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Production of Bio-fuel from Crude Neem Oil and its Performance

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Abstract

The contribution of neem as a source for biodiesel production will be of great importance in the coming day. In India Neem tree is a widely grown up termed as a divine tree due to its wide relevance in many areas of study. Neem is a large tree growing about 25 m in height with semi-straight to straight trunk, 3 m in girth and spreading branches forming a broad crown, starts fruiting after 3-5 years. From the tenth year onwards it can produce up to 50 Kg of fruits annually. The tree has adaptability to a wide range of climatic, topographic factors. It thrives well in dry, stony shallow soils and even on soils having hard calcareous or clay pan, at a shallow depth. Neem tree requires little water and plenty of sunlight and rainfall in the range of 450 to 1200 mm with wide temperature range of 0°C to 49°C. However, it has been introduced successfully even in areas where the rainfall is as low as 150 to 250 mm .It grows on almost all types of soil including clayey, saline and alkaline soil, but does well on black cotton soils and deep well drained soil with good sub-soil water.

This paper deals with Biodiesel production from neem oil, which is monoester produced using transesterification process. It has high lubricity, clean burning fuel and can be a fuel component for use in existing unmodified diesel engine. The fuel properties of biodiesel including flash point-and fire point were examined. The engine properties and pollutant emissions characteristics under different biodiesel percentages were also studied. The results shows that the biodiesel produced using neem oil could reduce Carbon monoxide and

smoke emissions significantly while the Nitrogen oxide emission changed slightly.

1. Introduction

In the current energy scene of fossil fuel, renewable energy sources such as biodiesel, bio-ethanol, bio-methane, and biomass from wastes or hydrogen have become the subjects of great interest. These fuels contribute to the reduction of dependence on fossil fuels. In addition, energy sources such as these could partially replace the use of those fuels which are responsible for environmental pollution and may be scarce in the future. For these reasons they are known as “alternative fuels”. Vegetable oil cannot be directly used in the diesel engine for 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.

The growing demand for fuel and the increasing concern for the environment due to the use of fossil fuel have led to the increasing popularity of biofuel as a useful alternative and environmentally friendly energy resource.

Fig. 1

1.1 Advantages of Biofuels

- Biofuel is Environmentally Friendly.
- No Engine Modifications Necessary.
- Biofuel prolongs Engine Life.
- Emits less CO, unburnt HC, SO_x other than NO_x.
- Higher flash point and hence safe to handle storage and transport.
- Supports the Indian formers.
- Biodiesel can be made at home.
- Biodiesel has economic advantages.

1.2 Extraction of neem oil and production of biodiesel

Biodiesel is a mono- alkyl ester produced through trans-esterification processes. It is obtained from the transesterification of vegetable oil or animal fats. Transesterification reaction is the transformation of an ester, a triglyceride (vegetable oil) into another ester in the presence of acid or base as a catalyst. In the production of biodiesel, the products are mixtures of fatty esters (biodiesel) and glycerol.

Following steps describe cleaning of neem seeds, extraction of neem oil and production of biodiesel.

1.3 Cleaning of Neem Seeds

The first step in obtaining oil from neem for Bio-diesel is to remove the seed-coat and husk in a process referred to as De-hulling. In developing countries, hard objects are used to crack the shells are popular.

Neem seeds Neem Kernel Neem Kernel after drying

Fig. 2

Once the nuts are cracked, the oil-bearing seeds are cleaned and dried. Seed cleaning involves the removal of the seed coat and the separation of the chaff. Seed drying can be done by placing the seeds under the sun or by heating carefully on the fire for a short while. Once this is done, the next step is to begin the crucial extraction process.

1.4 Method of Neem oil Extraction

Extraction with ram press and expeller are referred to as cold pressing extraction. Expellers are the most popular oil extraction Engines. They are designed into small output devices that can cater for small scale extraction. Oil seed ram press is simply a piston inside a cage. With the seeds placed inside the cage, the piston can compress the seeds and force out the oil. Sometimes the operating force of the ram can be from a manual pump lift.

Fig. 3: Expeller.

1.5 Procedure to Calculate FFA (Free Fatty Acid)

Before moving to the production of bio diesel first we have to calculate its FFA (Free Fatty Acid) value. The free fatty acid ratio is an important quality characteristic. The lower it is, the better the storage and shelf life of the respective oil or fat will be. Crude pressed oils usually have a ratio of 0.1 or 3%, refined oils 0.01 to 0.1%. Free fatty acid (FFA) content of a small sample of oil should be calculated and the result should be used to determine the amount in the total volume of oil intended to make the Bio-diesel. The process is mimicry of acid-base-titration neutralization reaction in elementary chemistry except that the base is titrated against the oil, instead of an acid against the base. The implication is that, the Burette will contain the base, while the oil will be in the conical flask.

1.6 Calculation of amount of free fatty acid in oil

Before calculating the amount of FFA in the oil, we should write down the equation of the reaction. You should also know that the general formulae for a fatty acid chain are represented as RCOOH. Where R is an alkyl group. Hence,

RCOOH (aq) + KOH(aq) → RCOOK (aq) + H2O(L)

Formula for FFA calculation

% FFA (as oleic) = Titre x N x 28.2/ (Weight of sample)

Where N = molarities of base

1.7 Transesterification of vegetable oils

Transesterification is the reaction of a fat or oil with an alcohol to form esters and glycerol. Alcohol combines with the triglycerides to form glycerol and esters. A catalyst is usually used to improve the reaction rate and yield. Since the reaction is reversible, excess alcohol is required to shift the equilibrium to the product side. Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol. Alkali-catalyzed transesterification much faster than acid-catalyzed transesterification and is most often used commercially.

R1, R2, R3 and R’ represent various alkyl groups. The process of transesterification brings about drastic change in viscosity of vegetable oil. The

biodiesel thus produced by this process is totally miscible with mineral diesel in any proportion.

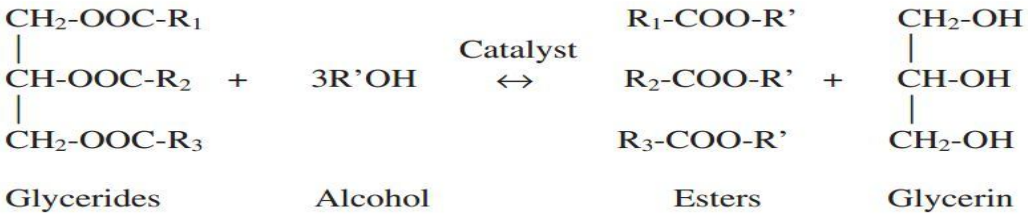

Fig 5.5: Chemical reaction.

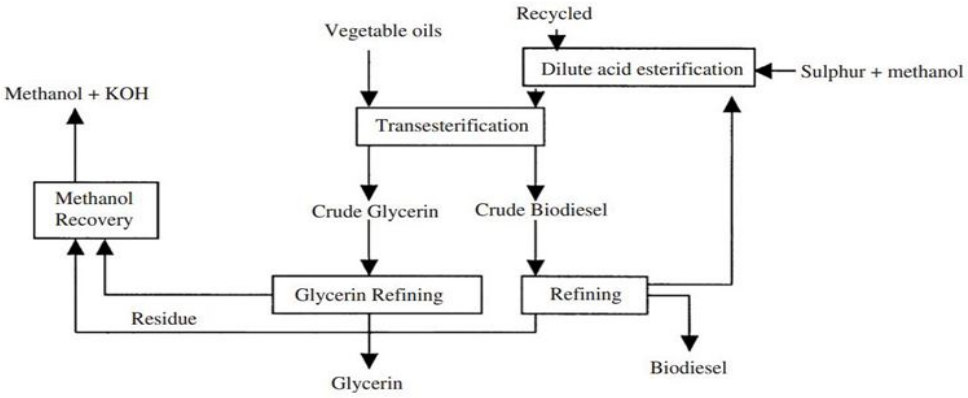

Fig. 4: Process flow chart.

1.8 Procedure of Transesterification

1. Measure 1L of neem crude oil using measuring cylinder and pour it in three mouth flask.
2. Three mouth flask should be provided with cooling system to circulate methanol.
3. Heat crude oil using electric heater it up 75° and stir it continuously using magnetic stirrer.
4. Prepare a solution of 300ml of methanol and NaOH crystals.
5. When temperature of three mouth flask reaches 75°, slowly add above prepared solution to the flask.
6. Continue heating till one and half hour make sure that temperature remains constant.
7. Pour the content of flask into separation funnel and keep it for at least 6 hours which permits glycerin to settle down hence it being denser then biodiesel.
8. Remove the glycerin from the separating funnel.

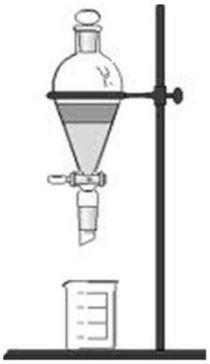

Fig. 5: Neem biodiesel and glycerin separation setup.

1. Now wash the biodiesel obtained with water so as to remove the chemicals.
2. Heat the biodiesel to remove any traces of water to obtain pure biodiesel.
3. Now we have obtained pure neem biodiesel which if free from all chemicals and any water, we added in the process.

2. Results and Discussion

The study was conducted to investigate the performance of a stationary single cylinder diesel engine running on neem oil and neem biodiesel blended with diesel with varying proportion of 10%, 20%, and 30% by volume and also on diesel fuel alone. Diesel fuel results were considered as base line data for comparison of performance parameters.

For performance testing different blends of pure neem - diesel and neem biodiesel-diesel was prepared.

Different blends used for the testing are:

N10: 10% pure neem oil and 90% diesel by volume.
N20: 20% pure neem oil and 80% diesel by volume.
N30: 30% pure neem oil and 70% diesel by volume.
B10: 10% neem biodiesel and 90% diesel by volume.
B20: 20% neem biodiesel and 80% diesel by volume.
B30: 30% neem biodiesel and 70% diesel by volume.

The experiment and fuel property testing were conducted in our department lab. The engine was tested under varying load conditions (0% load, 10% load, 25%load, 50% load, 75% load, and 100% load) and varying injector opening pressure (200 bar and 220 bar) for each percentage of blending.

2.1 Comparison of Brake thermal efficiency for best blend

We can see that B20 has same thermal efficiency as diesel, at both pressures. By comparing values of B20 at 200 bar injection opening pressure it has slightly low thermal efficiency as compared to diesel. But at 220 bar pressure B20 curve almost overlap with the diesel curve.

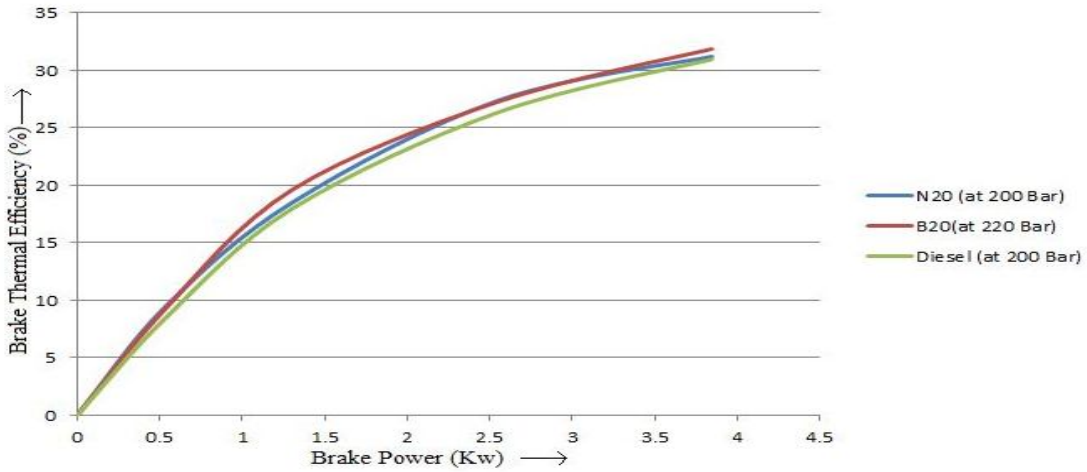

Fig. 6: Brake thermal efficiency vs brake power.

From above comparison graph it is clear that brake thermal efficiency of N20(at 200 bar) and B20(at 220 bar) are greater then diesel. At all range of loads B20 at 220 bar, has higher brake thermal efficiency than diesel and N20.

Hence B20 at injection pressure of 220 bar can be used as an alternate to diesel.

3. Conclusions

Based on the above study made on blend of neem oil and neem biodiesel considering diesel parameters as base, following observations are made:

- Filtered neem oil (biodiesel) can be substitute of diesel because the properties like calorific value, density and viscosity are very much comparable with diesel.
- At 200 and 220 injection pressure, neem blends has almost same BSFC as diesel. N20 has high BSFC at low load.
- At 200 bar injection pressure diesel had highest peak pressure followed by B30, B20 and B10 this trend remain same as the load increases. Among all blends cylinder pressure of B20 and B30 were almost same as diesel at all loads.at 220 injection pressure all blends of biodiesel has comparable value as diesel at 25% load. At 0% load B20 had least cylinder pressure.
- It is observed that the there is no variation in peak pressures for neem oil blends and neem biodiesel blends. But in case of neem oil blends, the peak pressures is highest at 200 bar. In case of neem biodiesel blends the peak pressure at 200 bar and 220 bar is almost same.

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