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Characterization of a Diesel Engine Fueled with Neem oil Methyl Ester and Dimethyl Carbonate

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Abstract:- **In the present work Neem oil is used as a hotspot for biodiesel generation by means of base catalyzed transesterification and biodiesel created all the while is joined with an added substance (Dimethyl Carbonate) in shifting volume extents to make a bit of test energizes for engine application. Analyses were run out on a diesel motor under differing loading condition to examine around the performance and emission qualities of the motor fuelled with the present test fuels. The aftereffects of examination show an increment in brake power and brake warm effectiveness with burden for all test powers. It is likewise noted that the brake warm effectiveness picks up with the rate of added substances in the test bombs. The brake particular fuel utilization diminishes with increment in added substance rate in the test bombs. The exhaust gas temperature increments practically directly with burden for all test powers and abatements with an increment in added substance rate in the fuel. Results demonstrate that the CO and HC outflows have a tendency to decrease with the increment in the added substance rate in biodiesel. The smoke and NOx outflows additionally diminish with increment in added substance rate in the biodiesel fuel.**

Index Terms— Neem oil, Biodiesel, Additive, Performance, Emission

1. INTRODUCTION

Because of the abundance utilization of the petroleum based fuels for industry and auto application in present time, the world will be confronting extreme issues like worldwide vitality emergency, natural contamination and worldwide warming. In this way, worldwide awareness has taken up to develop to keep the fuel emergency by delivering option fuel hotspots for motor application. Numerous exploration projects are coming to supplant diesel fuel with an attractive option fuel like biodiesel. Non-consumable sources like Mahua oil, Karanja oil, Neem oil, Jatropha oil, Simarouba oil and so forth are being examined for biodiesel generation. Unsaturated fats like stars, palmitic, oleic, linoleic and linolenic corrosive are regularly situated up in non-palatable oils [1]. Vegetable oils mixed with diesel in different extents has been tentatively demonstrated by a number of analysts in different states. In creating nations like India, it is effectively conceivable to get these non-eatable vegetable oils, yet not monetarily feasible to persuade them to methyl esters experiencing diverse sorts of concoction methodology [2], [3]. In this manner, preheated oils mixed with diesel are utilized and tried as option fills in motors. This report reports the discoveries of tests directed on a diesel motor to examine about its operation and emanation parameters with various test energizes readied from Neem biodiesel and an added substance (Dimethyl carbonate). The plan of utilizing an added substance as a part of a mixed structure with biodiesel is to improve the ignition and bring down the motor fumes outflows.

Transesterification is a reversible response in the middle of triglyceride and liquor in the heading of an impetus to create glycerol and mono alkyl ester which is known as biodiesel [2]-[4]. The weightiness of the mono alkyl ester is one third of that of regular oil and hence conveys a lower consistent. Antacid (NaOH, KOH), corrosive (H2SO4, HCL) or catalysts (lipase) catalyzed response. Corrosive catalyzed transesterification is most normally utilized procedure on the grounds that it is a reversible response. In the transesterification process methanol and ethanol are more regular. Methyl liquor is all the most broadly utilized because of its ease and physiochemical favorable circumstances with triglycerides and antacid are broken down in it [5]. Reviews have been done on diverse oils like soybean, Sunflower, Jathropa, Neem, Neem, and so on. Basically biodiesel is delivered by a base catalyzed transesterification procedure of vegetable oil and it is cheaper. Here the method is a response of triglyceride with liquor to structure mono alkyl ester regularly referred to as biodiesel and glycerol as by item. The essential driver for doing titration to biodiesel is to recoup out the sum soluble expected to totally kill any free unsaturated fat present, accordingly safeguarding a complete transesterification [3], [4].

2. MATERIALS AND METHODS

2.1Materials

2.1.1Neem tree

Neem (Azadiractha indica), local to India, fits in with the mahogany gang. It is an evergreen plant with a life compass of more than 200 years. It is become in semiarid also subhumid areas [6]. Neem is likewise become in

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tropical and subtropical atmospheres and gets by at yearly mean temperature of 21–32 °c. The plant does well in territories of yearly precipitation beneath 400 mm. Neem endures temperatures as high as 48 °c with amazingly dry conditions [7]. The plant can't, on the other hand, make due under solidifying conditions especially, in the early phases of development. Neem becomes on very nearly numerous sorts of soils including mud, saline and antacid soils with ph of 8.5. It can be become specifically by sowing the seed/s or by transplanting nursery raised seedlings with little care. Neem is not agreeable to domesticated animals and in this way not expended. The plant is additionally less influenced via maladies and nuisances [6]. Neem trees begin bearing harvestable seeds inside 3–5 years. Full creation can be attained to in 10 years and can proceed up to 150–200 years. Averagely, an experienced neem plant can deliver 30–50 kg of soil grown foods.

2.1.1 Neem seed oil as source

Neem plant can create numerous hundreds and a large number of blooms. In one blossoming season, a developed plant can deliver an extensive number of seeds. Neem seeds can yield 40–60% oil. Considering the traditionalist level of oil substance of 30% every seed, yearly neem oil creation could be dependent upon 30,000 tons. For most extreme oil generation, the dampness of the seeds is kept at a low sum. To guarantee nonstop seeds accessibility, the capacity of the seeds is imperative since their accessibility is occasional. Free fatty acid composition of neem sed oil is depicted in Table 1.

Table 1 Free fatty acid composition of Neem oil

Fatty acid	Structure	Neem oil
Myristic acid	C14:0	0.26
Palmitic acid	C16:0	14.8
Palmitoleic acid	C16:1	0.1
Stearic acid	C18:0	20.6
Oleic acid	C18:1	43.8
Linoleic acid	C18:2	17.8
Linolenic acid	C18:3	0.5

2.1.1 Dimethyl carbonate

Dimethyl carbonate is a natural compound with the equation OC(OCH3)2. It is a dismal, combustible fluid. It is named a carbonate ester. This compound has discovered utilization as methylating specialist and all the more as a dissolvable that is absolved from grouping as an unpredictable natural compound in US. Dimethyl carbonate (DMC) is frequently thought to be a green reagent [8].

Table 2 Characteristic properties of DMC

Quantity	Value
Molar gas constant	8.314 KgJ/mol K
Moalr mass	90.07 g.mol
Critical temperature	557 K
Critical pressure	4908.8 kPa
Critical density	4.0 dm^{-3}
Triple point temperature	277.06 K
Triple point pressure	2.2 kPa
Vapor density at the triple point	$9.68*10^{-4}$ mol dm^{-3}
Liquid density at the triple point	12.111 mol dm^{-3}
Normal-boiling-point temperature	363.25 K
Vapor density at the normal boiling point	0.035 mol dm^{-3}
Liquid density at the normal boiling point	10.813 mol dm^{-3}

2.2 Methodology

One liter of neat Neem oil is heated in an open beaker to a temperature of 100-110 0C to remove water particles present in oil followed by filtration of oil. The petroleum is processed under base catalyzed transesterification method where it is mixed with 200 cc of methanol and 6.5 grammes of sodium hydroxide pellets in a round bottom flask on a hot plate magnetic stirring arrangement for 1-1.5 hours up to 60 0C and then it is earmarked to sink down for approximately 6-8 hours to obtain biodiesel and glycerin. The biodiesel obtained in the process is further washed with distilled water for 2 to 3 times for the removal of acids and heated above 100 0C to separate the moisture present in the biodiesel. Hence, pure neem biodiesel is obtained.

2.3 Provision of test fuel blends

Various test fuel blends were made by blending Neem biodiesel with additive in various volume proportions. In the present work B15, B10, B 05, B100 and the diesel fuel are used as the test fuels where B15 represent 85% biodiesel and 15% additive. Similarly B10 and B 05 represents 90% biodiesel with 10% additive and 95% biodiesel with 5% additive respectively. B100 represents pure biodiesel without additive.

2.3 Physico-chemical characteristics of Neem oil

2.1.1 Kinematic viscosity

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Kinematic viscosity is a measurement of a fluids thickness over time. For biodiesel, the viscosity is an important factor when it comes to the performance of fuel in engine.ASTM D445 is the preferred method of measuring viscosity. The acceptable viscosity range of biodiesel according to ASTM D 6751 is betwen 1.9 and 6.0 mm2 [9-12].

2.1.2 Flash point

In termas of shipping and saftey regulations, the flash point is generally used to define the flammable or combustible properties of biodiesel. It varies with fluid volatility. Biodiesel is calssified as non-flammable if the flash point is above 130 0C as specified in ASTM D6751 regulation indicating ASTM method D93. [10-12]

2.1.3 Carbon residue

This test gives a measure of the tendency of a fuel to produce carbon deposits. The result depends upon the specific test conditions. High carbon residue shows an indication of excess glycerol in the biodiesel sample. The referee test for detecting carbon is ASTM D 4530. ASTM D6751 permits a maximum of 0.05 % (by mass) carbon residue in biodiesel sample.

2.1.4 Cloud point and pour point

Cloud point is the temperature at which crystallization of small crystals starts, when the fuel cools. The pour point is the lowest temperature at which the fuel becomes semi-solid and loses its flow characteristics. The pour point is always beneath the cloud point. ASTM D2500 and D97 are utilized for measurement of cloud point and pour point [9-13].

2.1.4 Calorific value

Calorific value is an important property, which represents the amount of heat transferred to the chamber during combustion and indicates the available energy in the fuel. The referee test method for CV detection in biodiesel is ASTM D 240, using a bob calorimeter [9-12].

Table 3 Properties of Neem oil and Neem oil methyl ester (NOME)

Properties	**Diesel**	**Neem Oil**	**NOME**
Density (kg/m^3)	846.3	913.2	874
Kinematic Viscosity a 40 ^{0}C	3.64	37.3	4.11
Acid Value(mg KOH gm)	0.35	9	0.34
FFA (mg of KOH gm)	0.175	5.4	0.502
Pour point ^{0}C	-15	28.6	4
Flash point ^{0}C	55	261	173
Fire point ^{0}C	74	283	191
Calorificvalue (MJ/Kg)	42.72	37.54	38.36
Cetane Index	48.3	41.6	53.7
Carbon (%, w/w)	81.33	78.31	N/d
Hydrogen (%, w/w)	12.78	11.02	N/d
Nitrogen (%, w/w)	1.97	NIL	NIL
Oxygen (%, w/w)	1.21	10.67	N/d
Sulphur (%, w/w)	0.2	0.002	NIL
Moisture (%, w/w)	0.05	0.100	0.089
Ash content (%, w/w)	0.01	-	N/d

2.4 Test setup

The test bed consists of a four stroke, single cylinder direct injection water cooled diesel engine equipped with eddy current dynamometer, orifice meter in conjunction with U-tube manometer measuring volume flow rate of air, graduate burette for volume flow rate of fuel in (cc) and measuring jar for measuring cooling water flow rate. The detailed engine specifications are tabulated in Table 4. The prepared bio-diesel is poured into the cylindrical tank. Then the level of fuel and lubricating oil is controlled. The 3-way cock is opened so that the fuel flows to the locomotive. Cooling water is furnished through the intake tube. The locomotive is then started with the supply of the fuel [14]. The hurrying of the engine is held constant at 1500 RPM under varying load conditions and performance parameters like brake power, torque, brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature were measured for diesel and all test fails. CO, HC, CO2 and NOx emissions were too evaluated for both diesel and all test files with the aid of a multi gas analyzer.

Table 4 Specification of Test Engine

Make	Prakash Diesel Pvt.
Rated horse power (HP)	14
No. of cylinders	2
No. of strokes	4
Rotation per minute (rpm)	1500
Compression ratio	16:1
Stroke length (mm)	110
Bore diameter (mm)	114
Injection pressure (bar)	220

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3. RESULT AND DISCUSSION

3.1Brake thermal efficiency

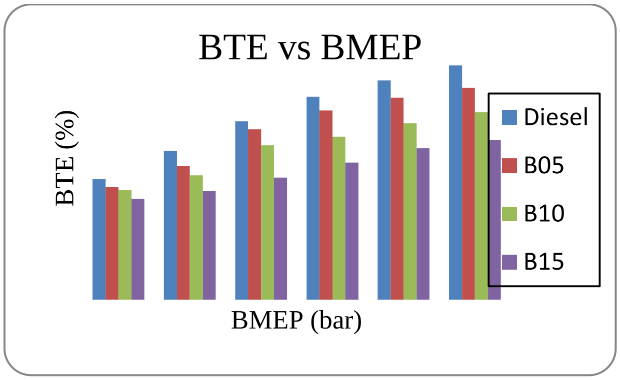

Fig. 1 BTE with respect to BMEP

Figure 1 demonstrates that the brake thermal efficiency for all test fuels increase with load and is higher for test fuels having more additive percentage. BTE is found lower for pure biodiesel due to its higher viscosity and lower calorific value [1]. Addition of additive (DMC) to the test fuel reduces brake thermal efficiency which may be attributed because of insufficient oxygen for the complete combustion of fuel.

3.2 Brake specific fuel consumption

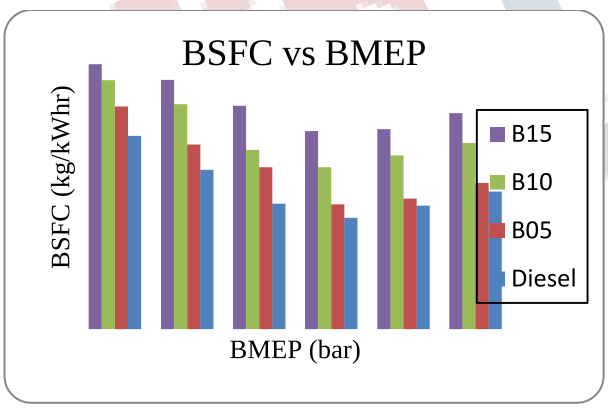

Fig. 2 BSFC with respect to BMEP

From Figure 2 it is observed that diesel has lower BSFC where as pure biodiesel exhibits highest BSFC at all loads which is due to higher density and viscosity and lower heating value of biodiesel. Results also show that BSFC reduces as the percentage of additive increase in the fuel[6]. This may be due to better combustion with increased additive percentage. Addition of additive (DMC) to the test fuel reduces brake specific fuel consumption, which may be attributed because complete combustion and higher flame velocity relatively at a higher charge temperature.

3.3 Carbon monoxide emission

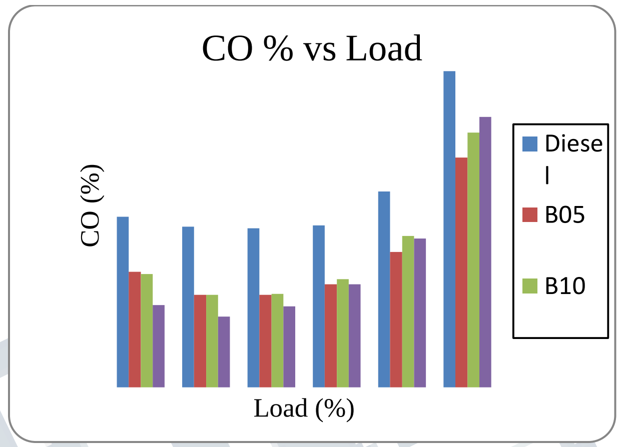

Fig. 3 CO with respect to load

The CO emission depends solely depends upon the persuasiveness of the mixture, availability of oxygen and viscosity of fuel. From Figure 3 it is noted that the CO emission initially decreases at lower loads sharply increases after 80% load for all test fails. This is due to incomplete combustion at very high loads which results in higher CO emissions. CO emission is found higher in diesel and lowest for pure biodiesel at all lots. It is also determined that the CO emission decreases with increase in percentage of additives in the blends[9]. From the chassis, it is revealed that B100 shows lowest carbon monoxide emission compared to all other test fuels up to 80% load and then increases due to incomplete burning.

3.4 Hydrocarbon emission

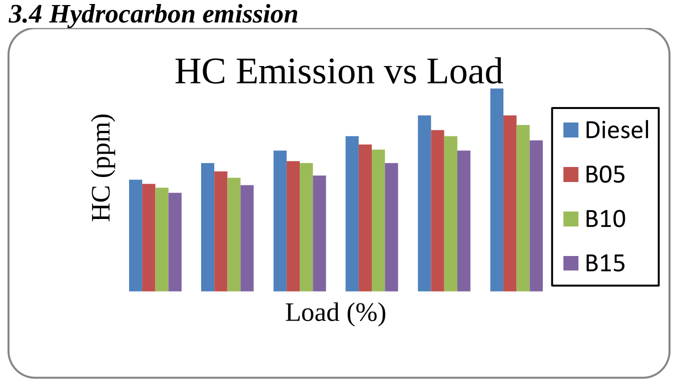

Fig. 4 HC with respect to load

The HC emission solely depends upon the strength of the mixture, availability of oxygen and viscosity of fuel. Figure 4 shows that the HC emission increases with load for all test fuels. Besides the increase in HC emission is sharp above 80% load. This is again due to incomplete combustion at very high loads which causes higher HC emissions[10]. It is also considered that the HC emission decreases with an increase in the additive percentage in biodiesel. B15 shows lowest HC emission at 80% load and then increases due to incomplete burning.

3.5 Smoke opacity emission

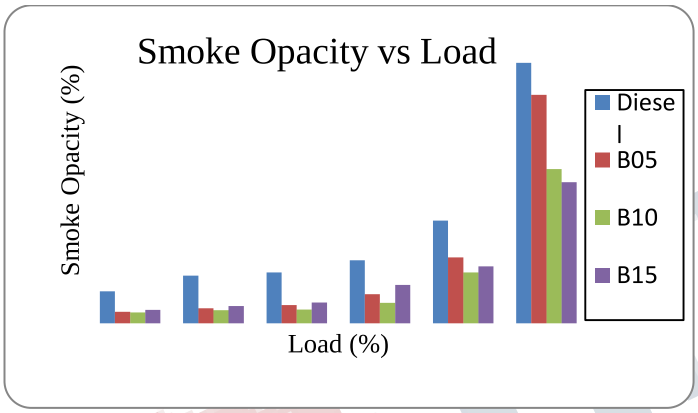

Fig. 5 Smoke opacity with respect to load

From Figure 5 it is noticed that the smoke opacity for all test fuels almost linearly increases up to 80% load and then increases very sharply, which is due to incomplete combustion and lack of oxygen at very high loads. Highest smoke emission is observed for pure biodiesel and lowest for diesel which is because of the lower heating value and higher viscosity of biodiesel. It is also determined that smoke emission decreases with increase in additive percentage in the biodiesel. B15 shows low smoke emission compared to other test fuels up to 80% load and then increases due to incomplete combustion and deficiency in oxygen at higher loads.

4. CONCLUSION

From the present experimental investigation the following conclusions are made.

- The brake thermal efficiency increases with the growth in the additive percentage in biodiesel and it is lower in case of pure biodiesel.
- Brake specific fuel consumption is higher for pure biodiesel and decreases with an addition in the additive percentage in biodiesel.
- Exhaust gas temperature is found highest for pure biodiesel and tends to diminish with the increase in the additive percentage in biodiesel.
- CO and HC emission are found highest for diesel and reduction with an increase in the additive percentage in biodiesel.
- Smoke emission is found highest for pure biodiesel and decrease with an increase in the additive percentage in biodiesel.

NOMENCLATURE

NaOH	Sodium hydroxide
KOH	Potassium hydroxide
HCL	Hydrocloric acid
H2SO4	Sulfuric acid
DMC	Dimethyl carbonate
NOME	Neem oil methyl ester
B05	5% DMC + 95% biodiesel
B10	10% DMC + 90% biodiesel
B15	15% DMC + 85% biodiesel
BTE	Brake thermal efficiency
BSFC	Brake specific fuel consumption
CO	Carbon monoxide
HC	Hydrocarbon
ASTM	American Society for Testing and Materials

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