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Experimental Investigation On Effect Of Mgo Nanoparticles On Performance And Emission Characteristics Of Candlenut Oil Methyl Ester.

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Abstract:
Background*: The escalating global demand for energy is driving a continuous rise in fossil fuel consumption, resulting in its inevitable depletion. The unavailability of fuel leads to an increase in fuel prices. The rise in fuel prices is significantly affecting the economic growth of countries. In this paper a biodiesel from non-edible source candlenut oil is used as substitute to diesel fuel Blend of candlenut oil methyl ester (CME20D80) and diesel, neat diesel is tested in single cylinder four stroke CRDI Diesel engine to check the performance and emission characteristics. To the CME20D80 blend MgO nano particles of size below 100 nm are added in varying quantities like 50 ppm,100 ppm and again tested in the same engine. Results indicated that the efficiency of biodiesel blend is less relative to neat diesel, but with the incorporation of magnesium oxide nanoparticles 2.45% rise in efficiency and 1.66% decrease in specific consumption is observed for CME20D80MgO100 compared to neat diesel. And emissions of HC,CO are decreased remarkably. NOx emissions slightly increased for biodiesel, with addition of nanoparticles to biodiesel blend NOx emissions decreased compared to neat diesel.CO_2 emissions increased for all test fuels compared to diesel due to complete combustion.*

Keyword*: CME, CME20D80, COME20D80MgO50, COME20D80MgO100, BTE,SFC.*

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I. Introduction

In India currently no guidelines available for Fossil fuels that are not renewable are used in internal combustion engines, and this has a big financial impact. Because conventional fuel is widely used, governments have long been required to carefully explore alternate fuels. Because they can be generated locally, biofuels are the best renewable fuel. Vegetable oil is becoming more popular as a source of bio-diesel since it is non-toxic, renewable, biodegradable, and less polluting. Edible biodiesels made from sunflower, canola, peanut, soybean, and coconut oils are used globally. Some of India's edible oil seeds must be tapped in order to produce biodiesel because the nation is not self-sufficient in producing edible oil. Numerous inedible oils, such as sal, neem, rubber, jatropha, karanja ,tamanu, mahua etc. can be served as substitute fuel to diesel .One researcher Investigated the mixing of 10%, 20%, and 30% of candlenut biodiesel with diesel fuel as experimental combinations for engine testing. With increase percentage of biofuel in combinations, Brake Power deminishes, BSFC increases, BTE reduces, EGT increases, hydrocarbon and carbon monoxide significantly reduced with rise in NOx emissions. B10 exhibits similar trends to diesel fuel[1].

Another researcher reported that for candlenut oil (CNO) emissions of carbon monoxide and hydrocarbons are significantly reduced, however nitrogen oxides are elevated in contrast to those from diesel. At 100% engine load, carbon monoxide and hydrocarbon emissions from CNO were each 60% lower compared to diesel, however NOx emissions were 70% higher. [2].Another researched the emission level and the combustion process of biodiesel fuels with the composition of B20 candlenut and High Speed Diesel fuel (HSD). For the emission levels produced, biodiesel fuel B20 has higher NOx emission levels when compared to HSD fuels at 1,000 watts, 2,000 watts, and 3000-watt loads, while at 4,000 watt of biodiesel B20 candlenut produces lower emission of NOx[3]. Candlenut biodiesel blended with cerium oxide nanoparticles tested in VCR engine with no modifications. B20(20% candlenut biodiesel + 25 PPM CeO2 + diesel). B40(40% candlenut biodiesel + 25 PPM CeO2 + diesel). It is concluded that B20 blend shows higher brake thermal efficiency and lower specific fuel consumption than the B40 blend. And B40 blend showed lower emissions than B20 and pure diesel. It is observed that the smoke emitted by B20 blend is higher than the neat diesel and B40 fuel blends. The NOx emissions decreased in the order of B40, B20, and D100[4].Another investigation revealed that blending butanol and diesel with biodiesel reduces Brake Power (24.65–26.35%), HC emissions (52.57–38.71%), CO emissions (39.18–30.4%) and increase in BSFC (38.17–41.14%) and NOx (24.18–8.35%) compared to diesel[5]. Another investigator experimented with blend of soap nut methyl ester and candlenut oil methyl ester all the blends CN10 + 90SN, CN90 + 10SN, CN50 + 50SN reported 6%, 10% and11% higher than neat diesel .The high oxygenated biodiesel and high combustion temperature influence the carbon monoxide emission, hydrocarbon emission and smoke density of biodiesel to a diminished level compared to all other diesel fuel. The increased level of oxygen rich biodiesel influences the emissions of nitrogen of biodiesel to an amplified level compared to the other diesel fuel [6.]Another researcher observed 31.25% reduction in CO in the WSOB5+100 ppm MgO fuel sample,41.6 % reduction in HC in the COB5+100 ppm MgO fuel sample and 36.92% reduction in smoke(soot)in COB5+100 ppm MgOfuel sample.COB5+100 ppm MgO sample shown 2.35% increase in efficiency compared to biodiesel without nanoparticle addition and also observed improvement in in-cylinder temperature and ignition delay and Combustion duration.[7].Another researcher experimented with tamarind seed oil blended with three different oxide nanoparticles of Alumina oxide (Al_2O_3), silicon oxide (SiO_2), and magnesium oxide (MgO) observed that a higher HRR, cylinder pressure were reported as 75 J/deg and 77 bar and a higher BTE of 32 % was recorded at full load conditions for the same D80TSOB20A nano-fuel blend, which is a better BTE value than Diesel. CO, UHC, NOX, and smoke capacity using tamarind seed oil biodiesel with Al_2O_3 nanoparticles gives a lesser value than other fuel blends[8].Another researcher experimented with with blends of neat pongamia biodiesel mixed with varying quantities of (100 ppm,200 ppm) of MgO nanoparticles in a four stroke single cylinder engine reported reduction in NOx, HC, CO and smoke emissions with increase in concentration of MgO[9]. Another researcher investigated the effect of blending Jatropha biodiesel with ZnO, Zno-MgO,TiO_2, and SiO_2 nano particles on physio-chemical properties. it is observed that the calorific value, oxidation stability, dynamic viscosity are improved for Pongamia biodiesel blended with Zn-MgO nanoparticles[10].Another researcher investigated with blends of waste cooking oil methyl ester blends (100%WCO ,20%WCO80%Diesel,30%WCO70%Diesel) mixed with varying quantities(20 ppm, 40 ppm and 50 ppm) of MgO nanoparticles in single cylinder diesel engine. He reported that 30 ppm concentration of MgO nanoparticles showed improvement in cloud point, cold filter plugging point and pour point of the test fuel. It is observed that brake specific fuel consumption of B100W30A, B20W30A and B10W30A and B10W30A fuels were 28.2%,9.48%,2.45% higher than B100, B20 and B10 fuel respectively. The BTE of the B100W30A, B20W30A and B10W30A and B10W30A were 4.57% and 1.17% higher than those of B100,B20,B10 respectively. The MgO nanoparticle blended fuels shown lesser emissions than B100,B20,B10 and diesel[11] Another researcher experimented with waste cooking oil (WCO) biodiesel blends (B20,B40,B60) mixed MgO and CeO2 nanoparticles separately. It is observed that efficiency of blends increased and specific fuel consumption decreased with addition these nanopartciles to different blend [12].As not many investigators focused on blending CME with MgO nanoparticle, in the current study investigates the effect of blending MgO nanoparticles of different quantities(50 ppm,100 ppm) to candlenut oil methyl ester and diesel blend to check for performance and emission characteristics.

II. Material And Methods

In this investigation different chemicals (Methanol, KOH and MgO nanoprticles) chemicals were purchased from local market in Hyderabad, while raw candlenut oil was obtained from a nearer oil provider. Processing is required before candlenut oil may be used as a fuel. One of the techniques is transesterification, in which Candlenut raw oil is chemically converted to methyl esters in the presence of potassium hydroxide (catalyst) and methanol. The procedure produces glycerol as a byproduct. The candlenut oil methyl ester mixed with MgO nanoparticles in varying proportions (50ppm and 100ppm) using magnetic stirrer. TABLE 1 illustrates the CME biodiesel Compositions with MgO (nano particle additive) and diesel. TABLE 2 details CME's characteristics and blend compositions. A comprehensive comparison of the physiochemical parameters of biodiesel to those of diesel was conducted experimentally.

Table 1 Fuel details

S.NO	Candlenut oil	Diesel	MgO nano additive (PPM)
01	20%	80%	--
02	20%	80%	50
03	20%	80%	100

Table 2 Blends and Diesel Properties

S.no	Parameters	Diesel	CME20D80	CME20D80MgO50	CME20D80MgO100
1	Kinematic	2.98	2.69	2.60	2.60

	viscosity CSt @40˚C				
2	Density g/cc @30˚C	0.840	0.833	0.837	0.840
3	Gross calorific Kcal/kg	10,000	9294	9494	9694

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Variable compression ratio research engine

The setup as shown in Fig.1& Fig.2 consists of single cylinder, four stroke, CRDI VCR (Variable Compression Ratio) engine connected to eddy current dynamometer. It is provided with necessary instruments for combustion pressure, crank-angle, airflow, fuel flow, temperatures and load measurements. Rotameters are employed to measure cooling water flow to engine and exhaust calorimeter. A high-speed data collecting device connects these signals to the computer. For on-line performance evaluation "Engine-Soft" software is employed. For engine exhaust measurement, a multi gas analyzer model MN-0 was employed. Table 3 shows the engine specifications.

Fig.1. CRDI VCR Diesel Engine

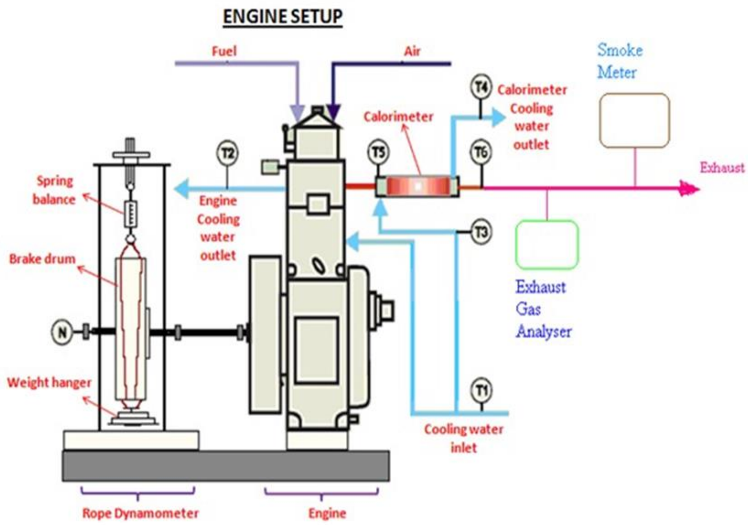

Fig.2 CRI VCR Diesel Engine Test Rig

Engine Specifications

Product	CRDI VCR Engine test (Computerized) Code 244
Make & Type	Make Kirloskar, Single cylinder 4 stroke Diesel
Swept volume (CC)	661
Stroke length (mm)	110
Power	3.5 kilowatts
Engine type	CI Engine (Vertical Type)
C.R.(Compression ratio)	12-18
Rated speed (RPM)	1500
Dynamometer	Type eddy current, water cooled, with loading unit
Load measurement method	Strain Gauge
Maximum load	12-kilogram
Cooling	Water

Experimental analysis

The experiment was conducted with pure diesel and different fuel blend conditions. The diesel was first put into a fuel tank. An 18:1 compression ratio was set for the experimental analysis. After checking all of the electrical connections, the power was turned on. The "Engine-Soft" software suite for on-screen performance assessments was launched. After a stable running condition of the engine with the pure diesel, others fuel strategy and different loading conditions data has been recoded

III. Results And Discussions

From the Experimental setup the engine test had been carried out with compression ratio of 18:1and fuel injection pressure 400 bar for various loads with different blends of candlenut methyl Ester. Therefore, to obtain the performance parameters such as Brake Specific Fuel Consumption (BSFC), Brake thermal efficiency (BTE), along with emission parameters such as Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydro Carbons (HC) and Nitrous Oxide (NO_x).

Brake Thermal Efficiency (BTE)

It is the ratio of brake power of the engine to the fuel's chemical energy. It depends upon the chemical characteristics of the fuel.

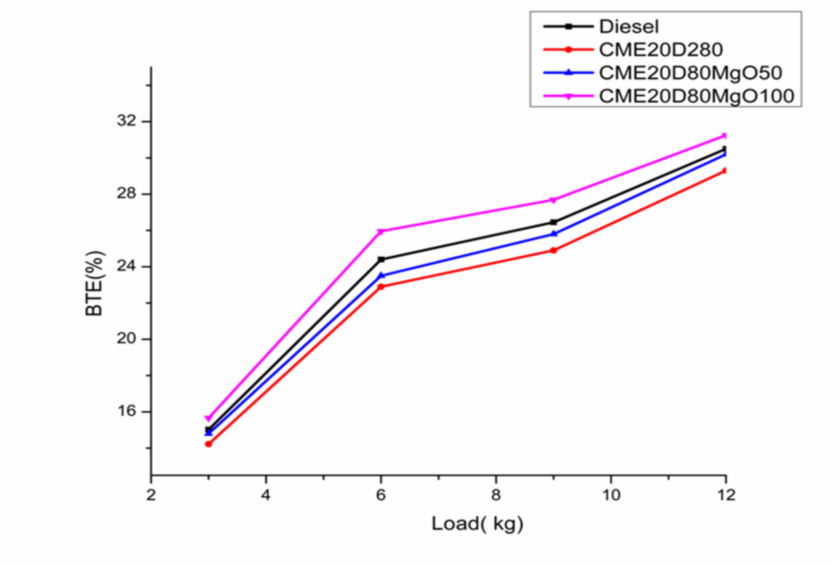

Fig. 3. BrakeThermal Efficiency (BTE) Vs Load

From the Fig.3 it is observed that the BTE of diesel and all test fuels increased along with the load. Candlenut oil methyl ester blend (CME20D80) has less BTE when compared with other test fuels because of higher viscosity, lower heating value and lower volatility in comparison to other blends. At full load, for CME20D80MgO100 blend brake thermal efficiency of engine increased by 6.65% compared to CME20D80 and it is 2.45% higher than pure diesel. As the quantity of MgO nanoparticle added to biodiesel blend increase BTE also increases. The inclusion of magnesium oxide nanoparticle improves oxidation, heat release rate, and in-cylinder pressure, is primarily responsible for the increased BTE. Nanoparticles in biodiesel blends have a larger surface area to volume ratio than CME20D80, allowing for more combustion within the combustion chamber. Similar outcomes were obtained with the presence of nanoparticles in biodiesel blends in other studies [7].

Brake Specific Fuel Consumption (BSFC)

It is the amount of fuel consumed for producing unit brake power generated in unit time. BSFC depends on fuel quality and fuel burning or combustion rate. As the load increases BSFC decreases as seen in Fig.4.The same trend is followed by all test fuels. BSFC is high for candlenut biodiesel blend compared to diesel because of density, low volatility and high viscosity [13]. At full load BSFC of CME20D80mgo100 blend is 7.8% less than CME20D80 and it is 1.66% lesser than pure diesel. With increase in the quantity of nanoparticles in biodiesel blend BSFC decreases. The presence of MgO nanoparticles provides further oxidation and stimulates complete combustion, and hence it results in the reduction of BSFC at a constant speed. This was mainly because of the higher oxygen content in magnesium oxide nano additives, which promotes further combustion and decreases the combustion chamber's fuel-rich region.

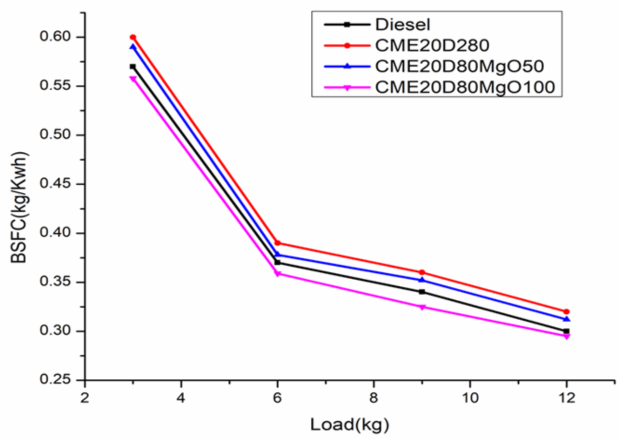

Fig.4.Brake specific fuel consumption (BSFC) Vs Load

Hydro Carbon (HC) emission

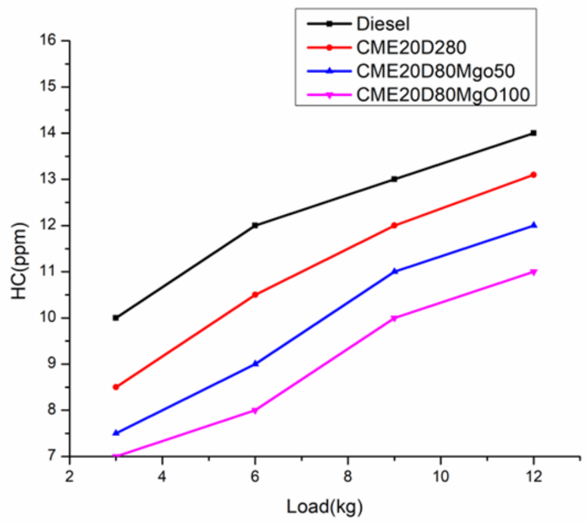

Fig.5 Hydro Carbon (HC) Vs Load

It is seen from Fig.5 that unburnt hydrocarbon emissions of all test fuels increase with increase in load [14].which is due to flow of rich mixtures in to the engine at higher loads. Candlenut biodiesel blend produces low hydrocarbon emission when compared to diesel at all loads because of high combustion efficiency due to higher oxygen content. At full load condition 21.4% and 16.1% reduction in HC emission is observed for CMEB20D80100 compared to diesel, CMEB20D80.With the availability of higher oxygen content in the fuel, unburnt hydrocarbon remained in the exhaust gases mixes with oxygen in the fresh charge to form CO_2.It is also observed that as the MgO quantity is increased in the fuel the HC emission is also decreased. MgO nanoparticles added to the biodiesel blends act as catalysts which enhance the reactivity in the fuel, which in turn promotes complete combustion and reduces hydrocarbon emission.[14]

Carbon monoxide (CO) emission

Figure 6 depicts that carbon monoxide emissions for all test fuels initially decreased from higher values at lower loads to minimum values at medium loads and then rose with higher loads. It is observed that carbon monoxide emission for biodiesel is less than diesel at all loads because of better combustion, which is primarily due to the availability of oxygen within the fuel. At full load condition 18.7%, a 12.3% reduction in CO emission is observed for CMEB20D80MgO100 compared to diesel, CMEB20D80. Carbon monoxide emission for biodiesel blended with MgO nanoparticle is decreased with an increase in nanoparticle quantity because of proper combustion and improvement in fuel characterization. Proper combustion occurs with the availability of oxygen in the MgO nanoparticle, which promotes further oxidation.

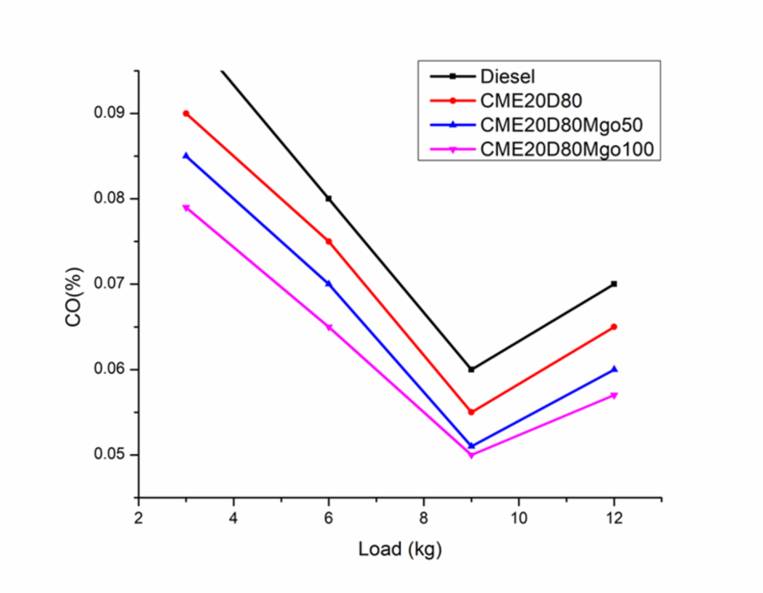

Fig.7 Carbon Monoxide (CO) Vs Load

Carbon Dioxide (CO_2) Emission

Fig.7 depicts that carbon dioxide increased with an increase in the load for all test fuels because of complete combustion. For neat diesel, CO_2 emissions are less than all other blends. CO_2 emissions are high for biodiesel blends as they are oxygenated fuels. At full load, there is a 11.3% and 8.8% increase in CO_2emissions for CMEB20D80mgo100 compared to diesel, CMEB20D80. It is also seen that carbon dioxide emissions increased with an increase in the percentage of nanoparticle addition. The addition of nanoparticles promotes complete combustion of fuel, which leads to more CO_2 emissions.

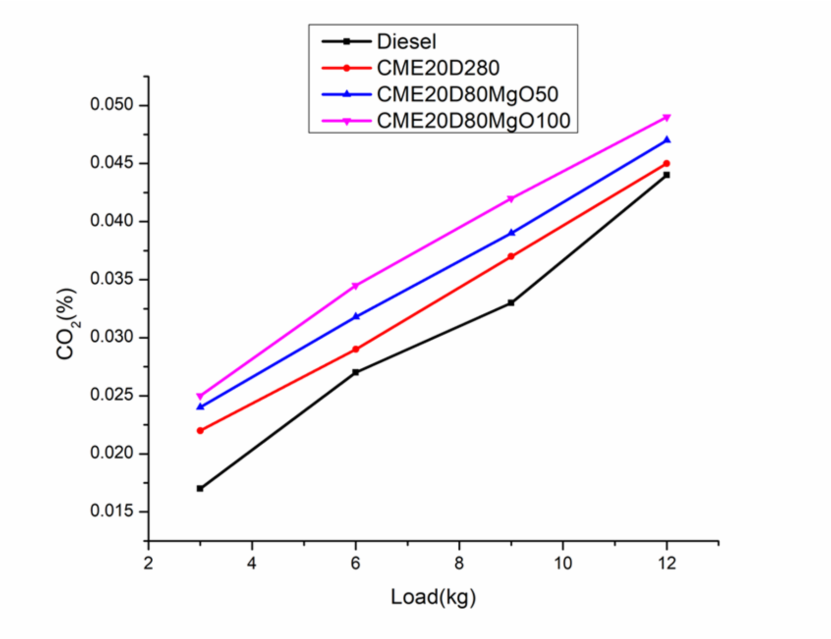

Fig.7 Carbon Dioxide (CO2) Vs Load

Nitrous Oxide (NOx) Emission

NOx formation is affected by adiabatic flame temperature as a result of fuel combustion. A fuel with a higher heat release rate in the premix combustion phase and a lower heat release rate in the late combustion phase increases NOx emissions. Fig.8 depicts the rise of NOx emissions with the rise of load because of high pressure and temperature in the cylinder at higher loads. When the results obtained from the experimental data are examined, it is seen that the lowest NOx emission values are in diesel fuel in all load conditions. It is observed that for biodiesel blends, NOx emissions increased because of their oxygen content. High oxygen leads to high temperatures during combustion in the cylinder [7].Elevated temperatures causes formation of NOx in the cylinder.At full load condition, 2.96% and 7.75% reduction in NOx emissions is observed for CMEB20D80mg100 compared to diesel, CMEB20D80. Results also show that NOx emissions decrease with an increase in the quantity of nanoparticle addition. Reduction in NOx emissions for CMEB20D80mgO100 is because the addition of nanoparticles in the biodiesel blend promotes combustion at lower temperatures, which is increased reactivity in nature of fuel, which in turn is improved because of the catalytic nature of MgO nanoparticles, and heat transfer capability is improved as they have a larger surface area to volume ratio than CME20D80.

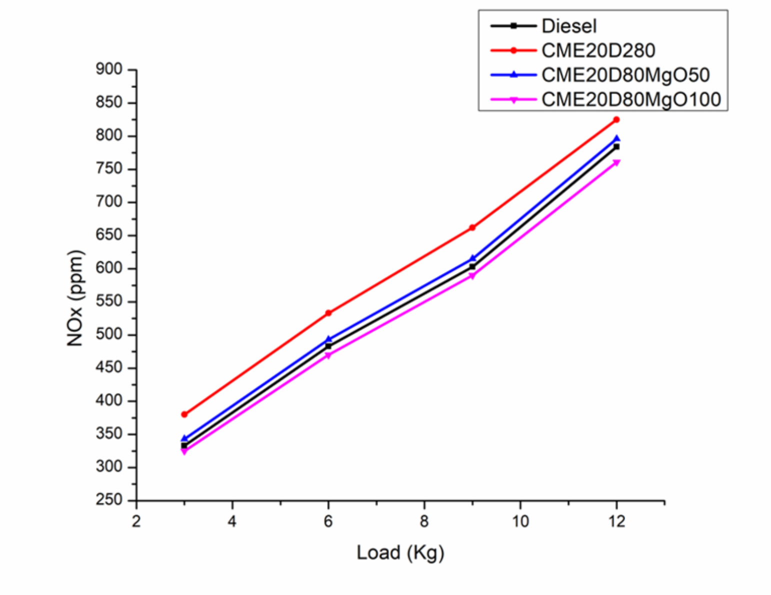

Fig.8 Nitrous oxide (NOx) Vs Load

IV. Conclusions

Based on the results of this work, the following specific conclusions were drawn:

- The brake specific fuel consumption decreased and brake thermal efficiency increased with increase in the proportion of MgO nano Particles in Biodiesel. A reverse trend was observed with increase in Engine Load.
- The amount of CO, HC and NOx in exhaust emission reduced with increase in percentage of MgO Nano particles in CME Biodiesel. However, the level of Emissions increased with increase in Engine load for all fuels tested except CO.
- The emission parameters for different biodiesel blend were better compared with diesel.
- From these findings, it is concluded that CME biodiesel could be safely blended with diesel without significantly affecting the engine performance (BSFC, VE, BTE, Indicated Brake Thermal Efficiency and Mechanical Efficiency) and Emissions (HC, CO, NOx, CO_2) and thus could be a suitable alternative fuel for Diesel Engines.

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