Study of Engine Performance and Emission with Neem Oil (NOME) Based Bio-Diesel

Tejaswita Kajale[1*], Abhay Pawar[2], Channapatana[3]

[2]HOD, Department of Mechanical Engineering, JSPM's RSCOE, Pune, Maharashtra, INDIA.

[*]Corresponding Address:

kajaletejaswita@gmail.com

Research Article

Abstract: The world is getting modernized and industrialized day by day. As a result vehicles and engines are increasing. But energy sources used in these engines are limited and decreasing gradually. This situation leads to seek an alternative fuel for diesel engine is biodiesel. Biodiesel is a non-toxic, biodegradable and renewable alternative fuel that can be used in diesel engines with little modification. Biodiesel is currently expensive. It could be produced from low-cost Neem seed oils. The objective of this study was to investigate the effect of the biodiesel produced from high free fatty acid feed stocks on engine performance and emissions. Biodiesel performance and testing is done in C.I. engine. Neem oil was extracted from neem seed by solvent extraction. Refractive index, density, viscosity, ash content, Saphonification value, iodine number was studied. Biodiesel has been prepared from NEEM oil by esterification and transesterification. It was examined for physical and chemical properties and chemical properties. HC, CO, NO_x, SO_x, and particulate matter was studied. The conversion of the biodiesel fuel's energy to work was equal to that from diesel fuel. The results also clearly indicate that the engine running with biodiesel and blends have higher NOx emission by up to 20%. However, the emissions of the CI engine running on neat biodiesel (B100) were reduced by up to 15%, 40% and 30% for CO, CO2 and THC emissions respectively, as compared to diesel fuel at various operating conditions.

Keywords: Biodiesel, Diesel engine, Engine performance, Neem oil, Transesterification.

Introduction

It is not a new idea to use bio diesel in engine, it was first used by Rudolph diesel at Paris Exposition of 1900 [1]. Biodiesel is defined as a "fuel comprised of mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats". Nowadays, most Biodiesel is produced by transesterification of vegetable oils, animal fats or recycled cooking oils, and consists of long-chain alkyl esters, which contain two oxygen atoms per molecule using methanol with alkaline catalyst NaOH / KOH [2 -6]. Fatty acid methyl esters (FAME) biodiesel, appear to be the most popular diesel fuel substitute, since their properties are similar to mineral diesel and can be used in conventional diesel engines without significant modifications It has also been shown that biodiesel has significant potential to reduce CO2, CO, THC and PM emissions [7, 8].A number of methods are currently available and have been adopted for the production of biodiesel fuel. There are four primary ways to produce biodiesel: pyrolysis, micro-emulsification, dilution and Transesterification [9]. The most commonly used method for converting oils to biodiesel is through Transesterification process using sodium hydroxide or potassium hydroxide catalyst. Biodiesel has a higher cetane number than diesel fuel, no aromatics, almost no sulfur, and contains 10 to 11% oxygen by weight. These characteristics of biodiesel reduce the emissions of carbon monoxide (CO), hydrocarbon (HC), and particulate matter (PM) in the exhaust gas compared with diesel fuel [10]. Over the past 7 years, considerable research has been conducted to investigate the properties of biodiesel and its performance in engines [11-16].Biodiesel is also predicted to reduce fuel economy by 1-2 percent for a 20 volume percent biodiesel blend. Neem oil contains a high percentage of monounsaturated fatty acids (C16:1, C18:1), a low proportion of polyunsaturated acids (C18:2, C18:3) and a controlled amount of saturated fatty acids (C16:0, C18:0) [17]. The compositions of the oil make it to be a useful renewable source for biodiesel production. The basic reaction involved in the production of biodiesel (also called fatty acid methyl esters, FAME) is not knew and has been reviewed in the literatures [18-21] reaction between triglycerides with methanol in the presence of a strong base as a catalyst yielding the desired FAME and a byproduct, glycerol . It has been reported that the triglycerides used in alkaline transesterification reactions should contain not more than 1% free fatty acids (FFA), which is equivalent to 2 mg KOH/g triglyceride, otherwise saphonification reaction will hinder separation of the ester from glycerine thereby reducing the yield and formation rate of FAME. [22-24]. A two step acid – base catalyzed transesterification reaction has been shown to be appropriate for biodiesel production from Neem oil due to its high FFA (32.538 mg KOH/g) [25-27]. The aim of this study was to investigate the production of biodiesel from neem oil with a view to determine its performance in Internal Combustion engine (I.C. engine). The physicochemical properties of the biodiesel produced were studied.

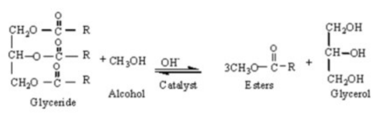
Materials and Methods

Materials

Neem seed oil, Methanol. Sodium Hydroxide, Exhaust Gas Analyzer, Variable compression ratio, IR spectr on perkins Elmer 221 IR Spectrophotometer using KBr Pellet techniques.

Methods

The experimental setup included 250 ml glass three necked batch reactor equipped with a reflux condenser, a mechanical stirrer and a thermometer, immersed in a constant-temperature bath. 100 ml oil, 200ml methanol and 10 ml conc. Sulphuric acid is poured into the reaction flask slowly. The reaction takes place at constant stirring with suitable speed and process is carried out at 60⁰C for about 4hour. After the completion of process, the mixture is transferred into a separating flask and then allowed to settle down to separate into two phases. The upper layer is dark acid layer and the lower layer is oil. The upper layer is biodiesel which consists of methyl esters, the middle layer is glycerol and the lower layer is NaOH catalyst. The biodiesel obtained is washed with warm water of 40°C and allowed to settle for 1 hour. A bottom layer of soap water will slowly start to form and the soapy water is drained down carefully. The above procedure is repeated 10 to 15 times, till the clean wash water is got back which indicates that the catalyst is not present in the biodiesel.



General reaction of Transesterification

Result and Discussion

NOME of neem seed oil shows Ester content, density, viscosity and Carbonious residue 96.4 (%m/m), 884.26 (%m/m) at 15⁰C, 4.16 (Mm2/s) at 40⁰C and 0.166(%m/m). Acid value is 0.26 (mg KOH/g of oil) , Iodine and saphonification value 44 (g/100g of Oil), 117(mg KOH/g of oil) of NOME respectively. Moisture content 0.0002 (%) , Ash content <0.015 (%m/m). NOME contain sulphur, phosphorus and free glycerol 0.066 (%m/m), 270 (%m/m) and 0.194 (%m/m). Figs.1 and 2 shows torque and SFC for diesel and NOME; the curves represent average results of test series reported to ISO conditions. No modification has been done on engine set-points, in order to allow complete fuel interchangeability. The increase of biodiesel percentage in the blend involves a slight decrease of both power and torque over the entire speed range. Figs.3 and 4 show the injection advance effect on torque and SFC when pure biodiesel issued. The SFC for pure diesel oil at nominal injection advance is also reported for comparison. A significant increase of SFC over the entire speed range is registered with biodiesel (about +16% average), due to its lower LHV and greater density. However, by reducing the injection advance, it is possible to optimize combustion, improving performances especially at low and medium speed, with respect to nominal injection advance operation, by reducing the injection angle, torque are increased up to almost pure diesel oil levels while SFC is reduced.

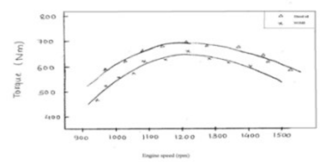


Figure1: Torque for Diesel Oil and NOME Biodiesel Blends

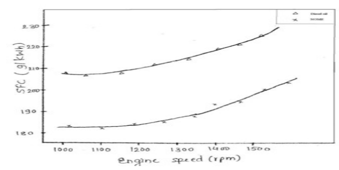


Figure 2: Specific fuel consumption (SFC) for Diesel Oil and NOME Biodiesel Blends

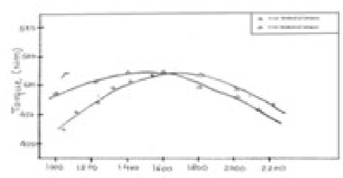


Figure 3: Effect of Injection Advance on Torque

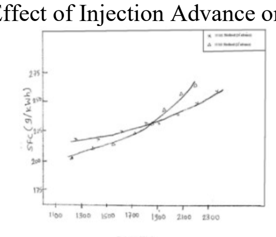


Figure 4: Effect of Injection Advance on Specific fuel consumption (SFC)

Table 1: Physicochemical properties of NOME (Neem Oil Methyl Ester)

Ester content	96.4 (%m/m)
Carbonious residue	0.166 (%m/m)
Iodine No.	44 (g/100g of Oil)
Sulphur	0.066 (%m/m)
Ashes	<0.015 (%m/m)
Density at 15⁰C	884.26 (%m/m)
Free glycerol	0.194 (%m/m)
Phosphorus	270 (%m/m)
Saphonification Value	117 (mg KOH/g of oil)
Viscosity at 40⁰C	4.16 (Mm2/s)
Moisture	0.0002 (%)
Acid Value	0.26 (mg KOH/g of oil)

Conclusion

In the study, combustion and exhaust emission with neat diesel-NOME (Neem Oil Methyl Ester) blend were investigated. In addition, the use of biodiesel involves reduction of some emitted pollutants. This is much helpful in reducing pollution caused due to engine emission. Biodiesel is associated with lower emissions HC, CO, and particulates these lower emission levels were likely due mostly to the fact that biodiesel contains about ten percent oxygen by weight, and this oxygen helps to oxidize these combustion products in the cylinder. With neat biodiesel, measurable HC emissions were generally eliminated, while CO was reduced roughly 42 percent from levels found on diesel. Particulate emissions were reduced between 30 and 60 percent, depending on the engine.

References

1. Bobade S.N and Khyade V.B, Detail study on the Properties of *Pongamia Pinnata (Karanja)* for the Production of Biofuel, Research Journal of Chemical Sciences, 2012, 2(7), 16-20.
2. Mishra Sruti Ranjan, Mohanty Mahendra Kumar, Pattanaik Ajay Kumar, Preparation Of Biodiesel from Crude oil of *Simarouba glauca* using CaO as a Solid Base Catalyst, Research Journal of Recent Sciences, 1, 2012, 49-53.
3. Agarwal AK. Biofuels (alcohols and biodiesel) applications as fuels in internal combustion engines. Progr Energy Combust Sci 2007, 32,233−71.
4. Demirbas A. Biodiesel production from vegetable oils via catalytic and non-catalytic supercritical methanol transesterification methods. Progr Energy Combust Sci 2005, 31,466−87.
5. Graboski MS, McCormick RL. Combustion of fat and vegetable oil derived fuels in diesel engines. Progr Energy Combust Sci 1998, 24,125−64.
6. Komninos NP, Rakopoulos CD. Modeling HCCI combustion of biofuels: A review. Renew Sustain Energy Rev 2012,16,1588–610.
7. Dorado, M. P., Ballesteros, E., Arnal, J.M.; Gomez, J., Lopez, F.J. Exhaust emissions from a Diesel engine fueled with transesterified waste olive oil. Fuel 2003, 82, 1311–1315.
8. Utlu, Z., Kocak, M.S. The effect of biodiesel fuel obtained from waste frying oil on direct injection diesel engine performance and exhaust emissions. Renew. Energy 2008, 33, 1936–1941.
9. S. P. Singh, Dipti Singh, Biodiesel Production Through The use Of Different Sources and Characterization of Oils and Their Esters as the Substitute of Diesel: A Review, Renewable and Sustainable Energy Reviews, 14, 2010, 200-216.
10. Graboski, M. S. and R. L. McCormick. Combustion of fat and vegetable oil derived fuels in diesel engines. Prog. Energy Combust. Sci., 1998, 24, 125-164.
11. Chang, D. Y. Z. and J. H. Van Gerpen. Fuel properties and engine performance for biodiesel prepared from modified feed stocks. 1997, SAE Paper No. 971684.
12. Schumacher, L. G. and J. H. Van Gerpen, Research needs resulting from experiences of fueling of diesel engines with biodiesel. In Liquid Fuels and Industrial Products from Renewable Resources Proceedings of the Third Liquid Fuel Conference,1996, 207-216,
13. Schmidt, K. and J. H. Van Gerpen, The effect of biodiesel fuel composition on diesel combustion and emissions.1996, SAE Paper No. 961086.
14. Zhang Y. and J. H. Van Gerpen., Combustion analysis of esters of soybean oil in a diesel engine. 1996,SAE Paper No. 960765.
15. Chang, D. Y. Z., J. H. Van Gerpen, I. Lee, L. A. Johnson, E. G. Hammond, and S. J. Marley. Fuel properties and emissions of soybean oil esters as diesel fuel. JAOCS, 1996, 73(11), 1549-1555.
16. Sharp, C. A. Characterization of biodiesel exhausts emissions for EPA 211(b). Final report for National Biodiesel Board. Southwest Research Institute, San Antonio, Texas.1998.
17. Wang R, Hanna MA, Zhou WW, Bhadury PS, Chen Q, Song BA, Yang S Production and selected fuel properties of biodiesel from promising non-edible oils: *Euphorbia lathyris L., Sapium sebiferum L,and Jatropha curcas L.* Bioresour. Technol.2011, 102(2), 1194-1199.
18. Fukuda H, Kondo A, Noda H, Biodiesel fuel production by transesterification of oils. J. Biosci. Bioeng. 2001, 92(5): 405-416.
19. Kusdiana D, Saka S, Kinetics of transesterification in rapeseed oil to biodiesel fuel as treated in supercritical methanol. Fuel, 2001, 80(5), 693-698.
20. Ma F, Hanna MA, Biodiesel production: a review1. Bioresour. Technol. 1998, 70(1), 1-15.
21. Schuchardt U, Sercheli R, Vargas RM, Transesterification of vegetable oils: a review. J. Braz. Chem. Soc. 1998, 9(3), 199-210.
22. Mittelbach M, Diesel fuel derived from vegetable oils, VI: Specifications and quality control of biodiesel. Bioresour. Technol.1996, 56(1), 7-11.
23. Zhang Y, Dube M, McLean D, Kates M, Biodiesel production from waste cooking oil: 1. Process design and technological assessment. Bioresour. Technol.2003, 89(1), 1-16.
24. Berrios M, Siles J, Martin M, Martin A, A kinetic study of the esterification of free fatty acids (FFA) in sunflower oil. Fuel, 2007, 86(15), 2383-2388.
25. Berchmans HJ, Hirata S, Biodiesel production from crude *Jatropha curcas L.* seed oil with a high content of free fatty acids. Bioresour. Technol. 2008, 99(6): 1716-1721.
26. Jain S, Sharma M, Kinetics of acid base catalyzed transesterification of *Jatropha curcas oil*. Bioresour. Technol. 2010, 101(20): 7701-7706.
27. Lu H, Liu Y, Zhou H, Yang Y, Chen M, Liang B ,Production of biodiesel from *Jatropha curcas L.* oil. Comput. Chem. Eng. 200933(5):1091-1096.
28. Research and Development Report, Tree Born Oilseeds by National Oilseeds and Vegetable Oils, Development Board, Government of India, 2009.
29. S. P. Singh, Dipti Singh, Biodiesel Production Through The use Of Different Sources and Characterization of Oils and Their Esters as the Substitute of Diesel: A Review, Renewable and Sustainable Energy Reviews, 14, 2010, 200-216.