International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Review Article

Comparison of Performance and Exhaust Emissions of Jatropha, Palm and Calophyllum Inophyllum Biodiesel: A Review

Swapnil D. Ambhore*, P.E. Chaudhari and S.H.Barhatte

Department of Mechanical Engineering, MIT College of Engineering, Savitribai Phule Pune University, Pune, India.

Accepted 12 March 2017, Available online 16 March 2017, **Special Issue-7 (March 2017)**

Abstract

The world is facing serious issue of environmental pollution and warming. Also, crude oil can become rare and faces severe shortfall within the close to future. Hence, this offers rise to researchers to seek out different fuel sources as alternate energy sources. Biodiesel is the fuel that has been thought of the best substitution for petroleum-diesel fuel as a result of it may be employed in any diesel-engine without any need of modification. Biodiesel is that the renewable fuel and additionally it's having sensible exhaust emissions as compare to diesel. Jatropha biodiesel, palm biodiesel and Calophyllum Inophyllum biodiesel falls within standard quality limits, hence they may be used as the alternative to diesel oil. The performance and exhaust emissions of Jatropha, palm and Calophyllum Inophyllum biodiesel are reviewed in this paper. Among the numerous biofuels available, vegetable oil is foremost economical in case of farmland usage, potency and productivity as it is the crop having oil carrying tendency. The problem associated with edible-vegetable biodiesel is that there's competition among oil as source of fuel or food. This makes edible oil not a perfect feedstock for production of biodiesel. Hence, more consideration is towards different non-edible oils like Jatropha oil, Calophyllum Inophyllum oil. Calophyllum Inophyllum oil may be being thought of as a possible fuel by following transesterification. However in comparison with Jatropha and vegetable oil biodiesel productions, biodiesel from Calophyllum Inophyllum continues to be in an exceedingly analysis state. Hence, long analysis and experimental studies got to be dole out previously considering this oil primarily based biodiesel as an alternate fuel to crude diesel.

Keywords: *Biodiesel, Transesterification, Engine performance, Emission characteristics*

1. Introduction

The demand of fossil fuels is increasing daily however there production is limited. In close to future the sources from that fossil fuel diesel extracted are finished. Hence, it's necessary to search out the alternate fuel for diesel.

Biodiesel is that the most suitable choice for diesel. Biodiesel will be turn out from animal fats or oil. Biodiesel fuel is mono chemical group organic compound derived from vegetable or animal fats. And then it's blended with diesel oil that has characteristics just like diesel oil and has lesser exhaust emissions. On the opposite hand, the most drawbacks of oil got to overcome owing to the high viscousness and low volatility which is able to cause a poor combustion in diesel engines. Hence transesterification is that the method with success used to cut back the viscousness of biodiesel and improve the other few characteristics also. Currently, quite ninety fifth of the planet's biodiesel is made from edible oil that is well out there on an outsized scale from the agricultural trade. However there is always battle between edible oil supply and biofuel supply makes it not appropriate for fuel production.

In this paper the comparison of performance and exhaust emissions are discussed.

2. Biodiesel

Vegetable oils are having chemical structure that has triglycerides in 98% and the remaining part is comprised of mono and diglycerides. Biodiesel is comprised of mono-alkyl esters of oil or animal fats. Transesterification is that the method of performing the reaction within triglyceride and an alcohol with the presence of a catalyst. The reaction products are glycerol and carboxylic acid esters is employed for making biodiesel from raw oil.

The combustion characteristics of biodiesel are just like diesel. But there various blends are having shorter ignition delay, ignition temperature found to be higher and pressure too. The peak heat discharge from exhaust is also higher in contrast to diesel oil. Furthermore, the power output and brake power of engine was found to be reminiscent of diesel oil.

*Corresponding author: **Swapnil D. Ambhore**

Biodiesel and there blends will scale back smoke opacity, particulate matters. Combustion of biodiesel reduces amounts of unburnt hydrocarbons, CO, CO_2 in exhaust emissions however emissions of NO_x have lightly augmented.

Yet, the most disadvantage of biodiesel fuel is they are viscous in nature and less volatile, because of this they performs poor combustion in diesel engines as well as deposits also formed. By performing trans-esterification of this oil the viscosity can be decrease to a variety of 4–5 mm^2/s nearer there to of diesel and therefore combustion process can be improved. Biodiesels or carboxylic acid esters area unit economical, delicate and natural energy substitute to fuel.

3. Material and Method

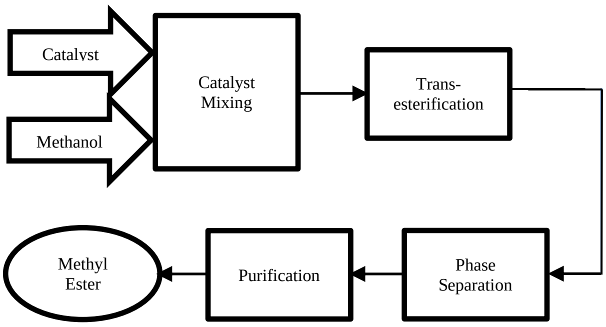
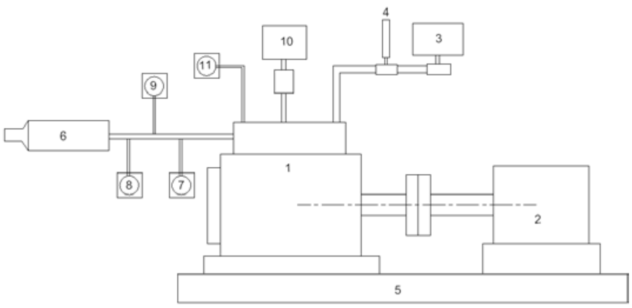


Fig.1 Procedure of making Biodiesel



1. Engine setup, 2. Dynamometer, 3. Fuel-tank, 4. Fuel pipe., 5. Platform, 6. Muffler, 7. Smoke meter, 8. Exhaust gas analyzer, 9. Exhaust temperature sensor, 10. Flow-meter for air, 11. Stop-Watch.

Fig.2 Engine Setup

3.1 Jatropha biodiesel

Free fatty acid (FFA) content of raw genus Jatropha oil is 21.6%. Hence, it became necessary to reduce it. The raw Jatropha oil was taken into a cone-shaped flask and this oil heated to temperature between 60°C to 65°C. A combination of concentrated sulphuric acid (H_2SO_4) (1% w/w) as a catalyst with methanol (99% pure) (30% v/v) was taken in another container and heated severally at (50°C). Afterwards the combination of sulphuric acid and methanol was added to the raw heated oil. Then with magnetic stirrer the new mixture was stirred for one hour. Then the mixture was kept aside for settling down for two hours. Remaining procedure is same as Calophyllum inophyllum based biodiesel.

3.2 Palm biodiesel

The procedure of making biodiesel from raw palm oil is similar to Calophyllum Inophyllum based biodiesel. Both requires transesterification. The major difference was there proportion, palm oil and methanol was taken in the molar ratio 1:3.

3.3 Calophyllum Inophyllum

Calophyllum Inophyllum oil comprised of 19.58% FFA. The alkyl group organic compound i.e. methyl ester or biodiesel was made by chemical reaction of raw Calophyllum inophyllum oil with methanol as alcohol, with the presence Sodium Hydroxide or Suphuric acid as catalyst. Adding catalyst reduces the time of reaction by increasing rate of the reaction. A two-step method was adopted for performing transesterification of Calophyllum inophyllum oil.

As raw oil contains FFA, thus 1st stage of the method was esterification. In this step the heated oil mixed with methanol (99%pure) and sulphuric acid (which was used as catalyst to reduce the time of reaction or enhance the reaction rate).Then the mixture was heated for one hour in an exceedingly closed reactor vessel at about 57-58°C. While doing this, first it was heated to 50°C and catalyst added in amount of 0.7% (w/w% of oil) along with methyl alcohol in the ratio 1:6 by molar mass of oil. The addition of methyl alcohol was in excess quantity to hurry up the reaction. The mixture was stirred with magnetic stitter for making the mixture more homogeneous. The speed of stirrer was about 650 revolutions per minute and heating was done upto 90 minutes at the controlled temperature of 55-58°C. After cooling it naturally the organic compound of fatty ester is separated. Then in 2nd stage, the separated oil from the separating funnel has got to endure transesterification. Methanol and sodium hydroxide was mixed with this organic compound and heated at 65°C for a period of two hours. While heating this mixture was stirred with magnetic stirrer. Same mixture was kept aside for eight hours for cooling naturally. After cooling this mixture settles down in two layers, the upper layer was biodiesel and at bottom another was glycerol which is by product of this reaction. Glycerol was taken out from flask by separating funnel. Now the remaining content within the flask was only biodiesel.

The obtained biodiesel by this technique was having varied impurities like small amount of glycerol, unreacted methanol, soap particles and other. Therefore water and air washing was carried out to clean the biodiesel from impurities. For this equal amount of water was added gradually from side walls of beaker in which the biodiesel was placed. Then an electric bubbler was used to flow the air from biodiesel from bottom.

The principle of this air washing process is to carry out the impurities by means of bubbles as air will carry the impurities and will go upwards, as water placed above biodiesel, the impurities will mix with the water. And also water will dilute the excess methanol. As remaining amount of glycerol and soap particles mixed with the water so it became like soap water. The period of air washing was not specific. It was done till the water became like soap water. The bubbler was tuned off after water became like soap water. Then the biodiesel was permitted to settle down. Again the biodiesel was drained out by using separating funnel. This obtained biodiesel was in the pure form and was directly used and also along with mixing with diesel i.e. blending in diesel engine without any modification.

Table1: Properties of Jatropha, Palm and Calophyllum Inophyllum biodiesel

Properies	Unit	Jatropha	Palm	C.I.
Density at 15°C	kg/m³	862	879.3	868.8
Cetane number	-	57	52	57
Viscosity at 40°C	mm²/s	4.8	4.8	4.0
Flash point	°C	135	181	140
Cloud point	°C	6	15	13.2
Pour point	°C	2	14	1.3
Calorific value	kJ/kg	39,230	36,764	41,397
Water content	w%	0.024	0.03	0.006
Ash content	w%	0.012	0.0067	-
Carbon residue	w%	0.21	0.071	-

4. Biodiesel Performance

Various data obtained from testing the biodiesel and its blends in diesel-engine were investigated. The performance parameters for comparison between biodiesels and there blends are brake thermal efficiency, power output and specific fuel consumption for Jatropha, palm and calophyllum inophyllum biodiesels are mentioned below.

4.1 Jatropha biodiesel

The examination of effect of compression ratio on CO, CO_2, NO_x emissions and exhaust gas temperature at varied biodiesel blends is investigated (Amar Pandhare, *et al*, 2013). Results show that for pure Jatropha biodiesel i.e. with no diesel added, the highest fuel consumption was 15% over that of diesel oil. For pure biodiesel and varied blends the brake thermal efficiency is slightly more at varied load conditions. As the amount of biodiesel increases in blend proportion the exhaust gas temperature (EGT) also rises. 430◦C was the highest temperature of exhaust gas with biodiesel for load conditions of 1.5 kW, 2.5 kW, 3.5 kW and in case of diesel it had been 440◦C.

The parameters selected for comparing the exhaust emissions are smoke opacity, hydrocarbons, carbon dioxide, carbon monoxide and nitrogen oxides. As the proportion of biodiesel was increased in blend the emissions of HC, CO_2, and CO were increased. At high load conditions the emissions of HC, CO_2, CO and NO_x were reduced compare to diesel. However, at low load conditions the Jatropha biodiesel has approximately equal emissions as diesel. This is because this biodiesel is having higher ignition temperature and higher combustion provides reduced exhaust emissions compare to diesel. Some researchers found that emissions of HC, NO_x and EGT, smoke are reduced by increasing the compression ratio and injecting pressure in case of pure Jatropha biodiesel (Jindal, *et al*, 2010). Jatropha biodiesel (esterified) and raw Jatropha oil each emits the smoke and particulate matter. But, transesterified Jatropha biodiesel produces higher amount of CO and HC than diesel. Thus, heating of biodiesel and mixing in less proportion with diesel before using in diesel engine have decreased emissions.

4.2 Palm biodiesel

The combustion performance and exhaust emissions of vegetable oil biodiesel blends were executed experimentally by (Soni S.Wirawan, *et al*, 2008). When the palm oil heated at 100°C its performance is enhanced. The viscosity of biodiesel decreased, its combustion was improved and also the amount of deposit was reduced. The caloric value of palm biodiesel is less than diesel so it requires more amount of biodiesel to produce same amount of power as diesel can produce. Hence the specific fuel consumption of biodiesel in diesel engine is slightly over diesel oil.

As the amount of biodiesel in blends with diesel increases, the emissions of carbon monoxide. hydrocarbons and particle reduced significantly. At 10% mix, reduction in emission of particle was terribly sharp. Whereas from 20% mix, sharp reduction in emission of HC was initiated. Additionally, in test results it is found that NO_x emissions are also reduced. Furthermore higher power and torque is obtained for biodiesel mix comparison to it of diesel oil. This result may well be as a consequence of the properties of tested palm biodiesel, that has higher cetane number and lower viscosity compared to the diesel.

It can be concluded from the result that higher amount of palm biodiesel in the blend can lower the emissions of hydrocarbons, carbon monoxide, carbon dioxide and particulate matter. It was also observed that when the amount of palm biodiesel was raised in the blend, the emission of nitrogen oxides were also reduced, this is contradictory because other biofuels it's found that with increasing blend proportion NO_x emissions increases significantly.

4.3 Calophyllum Inophyllum biodiesel

The emissions of Calophyllum Inophyllum biodiesel as an alternate fuel to diesel was tested (Rahul Krishnaji Bawane, *et al*, 2014). Throughout half throttle condition, the obtained test results showed that, the mix with higher proportion of Calophyllum Inophyllum biodiesel with diesel contribute to decrease the exhaust smoke well. Also this biodiesel shows reduction in HC and CO. Yet, with this biodiesel increases the emissions of CO_2 and NO_x is observed.

Conclusion and Discussion

Biodiesel is obtaining a lot of attention as substitutional oil for petro-diesel due to its less harmful emissions as compare to diesel and diminishing supply of fossil fuels. Various biodiesels and there blends can reduce hydrocarbons, carbon monoxide, carbon dioxide particulate matter and smoke opacity too. However the emissions of NOx increases slightly. For reducing emissions of NOx various strategies can be obtained such as, reciculating exhaust gases, advancing the cetane number, retarding the timing of injection.

In case of vegetable oil, the main drawback is that it is having high viscous and less volatile nature which is a cause of low combustion in petro-diesel engines. Various methods can be implemented to lower the trouble of high viscosity such as preheating the biodiesel, blending with diesel, thermal-cracking and trans-esterification.

In case of Calophyllum Inophyllum biodiesel, the viscosity of blend is very close to diesel. The viscosity of pure Calophyllum Inophyllum oil is higher than that of the diesel so it is reduced by blending these biodiesel with the diesel. It can be concluded that engine performance when fuelled with the biodiesel (Calophyllum Inophyllum) are comparable to that when fuelled with diesel. Since a little more biodiesel (Calophyllum Inophyllum) must be supplied to the engine to produce an equivalent amount of power, as evidence by the lower calorific value of biodiesel. But still Calophyllum Inophyllum is having the highest calorific value than jatropha and palm biodiesel, hence its BSFC is less compare to jatropha and palm biodiesel and is slightly equal to diesel. Hence efficiency is also greater than jatropha and palm biodiesels.

References

Amar Pandhare and Atul padalkar, (2013), Investigations on Performance and Emission Characteristics of Diesel Engine with Biodiesel (Jatropha Oil) and Its Blends, *Journal of Renewable Energy*, Volume 2013 Article ID 163829.

Jindal S, Nandwana BP, Rathore NS, Vashistha V., (2010), Experimental investigation of the effect of compression ratio and injection pressure in a direct injection diesel engine running on Jatropha methyl ester, *Applied Thermal Engineering* 2010;30(5):442–8.

Soni S.Wirawan, Armansyah H. Tambunan, Martin Djamin and Hiroshi Nabetani, (2008), The Effect of Palm Biodiesel Fuel on the Performance and Emission of the Automotive Diesel Engine, *Agricultural Engineering International: the CIGR Ejournal*. Manuscript EE 07 005. Vol. X. April, 2008.

Rahul Krishnaji Bawane, Nilima Baliram Gadge, Swapnil Ambhore and Aquib Shaikh, (2014), Experimental Investigation of Emission Characteristics of Calophyllum Inophyllum Linn (Honne) Oil as Alternative Fuel in CI Engine, *International Journal of Scientific & Engineering Research*, Volume 5, Issue 6, June-2014, ISSN 2229-5518.