Experimental Investigation of Performance Parameters of CI Engine fuelled with Blends of Neem Biodiesel and Diesel

Ajay Gahadwal & Sanjay Yadav
[1]M.Tech. Scholar, Dept. of Mech. Engg. IFTM University,Moradabad-244001,India
[2]Astt.Professor, Dept. of Mech. Engg. IFTM University, Moradabad-244001, India
Email – ajaygahadwal@gmail.com

1.ABSTRACT

A 3.5 kW, constant speed diesel engine was tested on diesel, NOME-diesel blends in 10:90, 20:80, 30:70, 40:60 and 50:50 ratio. The performance of the engine was found to be satisfactory on the blends. The engine was able to develop power similar to diesel on all the NOME- diesel blends.The brake thermal efficiency of the engine on NOME-diesel blends was found higher than diesel but BSFC of the engine on NOME-diesel was also found higher than the diesel. The engine performance was the best on B20 as the brake thermal efficiency was found to be highest and BSFC was found to be lowest on this blend.

Key words –

Neem Oil Methyl ester(NOME); B10; B20; B30; B40; B50; Brake power

2.INTRODUCTION

The ongoing economic expansion, robust GDP growth, urbanization, agriculture mechanization and increase in vehicular population would increase the demand for transportation fuel in short and medium term at high rates. The crude oil import bill has gone to Rs. 450,000 crore in the year 2011 and this has already depleted foreign exchange reserves and made dent in Indian economy. Thus, alternate fuel technology availability and use will become more common for both automobile application and for stationary motive power in coming decades. Another reason motivating the development of alternative fuels for internal combustion engine is concern over the emission problems of gasoline and diesel engines.

Liquid fuel such as vegetable oils, alcohols and gaseous fuel such as biogas, compressed natural gas (CNG), liquefied petroleum gas (LPG) and hydrogen are found to be promising for use in compression and spark ignition engines. In addition some these alternative fuels are seen as potential for lower emission than are associated with diesel and petrol fuels.

Consequently, in the recent years systematic efforts have been made to persuade investigation in technology and utilization of vegetable oils as alternative to diesel in the compression ignition engines.

The advantages of using vegetable oils as fuel for diesel engines include better self ignition characteristics, better compatibility with fuel injection system used in existing CI engine, high energy content and self processing and handling. Above all, these fuels can be readily incorporated into energy pool, should the need arise due to sudden shortage or disruption in the existing petroleum system. Moreover, vegetable oil fuels produce greater thermal efficiency than diesel fuel **(Goering *et al.*, 1981)**. However, the use of vegetable oil in direct injection type diesel fuel engine is limited by at least an important physical property i.e. viscosity. Viscosities of vegetable oils are reported to be 10 to 20 times more than that of diesel fuel and are considered to be lower in total energy and higher in density, carbon residue, and particular matter **(Ali, 1994)**

For feedstock diversification and utilization of currently available local resources, non-edible sources like Neem, Karanja, Mahua, Sal etc. should be scientifically investigated for efficient biodiesel production and engine utilisation.

Keeping this background in consideration, production of biodiesel from Neem oil and its utilization as a potential alternative fuel for diesel engine has been investigated.

3.LITERATURE REVIEW

This chapter reviews the feasibility of this fuel source and some of the results obtained from investigation on the use of vegetable oils and their esters as fuel in CI engine.

3.1 Use of edible vegetable oil as engine fuel

He Yong (1998) conducted an experimental research on a S195 type diesel engine using cottonseed oil as an alternative fuel for a single cylinder diesel engine. The fuel used was a blend of 30 percent cottonseed oil and 70 percent diesel oil. The working of the engine on the blend and diesel fuel was compared by studying the effect of intake valve closing angle, exhaust valve opening angle, fuel delivery angle, injection pressure and specific fuel consumption on engine performance. It was concluded that cottonseed oil could be a promising alternative fuel source for diesel engine as its use does not require any structural change in the engine.

However, in order to get the highest power and thermal efficiency, the relevant working parameters of the engine should be readjusted.

It was suggested that the fuel delivery angle be advanced for improving combustion performance when using cotton seed oil as fuel.

Singh (2003) carried out the feasibility of supplementing rice bran oil in a CI engine. A 3.73 kW Kirloskar make, single cylinder water cooled compression ignition engine having a displacement volume 552.92 cc and compression ratio 16.5:1 was tested. The fuel types used were blends of diesel-rice bran oil in 90:1, 80:20, and 70:30 and diesel methyl ester of rice bran oil blended in 90:10, 80:20, 70:30, 60:40, 50:50 ratio.

The characteristic fuel properties of all the above fuel blends were reported to be comparable with diesel fuel. It was observed that there was an increase in the ash and carbon residue content in the blend with increase in concentration of rice bran oil in the fuel blend. All fuel types found to be stable and homogeneous at normal room temperature. All the fuel types showed similar power producing capabilities at rated load. The fuel consumption of the engine was found to be lower on all the fuel blends compared to diesel at rated load. The brake thermal efficiency of the engine on diesel-methyl ester rice bran oil was comparable with diesel. The emission of CO, HC and NOx from the engine on above fuel blends was within the limits. However, the exhaust gas temperature of the engine on blends of rice bran oil and diesel and methyl ester of rice bran oil and diesel was reported to be lower than that observed on diesel at rated load condition.

3.2 Use of Neem oil as CI Engine Fuel

Ragit *et al.* (2011) conducted experiments on standardization of transesterification process parameters for the production of methyl ester of filtered neem oil and fuel characterization for engine performance. The effect of process parameters such as molar ratio, preheating temperature, catalyst concentration and reaction time was studied to standardize the transesterification process for estimating the highest recovery of ester with lowest possible viscosity.

It was observed that filtered neem oil at 6:1 M ratio (methanol to oil) preheated at 55ºC temperature and maintaining 60ºC reaction temperature for 60 min in the presence of 2 percent KOH and then allowed to settle for 24 h in order to get lowest kinematic viscosity (2.7 cS) with ester recovery (83.36%). Different fuel properties of the neem methyl ester and neem oil were also measured.

Viscous oil when injected to the cylinder do not atomize properly and may results in incomplete combustion of fuel, build- up of carbon deposits on injectors, cylinder head and piston. Some this unburnt fuel blow by the piston rings into crankcase causing dilution of lubricating oil to solidify due to oxidation and polymerization of vegetable oils which may result in complete failure of the lubricating oil and may ruin the engine.

However, the above problems can be overcome with the use of esterified oils and their blends with diesel. Since the ester are less viscous than neat vegetable oils and, therefore, improved engine performance through better atomization and combustion in the cylinder was observed when either neat esterified oils or their blends with diesel were used. The esterification reduces the viscosity and removes glycerol from the oil. Hence the problem of cold start, plugging of filters, fuel lines, injectors carbon deposition, oxidation and polymerization of lubricating oil are least associated particularly when blends of esterified fuel were used as engine fuel. In view of above, use of either esterified vegetable oil alone or their blends with diesel appear to be promising alternative fuels of the future.

4.MATERIALS AND METHODS

This chapter briefly describes the methodology used for the experimental procedure adopted to evaluate performance of a **VCR diesel engine** on the blends.

4.1 Selection of Fuel Constituents

The experiments were carried out using diesel as reference fuel and neem oil methyl ester (NOME) and their blends with diesel in various proportions as engine fuel.

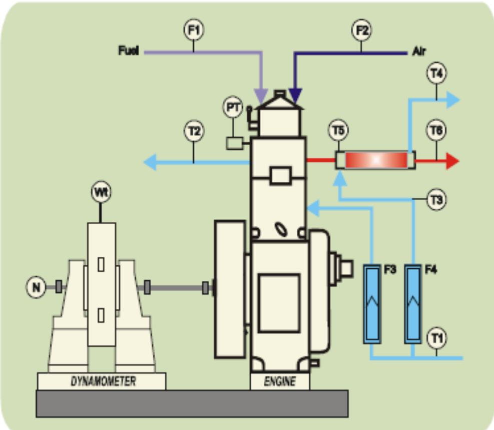
4.2 Preparation of Fuel Blends

High viscosity of neem oil makes it unsuitable as complete replacement of diesel for the CI engine. The neem oil methyl ester (NOME)-diesel blends were prepared by blending neem oil methyl ester (NOME) with diesel.

4.3 Test Engine

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio)Diesel engine connected to eddy current type dynamometer for loading.

softLV" is provided for on line performance evaluation.



Schematic arrangement

F1	Fuel consumption	kg/hr
F2	Air consumption	kg/hr
F4	Calorimeter water flow	kg/hr
T3	Calorimeter water inlet temperature	°K
T4	Calorimeter water outlet temperature	°K
T5	Exhaust gas to calorimeter inlet temp.	°K
T6	Exhaust gas from calorimeter outlet temp.	°K

Figure – 3.10 A VCR Engine connected with computer system

Table 3.1 Neem Oil Methyl Ester – Diesel Blends selected for Experiments

S. No.	Fuel Types	Nomenclature
1.	Diesel	-
2.	Raw Neem oil	-
3.	10% Neem Oil Methyl Ester + 90% Diesel	B10
4.	20% Neem Oil Methyl Ester + 80% Diesel	B20
5.	30% Neem Oil Methyl Ester + 70% Diesel	B30
6.	40% Neem Oil Methyl Ester + 60% Diesel	B40

7.	50% Neem Oil Methyl Ester + 50% Diesel	B50

4.4 Engine Performance Test

The performance of the engine was evaluated by conducting fuel consumption and rating tests as per **IS: 10000 [P: 8]:1980.**

4.5 Fuel consumption test

The performance of the engine on selected fuels was evaluated at the following load condition.

No load
2 kg load
4 kg load
6 kg load

The following parameters were measured during the test:

Brake power, kW
Indicated power,KW
Fuel consumption, l/h
Specific fuel consumption
Brake thermal efficiency
Indicated thermal efficiency

4.6 Measurement of engine parameters

Brake power

The brake power developed by the engine under different test condition was measured. In order to make the measurement the engine was initially run on no load condition and its speed was adjusted constant.

The corresponding torque to be applied to the engine when delivering rated power (3.5 kW) at rated speed of 1500 rpm was calculated using the equation given below:

$$BP = \frac{2\pi \times N \times T}{60000}$$

Where,

T= Torque, N-m

N= Engine speed, rpm

Fuel consumption

The fuel consumption was measured with the help of fuel consumption unit as shown in the engine set up. The hourly fuel consumption was calculated using equation as given below:

$$f_c = \frac{V_{cc} \times 3.6}{T}$$

Where,

f_c = Fuel consumption, l/hr

V_{cc} = Volume of fuel consumed,

T = Time, hr

3.6 = Unit constant

The brake specific fuel consumption was calculated using the following relationship:

$$\text{BFSC} = \frac{\textit{Fuel consumption rate}}{\textit{Brake power}}$$

$$= \frac{V_{cc} \times \rho \times 3.6}{BP \times t}$$

Where,

BFSC = Brake specific fuel consumption, kg/kW-h

Vcc= Volume of fuel consumed, 25 cc

ρ = Density of fuel, g/cc

BP = Brake power, kW

T = Time taken to consume 25 cc fuel, s

Brake thermal efficiency

The brake thermal efficiency of the engine at the different loads was determined using the equation as given below:

$$\eta_{th} = \frac{\textit{Brake power}}{\textit{Fuel power}}$$

$$= \frac{Ks}{HV \times BSFC}$$

Where,

η_{th} = Brake thermal efficiency, percent

Ks = Unit constant, 3600

HV= Gross heat combustion, kJ/kg

BFSC = Brake specific fuel consumption

5.RESULT AND DISCUSSION

The fuel consumption test and rating test of 3.5 kW, constant speed CI engine was also conducted to evaluate the performance of the engine on diesel as well as different blends of NOME with diesel.

A 3.5 kW, stationary, constant speed, single cylinder diesel engine was tested on diesel and selected NOME-diesel blends. The fuel consumption test of the engine were conducted as per **IS: 10000 [P: 8]:1980** and break power, specific fuel consumption, brake thermal efficiency were calculated.

5.1 Engine Performance on Selected Fuels

The performance of 3.5 kW, constant speed diesel engine was evaluated on selected fuels and compared with diesel. The fuel consumption test of the engine was conducted as per **IS: 1000 [P: 8]: 1980.**

5.2 Engine performance under fuel consumption test

The performance of the engine was evaluated on diesel, B10, B20, B30, B40, B50 under the fuel consumption test at different load condition in terms of brake power, fuel consumption, specific fuel consumption, brake thermal efficiency.

5.3 Indicated and brake power

The Indicated and brake power, corresponding brake load when operating on diesel, B10, B20, B30, B40, B50 at no load,load of 2kg,load of 4kg,load of 6kg. is shown in Fig. 4.3 to 4.4.

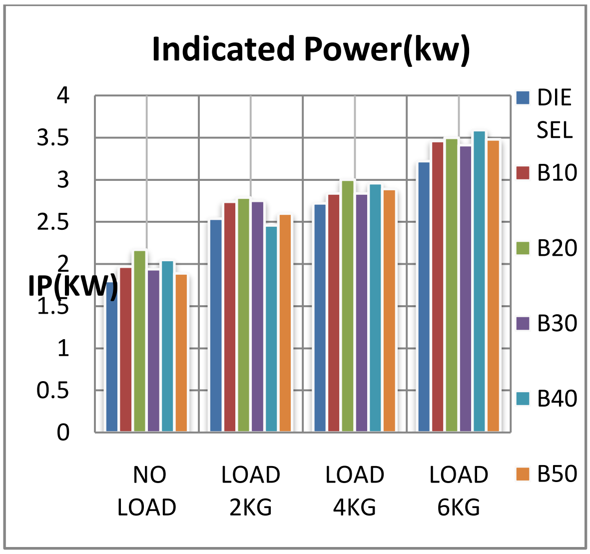


Figure 4.3 Indicated Power Produced by Diesel and its Blend with NOME

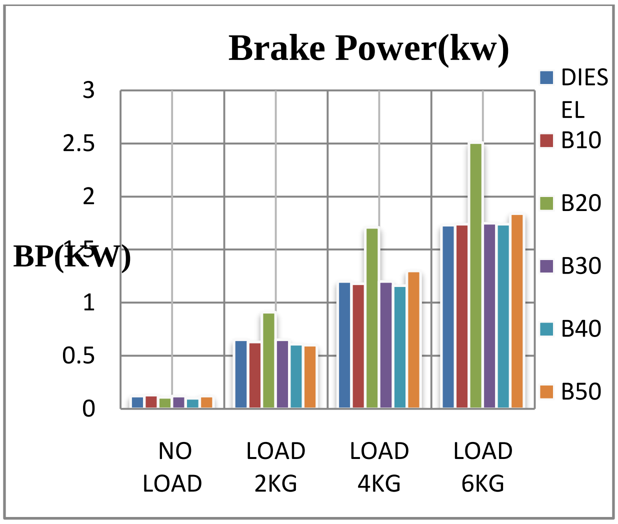


Figure - 4.4 Brake Power Produced by Diesel and its Blend with NOME

The figures indicate an increase in Indicated and brake power with increase in brake load of the engine under all fuel types. The figures also reveal that with increase in brake load there was an increase in brake power and decrease in engine speed on all the NOME-diesel blends.

It was observed that the engine was able to develop similar power on all fuel types at every selected brake load condition. This could be due to the reason that the volumetric fuel flow rate on biodiesel was higher thus contributing energy supply near to diesel.

5.4 Fuel consumption

The observed fuel consumption (l/h) of the engine on diesel and NOME-diesel blends is shown in Fig 4.5 shows the relationship between brake load and the fuel consumption of the engine on different fuel types.

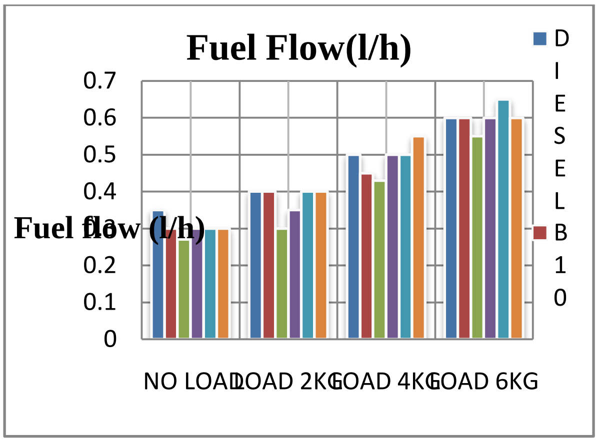


Figure-4.5 fuel flow for different blends and diesel

It is observed from the figure that the fuel consumption of the engine gradually increased with increase in brake load and was found to maximum on all selected fuel types. It is clear from the figure that except B20 the engine consumed more fuel than diesel on almost all the blends of NOME and diesel. The fuel consumption of the engine on B20 was found lesser than that of diesel.

5.5 Specific fuel consumption

The relationship between the specific fuel consumption of the engine and brake load on different fuel types is presented in Fig 4.6.

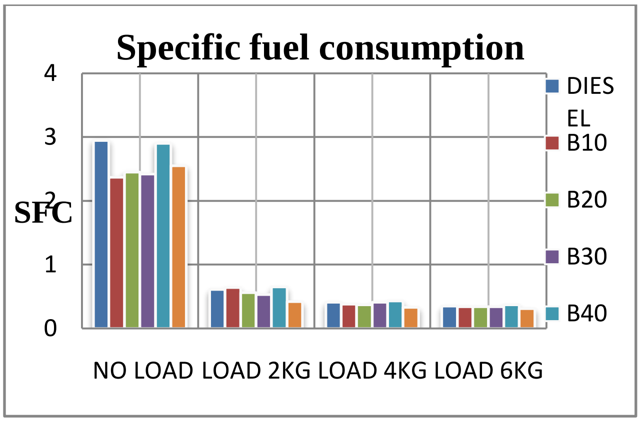


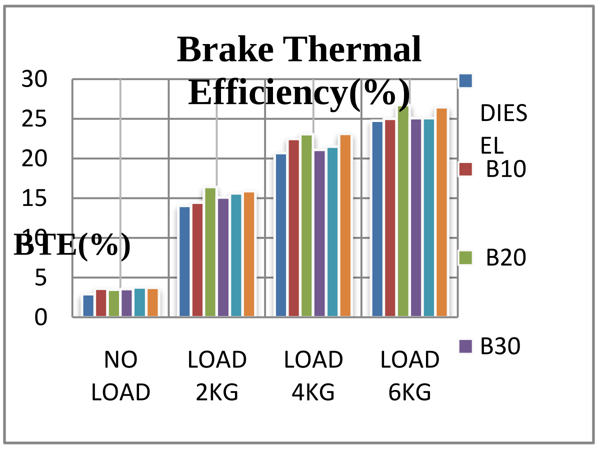
Figure – 4.6 Specific fuel consumption for different blends and diesel

It is clear from the figure that except B20 the BFSC of the engine is higher than that of diesel on almost all the blends of NOME and diesel.

5.6 Indicated and Brake thermal efficiency

The relationship between brake thermal efficiency and the brake load is shown in Fig 4.7 and 4.8.

Figure – 4.7 Indicated Thermal Efficiency of different blends and diesel



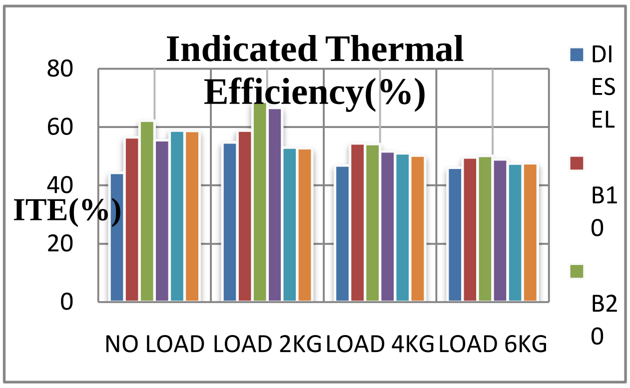


Figure – 4.8 Brake Thermal Efficiency for different blends and diesel

Indicated Thermal Efficiency is decreasing with the increase in load. Brake thermal efficiency of the engine on diesel at rated brake load was observed to be 20.96 percent. The comparison of observed brake thermal efficiency indicates that when engine developed its rated power , it was 21.38, 22.34, 21.51, 21.155, 21.49 and 21.17 percent on B10, B20, B30, B40, B50 and NOME respectively. It is clear from the figure that the NOME-diesel blends mostly are having higher brake thermal efficiency than diesel.

5.7 Exhaust Emissions of the Engine

Engine exhaust emissions of selected fuels are shown in figures 4.9 to 4.12.

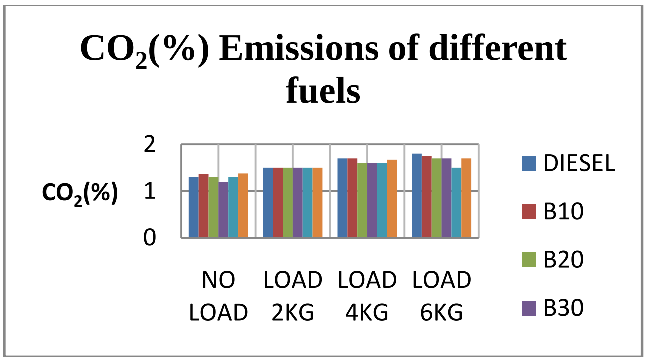


Fig -4.9 Exhaust Emissions of Carbon dioxide for different fuels

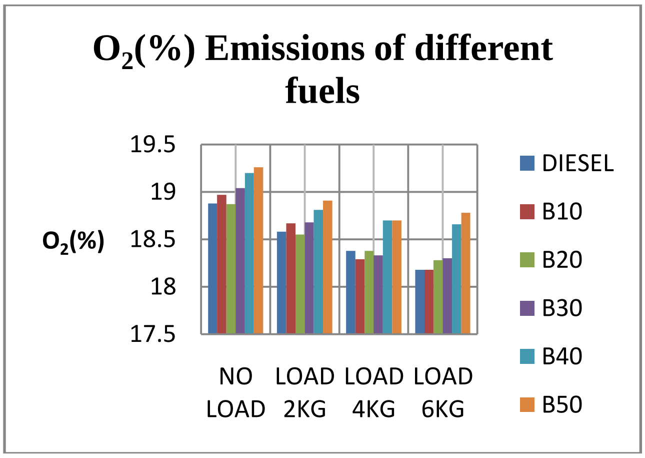


Fig –4.10 Oxygen Emissions of different fuels

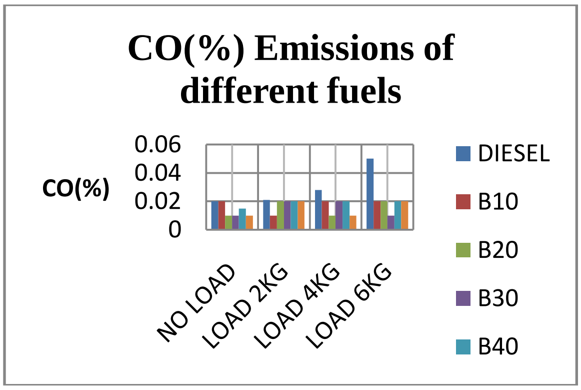


Fig – 4.11 Carbon mono oxide Emissions of different fuels

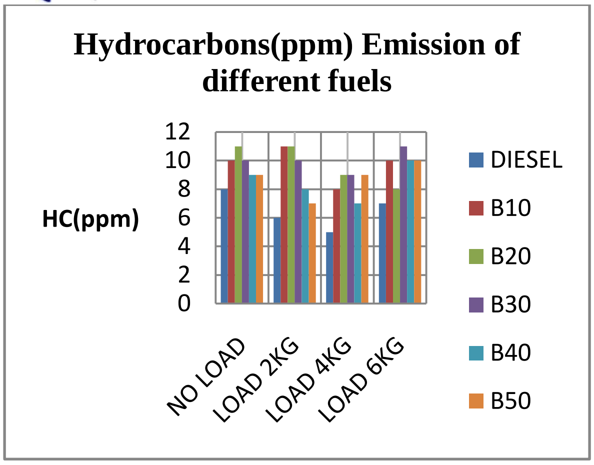


Fig – 4.12 Hydrocarbon Emissions of different fuels

From the figure - 4.10 of CO_2 it is observed that Carbon Dioxide emissions increases with increase in load.As load is increasing NOME gives lower CO_2 emissions.

From the figure – 4.11 of O_2 it is observed that At all loads, Oxygen level increased with diesel fuels and levels of oxygen for blends slightly increased as blend ratio increased, may be because fuels were oxygenated. Higher oxygen levels in fuel blends are always preferred.

From the figure – 4.12 Carbon Mono Oxide Emissions it is observed that CO emissions increases with increase in load. Engine emits more CO using diesel as compared to that of biodiesel blend under all loading conditions.With increasing biodiesel , CO emission decreases.Biodiesel itself has 11% oxygen,which help for complete combustion.Hence CO emissions decreases with increasing biodiesel percentage in fuel.

From the figure – 4.13 Hydrocarbon emissions it is observed that Variation of unburnt hydrocarbon with respect to load indicates that NOME is not shows decreasing trend at all loads.

6.Summary and Conclusion

A 3.5 kW, constant speed diesel engine was tested on diesel, NOME-diesel blends in 10:90, 20:80, 30:70, 40:60 and 50:50 ratio. The performance of the engine was found to be satisfactory on the blends. On the basis of the results obtained from the whole experiment the following conclusion can be drawn:

1. The performance evaluation of 3.5 kW diesel engine under the fuel consumption test on blends of NOME and diesel was found satisfactory on the basis of brake power, brake specific fuel consumption and brake thermal efficiency.
2. The engine was able to develop power similar to diesel on all the NOME- diesel blends.

3. The brake thermal efficiency of the engine on NOME-diesel blends was found higher than diesel but BSFC of the engine on NOME-diesel was also found higher than the diesel.
4. The engine performance was the best on B20 as the brake thermal efficiency was found to be highest and BSFC was found to be lowest on this blend.
5. CO emissions increases with increase in load. Engine emits more CO using diesel as compared to that of biodiesel blend under all loading conditions. With increasing biodiesel, CO emission decreases.

The above discussion indicate that neem oil methyl ester (NOME) may be recommended as CI engine fuel. However for the better performance of the engine B20 may also be recommended.

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