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Experimental Investigation on Combustion, Performance and Emission Characteristics of Neem Oil Bio-Diesel in Four Stroke Single Cylinder Diesel Engine

Balamurugan M[1]
[1]*Assistant Professor, Departmentof Mechanical Engineering, GCE Bodinayakanur, Tamilnadu, India*

Abstract: ***Biodiesel as one promising alternative to fossil fuel for diesel engines has become increasingly important due to environmental consequences of petroleum-fuelled diesel engines and the decreasing petroleum resources. Biodiesel refers to a family of products made from vegetable oil or animal fats and alcohol, such as methanol or ethanol, called mono alkyl esters of fatty acids. Biodiesel production is a promising and important field of research because the relevance it gains from the rising petroleum price and its environmental advantages. The present study was intended to analyse the improvement of combustion, performance and emission on four stroke CI engine using biodiesel with various proportions ranging from 10% to 30%..Three blends of biodiesel with proportion ranging from 10% to 30% were prepared. Properties of these blends were compared with pure diesel these three blends were selected to compare the properties and performance with pure diesel. Performance tests were conducted for combustion, performance, and emission on four stroke CI engine. The results were compared.***

Keywords: ***Biodiesel, Need oil, trans esterification, CI engine, ASTM testing methods***

I. INDRODUCTION

The demand fornon-renewable energy sources are increasing day by day due to modernization and mechanization. Demand for electricity and enormous increase in the number of automobiles has result edin greater demand for petrol eum products. The increasing demand for the petroleum based fuels hassled to oil crises in there centimes. There for attention has been focused on developing there new able or alternate fuels to replace the petrol eumbased fuels for transport vehicles. Fossil fuels are still being created to day by underground heat and pressure; they are being consumed more rapidly than they are being created. Insufficient quantities or unreasonable price of petroleum fuels deeply concerns us where as the renewable energy is a promising alternative solution because it is clean and environmentally safe. Due to petroleum fuel, Pollution and accelerating energy consumption have already affected equilibrium of the earth's landmasses and bio diversity. Since petroleum diesel and gasoline consist of blends of hundreds of different chemicals of varying hydrocarbon chains, many of these are hazardous and toxic. Carbon monoxide (produced when combustion is in efficient or incomplete),nitrogen oxides(produced when combustion occur sat very high temperatures), sulphur oxides (produced when elemental sulphuric present in the fuel),and particulates that are generally produced during combustion are other specific emissions of concern. So it is time to search for its alternative fuels. There are sever all alternative sources of fuel like vegetable oils, biogas, biomass, primary alcohols which are all renewable in nature. Among these fuels, vegetable oils appear to have an exceptional importance as they are renewable and widely available, biodegradable, non-toxic and environment friendly. The alternative fuel that much closer to diesel engine is 'biodiesel'. Biodiesel refers to a family of products made from vegetable oil or animal fat sand alcohol, such as methanol or ethanol, called monoalkylesters of fatty acids. Study shows that, on the mass basis, bio diesel has an energy content of about12% less than petrol embossed diesel fuel. It reduce sunburned hydro carbons(HC),carbon monoxide(CO),and increase oxides of nitrogen (NOx) than diesel-fuelled engine. It is a domestic, renewable fuel for diesel engine derived from natural oil like Need oil. Bio diesel is environment friendly liquid fluid similar to conventional diesel fuel in engine tests, the power and fuel consumption. Neem is a tree in the family 'maliaceae' which grows various parts in Bangladesh. its scientific name 'Azadirachta indica'. The ever green tree is large, reaching 12 to 18 meters in height with a girth of up to1.8 to 2. 4meters. The seeds have 40% oil which has high potential for the production of biodiesel. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel. Neem oil is generally light to dark brown, bitter and has a strong odour that is said to combine the odours of peanut and garlic.

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II. BIODIESEL PRODUCTION PROCEDURE

A. Two – step Acid – Base Catalysed Trans esterification

Crude Neem oil when transesterified using NaOH catalyst produced significant amount of soaps from saponification side reaction. This was due to the high level of free fatty acids and small quantity of moisture in the crude Neem oil. Therefore, a two-step process acid catalysed Trans esterification followed by alkali catalysed trans esterification was employed according to the method of Berchmans and Hirata (2008).

B. Acid Pre-treatment (Acid Catalysed Esterification)

The method of acid Tran's esterification is listed below:

1) The crude Neem oil of 200ml is taken
2) It is heated at 60°C for about 10 min and mixed with 60 ml of methanol
3) To the mixture 2ml of concentrated H2SO4was added.
4) Then the mixture was stirred on magnetic hot plate for 1 hr. at 50°C
5) It was allowed to settle for 2 hr.
6) The pre-treated oil was separated from the methanol - water phase at the top.

Figure 3.5.2 Magnetic stirrer with the Neem oil

C. Base Catalyzed Transesterification

The method of base catalysedtrans esterification is listed below

1) The pre-treated oil was measured (200ml) and taken in beaker.
2) Methanol of 50 ml was taken and added to it.
3) The mixture is heated on the magnetic stirrer at a temperature of 60°c.
4) The agitation rate is kept at 1000 rpm.
5) A solution of NaOH in methanol (1%) was dissolved at room temperature and the pre-treated oil was added
6) The reaction was allowed for a period of 2hr.
7) The resulting mixture was poured into a separating funnel and allowed to settle under gravity for 24 hr. for separation of biodiesel
8) The lower glycerol layer was tapped off.

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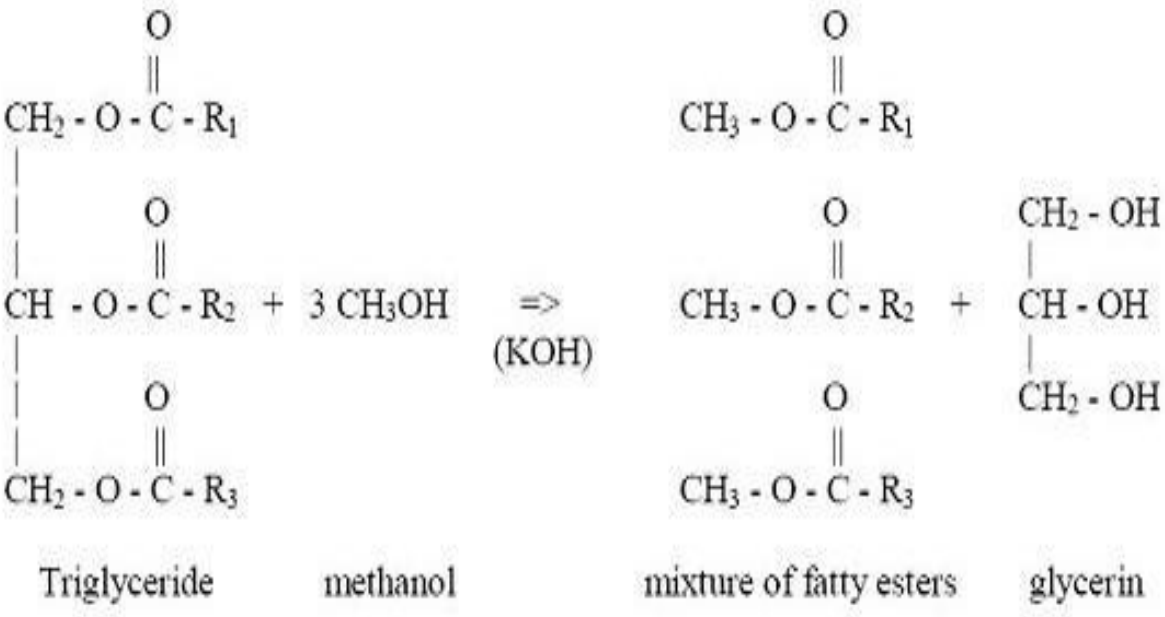
Figure 2 Biodiesel in Separating Funnel

The reaction is as follow



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III. CALCULATION OF MOLAR RATIO FOR TRANSESTERIFICATION

Molecular weight of Methanol = 32.04 g/mol
Weight of one litre of Methanol = 793 gms
Number of moles in one litre of Methanol is calculated by weight to molecular weight of methanol.
Therefore, No of moles in 1 litre of methanol = 793/32.04
= 24.78 moles (round off)
=25 moles (approx)
Similarly for oil, number of moles has to calculate.
Molecular weight of Neem oil = 885 g/mol
Weight of one litre of Neem oil = 910 gms
Total volume of oil used for transesterification was 4.7 litres.
Therefore total weight of Neem oil was 4.7 × 910 = 4277 gms
Number of moles in 4.7 litres of Neem oil is to be calculated by total weight of Neem oil used in transesterification reaction to the molecular weight of Neem oil.
Number of moles in 4.7 litres of Neem oil = 4277/885 = 4.83 moles (round off)
= 5 moles (approx)
Now equating number of moles of methanol to number of moles of Neem oil to find the optimal molar ratio of methanol to oil for transesterification reaction.
5:25 = 1:5 is the optimal molar ratio for transesterification.

IV. BIODIESEL CHARACTERIZATION

A. Determination Of Specific Gravity

A clean and dry bottle of 25ml capacity was weighed (W_0) and then filled with the biodiesel sample stopper inserted and reweighed to give (W_1). The sample was substituted with water after washing and drying the bottle and weighed to give (W_2).
The specific gravity was determined by $(W_1-W_0) / (W_2-W_0)$

B. Determination Of Viscosity

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress.15ml of water was sucked through suction pipe till it crossed the upper mark of the viscometer, and then the time required by the water to flow from upper-mark to lower-mark was noted down with the help of a stopwatch. Further 15ml of biodiesel sample was taken in a viscometer. It was sucked through suction pipe till the sample crossed the upper mark of the viscometer. Then, the time required by the sample to flow from upper-mark to lower- mark was noted.
Relative Viscosity was determined by the equation T_o/T_w, Where T_o = Time taken for biodiesel to travel from upper mark to lower mark, T_w = Time taken for water to travel from upper mark to lower mark.

C. Determination of Flash Point

Flash point was measured using Pensky Marten's apparatus. The cup was rinsed, cleaned and dried before starting the test. The cup was filled up to the mark with the biodiesel sample and covered with the lid. Thermometer was inserted such that, the bulb got immersed in the sample and care was taken that stirrer would not touch the thermometer. The initial temperature of the sample was noted down. Heater was started and the power level was set such that temperature of sample rises at the rate of 3^o C/min. The stirrer rotated at 2 rev/ sec. Test flame was applied by operating shooter. For every 2ºC rise in temperature, the test flame was brought near cup surfacefor observing the phenomenon. When flash appeared on the surface of cup, the temperature was noted down and taken as Flash point.

Table 1 Properties of Diesel and Biodiesel

PROPERTIES	DIESEL	NEEM OIL BIODIESEL
Specific gravity (gm/cm^3)	0.823	0.920
Calorific value (kJ/kg)	43500	39197.9
Cetane number	50	47

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Kinetic viscosity (at40°C) [cSt]	3..05	38
Chemical formula	$C_{14}H_{22}$	$C_{18}H_{34}O_2$
Flash point (°C)	40	168
Fire point (°C)	44	178
Stoichiometric A/F	15	12.41
Carbon (%)	86	78.92
Hydrogen (%)	14	13.41

Table 2 Preparation of Blends with Diesel

Notation	Fuel Quantity (lit)	Neem(ml)	Diesel (ml)
B10	1	100	900
B20	1	200	800
B30	1	300	700

Table 3 Properties of Neem oil Methyl Ester blends:

Property	N_{10}	N_{20}	N_{30}
Calorific Value(kJ/kg)	42200	41900	41600
Kinematic Viscosity(cSt)at 40°C	0.423	0.457	0.533
Specific gravity	0.820	0.835	0.846
Flash Point	45	48	54
Fire Points	50	53	59.5

Fig 3 Neem Biodiesel

Fig 4 Biodiesel and Diesel

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V. PERFORMANCE AND EMISSIONS OF IC ENGINE WITH BIO-DIESAL

Lot of researchers and scientists conducted performance tests on compression ignition engines using different vegetable oils and biodiesel derived from different feed stocks. Gerhard Vellguth studied the performance of a direct injection single cylinder diesel engine with different vegetable oils. He reported that vegetable oils could be directly used as fuels in diesel engines on a short-term basis with little loss in efficiency. In long-term operation of engine with vegetable oils, he observed operational difficulties like carbon deposits, changes in the lubricating oil properties and ring sticking problems. Based on the previous research works, the performance tests were conducted on the given engine.

VI. EXPERIMENTAL WORK

The main objective of this investigation was to study the use of Neem bio-diesel oil infour stroke single cylinder diesel engine experimentally. The use of Neem oil biodiesel blended with mineral diesel as substitute for conventional mineral diesel. The purpose of the investigation is to analyze the effects on diesel engine performance when fuelled with the blends of biodiesel and diesel in various proportions on volume basis.—The fuel blends investigated for performance analysis are 100% diesel (B_{00}), blend of 10% biodiesel and 90% diesel (B_{10}), blend of 20% biodiesel and 80% diesel (B_{20}) and blend of 30% biodiesel and 70% diesel (B_{30}) and results are to be compared. The experimentation further extended to procure most desirable values for the relevant working parameters and their optimal combination based on the results. The performance parameters like,

Table 4Specifications of Experimental engine

DESCRIPTION	SPECIFICATIONS
Bore	87.5 mm
Stroke	110 mm
No of cylinders	1
Compression ratio	17.5:1
RPM	1500rpm
Cubic Capacity	661.45cc
Fuel Used	Diesel
Engine type	Diesel engine
Maximum power	3.5 KW @ 1500RPM
Cooling system	Water cooled

Figure 5 Experimental set up

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Figure 6 various components of experimental set up

VII. RESULTS AND DISCUSSIONS

Performance, combustion and emissions tests were carried out on a 3.7 KW constant speed 1500 rpm in engine using blends 10%, 20% and 30% of Neem oil (volume basis) biodiesel and the results are presented.

A. Performance Graphs

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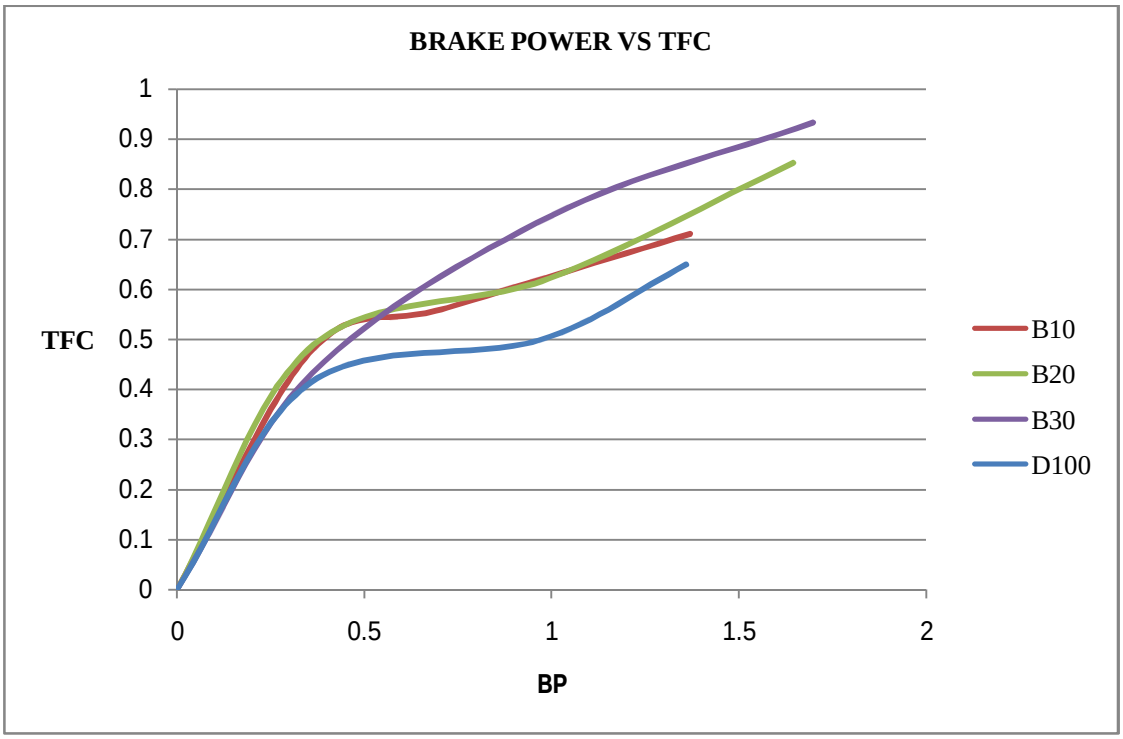

Figure 7 Brake power vs Total fuel consumption plot

Graph shows the variation of Total fuel consumption with Brake power for diesal and various peoportions of bio-diesel. From the graph it is conclude that the variation of BP affects the TFC. It is clear from the graph blend B_{30} gives the better performance which compared to all blends. But B_{20} is almost similar to diesel.

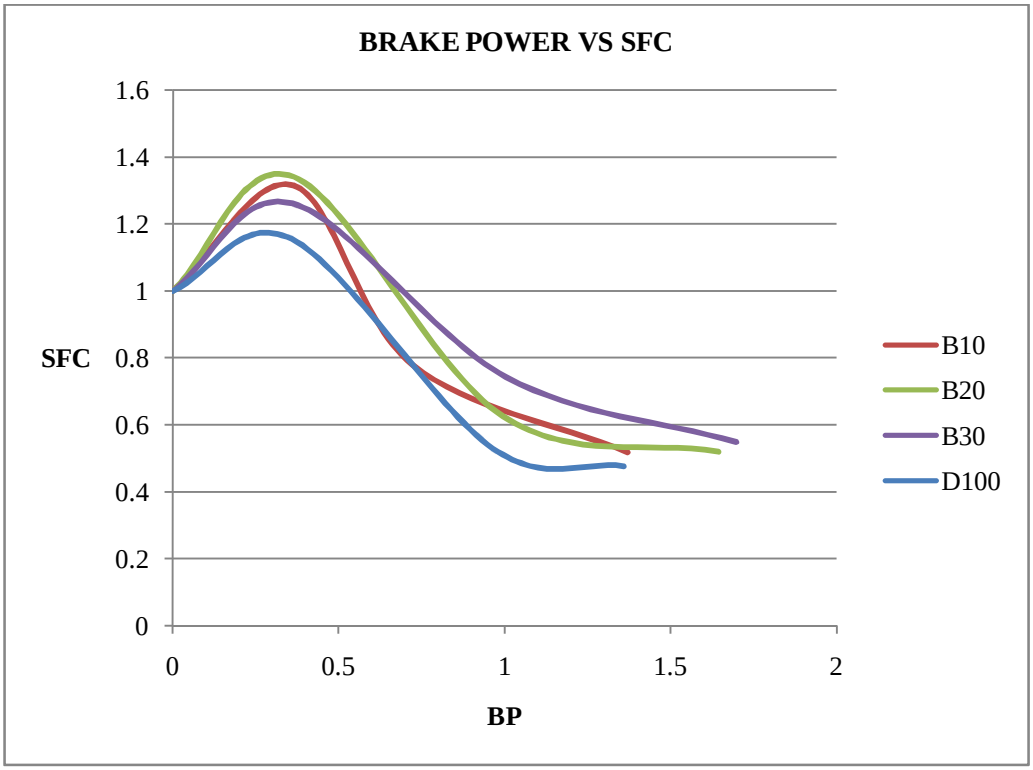

Figure 7 Brake Power Vs Specific fuel consumption plot

The above graph shows blend B_{30} gives the better performance which compared to all blends. But B_{20} is almost similar to diesel.

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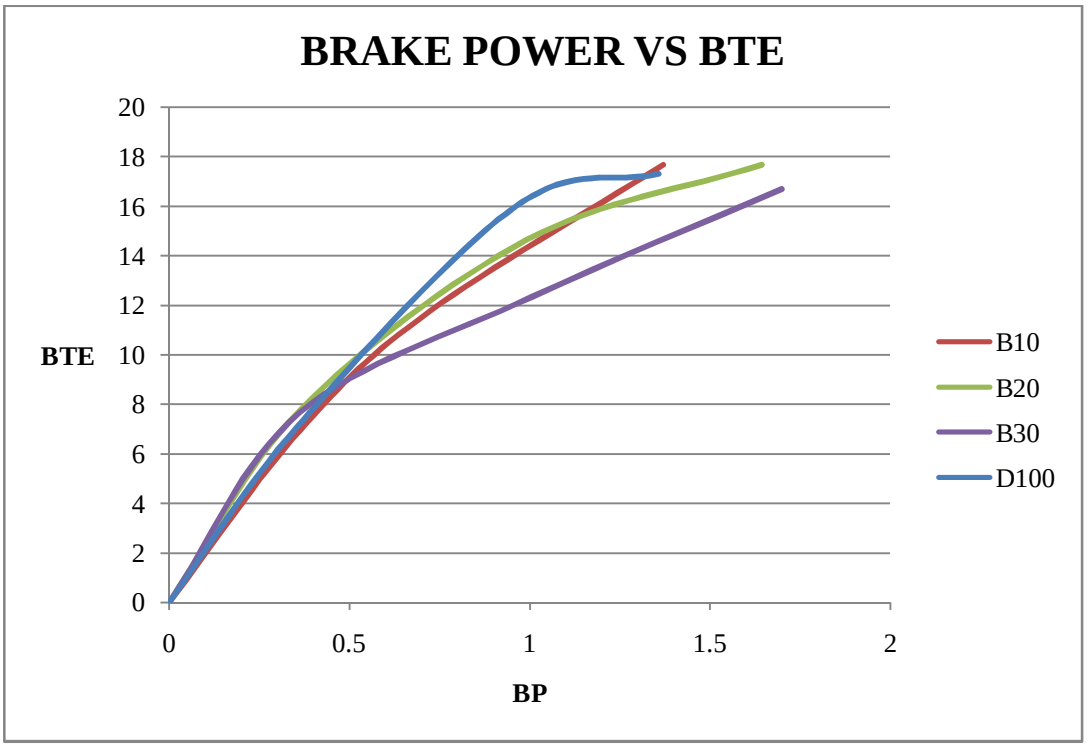

Figure 8 Brake Power Vs Brake Thermal efficiency plot

The above graph shows blend B_{30} gives the better performance which compared to all blends. But B_{20} is almost similar to diesel base line performance.

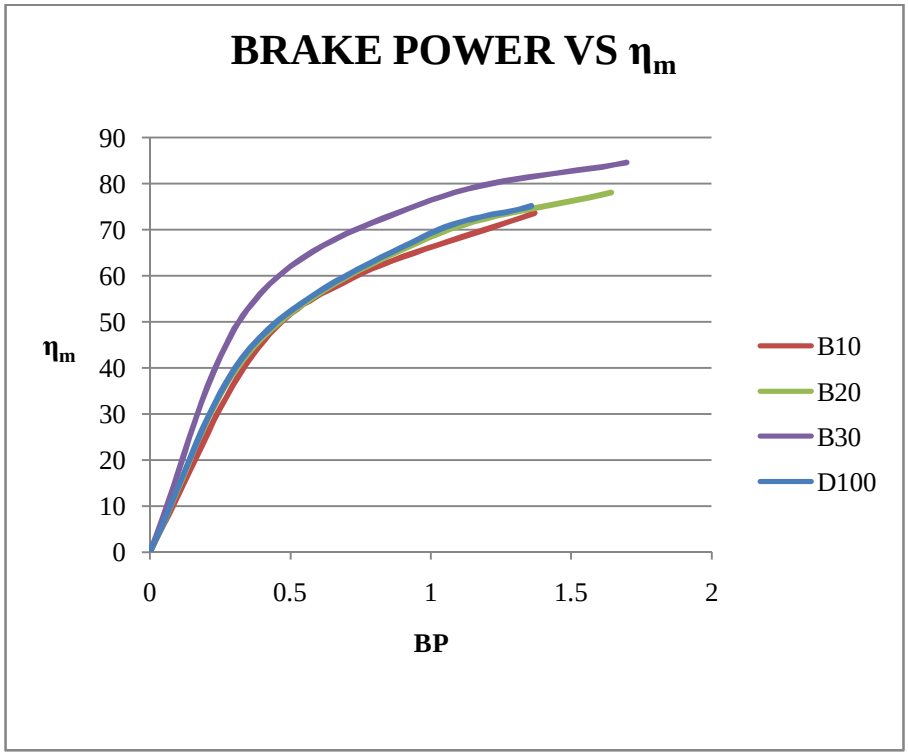

Figure 9 Brake Power Vs Mechanical Efficiency plot

The above graph shows the blend B_{30} gives the better performance which compared to all blends. But B_{20} is almost similar to that diesel.

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B. Emissions Graph

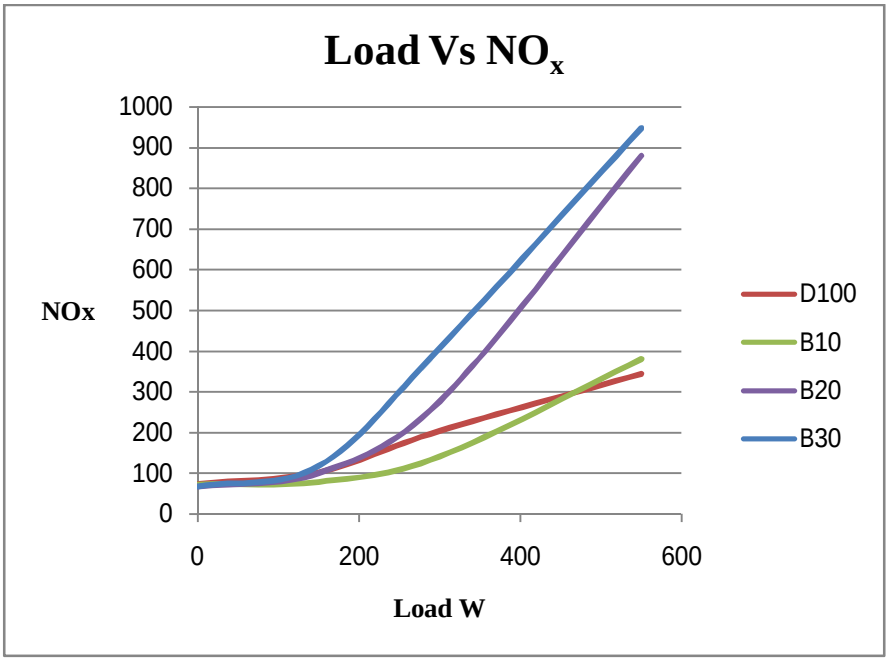

Figure 10 Load vs NO_x plot

The above curve shows the blend D_{100} and B_{20} which gives average emissions which compared to diesel NOx emissions.

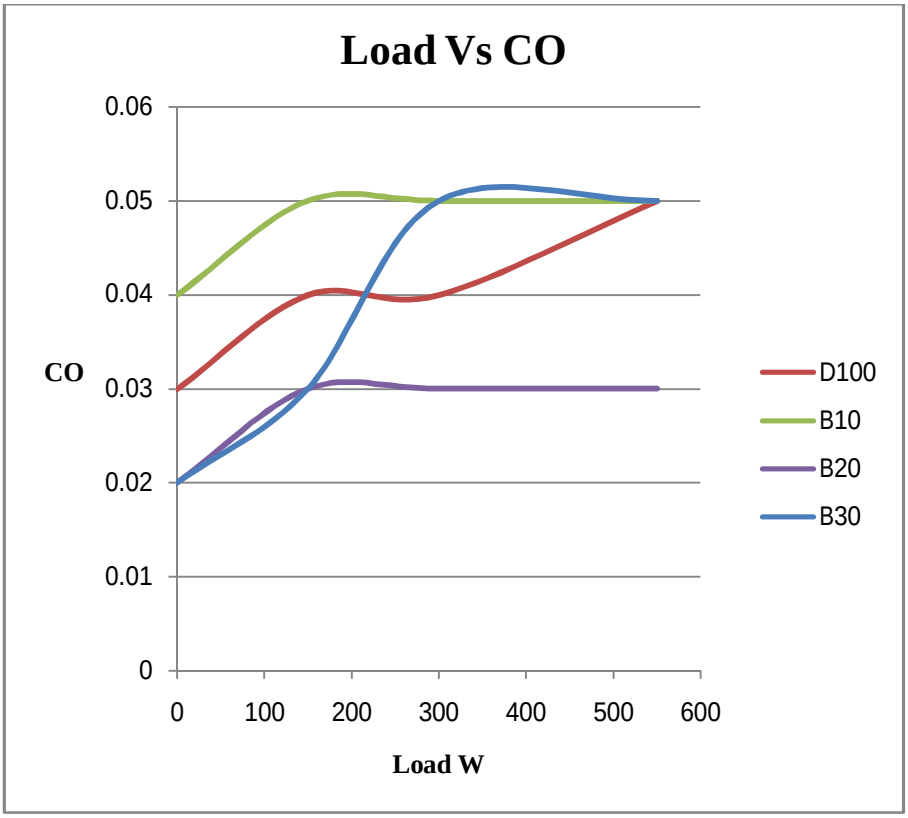

Figure 11 Load Vs Carbon Monoxide plot

The above curve shows the blend D_{100} and B_{20} which gives the average emissions which compared to diesel CO emissions.

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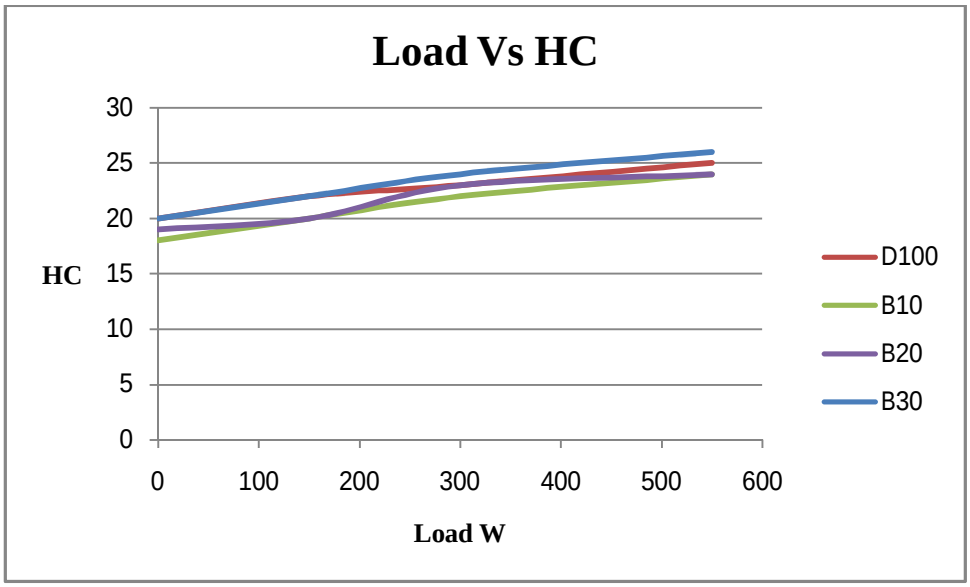

Figure 12 Load Vs HC plot

The above graph shows the blend B20 is almost similar to that diesel. The increase in biodiesel ratio tends to increase in emissions.

VIII. CONCLUSION

In this study comparative evaluation of the improvement of diesel was done while blended with Neem extracts i.e. Bio-Diesel. This bio-dieselimproved the fuel blend regarding density and viscosity which in turn improved atomization and showed better combustion characteristics through higher engine brake power, lower BSFC and higher BTE than normal diesel. The test results shows among the three blends of bio-diesel oils, blend B_{20} which gives the better performance when compared to diesel base line performance. Also the same blend B_{20} gives the average emissions of NOx, CO, O_2, CO_2, HC and λ when compared with diesel base line emissions.

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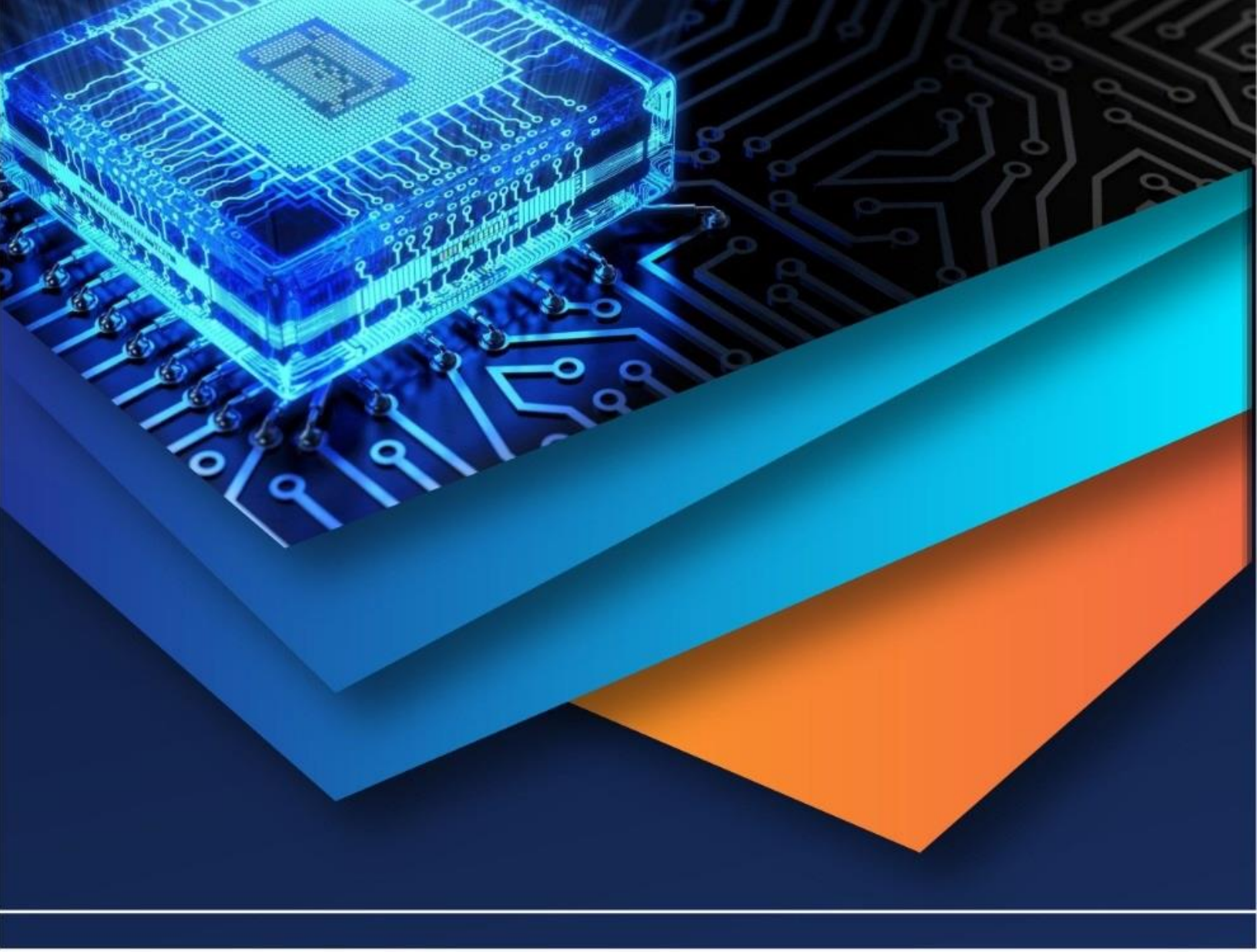

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