual fuel aids in reducing the emissions to those of neat diesel and enhancing the performance characteristics. Syed Javed et al. [6] (2016).

II. OBJECTIVE AND METHODOLOGY

2.1 OBJECTIVE

To investigate the effect of nano additives on engine performance and emission of the diesel engine using biofuel as fuel.

2.2 METHODOLOGY

- Initially problem was identified and literature survey was made.
- Selection of biofuel
Mahua oil (it is derived from the seeds of madhuca indica.)
- Selection of Nano-particles
 - 1) Aluminium oxide (Al_2O_3)
 - 2) Titanium oxide (TiO_2)
- Blending the Nano-particles with Biofuel (mahua oil) in different ratio
- Types of blends
 - Al₂O₃ Nano-particle
 - ❖ MO+25 ppm Al₂O₃, MO+50 ppm Al₂O₃
 - MO+75 ppm Al₂O₃, MO+100 ppm Al₂O₃
 - TiO₂ Nano-particle
 - ❖ MO+25 ppm TiO₂, MO+50 ppm TiO₂
 - ❖ MO+25 ppm TiO₂, MO+50 ppm TiO₂
- Sonication Process- Ultrasonicator.
- Experiment in diesel engine on performance and emission characteristics.
- Preparation of mahua oil emulsion test fuel a suitable proportion of 93% of Biofuel (Mahua oil) 5% of water 2% of Surfactant (span 80)
- Blending the Nano-particles with Mahua oil Emulsion in different ratio
- Types of blends
 - Al₂O₃ Nano-particles
 - ❖ Mahua oil Emulsion + 100 ppm Al₂O₃
 - TiO₂ Nano-particles

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- ❖ Mahua oil Emulsion+ 100 ppm TiO₂
- Sonication process- Ultrasonicator.
- Experiment in diesel engine on performance and emission characteristics
- Comparing the mahua oil with Nano-particles and mahua oil emulsion with Nano-particles in diesel engine on performance and emission characteristics.

III. PREPARATION OF FUEL

3.1 PREPARATION OF MAHUA OIL WITH NANO PARTICLES

For the blending of aluminum oxide nanoparticles in Mahua oil, taken a sample of Mahua oil say 1litre and then 0.025g of aluminium oxide in the nanoparticles form is added to make the dosing level of 25 ppm. The dosing level of 25 ppm is 0.025 g/l, respectively. After the addition of aluminum oxide nanoparticles the preparation of nano mahua begins by direct mixing of the Mahua oil as base fluid with the nanoparticles and ultrasonicated for about 30 min in an ultrasonic vibrator making uniform dispersion. Similar procedure carried out for 50ppm,75ppm,100ppm aluminum oxide and 25,50,75,100ppm titanium oxide.

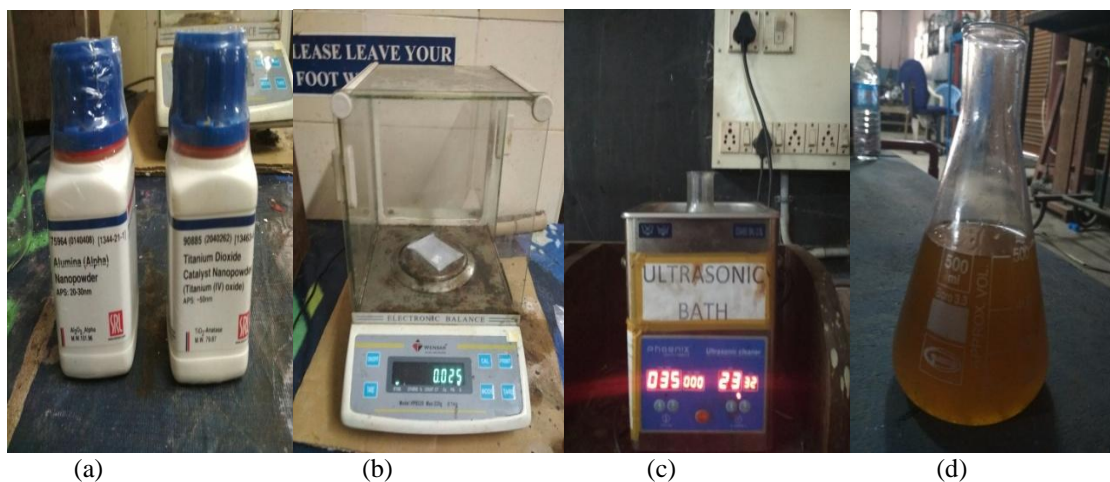


Fig:1 Sonication process a) Aluminum oxide (Al₂O₃) and Titanium oxide (TiO₂) b) Electronic weight machine c) ultrasonic bath d) nanomahua oil

3.2 PREPARATION OF MAHUA OIL EMULSION AND MAHUA OIL EMULSION WITH NANO PARTICLES

For the preparation of neat Mahua emulsion test fuel a suitable proportion of 5% of water, 93% of mahua oil and 2% of span80 by volume basis was mixed using mechanical stirrer with an optimum speed Span80 acted as surfactant and it would reduce surface tension. For the preparation of Mahua Nano emulsion test fuels a dosage of 100 ppm of Al₂O₃ and TiO₂ nanoparticle was dispersed with 1000 ml of neat Mahua emulsion fuel with the help of a ultrasonicator device.

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Fig2: emulsion and nano emulsion a) mechanical stirrer b) Mahua emulsion c) and d) Nano Emulsion

3.3 EXPERIMENT SETUP

An experimental setup is developed by Kirloskar AVI type single cylinder, four stroke, constant speed, water - cooled, direct injection compression ignition engine. The engine it can develop 3.7 kW rated power at 1500 rpm. The engine is coupled with eddy current dynamometer. A digital speed indicator is used to measure the engine speed. The fuel consumption of the engine is measured by using Burette and stop watch. Exhaust gas emissions are measured by AVL DI - gas analyzer. The AVL DI-gas analyzer can measure HC, CO, CO₂, O₂ and NO_x emission. Exhaust gas was trapped from exhaust line and feed in to AVL DI - gas separately by an exhaust probe. The exhaust gas was partially passed through the smoke meter. The smoke meter can measure the exhaust smoke level.



Fig:3 Singal Cylinder Four Stroke Diesel Engine

IV. RESULTS AND DISCUSSION

In the present study, the performance and emission characteristics of the engine fueled with neat diesel fuel, mahua oil, nano mahua oil (25,50,75,100ppm of aluminum oxide and titanium oxide nanoparticles), mahua emulsion and nano mahua emulsion (100ppm of aluminum oxide and titanium oxide nanoparticles) were compared and discussed.

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4.1 Performance Characteristics

4.1.1 Comparison of Brake Thermal efficiency:

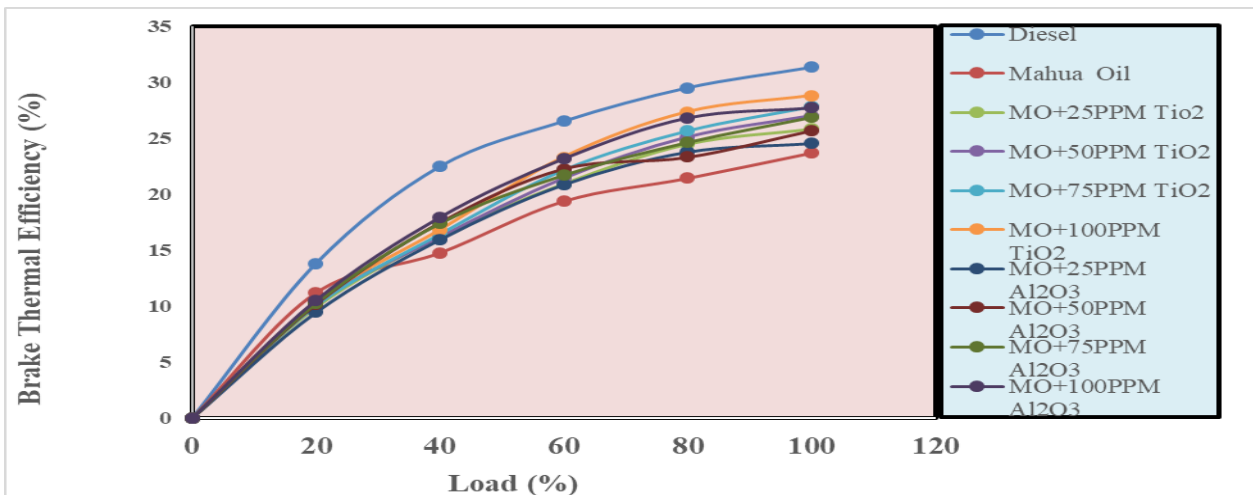


Figure 4.1 Variation of Brake thermal efficiency with Load

Above graph describes about the relation between BTE and engine load. It is shown that BTE increase with increase in engine load for all fuels. Diesel has maximum BTE of 31.3% and Mahua oil with 100 ppm of TiO₂ has 27% of BTE which is almost close to diesel BTE. Due to high viscosity of mahua oil reduces the BTE. But BTE of Mahua oil with 100 ppm of TiO₂ is more than raw mahua oil and it is achieved by addition of nano particles which increase the surface to volume ratio.

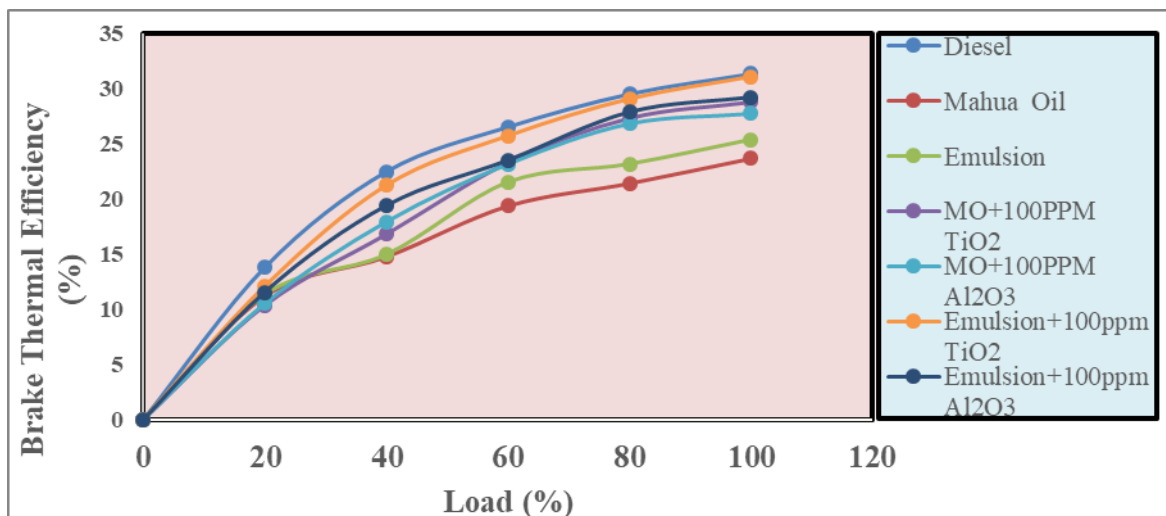


Figure 4.2 Variation of Brake thermal efficiency

Above graph describes about the relation between BTE and engine load. It shows that maximum BTE for diesel is 31.3 %, Mahua oil emulsion with 100ppm of TiO₂ is 31%, mahua oil emulsion with 100ppm of Al₂O₃ is 28% which are

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more than the raw mahua oil, due to the micro explosion of water in fuel increases the BTE of emulsion. Mahua oil emulsion with 100 ppm of TiO₂ has better BTE than Mahua oil emulsion with 100 ppm of Al₂O₃. This shows that titanium oxide is better oxidizing catalyst than Aluminium oxide.

4.1.2 Brake specific fuel consumption:

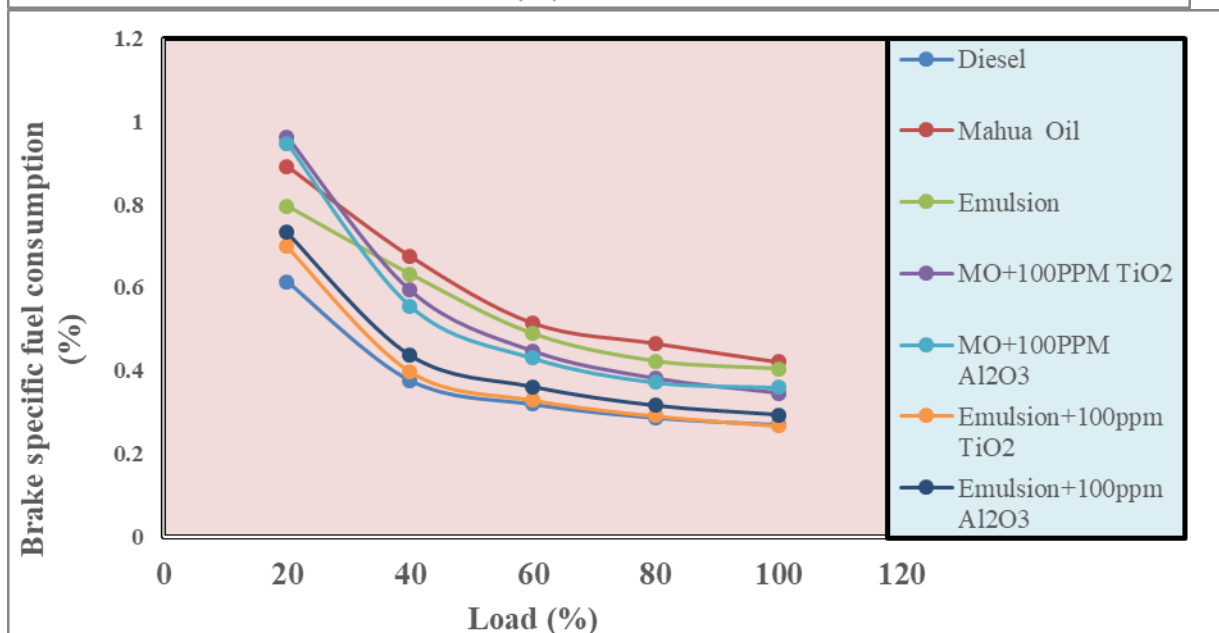
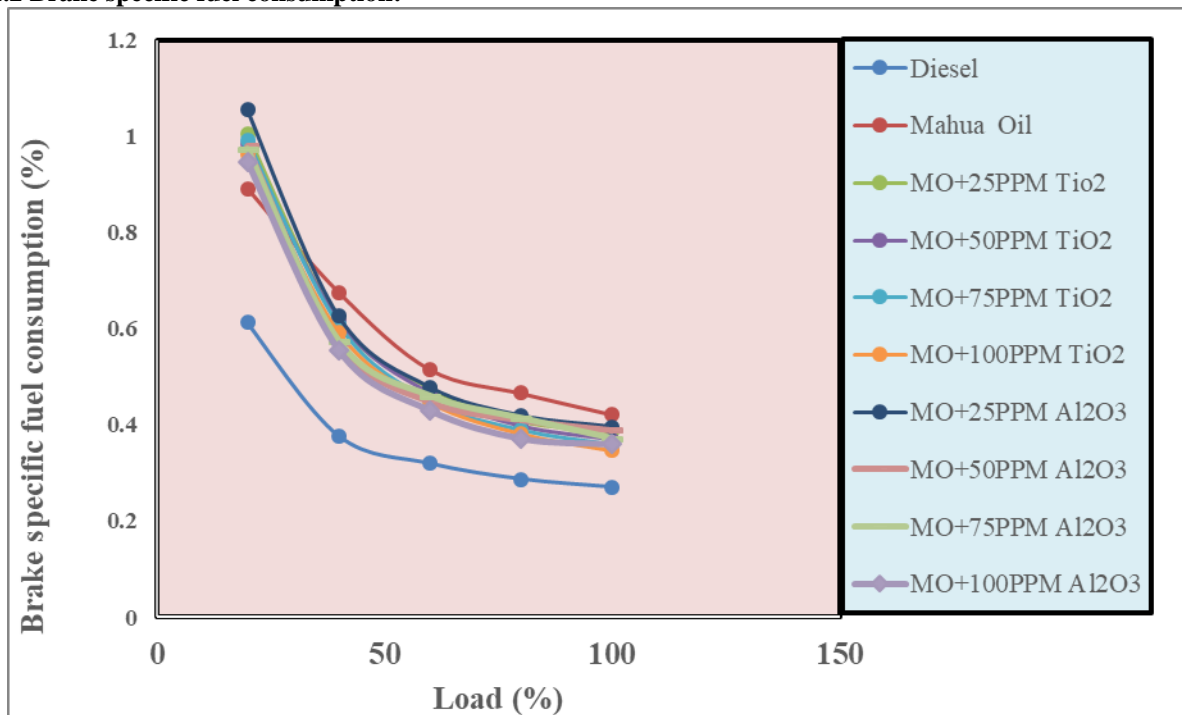


Figure 4.3, 4.4 Variation of Brake Specific Fuel Consumption with Load

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Above graphs describes about the relation between the brake specific fuel consumption and engine load. Diesel fuel has low BSFC where as other fuels has more BSFC. Raw mahua oil has the maximum BSFC because of high viscosity and poor atomization property. This is problem is reduced by addition of nano particle which increases the surface to volume ratio and in emulsion micro explosion of water in fuel increase the atomization and it leads to superior combustion than raw mahua oil.

4.2 Emission Characteristics

4.2.1 NO EMISSION

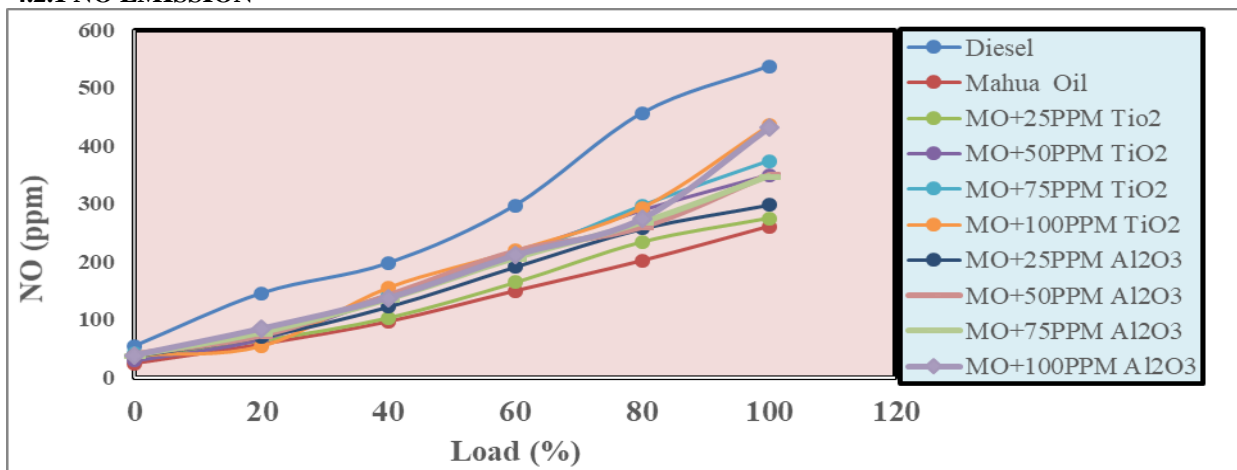


Figure 4.5 Variation of NO emission with Load

Above graph describes relation between NO and engine load. Raw mahua oil has lower NO emission than all other fuels due to high viscosity and poor atomization the combustion temperature is decreased. But NO emission for Mahua oil with 100 ppm of TiO_2 and mahua oil with 100 ppm of Al_2O_3 are higher than raw mahua oil due to presence of nano particles which increase the combustion temperature and it leads higher NO emission.

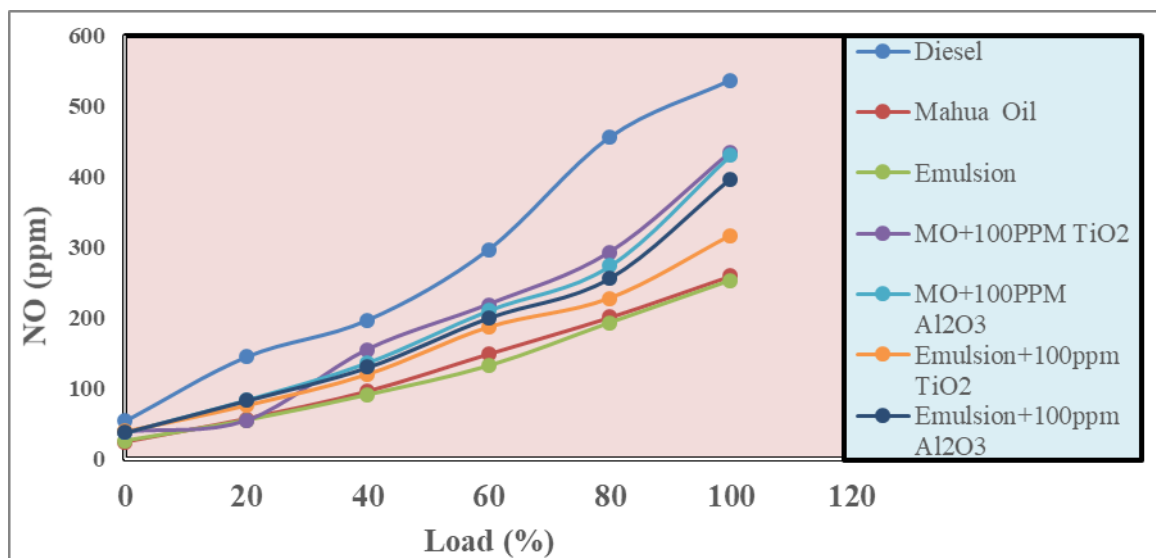


Figure 4.6 Variation of NO emission with Load

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Above graph describes the relation between NO and engine load. Diesel has higher NO emission than all other fuels due to superior combustion which increases the combustion temperature and it leads to higher NO. but NO emission for Mahua oil emulsion with 100 ppm of TiO₂ and mahua oil emulsion with 100 ppm of Al₂O₃ are low than diesel and mahua oil with nano particles due to water content present in emulsion reduces the combustion temperature.

4.2.2 HC EMISSION

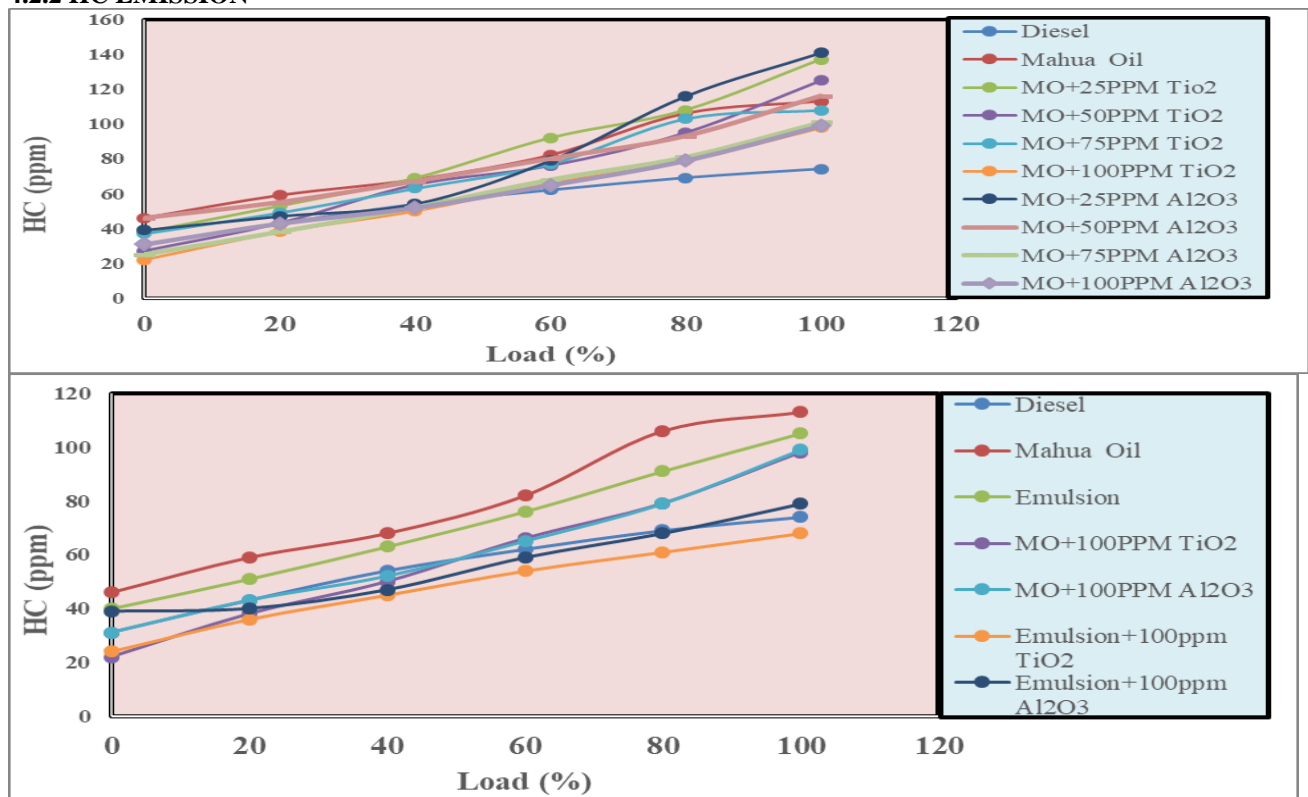


Figure 4.7,4.8 Variation of HC emission with Load

Above graphs describes the relation between HC and engine load. HC emission is more at high load conditions for Mahua oil and mahua oil with nano particles because of availability of relatively less oxygen for the reaction and activation energy of nano particles burns the carbon particles inside the cylinder which reduce the unburnt hydrocarbon contents. And in emulsion superior combustion is achieved by micro explosion of water in fuel so there is less unburnt hydrocarbon.

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4.2.3 CO EMISSION

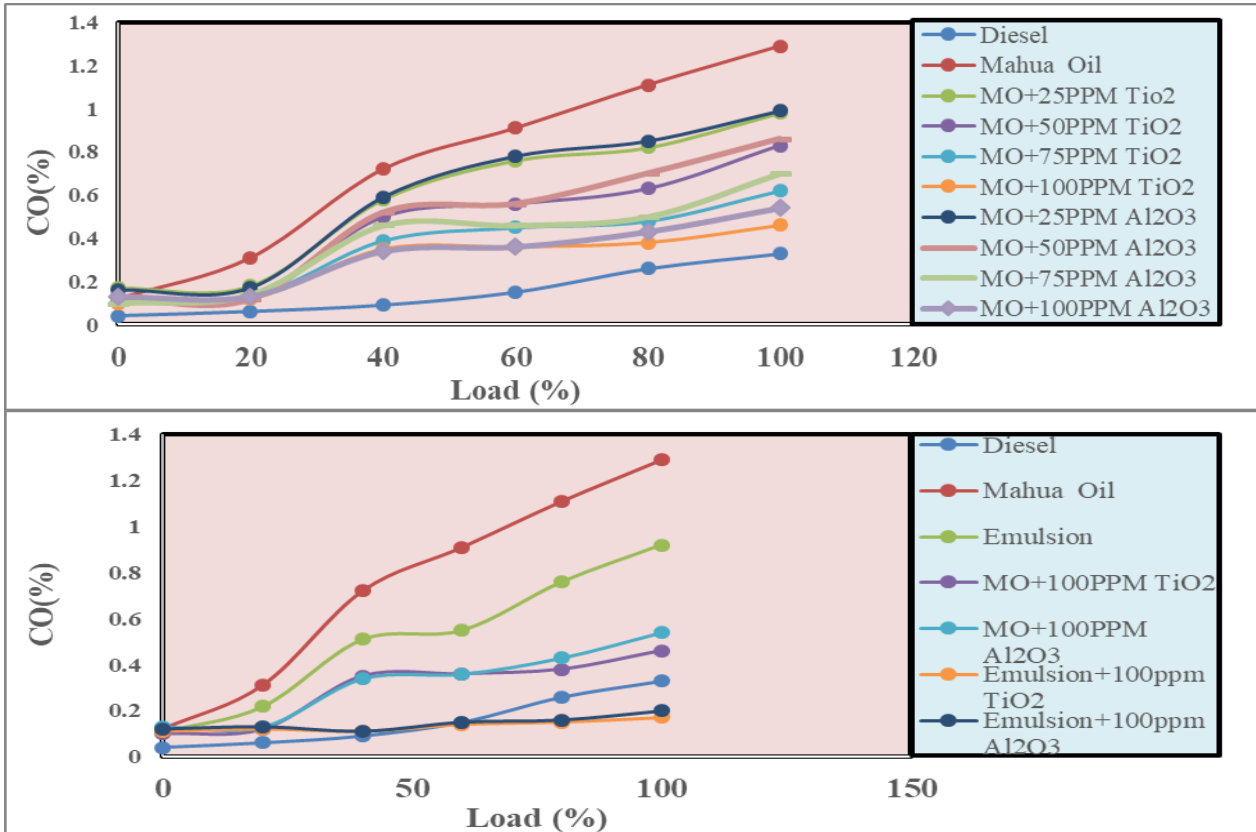
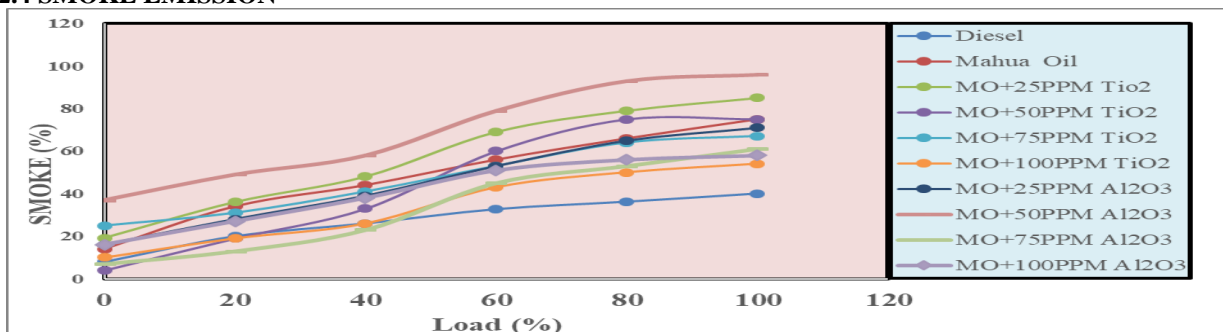


Figure 4.9,4.10 Variation of CO emission with Load

Above graphs describe about the relation between CO and engine load. CO emission is low for diesel and high for raw mahua oil due high viscosity and poor atomization leads to inferior combustion. Mahua oil with nano particles has low CO than raw mahua oil due to the increase in surface to volume ratio by nano particles. emulsion with nano particle has low CO emission than raw mahua oil and mahua oil with nano particles because of micro explosion of water in fuel leads superior combustion and it reduces the CO formation.

4.2.4 SMOKE EMISSION



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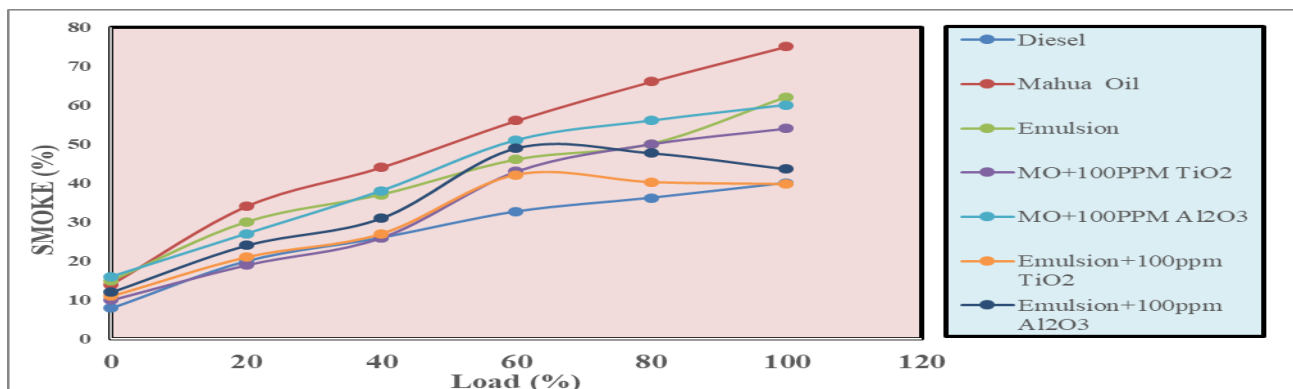


Figure 4.11,4.12 Variation of Smoke emission with Load

Above graphs describes about the relation between the smoke and engine load. Smoke emission is low for diesel other than all fuels. Raw Mahua oil has maximum smoke emission due to poor atomization it leads to inferior combustion. Whereas for mahua oil with nano particles has low smoke than raw mahua oil due to increase in activation energy and surface to volume ratio which increases the atomization of the fuel and this reduce the smoke emission.

V. CONCLUSION

The performance and emission characteristics of a single cylinder diesel engine using neat diesel ,mahua oil, mahua oil with nano particles (25,50,75,100ppm of Al₂O₃ and TiO₂),mahua oil emulsion and mahua oil emulsion with nano particals(100ppm) fuels were analyzed. Based on the investigation the following conclusions are drawn: Engine performance test shows that the brake thermal efficiency of Mahua oil with 100ppm TiO₂ is 28.7% and it almost near to diesel fuel (BTE= 31.3%).Brake thermal efficiency of mahua oil emulsion with 100ppm TiO₂ is 31% which is almost equal to diesel fuel. This is achieved by increased in surface to volume ratio due to the addition of nano particles.NO emission for Mahua oil with 100 TiO₂ is reduced by 18% and mahua oil emulsion with 100ppm TiO₂ is reduced by 40%, due to presence of water content that lowers the combustion temperature, when compared with diesel fuel. Other emissions smoke, HC and CO for mahua oil with 100 TiO₂ are increased by 35%, 32% and 39% than diesel fuel.

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