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Nerium (Adelfa) Biodiesel as an Alternative Fuel for CI Engine: Review

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ABSTRACT: Faster depletion of fossil fuels, day to day increase of automotives and increasing cost of petroleum fuel triggered the interest of researchers to arrive at an alternative fuel which is most suitable to compression ignition engines. Many alternative fuels like alcohols, biodiesels, liquid petroleum gas (LPG), compressed natural gas (CNG) etc. have been already commercialized in the transport sector. In this context Nerium oil renewed interest. Nerium oil is blended with diesel and used as alternative fuels for CI engine. This review has been taken up to identify the performance and emission using Nerium biodiesel.

KEYWORDS: Nerium biodiesel, performance, Combustion, blends, CI engine, emissions.

I. INTRODUCTION

Energy consumption is inevitable for the existence of human beings. Fuels derived from petroleum products have been the most important source of world's energy and mostly the transportation sector. It is estimated that towards the end of this century, crude oil and petroleum products will become very scarce and costly. Even though the fuel economy of modern engines are improving day by day, the enormous increase in the number of automobiles have started dictating the demand for fuel. It is believed that gasoline and diesel, which are the most widely used fuels these days, will be facing extinction towards the end of this century. So, it is the need of the hour to find other sources of eco-friendly, renewable fuels which can be used as an alternative to the conventional fossil fuels. With increased use and depletion of fossil fuels, alternative fuel technology will become much more common in the years to come. Biodiesels, produced from vegetable oils, has been under research as an alternative fuel for the past few years. Biodiesel can either be used as a sole fuel, known as neat biodiesel or can be blended with petroleum diesel in various proportions for use in diesel engines. Recent researches in this field show that biodiesels can be blended with diesel up to 30% by volume without any modifications to the engine. Further increasing the biodiesel content in the fuel blend requires minor modifications like varying the injection pressure, injection timing, compression ratio etc. In a few foreign countries, B20 (20% biodiesel + 80% diesel) fuel blend has been used widely in compression ignition engines as a partial alternative to petroleum diesel. Biodiesel could be produced from a wide variety of vegetable oils such as Rice bran oil, Coconut oil, Soyabean oil, Sunflower oil, etc. but most of the above are edible oils. As far as a developing country like India is concerned, the use of an edible oil for biodiesel production leads to an imbalance between the food and the fuel sector. So the main criterion to be followed in this case is that the alternative fuel (biodiesel) should be produced from a non-edible vegetable oil. Some of the main non-edible vegetable oils are Jatropha, Pongamia, Mahua, Nerium, Eucalyptus, Castor oil etc. The vegetable oil source from which the biodiesel is derived is selected depending upon their availability in that region of the country. It is estimated that if the farm lands available in the country are properly utilized, India could be a leading producer of biodiesel in the world. Therefore, the use of biodiesel as an alternative fuel would contribute to the overall development of agriculture, economy and environmental sector of the nation.

A. TRANSESTERIFICATION PROCESS

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

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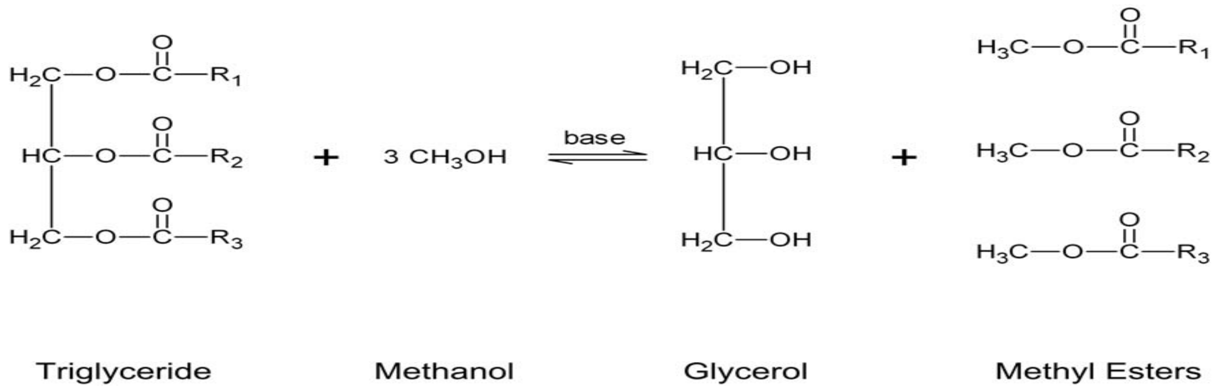

Fig-1: Transesterification reaction

B. PROPERTIES OF FUELS

Properties	Diesel	Nerium Oil Methyl Ester (NOME)
Density (kg/m³)	830	850 - 910
Kinematic viscosity at 40˚C (cSt)	1.57 – 3.9	3.7 – 6.5
Flash point (˚C)	49 – 58	70 – 148
Calorific value (MJ/kg)	42 – 43.2	36.57 – 42.65
Cetane number	49 – 50	45 – 51

Table-1: Properties of diesel and Nerium oil methyl ester

II. LITERATURE REVIEW

1. Pradeep Kumar A. R., Annamalai. K., Premkartikkumar. S R [1]

Conducted experiments on, influence of injection timing on emission parameters of Adelfa biodiesel (Nerium oil methyl ester – NOME) fuelled DI CI engine. In this work, transesterified Adelfa oil (Nerium oil methyl ester – NOME) was used as the test fuel and the results were compared with diesel fuel. The injection timing was retarded to 24° bTDC and advanced to 30° bTDC and 33° bTDC.

Results showed that, for all load conditions and for all injection timings the brake thermal efficiency was found to be maximum at three fourth of load condition. The maximum efficiency was obtained with diesel fuel to a value 25.608%. The decrease in the efficiency were found to be 11.71%, 3.71% and 3.87% when the injection timings were 24° bTDC, 27° bTDC and 33° bTDC. The brake thermal efficiency was found to be 25.502% when the injection timing was 30° bTDC. The hydrocarbon emission increases when the injection timing was retarded and decreases when the injection timing was advanced, for both diesel and A20 biodiesel. The hydrocarbon emission was found to be 73ppm at maximum load, with petroleum diesel with standard injection timing. The increase in hydrocarbon emission was found to be 2.74%, when the injection timing was retarded to 24° bTDC. The decrease in hydrocarbon emission was found to be 11.87% and 8.21%, when the injection timing was advanced to 30° bTDC and 33° bTDC. The CO emission increases with the decrease of injection timing and decreases when the injection timing was advanced. The CO emission was higher at initial load condition and decreases gradually with the increase of load, for both diesel and A20 biodiesel. The decrease CO emission was found to be 5.88%, 9.44%, 22.35% and 16.47% when the injection timings were 24° bTDC, 27° bTDC, 30° bTDC and 33° bTDC. The smoke opacity emission increases when injection timing was retarded and decreases when injection timing was advanced. The increase in smoke opacity was found to be 32.1%, when the injection timing was retarded to 24° bTDC. The decrease in smoke opacity was found to be 3.84% when the injection timing was advanced to 30° bTDC. NO_X emission increases with the increase of injection timing with A20 biodiesel fuel than diesel. The decrease in NO_X emission was found to be 18.04% when the injection timing was retarded. The increase in NO_X emission was 24.01% with A20 biodiesel at standard injection timing (27° bTDC). The increase in NO_X emissions were found to be 42.02% and 35.43% more than diesel, when the injection timings were 30° bTDC and 33° bTDC.

2. S. Prabhakar, V. N. Banugopan, K. Annamalai, S. Jayaraj [2]

Conducted experiments on, optimization of esters of Nerium biodiesel in a diesel engine. In this work, methyl and ethyl esters of Nerium oil were prepared by transesterification using both methanol and ethanol. The Nerium oil blends were prepared in the proportion of 20%, 40%, 60%, 80% and 100% with diesel.
Results showed that, the brake thermal efficiency was highest with diesel in all loads. The maximum efficiency was obtained for methyl esters of Nerium oil (MEON) blends compared with ethyl esters of Nerium oil (EEON) blends. The UBHC increases with increase in load for all fuels. The UBHC emission was less in case of MEON blends when compared to EEON blends. The amount of NO_X emission was increases with increase in load for all fuels. The NO_X emission was higher in case of EEON blends when compared to MEON blends.

3. Pradeep Kumar. A. R., Annamalai. K., Premkartikkumar. S R [3]

Conducted experiments on, emission parameters of transesterified Adelfa oil (methyl ester of Nerium oil). In this work, Adelfa (Nerium oil methyl ester – NOME) was blended with diesel 20% by volume and various emission tests have been carried out.
Results showed that, the brake power was maximum at three fourth of load condition and it was low at full load condition. There was a marginal decrease of 4.72% in brake thermal efficiency was observed when methyl esters of Adelfa oil blend was used. At three fourth of load, the hydrocarbon was the least for both reference and test fuel. The hydrocarbon emission of A20, was found to be 8.125% lower than petroleum diesel at three fourth of load condition. The carbon monoxide emission significantly better with A20 biodiesel compared to diesel. At three fourth of load the carbon monoxide emission of A20 was found to be 16.36% lower than diesel. The NO_X emission was more with methyl esters of Adelfa oil, at all load conditions, when compared to diesel. The increase in NO_X emission was about 129ppm when A20 was used.

4. K. Suresh Kumar, G. Guruvaiah Naidu, A. Venkata Vishnu [4]

Conducted experiments on, performance and emission evaluation of a DI diesel engine using Nerium oil as alternative fuel. In this work, the performance and emissions characteristics were evaluated on single cylinder four stroke water cooled diesel engine which was capable of developing a power output of 7.5 kW at 1500 rpm fuelled with 20%, 30% and 40% of Nerium oil blended with diesel.
Concluded that, the blends of Nerium oil showed lowest specific fuel consumption than diesel at part loads. Mechanical efficiency for NO 30 was higher compared to diesel fuel. Brake mean effective pressure was also increased as the percentage of the Nerium oil increases with the diesel. The volumetric efficiency was raised as the blend of Nerium oil increases in the diesel. CO emission decreases with increase in percentage of Nerium oil in the fuel up to 3000 W. CO_2 emissions of Nerium oil and its diesel blends were slightly lower than that of diesel. HC emissions of Nerium oil and its diesel blends were lower than that of diesel.

5. Suresh Kumar. S., Allen Jeffrey. J., Prabhu. A., Vijaya sharathi. N [5]

Conducted experiments on, preparation and performance analysis of Nerium oil blended with diesel. In this work, Nerium oil was extracted and it was converted into biodiesel as an alternative fuel for diesel engine. The testing was done by running a diesel engine with the biodiesel blends with base fuel in various proportions such as 5%, 10% and 15% to find out the optimum blend ratio.
Results showed that, for an applied load, the brake power was similar for both diesel and biodiesel. There was an increase of 0.12% of brake power when biodiesel was used. The TFC value was decreased by 0.1622 kg/hr when

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biodiesel was used at no load condition. The SFC value was decreased by 0.4187 kg/kW-hr when biodiesel was used at no load.

6. Isaac Joshua Ramesh Lalvani J., Parthasarathy M., Dhinesh Balasubramaninan, Annamalai K [6]

Conducted experiments on, DI diesel engine with renewable biodiesel – Adelfa. In this work, Adelfa oil methyl esters (AOME) were prepared using transesterification process and tests had been carried out in direct injection single cylinder diesel engine with their blends such as AOME 10, AOME 20, AOME 30, AOME 40 and AOME 100.
Results showed that, diesel showed the superior brake thermal efficiency on all loads. Brake thermal efficiency of the engine was reduced by increased blend ratio of Adelfa biodiesel with diesel. Specific energy consumption for the Adelfa biodiesel and their blends was higher than diesel. Unburnt hydrocarbon emission for Adelfa biodiesel blends were less as compared to diesel due to complete combustion. Carbon monoxide emission of Adelfa biodiesel blends were less as compared to diesel due to complete combustion. The NO_X emissions were higher for the Adelfa biodiesel and their blends as compared to diesel. Adelfa biodiesel and their blends showed complete combustion so they had lower smoke emissions.

7. Cijil. B. John, M. Subramanian [7]

Conducted experiments on, performance, emission and combustion parameters of a direct injection diesel engine using Eucalyptus and Nerium biodiesels as fuel. In this work, an experimental investigation on the performance, emission and combustion characteristics of two different biodiesels – Nerium and Eucalyptus biodiesel, in a single cylinder direct injection diesel engine. Both Nerium and Eucalyptus biodiesels were blended separately with diesel fuel 30% by volume (N30 and E30) and the various characteristics were studied.
Results showed that, the peak cylinder pressure was higher for eucalyptus biodiesel (E30 blend) at all tested loads. For an engine power output of 0.9 kW, the peak pressures were found to be 70 bar, 72.6 bar and 74 bar, respectively, for diesel, N30 and E30. For an engine power output of 3.6 kW, the peak cylinder pressures were found to be 86 bar, 87.4 bar and 90 bar respectively for pure diesel, N30 and E30 fuel blends respectively. At lower power outputs (0.9 kW), the SFC of pure diesel and the lower blends was found to be much lower than that of N30 and E30. The maximum BTE of the engine using diesel was observed to be around 28.6%. There was a marginal decrease in the BTE of nearly 6.9% while using E30 blend as the fuel. The BTE of the engine for N30 fuel blend was found to be further lower than that of both diesel and E30 blends. The HC emission for Eucalyptus biodiesel (E30) was found to be nearly 27% lower than diesel fuel at higher power outputs (3.6 kW). Similarly, the use of Nerium blend (N30) also recorded a reduced HC emission of nearly 16% lower than that of diesel. CO emissions of biodiesel blends were found to be significantly lower than that of diesel fuel. At all engine loads, the NO_X emissions of biodiesel blends (N30 and E30) were higher than that of diesel. For all the tested fuels, the maximum NO_X emissions were observed at a power output of 3.60 kW. E30 fuel blend resulted in an increase in smoke intensity when compared to diesel while the use of N30 fuel blend resulted in a slight decrease in the smoke especially at high engine loads.

8. Senthil Kumar R., Gopalakrishnan. V [8]

Conducted experiments on, performance and emission characteristics of four stroke diesel engine using Nerium oil as an alternative fuel. In this work, the Nerium oil blends were prepared in the proportions of 20%, 40%, 60%, 80%, 100% with diesel.
Results showed that, the brake thermal efficiency for neat diesel at full load was 28.75% and it was 24.08%, 23.56%, 22.45%, 21.923% and 21.07% for N20, N40, N60, N80 and N100. The best thermal efficiency was obtained for N20 blend and was 4.67% less than that of diesel at full load condition. The specific energy consumption was highest for N100 and least for N20 fuel. The specific energy consumption for N20 was 7.5% higher than diesel fuel. The UBHC emissions were approximately 16.86% less in case of biodiesel and its blends when compared to diesel. The UBHC emissions for N20 were approximately 5% less than diesel fuel. The CO emissions of N20 were 0.013% lower than the diesel fuel. The CO emissions were decreases with increase in load for all fuels. The amount of NO_X emissions were increases with increase in load for all fuels. The NO_X emissions of N20 were 17.9% higher than diesel fuel. The noise increases with increase in load for all fuels. The noise was 9.06% higher in case of biodiesels and its blends when compared to diesel. The noise of N20 was 3.9% higher than the diesel fuel. The CO_2 emissions were 34.2% higher in

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case of biodiesel blends when compared to diesel. The CO_2 emissions of N20 were 14.3% higher than diesel fuel. The amount of CO_2 emissions were increases with increase in load for all fuels. Peak pressure for pure diesel at 27° bTDC as 77 bar. Peak pressure for N20 was 66 bar, N40 was 63 bar, N60 was 61 bar, N80 was 59 bar and N100 was 58 bar. Instantaneous heat release rate for diesel was 76.50 J/deg CA. Instantaneous heat release rate for N20 was 80.23 J/deg CA, N40 was 83.73 J/deg CA, N60 was 86.17 J/deg CA, N80 was 88.1 J/deg CA and N100 was 91.9 J/deg CA. Cumulative heat release rate for N20 was 346.04 J/deg CA, N40 was 351.93 J/deg CA, N60 was 367.05 J/deg CA, N80 was 420 J/deg CA, N100 was 433.9 J/deg CA. Cumulative heat release rate for pure diesel was 329.04 J/deg CA.

9. S. Prabhakar, S. Prakash, M. Saravana Kumar [9]

Conducted experiments on, effect of Nerium biodiesel in diesel engine. In this work, the Nerium oil blends were prepared in percentage of 20%, 40%, 60%, 80% and 100% with diesel. First these blends were tested at normal injection timing 27º bTDC at constant injection pressure 200 bar and with a constant compression ratio 17.5. Then for the best efficiency blend, the tests were conducted at three different injection timings 24º bTDC, 30º bTDC and 33º bTDC.

Results showed that, at normal injection timing of 27º bTDC the brake thermal efficiency for neat diesel at full load was 26.48% and it was 24.08%, 23.56%, 22.45%, 21.923% and 21.07% for N20, N40, N60, N80 and N100. The best thermal efficiency was obtained for N20 blend and was 2.4% less than that of diesel for full load. Brake thermal efficiency at different injection timings for best efficiency blend (N20) at 24º bTDC was 22.60%, at 30º bTDC was 26.12% and at 33º bTDC was 24.61%. For N20 at 30º bTDC it was found to be 2.04% higher than N20 at 27º bTDC. The Specific energy consumption was highest at 33° bTDC and was least at 30º bTDC. The UBHC and carbon monoxide emissions were highest at 24º bTDC and were least at 30º bTDC. The oxides of nitrogen and carbon di-oxide emissions were highest at 30º bTDC and were least at 24º bTDC. The sound characteristic was highest at 33º bTDC and was least at 30º bTDC. Peak pressure for pure diesel at 27º bTDC was 72 bar. Peak pressure of N20 for 30º bTDC was 70 bar, 33º bTDC was 67 bar, 27º bTDC was 66 bar and 24º bTDC was 63 bar. Instantaneous Heat release rate for pure diesel was 76.50 J/deg CA at 27º bTDC. Heat release rate of N20 at 30º bTDC was 78.6 J/deg CA, at 33º bTDC was 79.7 J/deg CA, at 27º bTDC was 80.23 J/deg CA and at 24º bTDC was 86.12 J/deg CA. Cumulative heat release rate for pure diesel was 329.04 J/deg CA at 27° bTDC. Cumulative heat release rate of N20 at 30º bTDC was 335.01 J/deg CA, at 33º bTDC was 340.23 J/deg CA, at 27º bTDC was 349.04 J/deg CA, and at 24º bTDC was 366.60 J/deg CA.

10. A R P Kumar, K Annamalai, S R Premkartikkumar [10]

Conducted experiments on, Adelfa (NOME – Nerium oil methyl ester) with DEE as the fuel additive for NO_X reduction in DI diesel engine. In this work, Di ethyl ether (DEE) has been used as a fuel additive (20% Adelfa by volume with diesel + DEE). Comparison between diesel, A20 and A20+DEE with various proportions has been analyzed.

Results showed that, the maximum brake thermal efficiency obtained was 25.61% with diesel as fuel and it was decreased by 13.6% with A20 biodiesel fuel at three fourth of load. The decrease in brake thermal efficiency was found to be 10.8%, 8.2% and 2.77% for A20 + 5% DEE, A20 + 10% DEE and A20 + 15% DEE blends respectively. The brake thermal efficiency was found to be 24.9% with A20 + 15% DEE at three fourth of load. Specific energy consumption was more than diesel when A20 biodiesel was used as fuel and it gradually decreases with increase DEE blending up to 15%. The increase in specific energy consumption was 16% more when A20 biodiesel was used. The increase in specific energy consumption was found to be 16.41% and 15.04% when the fuels used were A20 and A20 + 5% DEE. Specific energy consumption was almost close to diesel when A20 + 10% DEE was used as fuel with variation of 1.05%. The pressure developed was highest when diesel was used and the pressure obtained was almost equal to diesel with A20 + 15% DEE with a marginal decrease of 0.72%. The lowest heat release next to diesel, was obtained when the A20 + 15% DEE blend was used. The percentage decrease of heat release rate with diesel was found to be 0.36% for A20 + 15% DEE, which was lesser than A20 and other blends of A20 + DEE. Heat release rate was 6.12% more than diesel with A20 biodiesel. A maximum increase of HC emission about 5ppm was found when A20 + 15% DEE was used as the test fuel, which was highest among all other blends. A maximum decrease of HC emission about 4ppm was found when A20 biodiesel was used. The CO emission increases with DEE blend was increased with biodiesel. CO emission of biodiesel (A20) was lesser than diesel. Smoke opacity emission increases when the load was increased. When DEE percentage was increased the smoke opacity emission decreased. NO_X emission decreases with

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the increasing content of DEE with biodiesel. When compared to diesel, maximum reduction of 31 ppm of NO_X was observed, when A20 + 15% DEE was used as the test fuel.

11. S. Prabhakar, K. Annamalai [11]

Conducted experiments on, biodiesels: an alternative renewable energy for next century. In this work, a comparative analysis of various methyl esters of different oils such as Nerium, Jatropha, Pongamia, Mahua, Neem was carried out. Results showed that, BTE of diesel was maximum compared with other biodiesels at all loads. Among biodiesels, Nerium showed better BTE than other oils. BTE trend at 20% blend of biodiesel was N20 > J20 > P20 > M20 > NE20. For other blends, trend was similar to that for B20 blend. HC emission of diesel was minimum compared with other biodiesels at all loads. Among biodiesels, Nerium showed minimum HC emissions than other oils. HC emission trend at 20% blend of biodiesel was N20 < J20 < P20 < M20 < NE20. As the load increases, HC emission decreases. For other blends, trend was similar to that of 20% blend. NO_X emission of diesel was minimum compared with other biodiesels at all loads. Among biodiesels, Nerium showed maximum NO_X emissions than other oils. NO_X emission trend at 20% blend of biodiesel was N20 > J20 > P20 > M20 > NE20. For other blends, trend was similar to that of 20% blend. As the load increases, NO_X emission increases.

III. CONCLUSION

Nerium biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on Nerium methyl ester with performance compared to diesel operation. The Nerium biodiesel can be successfully substituted as alternative fuel for CI engine.

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