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Production of Mixed Biodiesel Using Neem Oil and Sesame Oil and Testing of Performance Characteristics on Variable Cpompression Ratio Engine

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1. ABSTRACT

Stringent emission norms, Energy Crisis and environment degradation due to pollutants from automotive vehicles lead us to find the suitable alternative for petro-diesel. Non edible and edible grade vegetable oils are predominant feedstock for biodiesel production. Obviously biodiesel production from edible oil results in the high price of biodiesel. In some countries, non-edible oils such as Jatropha curcas or waste cooking oil are preferred due to their low price. Realistically, non-edible oils only cannot meet the demand of energy consumption therefore; it has to be supplemented from some edible oils. Operationally, biodiesel blends perform very similar to conventional diesel in terms of performance without major modifications of engine because the properties of biodiesel and conventional diesel are similar. It is evident from

literature that the major problem on utilization of blends of biodiesel is the increase in NO_X emission from diesel engines. To reduce No_X emission from diesel engine employing biodiesel blend as fuel. In this dissertation a complete analysis on the performance of diesel engine using Mixed Biodiesel (NOME+SOME) is done with an aim to reduce NO_X emission. The effect of blends of biodiesel (B10, B20 and B30) is evaluated in terms of Indicated power, Brake power, Friction power, fuel consumption, specific fuel consumption, Indicated thermal efficiency, Brake thermal efficiency, Air flow, Fuel Flow, IMEP, BMEP, FMEP, Torque, Mechanical Efficiency, Volumetric Efficiency . Experimental work is conducted on a four stroke, single cylinder, water cooled diesel engine with three blends of biodiesel. The performance of blends of biodiesel is compared with diesel.

Key Words-
Neem Oil Methyl Ester (NOME); Sesame Oil Methyl Ester (SOME); B10; B20; B30.

2. INTRODUCTION

Energy utilization plays extremely vital task in the economy of any nation. Oil is the main resource of the energy for the whole world as it suitable to store up and grip. During the 21st century, a startling insufficiency is supposed to arrive in the making of crude petroleum oil and they will not be economical to get and at the same time period there will likely be a huge increment in the number of automobile and other IC engine. Liquid fuel such as vegetable oils, alcohols and gaseous fuel such as biogas, CNG, LPG and hydrogen are found to be fine for use in CI engines and SI engines. Accordingly, in the recent years logical efforts have been made to persuade investigation in technique and use of vegetable oils as alternative to diesel in the CI engines. Initial studies deliberate that over small period of time total replacement of diesel by vegetable oil fuels performs satisfactorily in unmodified diesel engines for number of many vegetable oils. However, the troubles connected with their use are cold start, plugging and choking of filters, oil outline and injection devices and engine knocking. Neem oil (Azadirachta indica) is non-edible oil available in huge surplus quantities in South Asia. Yearly production of Neem oil in India is estimated to be 30,000 tons. Traditionally; it has been used as fuel in lamps for lighting purpose in rural areas and is used on a manufacturing scale for manufacturing of soaps, cosmetics, pharmaceuticals and other non-edible products. 'Azardiratchi' is the main biochemical component of the Neem that is used for medicinal purposes. Neem oil can be used for transesterification after the extraction of 'Azardiratchi'. The seed oil yield is 30–60% of the weight of the kernel. However this oil suffers from the problem of high FFA therefore transesterification process cannot be used to proficiently convert it to biodiesel. Ragit et al. has reported 83% ester yield of base catalyzed transesterification of Neem oil with 6:1 alcohol ratio.

Moreover, vegetable oil can perform with better thermal efficiency than diesel fuel **(Goering *et al.*, 1982)**. Initial studies deliberate that over small period of time total replacement of diesel by vegetable oil fuels performs satisfactorily in unmodified diesel engines for number of many vegetable oils. However, the troubles connected with their use are cold start, plugging and choking of filters, oil outline and injection devices and engine knocking.

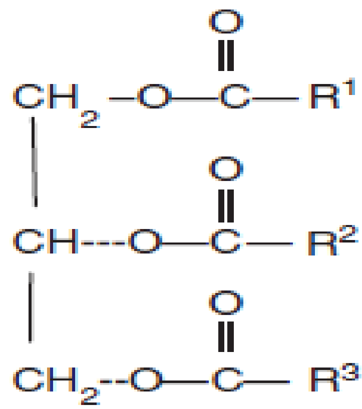

Fig. 1 Chemical Structure of Vegetable oil

In the long time uses, the evils may direct to cheap presentation or even total stoppage of the engine. These are cocking of injector nozzles, carbon accumulation on the parts of cylinder, dilution of crank case lubricating oil, glut wear on the rings, piston and cylinder and breakdown of the engine lubricating oil due to corrosion and polymerization. These problems have been linked gums, high thickness acidic composition, FFA content and low cetane ratings. It is crucial to understand and look forward to these evils before an exertion is made to use vegetable oils.

3. REVIEW OF LITRATURE

The diesel fuel molecules are saturated non-branched molecules with carbon atoms which range between 12 and 18, whereas vegetable oils are the combination of organic compounds which range

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Volume 03 Issue 11
July2016

from simple straight chain compound to complex arrangement of proteins and fat-soluble vitamins. Fats and oils are mainly water-insoluble, hydrophobic substances in the plant and animal kingdom that are made up of solitary mole of glycerol and triple moles of fatty acids and are commonly referred to as triglycerides. **(Pryde, 1982).**

2.1 Transesterification of Vegetable Oil

Vegetable oils have to go through the procedure of transesterification to be utilizable in IC engines. Biodiesel is the item for use after the process of transesterification. Biodiesel is recyclable, harmless and effectively liberated from sulfur; it is recyclable and can be formed from farming and plant assets. Biodiesel is an substitute fuel, which has a connection with sustainable progress, energy preservation, supervision, competence and ecological perpetuation.

Transesterification is the result of oil with an alcohol to make esters and glycerol. Alcohol joined with the triglycerides to give the result as glycerol and esters. A catalyst is frequently taken to get better reaction speed. Since the reaction is reversible, surplus alcohol is necessary to transfer the equilibrium to the product region. Amongst the alcohols that can be used in the transesterification procedure are methanol, ethanol, propanol, butanol and amyl alcohol. Alkali-catalyzed transesterification is more rapid than acid-catalyzed transesterification and is commonly used on commercial level.

2.2 Use of edible vegetable oil as engine fuel

Worgetter(1981) approved out a series of experiments using a tractor fuelled with a blend of 50 % food grade quality rapeseed oil and diesel prepared on volume basis. The test showed a power thrashing after 100 hours. After 350 hours of test, the injection nozzle was found to have carbon residues which however, were deemed suitable for continued use of the manufactures.

A research carried out 600 hours endurance test of a John Deere, 6-cylinder, direct injection turbocharged engine with 1:2 and 1:1 fuel mixture of soybean oil and diesel fuel. The result showed that the unacceptable thickening and potential for gelling did exist in crankcase oil with 1:1 blend, but it did not occur with 1:2 blends. Based on the observed data the use of soybean oil and diesel in 1:2 proportions was suggested for farming tools during periods of diesel fuel shortages.

2.4.2 Use of non-edible vegetable oils as engine fuel

A short term engine performance test of a direct injection, naturally aspirated, three cylinders, CI engine on pure Chinese tallow and stillingia oil and their blends with

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p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 11
July2016

diesel in 25, 50, and 75 proportions (mass basis) was carried out. It was observed that the cetane rating and heat of combustion of blends were lower. Based on engine performance, 50 percent replacement of diesel with Chinese tallow and stillingia oil was recommended. However, fuel flow restriction problem in the filters requiring the use of a fuel pump was reported with pure oil or their blends having concentration more than 50 percent.

Bhatt et al. (2001) studied the potential of Karanja oil as a diesel fuel. The test were carried out on fuel mixture containing diesel fuel and Karanja oil mixed in 20, 40, 60, 80, 100 percent (by volume). A Ricardo E6/S variable compression ratio, single cylinder, four stroke, water cooled diesel engine was tested on the blends. The result revealed that the act of engine enhanced on karanja oil blends with higher compression ratio from 16:1 to 20:1. The BThEff falls with the raise in concentration of karanja oil in diesel in link with pure diesel. The short term engine act study tells karanja oil supplementation up to 40 % level.

4. MATERIAL AND METHODS

4.1 Selection of Fuel Constituents

In this project, diesel oil is used as a reference fuel. Apart from diesel fuel, mixture of bio-diesels of Neem Oil Methyl Ester (NOME) and Sesame Oil Methyl Ester (SOME) and their blends are taken with diesel. Mixtures of all these fuels are taken in different proportion as an engine fuel to perform different experiments.

4.2 Preparation of Neem oil methyl ester (NOME)

Figure-4.1 A flask filled with mixture of methanol and sulphuric acid

Figure–4.2 Heating of Neem oil by Magnetic Stirrer Heater

p-ISSN: 2348-6848
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Volume 03 Issue 12
August 2016

Figure–4.3 Washing of NOME in a separating funnel

International Journal of Research
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e-ISSN: 2348-795X
Volume 03 Issue 11
July2016

Figure-4.4 separation of NOME and glycerol

4.3 Preparation of sesame oil biodiesel or sesame oil methyl ester (SOME)

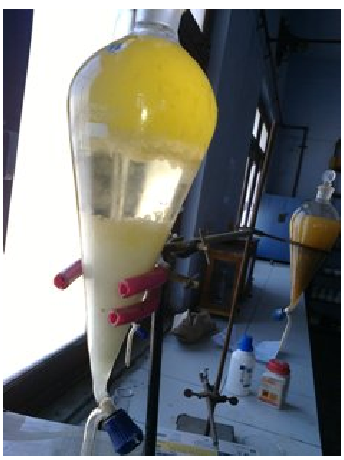

Figure-4.5 Separation of biodiesel from glycerol and excess methanol

Figure-4.6 Separation of water and biodiesel after Water washing of biodiesel

4.4 Mixing of NOME (NEEM OIL METHYLE ESTER) and SOME (SESAME OIL METHYLE ESTER)

After obtaining the two bio-diesel named NOME (Neem Oil Methyle Ester) and SOME (Sesame Oil Methyl Ester) by trans-esterification process as explained above in detail. The mixing of these two bio-diesels NOME (Neem Oil Methyle Ester) and SOME (Sesame Oil Methyl Ester) are carried out in the ratio of 50:50 to obtain blends of fuel. This mixture is then heated for 15 minutes at the maximum temperature of 60^{o}C and atmospheric pressure.

4.5 Preparation of Fuel Blends

The viscosity of this mixture of Neem oil and sesame oil makes it unsuitable as a complete replacement of diesel for combustion ignite engine. NOME and SOME and diesel blends were prepared by mixing all these oils. So this mixture is mixed with diesel in the ratio of 10:90, 20:80 and 30:70. These blends of mixed biodiesel and diesel are tested in engine for

p-ISSN: 2348-6848
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Volume 03 Issue 12
August 2016

testing of performance characteristics. If this ratio of replacement of diesel gives the satisfactory results, there would be a saving of diesel on the large scale. Moreover it many blends with different ratio can be formed to achieve more appropriate consequences. The description of the blends used in this experiment is given in the table 4.1.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 11
July2016

S.No.	Fuel Types	Nomenclature
1.	Diesel	-
2.	Neem oil + Sesame oil	-
3.	10% (Neem oil + Sesame oil) + 90% Diesel	B10
4.	20% (Neem oil + Sesame oil) + 80% Diesel	B20
5.	30% (Neem oil + Sesame oil) + 70% Diesel	B30

Table 4.1: NOME + SOME+ Diesel Blends for Experiments

4.6 Test Engine

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

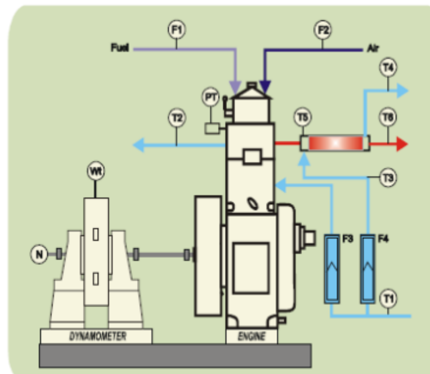

Figure-4.7 Block diagram of Engine Setup

Figure-4.8 A VCR Engine connected with computer system

4.7 Experimental Procedure

An eddy current dynamometer with electronic controller.

i. A kirloskar make, 3.5 kW, steady speed of engine

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 12
August 2016

ii. A Software to estimate engine performance parameters.

4.8 Engine Performance Test

The performance of the engine was evaluated by conducting fuel consumption

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 11
July2016

and rating tests as per **IS:10000[P: 8]:1980.**

4.9 Fuel consumption test

The fuel consumption test was carried out on fuels shown in Table 3.3. The performance of the engine on selected fuels was evaluated at the following load condition.

i. No load
ii. 3 kg load
iii. 6 kg load
iv. 9 kg load
v. 12 kg load

The following parameters were measured during the test:

i. Brake power, kW
ii. Indicated power, KW
iii. Fuel consumption, l/h
iv. Specific fuel consumption
v. Brake thermal efficiency
vi. Mechanical efficiency
vii. Volumetric efficiency
viii. Indicated thermal efficiency

5. RESULT AND DISCUSSION

The fuel properties such as kinematic viscosity, relative density of raw Neem oil, raw sesame oil, NOME, SOME as well as their blends with diesel were compared.

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

5.1 Relative Density

S. No.	Fuel types	Relative Density(kg/m^3)
1	Diesel	812
2	Raw Neem oil	956
3	Raw Sesame oil	986
4	NOME	888
5	SOME	981
6	NOME + SOME	992
7	B10	816
8	B 20	824
9	B 30	828

Table 5.1 Relative Density of Different Fuels at 35ºC

5.2 Kinematic Viscosity

Serial no.	Name of fuel	Kinematic viscosity (cst)
1	Diesel	3.10

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 12
August 2016

2	Neem Oil	25.833
3	Sesame Oil	26.667
4	NOME	6.11
5	SOME	4.61

International Journal of Research
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p-ISSN: 2348-6848
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Volume 03 Issue 11
July2016

6	NOME + SOME	7.88
7	B10	3.29
8	B20	3.31
9	B30	3.50

Table-5.2 Kinematic Viscosity of different fuels at 35^0C

5.3 Engine Performance on Selected Fuels

5.3.1 INDICATED POWER, BRAKE POWER AND FRICTION POWER

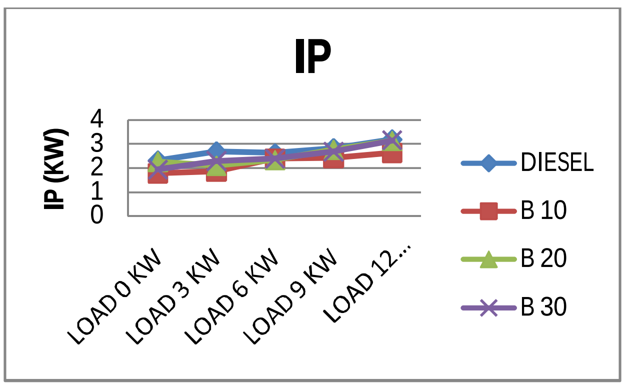

Figure-5.1 Indicated Power Produced by blends of diesel with NOME+SOME

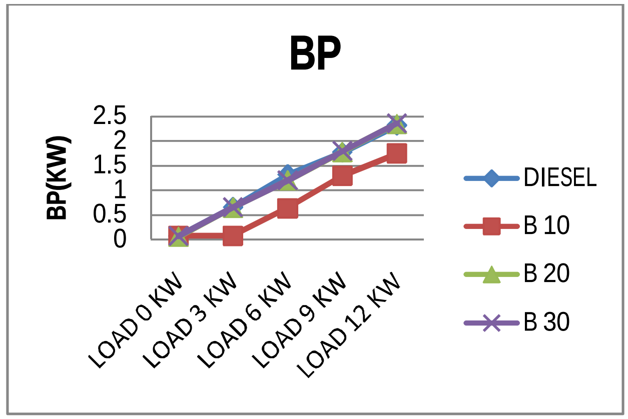

Figure-5.2 Brake Power Produced by blends of diesel with NOME+SOME

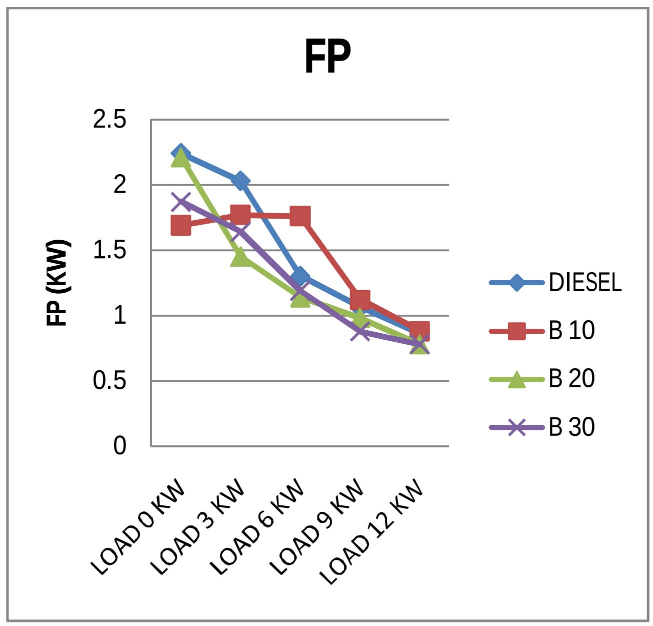

Figure-5.3 Friction Power Produced by blends of diesel with NOME+SOME

The above figures indicate that the increase in brake load gives the increase in indicated power and brake power and decrease in friction power under all type of fuel blends. It was observed that the engine was able to develop similar power on all fuel types at

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e-ISSN: 2348-795X
Volume 03 Issue 12
August 2016

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. It is also observed that the results with the blend B20 is almost same as the diesel. Mixed biodiesel of edible oil and non edible oil blended with diesel gives the satisfactory results. This observation moves ahead towards our objective.

5.3.2 IMEP, BMEP and FMEP

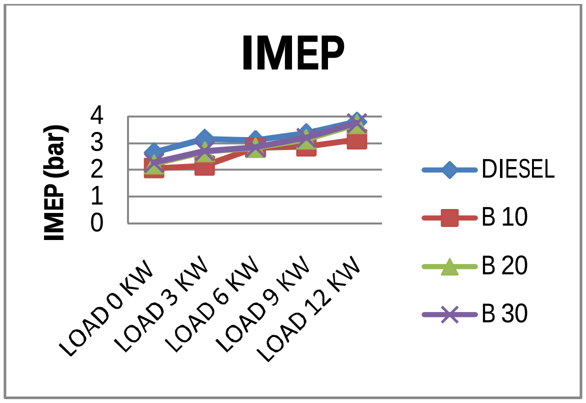

Figure 5.4 IMEP Produced by Diesel and its Blend with NOME+SOME

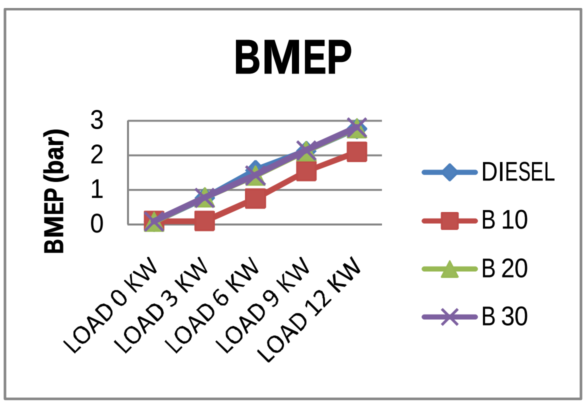

Figure 5.5 BMEP Produced by Diesel and its Blend with NOME+SOME

These figures indicate the Indicated mean effective power, Brake mean effective power and Frictional mean effective power. It is observed that blend B20 gives the result almost similar to that of diesel. IMEP, BMEP are increasing with increasing the load and FMEP is decreasing with increase in load. This is favorable to our objective. Since we can say that till now the observation indicates that B20 blend is the suitable for replacement of pure diesel.

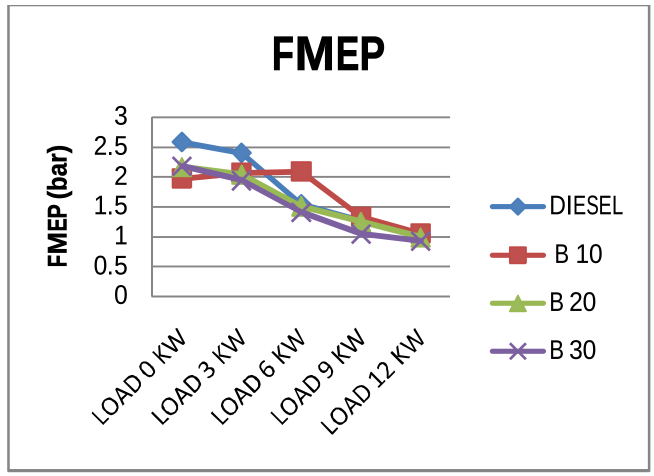

Figure 5.6 FMEP Produced by Diesel and its Blend with NOME+SOME

5.3.3 AIR FLOW AND FUEL FLOW

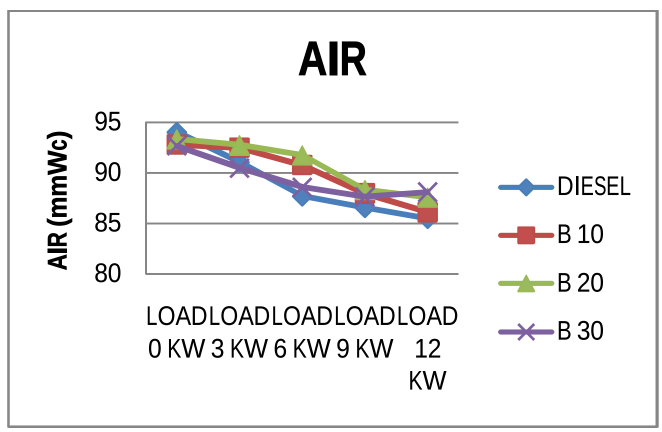

Figure 5.7 Air Flow for Diesel and its Blend with NOME+SOME

In the figure obtained for air flow and fuel flow, we can see the results of all types of blends and diesel separately. Air flow is decreasing with increasing the load and fuel flow is increasing for the same. We can notice here that B20 is the best blend to obtain the results similar to the diesel. As the load increases rich mixture of fuel is required. For obtaining the rich mixture air flow should be reduce and fuel flow should be increase.

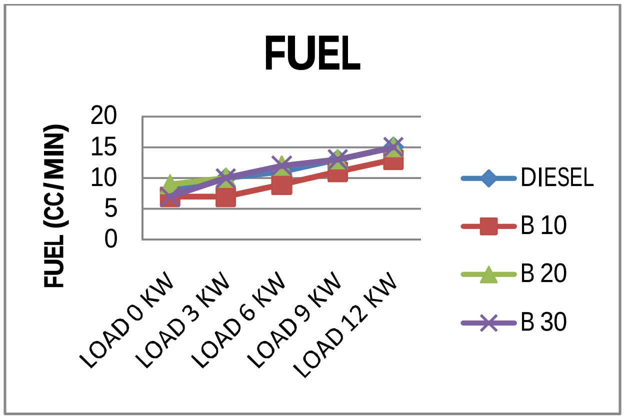

Figure 5.8 Fuel Flow for Diesel and its Blend with NOME+SOME

5.3.4 TORQUE, MECHANICAL EFFICIENCY AND VOLUMETRIC EFFICIENCY

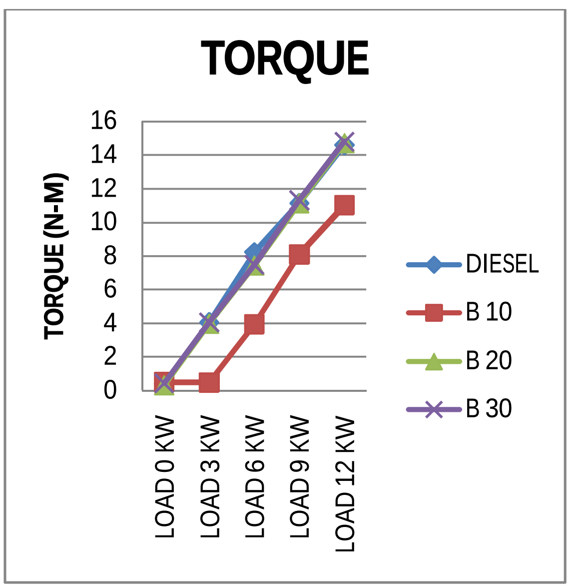

Figure 5.9 Torque produced by Diesel and its Blend with NOME+SOME

In these figure we can see that initially when engine is operating at no load, the torque is not produced. But as we increase the load the torque is increasing simultaneously. In the case of torque B30 blend gives the directly proportional graph and B20 behave like the diesel.

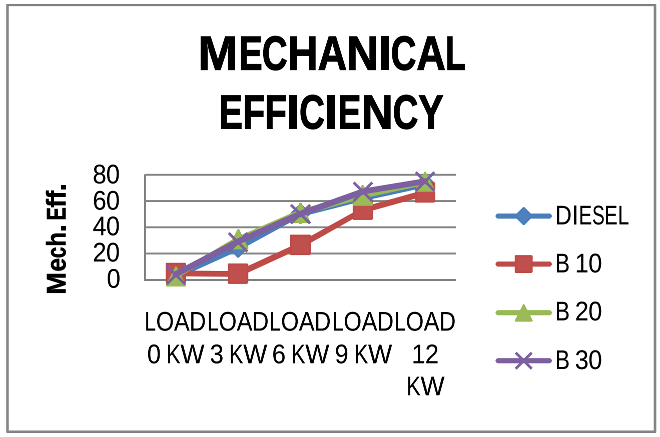

Figure 5.10 Mech. Eff. produced by Diesel and its Blend with NOME+SOME

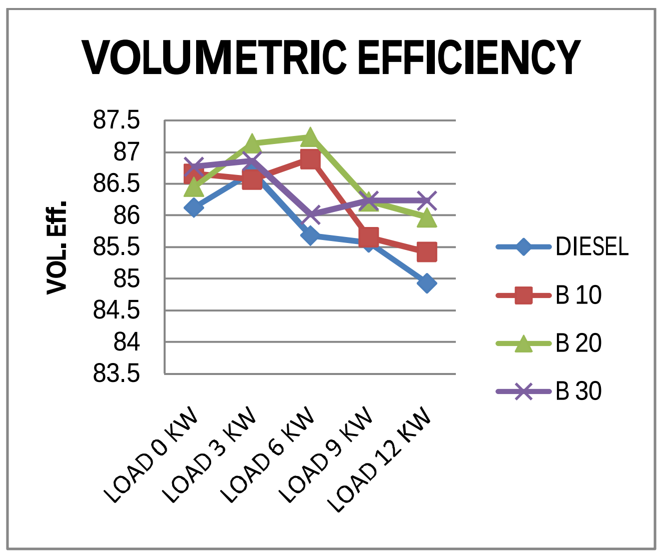

Figure 5.11 Vol. Eff. produced by Diesel and its Blend with NOME+SOME

Mechanical efficiency is increasing with load. But the volumetric efficiency initially

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Volume 03 Issue 12
August 2016

increases and then decreases. The results for blend B20 is closer to the diesel.

6. SUMMARY AND CONCLUSION

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

1. Two steps esterification is used to make the Neem oil biodiesel and Sesame oil biodiesel because FFA (free fatty acid) content in Neem oil and Sesame oil is very high.
2. The relative density of Neem oil and Sesame used in the experiment was higher than the diesel and NOME+SOME had the relative density higher than diesel.
3. The kinematic viscosity of Neem oil and Sesame oil used to make NOME and SOME was about 17 times higher than the diesel and NOME+SOME was about 3 times higher than the diesel.
4. The gross heat of combustion of Neem oil and Sesame oil is found to be higher than the diesel but NOME+SOME had the gross heat of combustion lesser than the diesel.
5. The performance evaluation of 3.5 kW diesel engine under the fuel consumption test on blends of NOME+SOME and diesel was found satisfactory on the basis of brake power, brake specific fuel consumption and brake thermal efficiency.
6. The engine performance was the best on B20 as the brake thermal efficiency was found to be highest and SFC was found to be lowest on this blend.

The above discussion indicates that Neem oil methyl ester (NOME) + Sesame oil methyl ester (SOME) may be recommended as CI engine fuel. However for the better performance of the engine B20 may also be recommended.

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