International Journal of Research in Engineering and Innovation (IJREI)
journal home page: http://www.ijrei.com
ISSN (Online): 2456-6934

Combustion performance analysis of a diesel engine using preheated ethanol (as a dope), neem oil and diesel oil blend

Anshu Agrawal[1], Arvind Kr. Siddharth[2], Himani Saxena[3]

[1,2] Department of Mechanical Engineering, Rajshree Institute of Management & Technology, Bareilly, U.P, India
[3]Department of Mechanical Engineering, Rakshpal Bahadur College of Engineering & Technology, Bareilly, India

Abstract

Diesel engines, now days are the main sources of energy consumption worldwide due to which there has been a remarkable effect of the increase in pollution. This research work is mainly done to test and analyze the performance analysis of a diesel engine when blended with preheated Ethanol (as a dope), Neem Oil and diesel fuel. For this experiment I used four stroke single cylinder water cooled diesel engine. Further I prepared four different blends of Ethanol, Neem Oil and diesel with 10% to 40% of Neem Oil at a difference of 10% along with 5% Ethanol mixed with it. Afterwards I evaluated the performance parameters at different blend ratios and further compared with that of the diesel. The mixture of preheated blend with equal racial volume of Neem Oil in diesel along with 5% Ethanol showed the efficient results when compared with solely unheated diesel or unheated blend. The results were fruitful and inferred that preheated blend gives the better performance than the blend at normal room temperature with reduced costs incurred.

Keywords: Ethanol (as a dope), Neem Oil and Diesel.

1. Introduction

Energy has become a crucial factor for humanity to continue the economic growth and maintain high standard of living especially after the inauguration of the industrial revolution in the late 18th and early 19th century. Due to high rate of energy consumption, the world has been confronted with energy crisis. In the past 30 years, the transportation sector has also experienced a very fast growth especially due to the increasing numbers of vehicles around the world. It has been estimated that the global transportation energy use is expected to increase by an average of 1.8% per year from 2018 to 2035 [1]. Globally, the transportation sector is the second largest energy consuming sector after the industrial sector and itself accounts for 30% of the world's total delivered energy, of which 80% is road transport. It is believed that this sector is currently responsible for nearly 60% of world oil demand [2] and will be the strongest growing energy demand sector in the future. The vast production and consumption of energy have caused bad consequences and resulted in severe environmental impacts across the world. Due to limited reserves of fossil fuels, increase in the cost and severe environmental consequences of exhaust gases from fossil fuels, attention has been focused on developing the renewable or alternate fuels to replace the petroleum based fuels for transport vehicles. There are several attractive alternative sources of fuel like vegetable oils, biogas, biomass, primary alcohols which are all renewable in nature over which many research have been done by many researchers to ensure its feasibility as alternative fuels for diesel engine [3-4] but my study will give very positive inferences when used preheated Ethanol and Neem oil as a bio-diesel fuel with Diesel as a blend.

2. Nomenclature

Some of the nomenclatures which would be used frequently in throughout the research are mentioned in the following table 1.

Table 1: Nomenclature of Blends

Name	Mixture Ratio / Name
B10	5% Ethanol + 10% NO + 85% Diesel
B20	5% Ethanol + 20% NO + 75% Diesel
B30	5% Ethanol + 30% NO + 65% Diesel
B40	5% Ethanol + 40% NO + 55% Diesel

Corresponding author: Anshu Agrawal
Email Address: anshuagrawalc54@gmail.com

CO	Carbon monoxide
HC	Hydrocarbon
NO_x	Oxides of Nitrogen

2.1 Neem Oil (NO) as Bio-Diesel

The scientific name of neem is Azadirachta Indica [5] which is a tree in the Mahogany family meliaceae and is one of two species in the genus azadirachta which grows in tropical and sub-tropical regions. The neem tree is native to India, and is light to dark brown in color and bitter in taste as well. It begins to bear fruit between 3 and 5 years and becomes fully productive in 10 years so a mature tree produces 30-50 kg fruit every year. The oil can be obtained either through pressing (crushing) of the seed by cold pressing or through a process incorporating temperature controls between 40 to 50 °C. Neem seed oil can also be obtained by solvent extraction of the neem seed, fruit, oil, cake or kernel. A large industry in India extracts the oil remaining in the seed cake using hexane.
Neem comprises mainly of triglycerides and large amounts of triterpenoid compounds. It contains four significant saturated fatty acids, of which two are palmitic acid and two are stearic acid. It also contains polyunsaturated fatty acids such as oleic acid and linoleic acids [6]. Since neem oil cannot be directly used in the diesel engine due to its high viscosity, high density, high flash point and lower calorific value so it needs to be converted into biodiesel to make it consistent with fuel properties of diesel [7-9]. This can be done by any of the known processes like:

- Direct use or blending in diesel fuel
- Thermal cracking of vegetable oils
- Micro emulsions in diesel fuel
- Transesterification

Out of the aforesaid four processes, I selected Transesterification as it is the best way for converting the vegetable oil into biodiesel [10]. It was conducted as early as 1853 by scientists E. Duffy and J. Patrick, many years before the first diesel engine became functional. For the purpose of soap production, in the 1940s this process was developed to improve the separation of glycerin.
Various properties of Neem Oil (NO) is shown in table 2.

Table 2: Properties of NO

Properties	Rating
Density(Kg/m^3)	893
Kinematic viscosity (cSt)	23.38
Calorific value(KJ/Kg)	29950
Flash point(oc)	230
Heating Value (MJ/kg)	38.67

2.2 Ethanol

Ethanol is widely known as alcohol, ethyl alcohol, and drinking alcohol as well which is a chemical compound too, a simple alcohol with the chemical formula C_2H_5OH and is often abbreviated as EtOH. Ethanol is a volatile, flammable, colorless liquid with a slight odor characteristic and is naturally produced by the fermentation of sugars by yeasts or via petrochemical processes. The largest single use of ethanol is as an engine fuel and fuel additive. It reduces harmful tailpipe emissions of carbon monoxide, particulate matter, oxides of nitrogen, and other ozone-forming pollutants [11]. Ethanol combustion in an internal combustion engine yields many of the products of incomplete combustion produced by gasoline and significantly larger amounts of formaldehyde and related species such as acetaldehyde [12] which leads to a significantly larger photochemical reactivity and more ground level ozone [13].

3. Experimental Setup

3.1 Engine Set-up

The experimental setup consists of a diesel engine with dynamometer to impart loads. The engine I used for the experimentation is a constant speed four stroke single cylinder vertical diesel Kirloskar engine which is water cooled and is mounted on a cemented bed with suitable supply for cooling system. The load applied on the engine is by means of mechanical loading device. The outlet temperature of the cooling medium is maintained to 50^0C by constantly maintaining the coolant supply.
Initially the setup was made to run on Diesel fuel so as to maintain the temperature and aid with all warm up conditions. Further, when the engine was in its running situation I switched the fuel supply from Diesel to unheated Blend of Ethanol, Neem Oil and Diesel and in the later stage to preheated Blend of Ethanol, Neem Oil and Diesel. The schematic arrangement of experimental setup is shown in fig.1 along with the photograph of actual experimental setup in fig. 2.

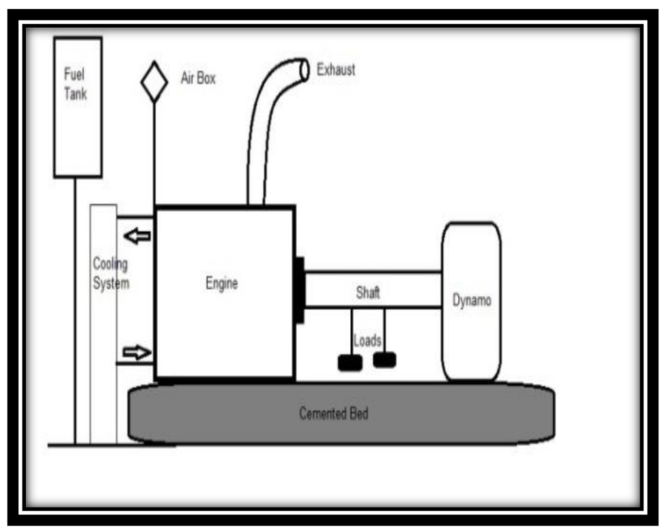

Figure 1: Schematic arrangement of experimental setup

Figure 2: Photograph of actual experimental setup

Engine specifications are given in table 3

Table 3: Engine Specifications

Illustration	Rating/Name
Model/ Manufacturer	Kirloskar
Brake power(hp)	5
Rated speed(rpm)	1500
Compression ratio	17
Kilo watt (kW)	3.7
Type of cooling	Water cooled
Injection type	Direct injection
Stroke length(mm)	110
Bore(mm)	80
Specific Fuel Consumption	245g/kW-h
Lube Oil	SAE 40

3.2 Viscometer with heating element

As viscosity is the physical property of fluid which measure the resistance offered by fluid particles during flow and at the same time it is known that CI engines requires less viscous fluid for proper atomization in the combustion chamber for burning, so less viscous fuel should be used. If viscosity of fuel is higher, more will be difficulty in atomization of fuel and will result in the problem of choking of inlet system of fuel [14].

Figure 3: Photograph of Viscometer setup

So the viscometer was used for the measurement of viscosity of blends. It consisted of a cylindrical cup surrounded by a water bath as it maintains the temperature of the oil which is to be tested. The oil is then heated by an electric element provided in the cup and on the lid there is a provision made to stir the oil as it maintains the temperature uniformly. To record the temperature there is a digital temperature measuring unit. All this is done to determine the kinematic viscosity of the oil.

4 Results and Discussions

The comparison between the non-heated and preheated blend along with Ethanol, Neem Oil, and Diesel oil are mentioned underneath on the basis of

- ❖ Load Vs Thermal efficiency
- ❖ Load Vs Specific Fuel Consumption

4.1 Load Vs Thermal Efficiency

Variation of Thermal efficiency with various load conditions is shown in fig 4. The thermal efficiency for that of unheated diesel is 22.73% at full load and for unheated ethanol mixed blends, B10, B20, B30 and B40, thermal efficiency is 22.57%, 22.17%, 22.86% and 23.45% respectively. Here blend B30 shows effective thermal efficiency than simple diesel.

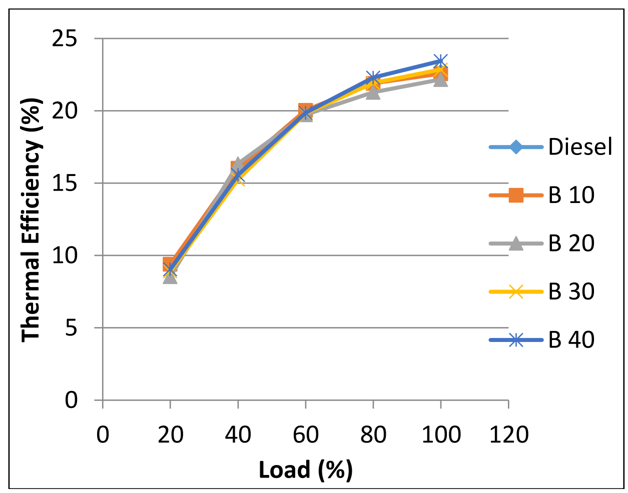

Figure 4: Variation of TE with Load for Unheated Diesel and Blends

Variation of Thermal efficiency with various load conditions is shown in fig 5. The thermal efficiency for that of Pre-heated diesel is 23.515% at full load and for pre-heated ethanol mixed blends, B10, B20, B30 and B40, thermal efficiency is 23.89%, 22.57%, 24.96% and 24.36% respectively. Here the blend B30 again shows the very effective thermal efficiency than other blends.

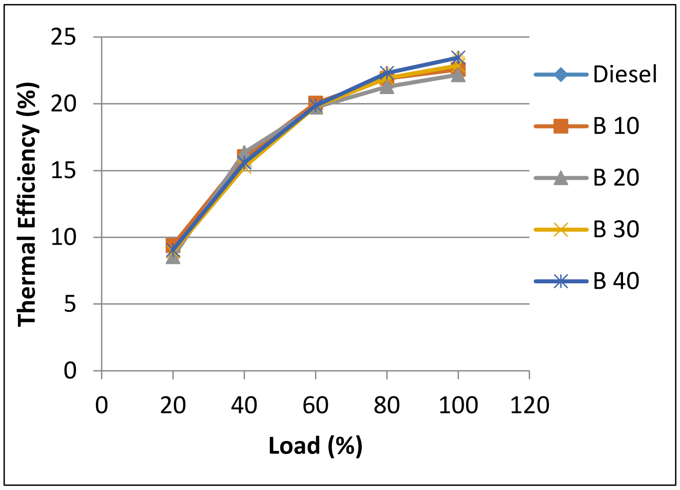

Figure 5: Variation of TE with Load for Pre-heated Diesel and Blends

4.2 Load Vs Specific Fuel Consumption

Variation of Specific Fuel Consumption with various load conditions is shown in fig.6. The observed specific fuel consumption values for unheated diesel fuel at full load is 0.318 and that of unheated ethanol mixed blend - B10, B20, B30 and B40 at full loading conditions are, 0.322, 0.336, 0.341 and 0.354 respectively.

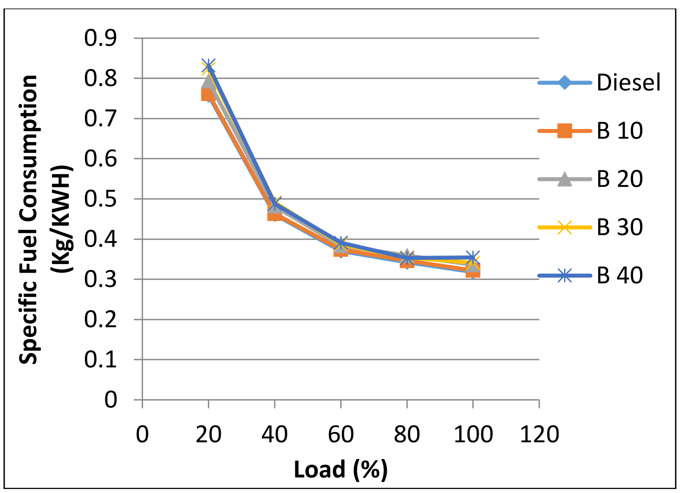

Figure 6: Variation of SFC with Load for Unheated Diesel and Blends

Variation of Specific Fuel Consumption with various load conditions is shown in fig. 7. The observed specific fuel consumption values for pre-heated diesel fuel is .307 and that of pre-heated ethanol mixed blend - B10, B20, B30 and B40 at full loading conditions are 0.309, 0.312, 0.314 and 0.316 respectively.

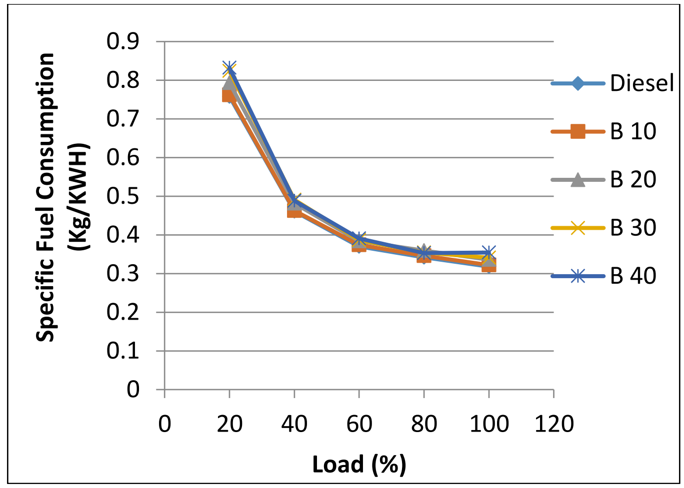

Figure 7: Variation of SFC with Load for Pre-heated Diesel and Blends

5. Conclusion

5.1 Effect on Thermal Efficiency

The graphs plotted between the loads and thermal efficiency showed that the thermal efficiency of engine for unheated diesel and various blends increases with increasing load and it was found to be highest of 23.45% for B40 blend because the calorific value at that blending limit was high. But it had the disadvantage that increased content of the Neem oil in B40 blend increased the viscosity and lowered the volatility which gave the poor combustion characteristics.
Whereas on the other hand, for preheated diesel and preheated Neem oil blends, the thermal efficiency of engine was found higher for the blend B30 than the unheated diesel and unheated Neem oil blends. These astounding results were suddenly because of the higher input temperature which leads to reduced viscosity and increased volatility. This perhaps allowed the better atomization and better mixing of fuel which indeed lead to better combustion characteristics.

5.2 Effect on Specific Fuel Consumption

The graph was plotted between the loads and specific fuel consumption and it was observed that for unheated diesel the SFC at full load was lowest i.e. of .318 and for unheated blend the lowest SFC at full load was that of B10 i.e. of .322. But as the proportion of unheated Neem oil is increased into the blend, the SFC is also increased which is definitely not desired. This was all because the calorific value of the Neem oil is lower than that of the diesel and thus as the proportion of the Neem oil is increased, the overall calorific value of the blend decreases. This eventually gives the poor combustion due to the increased viscosity and lower volatility.
On the contradictory, the SFC of the engine for preheated diesel and the entire preheated Neem oil blends were found much lower than that of the unheated diesel and all unheated Neem

oil blends. This was certainly due to decrease in the viscosity of blends as the preheating increased the temperature of the fuel and blend that allowed the better mixing and better atomization of Neem oil blends which indeed lead to better combustion.

5.3 Effect of Pre-Heating

Preheating of blended fuels within the range of 60^0C- 80^0C was done and further it was observed that the specific fuel consumption was reduced. Thermal efficiency was also observed to be increased to around 3% to 4% by using preheated fuels. Aforesaid benefits were achieved due to the decrease in the viscosity and increase in the volatility which resulted in the better atomization of fuel.

References

[1] https://www.eia.gov/energyexplained/?page=us_energy_transportation.

[2] https://www.statista.com/statistics/271823/daily-global-crude-oil-demand-since-2006/

[3] https://www.sciencedirect.com/science/article/pii/S1876610212002974/pdf?md5=20f9b43217bd9899b29bd950ba15d6f5&pid=1-s2.0-S1876610212002974-main.pdf

[4] https://www.researchgate.net/publication/286265728_Effect_of_compression_ratio_with_biodiesel_and_its_blends_on_performance_and_emission_characteristics_of_an_IC_engine/download

[5] "Azadirachta indica". Germplasm Resources Information Network (GRIN). Agricultural Research Service (ARS), United States Department of Agriculture (USDA). Retrieved 9 June 2017.

[6] https://pdfs.semanticscholar.org/1f09/4f43c1d1d991f8b7e5a076da78de8554c276.pdf

[7] https://www.researchgate.net/profile/Venkata_Mamilla/publication/284608848_Production_of_biodiesel_from_Neem_oil/links/578a6a9408ae254b1de0595e/Production-of-biodiesel-from-Neem-oil.pdf

[8] http://www.ep.liu.se/ecp/057/vol1/063/ecp57vol1_063.pdf

[9] https://www.sciencedirect.com/sdfe/pdf/download/read/noindex/pii/S1110062115301264/1-s2.0-S1110062115301264-main.pdf

[10] Walendzieuwski Jerzy. Engine fuel derived from waste plastics by thermal treatment. Journal of Fuel 2002;81:473e81

[11] California Air Resources Board, Definition of a Low Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05, second release, October 1989.

[12] Jump up ^ Lowi, A. and Carter, W.P.L. (March 1990) "A Method for Evaluating the Atmospheric Ozone Impact of Actual Vehicle emissions", S.A.E. Technical Paper, Warrendale, PA.

[13] Ethanol 101. American Coalition for Ethanol.

[14] https://www.researchgate.net/publication/309200478_Impact_of_Low_Viscosity_Engine_Oil_on_Performance_Fuel_Economy_and_Emissions_of_Light_Duty_Diesel_Engine.

Cite this article as: Anshu Agrawal, Arvind Kr. Siddharth, Himani Saxena, Combustion performance analysis of a diesel engine using preheated ethanol (as a dope), neem oil and diesel oil blend, *International journal of research in engineering and innovation (IJREI)*, vol 3, issue 1 (2019), 12-16.