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Review Paper

A Review of Neem Biodiesel As Fuel for CI Engine

Authors

[1] Dinesh Dabhi K., [2] Khiraiya Krunal B.*, [3]Nityam P. Oza

Address for Correspondence:

[1, 2] Mechanical Engineering Department, Gujarat Technological University, Gujarat, India
[3] Assistant Professor, Mechanical Engineering Department, Parul Institute of Engineering & Technology, Gujarat Technological University, Gujarat, India

Abstract:

Fuel crisis and environmental concerns have led to look for alternative fuel of bio origin successes such as vegetable oils, which can be produced from forests, vegetable. The effect of neem bio-diesel and its blending with pre- mineral diesel on different types of diesel engine combustion, performance and emission compared with this papers .The result shows that blending of bio-diesel of 20x shows better break thermal efficiency lower specific fuel combustion and less exhaust gas temperature while found less carbon monoxide, nitrogen oxide and hydrocarbons emission. This research paper also compares the experimental results carried out by different researches to evaluate break power, specific fuel consumption and exhaust gas emissions. When running on different engines with fuel additive blended with bio-diesel it is found that B20x produces higher performance with less exhaust emissions and fuel consumption as compared to blended diesel and mineral diesel.

Introduction:

An enormous increase in the number of automobiles in recent years has resulted in greater demand for petroleum products. With crude oil reserves estimated to last only for a few decades, therefore efforts are made on way to research on alternative to diesel. Depletion of crude oil would cause a major impact on the transport sector. Fossil fuels play the significant role in development of country. Continuous supply of fuel with increasing rate should be ensured to sustain and further development of country. Recently, significant problems associated with fossil fuel like short supply, drastically increasing price, non renewability, contamination of environment, adverse effect on bio systems compiles researcher to search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation has become highly pronounced in the present context. The situation is very grave in developing countries like India which import 70% of the required fuel, spending 30% of his total foreign exchange on oil imports [1]. In view of this, researcher found and analyse many energy sources like CNG, LNG, LPG, ethanol, methanol, hydrogen, bio-diesel and many more. Among these alternative fuels, India is having significant scope for development of bio fuel. Diesel engines are widely used in transportation, power generation, marine application, agriculture vehicles etc. Moreover, transportation and agriculture sector depends on diesel fuel therefore, it is essential that alternatives to diesel fuels must be developed. In the view of these, vegetable oils like palm oil, cotton seed oil, neem oil, are considered as alternative fuels to diesel which are promising alternatives.

Neem Biodiesel

Neem oil can be used as fuel in diesel engines directly and by blending it with methanol. The economic evaluation has also shown that the biodiesel production with a high calorific value matches diesel. Its blends with diesel substituting nearly 35% of the later have been suggested for use without any major engine modification and without any worthwhile drop in engine efficiency [7]. Engine tests with neem oil and neem biodiesel were done in India and Bangladesh, showing satisfactory engine performance. Yield of biodiesel from different non-edible oils (Jatropha curcas, Pongamia pinnata, Madhuca Indica and Azadirachta Indica) which are commonly available in India were examined and the results recommended the biodiesel production from Azadirachta Indica oil on the basis of high yield and quality from neem is very profitable. Physical and chemical properties of neem oil, neem methylester and conventional diesel are presented in Table 1 .The fuel properties of neem biodiesel were within the limits and comparable with the conventional diesel. Except calorific value, all other fuel properties of neem biodiesel were found to be higher as compared to diesel.

TABLE 1: PROPERTIES OF NEEM OILS AND ITS ESTER [7]

Properties	Diesel	Neem oil	Neem biodiesel
Density(kgm^{-3})	830	912–965	820–940
Viscosity(cSt)	4.7	20.5–48.5	3.2–10.7
Flashpoint(C)	60	214	120
Cetane number	45	31–51	48–53
Calorific value(MJkg-1)	42	32–40	39.6–40.2
Sulphur (ppm)	0.042	1990	473.8
Iodine value	----	65-80	----
Titre(C)	----	35-36	----
Fire point(C)	65	222	128
Pour point(C)	-16	10	2
Cloud point(C)	-12	19	9
Total glycerine (%)	----	----	0.26
Free glycerine (%)	----	----	0.02
Oxidation stability (h),110 C	3-6 min	12.4	7.1
Coldfilter plugging point(C)	----	11	----
Carbon residue(%mass)	0.17	----	0.105
Water content (%)	0.02	0.098	0.036

Non Edible oil composition and its Potential in India

Anindita Karmakar et al. [7] assessed and integrated the biological, chemical and genetic attributes of the plant and describes about the different tree borne oilseeds in India. Non edibles oils from the sources such as neem mahua, pongamia ,karanji, babassu, and jatropha, are easily available in many parts of the world including India, and are very cheap compared to edible oils.. In India, there are several non -edible oils from different species such as Pungam (Pongamia pinnata), Jatrofa (Jatrofa curcas), Neem (Azadirachta indica) Mahua (Madhuca indica) and Simarouba (Simarouba indica) , which could be utilized for biodiesel production processes. According to a survey conducted in 2002, 12 species have been selected for its importance of present industrial usage and abundance in distribution [7].

Transesterification and Esterification Process

Pravin A. Manade et [10].al utilized biofuel from two different production process: esterification called ethyl esters and transesterification called methyl ester. They found that fuel is rather viscous compared to diesel. Chemically is equivalent to fatty acid methyl esters or ethyl esters, produced out of triacylglycerol (triglycerides) via transesterification or out of fatty acids via esterification. Transesterification (alcoholysis) is a reversible reaction in which one ester is converted into another by interchange of ester groups. In the reaction one mole of triglyceride oils contained in vegetable oils, animal fats, or recycled greases, reacts with three moles of alcohol to form one mole of glycerol (glycerine) and three moles of the fatty acid alkyl ester (biodiesel). In order to shift the equilibrium to the right, an alcohol, typically methanol is added in an excess over the stoichiometric amount, but ethanol can also be use. The two main products, glycerol and fatty acid methyl/ ethyl esters (FAME/FAEE), are hardly miscible and thus form separated phases: un upper ester phase and a lower glycerol phase. After transesterification the properties of crude vegetable oil like density, viscosity, cetane number, calorific value, vaporization rate, and molecular weight are improved [10]. The representation of transesterification chemical reaction is shown in equation 2.1.Triglycerides called as vegetable oil and R_1, R_2 and R_3 represents the fatty acid.

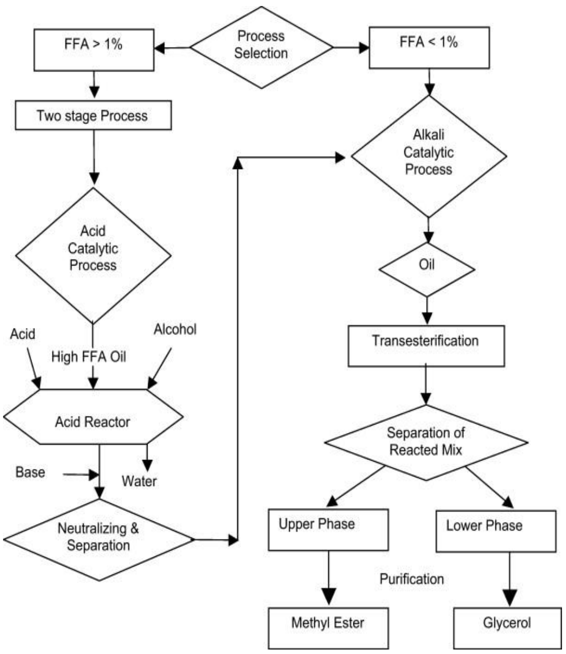
$$\begin{array}{lcl} CH_2\text{-}00C\text{-}R_1 & & R_1\text{-}COO\text{-}R \quad CH_2\text{-}0H \\ CH\text{ - }OOC\text{-}R_2 + 3CH_30H & \rightleftarrows & R_2\text{-}COO\text{-}R + CH\text{ - }OH \\ CH_2\text{-}00C\text{-}R_3 & & R_3\text{-}COO\text{-}R \quad CH_2\text{-}0H \end{array} \quad (1)$$

Author attributed that esterification is the process by which a fatty acid reacts with a mono-alcohol to form an ester. This reaction is a typically equilibrium reaction, so to increase the yield of fatty acid alkyl esters it is necessary to use an excess of alcohol or to remove one of the end products out of the equilibrium. The representation of esterification chemical reaction is shown in equation .2.

$$R_1COOH + CH_30H \xrightarrow{H^+} R_1COOCH_3 + H_20$$
$$R_1COOH + C_2H_50H \xrightarrow{H^+} R_1COOC_2H_5 + H_20 \quad (2)$$

Anindita Karmakar et.al[7] evaluated that the most commonly used method to produce biodiesel from crude vegetable oils and animal fats are to transesterify vegetable oils and animal fats to an alkyl ester to reduce their viscosity and increase in their volatility. The reaction of fats or oils with alcohols to produce biodiesel is called transesterification. In general, there are two methods of transesterification. One method employs a catalyst and another one is non-catalyst options such as super- critical processes, and co-solvent systems. A catalyst is employed to increase the reaction rate and yield. They analyzed that Various catalysts used are base catalysts that include NaOH, KOH, and NaMeO, acid catalysts that include H_2SO_4 ,H_3 PO_4 , and $CaCO_3$ and lipase enzymes. Methanol and ethanol are the two main light alcohols used for transesterification process. For biodiesel production alkaline or acidic catalysts are frequently used. The alkali-catalyzed reaction is reported to be much faster than acid-catalyzed one. Enzymes are also used as catalyst for trans- esterification. Glycerol is an important byproduct which can be burnt for heat or used as feedstock in cosmetic industry. Base catalyzed biodiesel production process generally consists of unit operations of transesterification reaction, distillation for recovery of excess alcohol, water washing for separating biodiesel from glycerol, catalyst and alcohol, distillation for crude biodiesel purification and glycerol purification. Fig. shows the process flow chart of generalized biodiesel production methods.

FIG.1: PROCESS SELECTION AND STEPS FOR BIODIESEL



PRODUCTION[7]

Performance of neem bio-diesel blends with Diesel in CI Engine

Atul Dhar et. al[11] investigated performance of CI engine using non edible oil and blend of oil with diesel produced from neem.A wide range of engine loads and volumetric blends of 5% neem biodiesel and 95% diesel, 10% neem biodiesel and 90% diesel, 20% neem biodiesel and 80% diesel, 50% neem biodiesel and 50% diesel are used for performance measurement of vertical, 4 stroke, single cylinder, constant speed, direct injection, water cooled, compression ignition engine of Kirloskar oil engine model no. DM-10. R.Senthilkumar et al[12] investigated the performance and combustion characteristics of Kirloskar made, single cylinder, naturally aspirated, water cooled, direct injection diesel engine running on diesel, volumetric blends of 10% neem biodiesel and 90% diesel, 30% neem biodiesel and 70% diesel, 40% neem biodiesel and 60% diesel, 50% neem biodiesel and 50% diesel. Nishant Tyagi et. al[13] evaluated the performance and emission characteristics of C I engine using diesel, 10% neem biodiesel and 90% diesel, 20% neem biodiesel and 80% diesel, 30% neem biodiesel and 70% diesel.The following performance and emission parameters investigated.

Brake thermal efficiency

Atul Dhar et. al[11] reported that brake thermal efficiency was highest among all test fuels. All blends showed higher brake thermal efficiency than mineral diesel. Author found 20% efficiency with mineral diesel, 23% efficiency with pure biodiesel of 100% blend, which is 15% higher. They attributed this increase in brake thermal efficiency is due to presence of oxygen in the biodiesel molecules which improves the combustion efficiency. R.Senthilkumar et al[12] observed that the brake thermal efficiency of blends 10% neem biodiesel and 90% diesel, 20% neem biodiesel and 80% diesel are almost very close to brake thermal efficiency of diesel. Brake thermal efficiency found 24.7% brake thermal efficiency by using pure diesel while 25.1% brake thermal efficiency by using30% neem biodiesel and 70% diesel, which is 1.63 % higher for blend 30% neem biodiesel and 70% diesel than pure diesel. They attributed this due to presence of increased amount of oxygen in respective fuels, which might have resulted in its improved combustion as compared to pure diesel. Nishant Tyagi et al[13] observed that break thermal efficiency of B10 is very close to break thermal efficiency of pure diesel. Author found 28% brake thermal efficiency by using pure diesel while 31% brake

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thermal efficiency by using20% neem biodiesel and 80% diesel. Break thermal efficiency of B20 is 14.2 % higher then break thermal efficiency of pure diesel due to the more oxygen content. Author attributed that an increase in break thermal efficiency may be attributed to the complete combustion of fuel because of oxygen present in blends perhaps also help in combustion of fuel.

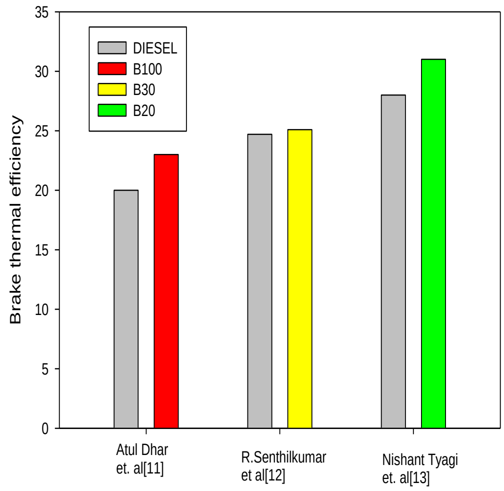

FIGURE.2: VARIATION IN BRAKE THERMAL EFFICIENCY FOR DIFFERENT FUEL

Specific fuel consumption

Atul Dhar et. al[11] observed that BSFC for the bio diesel and its blend increase due to lower calorific value of biodiesel in comparison with mineral diesel. Author found 0.38 kg/kwhr BSFC with mineral diesel, 0.36 kg/kwhr BSFC with blend 5% neem biodiesel and 95% diesel, 0.4 kg/kwhr BSFC with blend 100% neem biodiesel, which is 5.5% lower Author attributed that as the percentage of bio diesel increases break fuel consumption also increases. R.Senthilkumar et al[12] observed that the specific fuel consumption of blends 20% neem biodiesel and 80% diesel had 8.33 % lower than specific consumption of mineral diesel. Author found 0.6 kg/kwhr BSFC with mineral diesel, 0.55 kg/kwhr BSFC with blend 20% neem biodiesel and 80% diesel, Author attributed that this happened due to extra amount of oxygen present on the blend which is taking part in combustion process. Nishant Tyagi et al[13] investigated that specific fuel consumption of different load with all percentage of blending was found slightly decrease because of extra oxygen present on the blend which is taking part in combustion process.They observed that the specific fuel consumption of blends 20% neem biodiesel and 80% diesel had 13.33 % lower than specific consumption of mineral diesel. Author found 0.75 kg/kwhr BSFC with mineral diesel, 0.65 kg/kwhr BSFC with blend 20% neem biodiesel and 80% diesel Due to this extra amount of fuel is burning inside cylinder which improves the efficiency which result decrease specific fuel consumption.

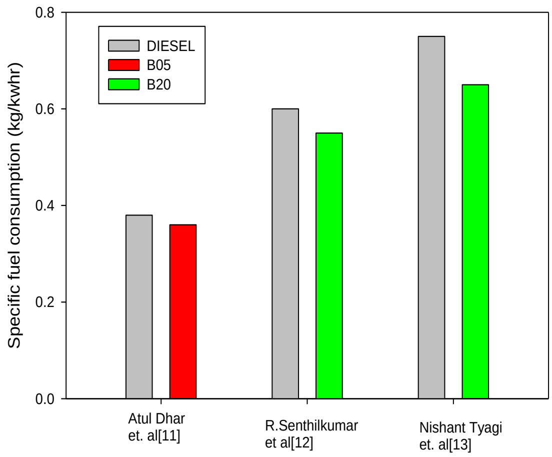

FIGURE .3: VARIATION IN BRAKE SPECIFIC FUEL CONSUMPTION FOR DIFFERENT FUEL

Exhaust gas temperature

Atul Dhar et. al[11] evaluated that exhaust gas temperature for all biodiesel blends is lower than mineral diesel. .Author found 280 °C EGT with pure diesel, 225 °C with blend 5% neem biodiesel and 95% diesel, 260 °C with blend 100% neem biodiesel. Author found that 20 % exhaust temperature decrease with 5% neem biodiesel and 95% diesel blend compare to mineral diesel. They attributed that combustion of higher biodiesel blends start relatively earlier and their combustion ends earlier also compare to lower biodiesel blends. **R.Senthilkumar et al[12]** evaulted that exhatst gas temperature for all blends of diesel and biodiesel are lower than the mineral.diesel Author found 287 °C EGT with pure diesel, 270 °C with blend 50% neem biodiesel and 50% diesel. Author found that 6 % exhaust temperature decrease with 50% neem biodiesel and 50% diesel blend compare to mineral diesel.Author attributed that this happen due to more oxygen present in the biodiesel and due to that complete combustion is done.

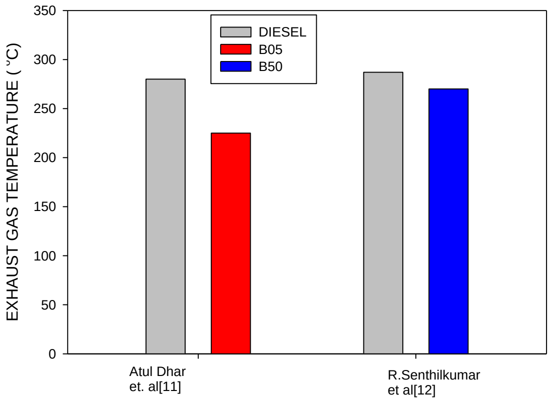

FIGURE.4 VARIATION IN EXAUST GAS TEMPERATURE FOR DIFFERENT FUEL

Carbon monoxide

Atul Dhar et. al[11] found 60 gm/kwhr with pure diesel, 40 gm/kwhr with blend 5% neem biodiesel and 95% diesel, 53 gm/kwhr with blend 100% neem biodiesel. Author found that 33.33 % COx decrease with 5% neem biodiesel and 95% diesel blend compare to mineral diesel. Author attributed that at higher engine loads, all the biodiesel blends except 50% blend show significant reduction in CO emissions. Reduction in CO emission is caused by the presence of oxygen molecules in the biodiesel blends, which facilitates the reburning of CO formed in the cylinder. **R.Senthilkumar et al[12]** investigated that emission of Cox for blends 20% neem biodiesel and 80% diesel is 16.67% lower than emission of COx for mineral diesel. They found 60 gm/kwhr with pure diesel, 50 gm/kwhr with blend 20% neem biodiesel and 80% diesel Author concluded that these lower emission of COx may be due to their more complete oxidation as compared to mineral diesel. **Nishant Tyagi et al[13]** observed that emission of Cox for blends 20% neem biodiesel and 80% diesel is 22% lower than emission of COx for mineral diesel. They found 90 gm/kwhr with pure diesel, 70 gm/kwhr with blend 20% neem biodiesel and 80% diesel Biodiesel produce less carbon monoxide than pure diesel because of better combustion due to extra oxygen present in the blend.

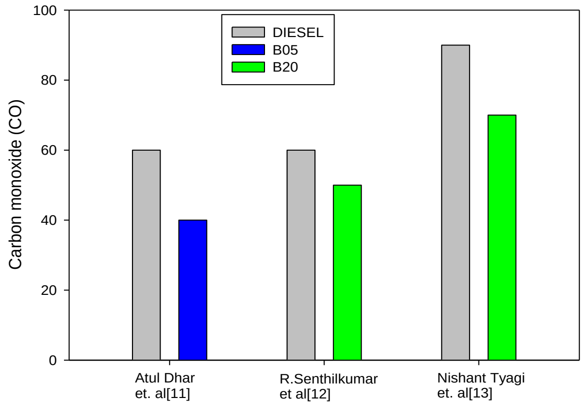

FIGURE .5 VARIATION IN CARBON MONOXIDE FOR DIFFERENT FUEL

Nitrogen oxides

Atul Dhar et. al[11] investigated that NOx emissions is 2.2% decrease with blends of neem biodiesel and 95% diesel. They found 3.2 gm/kwhr with pure diesel, 2.5 gm/kwhr with blend 100% neem biodiesel. NO formation is dependent on the temperature inside the cylinder and the concentration of available for reacting with nitrogen .higher oxygen content of biodiesel blends increases NOx emissions. **R.Senthilkumar et al[12]** investigated that 12% NO_X decreses with 30% neem biodiesel and 70% diesel. They found 7.69 gm/kwhr with pure diesel, 6.72 gm/kwhr with blend 30% neem biodiesel and 70% diesel. NOx emission found less compare to mineral diesel due to good mixture formation and lower smoke emissions these factor are highly influenced by viscosity density and volatility of fuel. **Nishant Tyagi et al [13]** investigated that NOx emissions is 21% lower than for B20 (20% neem biodiesel and 80% diesel biodiesel).Author found that slight decrease in NOx in B20 because of in complete combustion. This may be attributed due to higher viscosity which may lead to poor mixture formation.Author attributed that one of blend of biodiesel increases NOx increases because oxygen present in the blend perhaps also helped in complete combustion of fuel.

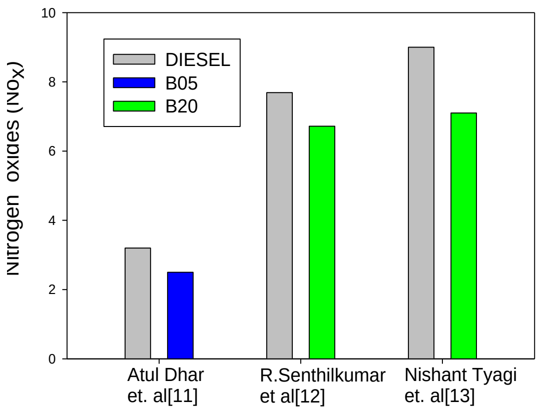

FIGURE .6: VARIATION IN OXIDES OF NITROGEN FOR DIFFERENT FUEL

Hydrocabon (HC)

Atul Dhar et. al[11] evaluated that emissions of hydrocarbon is 35.7 % decrease with blends of 20% neem biodiesel and 80 % diesel. They found 70 gm/kwhr with pure diesel, 45 gm/kwhr with blend 20% neem biodiesel and 80% diesel, 50 gm/kwhr with blend 100% neem biodiesel. They found that all biodiesel blends exhibit lower the HC emission compared to mineral diesel this may be due to combustion of biodiesel blends due to presence of oxygen. **R. Senthilkumar et al[12]** investigated that emissions of hydrocarbons is 36% lower for blend of 20 % neem biodiesel and 80 % diesel. They found 50 gm/kwhr with pure diesel, 35 gm/kwhr with blend 20% neem biodiesel and 80% diesel. Compare to pure diesel they attributed that the less emission compare to diesel due to good mixture formation.

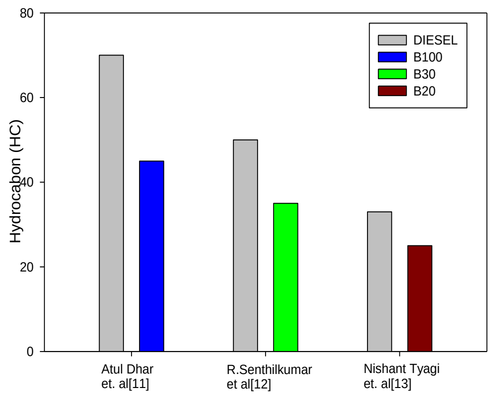

FIGURE .7: VARIATION IN HYDROCABON FOR DIFFERENT FUEL

Nishant Tyagi et al[13] experimentally found that hydrocarbon emission is 24.24% lower for blends of 20% neem biodiesel and 80 % diesel compare to pure diesel They found 33 gm/kwhr with pure diesel, 25 gm/kwhr with blend 20% neem biodiesel and 80% diesel. For B10 and B20 percentage of hydrocarbons decreases because of better combustion which may be attributed to extra oxygen present in they blend but for B20 the percentage of hydrocarbons increases slightly due to insufficient combustion because of higher viscosity which may lead to poor mixture formation due to poor atomization.

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krunal12345@rediffmail.com * Corresponding Author Email-Id