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EXPERIMENTAL EMISSION ANALYSIS OF DI DIESEL ENGINE USING NEEM OIL METHYL ESTER AND ITS DIESEL BLENDS

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ABSTRACT

The raising of fossil fuel consumption due to rapid improvement in quality of human life-style, the deterioration of fossil fuel reserves and increased unwanted exhaust emissions caused in search for alternative renewable energy resources. In the recent days, the vegetable oil based biodiesel became a prominent and most promised viable source of alternative fuel, because of not only its nearer chemical characteristics to diesel, but also it is more environmental friendly than fossil fuel. The objective of the present research investigation is to evaluate the emission characteristics of a direct injection (DI) diesel engine when fuelled with methyl ester of neen oil (NOME) and its diesel blends. The experimental evaluation was carried out using a single cylinder, 4-stroke, water cooled diesel engine fuelled with neat neem oil biodiesel and its blends with diesel fuel at different ratios of 20:80, 40:60, 60:40, 80:20 and 100:0 on volume basis. The results revealed that neem oil and all its blends have lower CO emission, NOx emissions, but has highest unburned HC emissions than fossil diesel fuel. The B100 blend of NOME has lowest CO and NOx emission and B20 blend has lowest unburned HC emissions when compared with all other tested NOME biodiesel blends. It was also observed that the neem oil biodiesel is more eco-friendly than fossil diesel fuel.

KEYWORDS: Biodiesel, Transesterification, Neem Oil, Methyl Ester, Engine Emissions.

I. INTRODUCTION

The global usage of fossil fuel has immensely increased for a variety of reasons, which include population increase, enhanced quality of life, industrialization, rapid growth in nations' economic especially developing countries, increased transportation of people and goods [1-3]. All fossil fuels are nonrenewable, and moreover profoundly located in specific locations of the world especially in middle-eastern countries, they will become expensive. The huge gap between demand and supply, the limited in available quantities and are expected to be close to depletion in the near future and new technological innovations in automotive industry lead to find and usage of alternative renewable energy sources in order to overcome the problems in energy sector. In addition, the energy extraction from the fossil fuels requires combustion, thus damaging the environment with air pollutants and greenhouse gas emissions. In order to sustain the future energy demand of the world with a clean and green environment, renewable energy is the evident alternative option undoubtedly. The benefits of alternative renewable energy sources include the following:

1. Eco-friendly with less toxic emissions
2. Independent of location, unlike fossil fuel reserves
4. No cause for global warming
5. Renewable and Non-depletive in nature
6. Stabilization of energy costs
7. Economically feasible
8. Creation of new jobs in rural area, so it improves the economy of rural areas [4]

At present, the edible oils are most widely used in the preparation of biodiesels and have a remarkable contribution in the preparation of alternative fuels. The edible oils like sunflower, soybean, rapeseed and palm are used as main feed-stocks of biodiesel throughout the world. Several countries including USA, Australia, Canada, Germany, and Malaysia have already using plant based biodiesels as a substitute to the conventional diesel [5-7].The edible oils usage as feed-stock of biodiesel has raised the concerned on hike of food-item

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prices and shifted the research efforts on non-edible oils such as jatropha curcas pongamia, mahua oil, Mustard oil, Linseed oil etc. These oils are poisonous and toxic chemical compounds and moreover they could grow in the uncultivable waste lands [8]. Huzayin et al. were conducted experimental analysis on emission and performance characteristics using Blends of jojoba oil with gas oil and their experimental results shown that slightly reduced engine power, trivial raise in brake specific fuel consumption (BSFC), reduction in NOx and soot emission using blends of jojoba oil with gas oil as compared to gas oil [9]. Shasidharan et al. have conducted experimental tests to evaluate the engine characteristics of a single cylinder, direct injection diesel engine using methyl ester of sunflower oil and castor oil and revealed that the thermal efficiency of methyl ester of sunflower oil and castor oil were comparable with diesel. Further, they revealed that the esters of sunflower oil were found to be better than ester of castor oil. It was also noticed 25% of less smoke emissions for both the methyl esters than diesel fuel [10]. Bhaskar S.V., conducted series of experimental tests using jatropha curcas oil methyl ester as fuel and experimental results revealed that B20J biodiesel blend has comparable brake thermal efficiency to that diesel fuel and the lowest BSFC, BSEC with less exhaust emissions [11]. Gupta et al. were conducted experimental tests on diesel engine using methyl ester mahua oil and fish oil and revealed that the tested biodiesels have lower HC, CO and PM emissions in comparison to diesel fuel [12].

II. MATERIALS AND METHODS

Biodiesel Preparation and Its Chemical Properties

The crude neem oil was transformed into its methyl ester by using the transesterification process. This process involves making the triglycerides of neem oil to react with methyl/ethyl alcohol in the presence of catalyst (NaOH/KOH) to produce glycerol and fatty acid ester. After completion of Transesterification process, two layers will be formed. The bottom layer consists of glycerol and top layer is the methyl ester of neem oil (NOME). The figure 1 below shows the Transesterification reaction used in production of biodiesel which is called methyl ester of neem oil (NOME). The chemical properties of diesel fuel and neem oil methyl ester (NOME) were assessed and are presented in Table 1.

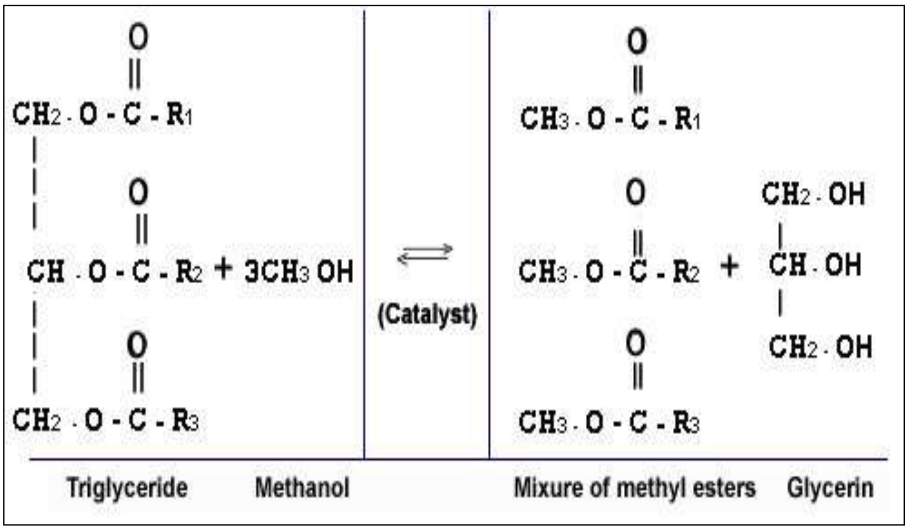

Figure 1: Transesterification Process

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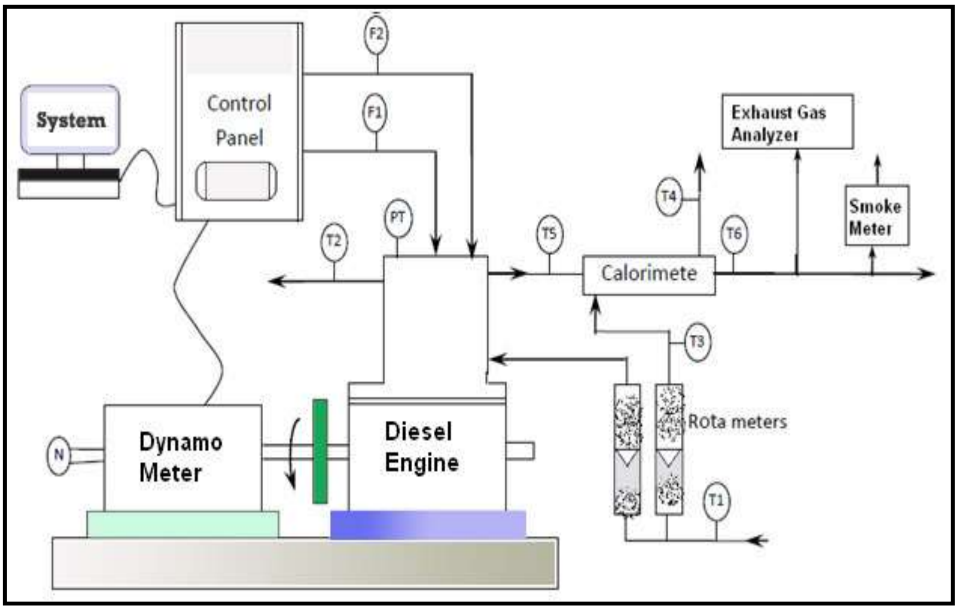
Table 1. Fuel Properties of Diesel and Biodiesel

Property	Diesel	NOME
Kinematic Viscosity at 40^0 C (Cst)	3.58	4.5
Density at 15^0 C (Kg/m^3)	830	870
Flash Point (^{0}C)	51	175
Cetane Number	50	53
Calorific Value (KJ/kg)	42000	41500
Total Sulphur (% by mass)	0.01	Nil

Experimental Setup

The experimental evaluation was carried-out using a single cylinder, 4-stroke, water-cooled, direct injection (DI) diesel engine fueled with diesel and blends of NOME biodiesel. The schematic diagram of test engine's setup is shown in figure 2. The neem oil methyl ester and its diesel blends in the ratio of 20:80, 40:60, 60:40, and 100:0 with diesel fuel were used as fuel in the test engine. The test engine was initially started with diesel and then continued with methyl ester of neem oil and its blends. After engine has reached the stabilized working condition at constant speed of 1500 rpm, time for 10ml of fuel consumption was recorded for each applied load for diesel and each biodiesel blend in order to calculate the performance characteristics of DI diesel engine. The specifications of the test engine are given in Table 2.



T1	Inlet water temparature	PT	Pressure transducer
T2	Outlet engine jacket water temp	F1	Air intake differential pressure unit
T3	Inlet water temparatue	F2	Fuel Flow differential pressure unit
T4	Outlet cal. water temparature	T6	Exhaust gas temparatue after Cal
T5	Exhaust gas temparatue before Cal		

Figure 2: Schematic Diagram of Test Setup

Table 2. Specifications of Test Engine

Engine Make	Kirloskar AV1, India
Engine Details	Single Cylinder, Four stroke, Water cooled
Injection Type	Direct Injection
Bore & Stroke	80 × 110 mm
Rated Power	3.7 KW (5 HP) at 1500 rpm
Speed	1500 rpm
Injection Pressure	200 bar
Compression Ratio	16.5:1
Dynamometer	Eddy Current

III. RESULTS AND DISCUSSION

The effect of neem oil methyl ester and its diesel blends on engine emission characteristics of single cylinder, DI diesel engine was evaluated in terms of CO emission, particulate matter (PM) and NOx emission. The test results and discussion was presented in below paragraphs.

CO Emission

The variation of CO emission of a DI diesel engine with engine load for diesel and neem oil methyl ester (NOME) blends at constant engine rated speed of 1500 rpm was presented in Figure 3. The graph in figure shows that 100% NOME has lower CO emission values among all blends of tested biodiesel and diesel fuel and the highest CO emission by fossil diesel fuel. The carbon monoxide emissions were decreased with the increase of percentage of NOME in biodiesel blend and increased CO emission with reference to increase in engine load. It was also noticed that CO emission from neat NOME biodiesel is less than the emission of diesel and lowest among all tested fuels.

Emission of Hydrocarbon

Figure 5 shows variation of unburned hydrocarbons (HC) with reference to engine load of a single cylinder, DI diesel engine when NOME biodiesel and its blends used as fuel. The emissions of unburnt hydrocarbon of diesel engine is low when compared with NOME biodiesel and its diesel blends. The higher temperature of burnt gases in combustion chamber when NOME biodiesel used as fuel helps in preventing condensation of higher hydrocarbon reducing unburnt HC [13]. The test results revealed that the HC emissions are higher with B100% as compared to diesel fuel and it is decreasing with the increase of NOME percentage in the biodiesel blend. The major reason for the formation of hydrocarbons is the incomplete combustion and the effects of higher viscosity of biodiesel fuel and density on the fuel spray quality could be expected to produce higher HC emissions with methyl esters [14]. It was noticed that B20N blend of NOME has highest unburned HC emission and B100N has lowest among all the tested biodiesel blends.

NOx Emission

Figure 6 presents the variation of oxides of nitrogen emission (NOx) with engine load for different blends of neem oil methyl ester (NOME) biodiesel and diesel fuel. Similar to other exhaust emissions of the tested diesel engine, it was observed that NOx emission increased with the increase in the engine load for all tested fuels at constant engine speed of 1500 rpm and at rated injection pressure. It was observed that an increase of oxides of nitrogen with increase in percentage of NOME biodiesel in the tested blend. At part load conditions the variation of NOx emission of biodiesel and diesel are slightly discernible, but at medium and full load conditions NOx emission of NOME are significantly distinct and B100 blend of NOME biodiesel has higher NOx values than diesel fuel and their other blends. The NOx emission for every 20% addition of NOME blend in the biodiesel was affected and decreased gradually with the increase of NOME percentage in the biodiesel blend. The B100N blend of NOME has the lowest NOx among all the tested blends of NOME biodiesel and diesel fuel and B20N has the highest in among biodiesel blends and after diesel fuel.

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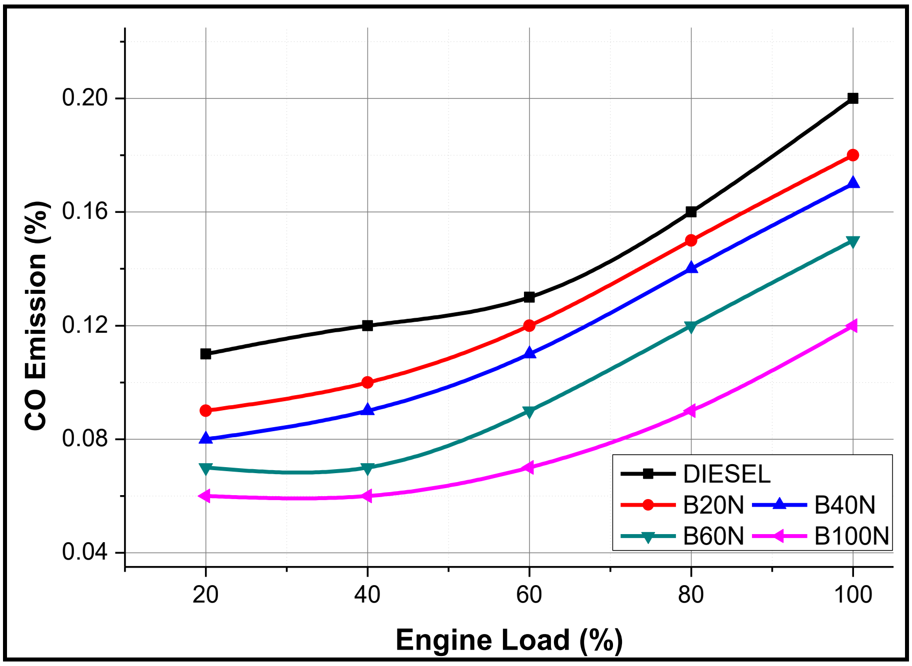

Figure 4: Variation of CO emission with engine load for different test fuels

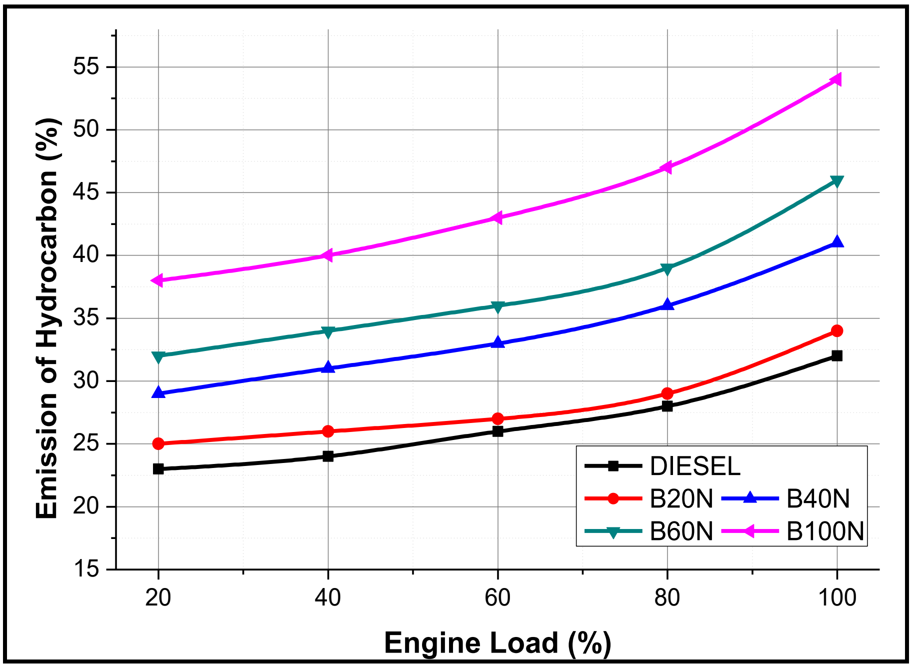

Figure 5: Variation of emission of Hydrocarbon with engine load for different test fuels

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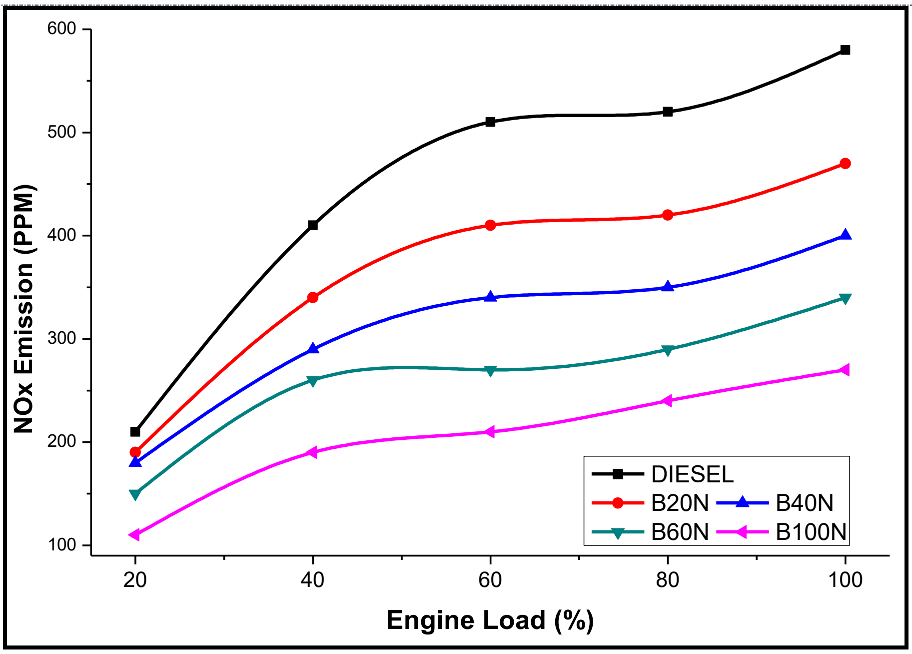

Figure 6: Variation of NOx emission with engine load for different test fuels

IV. CONCLUSION

The experimental results of the present research work that was carried-out using a single cylinder, four stroke, water cooled diesel engine fuelled with different blends (B20N, B40N, B60N, B80N and B100N) of neem oil methyl ester (biodiesel) at different engine load condition revealed that the engine has lowest CO and NOx with neem oil biodiesel when compared with diesel fuel, but higher unburned HC emissions than diesel fuel. All emission characteristics were increased with the increase of load at constant engine rated speed of 1500 rpm. The neat NOME biodiesel has lowest CO and NOx emissions but highest unburned HC emissions than diesel fuel. The test results substantiate that biodiesel prepared from neem oil can be directly used in diesel engine, because it is more environmentally friendly in nature than diesel fuel. It was also observed that when proportion of neem oil methyl ester (NOME) in the biodiesel increased, the engine emissions were decreased.

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