Determination of Various Properties of Biodiesel Produced from Different Feedstock

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***Abstract-* This paper analyzes the various properties of biodiesel such as pour point, cloud point, viscosity, calorific value etc. produced from different feed stocks. The aim of the work is to analyze change in these properties after converting feed stocks to biodiesel and then comparing it with ASTM 6751-02 standards to check whether they are suitable for diesel engines or not. The conversion of feed stocks is carried out by a process called Trans esterification. This conversion is carried out to reduce viscosity, pour point etc. It has been observed that there is some remarkable change in the properties of oil after conversion.**

Index Terms- Biodiesel, cloud point, pour point, flash point, calorific value.

1. INTRODUCTION

Since the commencement of industrial revolution in the late 18th and early 19th century, global energy consumption has been increasing multi-fold due to rapid population growth and economic development. Fig. 1 shows the world energy consumption by source from year 1800 to 2013 [1,2]. In 2013, the most consumed energy came from fossil fuels which accounted for 82.67% among other energy sources in which crude oil consisted of 30.92%, coal 28.95% and natural gas 22.81%, respectively. The petroleum fuels play a vital role in the development of industrial growth, agricultural sector, domestic needs, transportation, and to meet many other basic human needs. Globally, 11 billion tons of fossil fuel was consumed every year. At this rate, these sources will soon be exhausted [3].So there is an immediate need for look for alternative fuels in order to reduce the consumption of conventional fuels and to save the environment from the emissions. There are many alternative fuel choices available, out of these biofuels is most popular alternative and out of the biofuels biodiesel is gaining popularity day by day.

Biodiesel refers to a family of products made from vegetable oil or animal fats and alcohol, such as methanol or ethanol, called mono alkyl esters of fatty acids. Study shows that, on the mass basis, biodiesel has an energy content of about 12% less than petroleum based diesel fuel. It reduces unburned hydrocarbons (HC), carbon monoxide (CO), and increase oxides of nitrogen (NOx) than diesel-fueled engine. It is a domestic, renewable fuel for diesel engine derived from natural oil like Straight Vegetable Oils, Tallow oils, etc. Biodiesel is environment friendly liquid fluid similar to conventional diesel fuel in engine tests, the power and fuel consumption [4, 5].So the first step is to convert these feedstocks to biodiesel through some conversion processes.

2. BIODIESEL PRODUCTION PROCESS

The production process of biodiesel initiates with the choice of feedstock available for conversion. Following feed stocks are generally available:

a. Straight Vegetable Oils(VFO):They comprises of edible oils such as sunflower, soyabean, peanut, olive, palm, etc and nonedible oils such as neem, mahua, jatropha, cottonseed, karanja, kusum, etc.
b. Animal fat: tallow, yellowgrease, chickenfat,etc.
c. Waste Frying Oils(WFO)
   The use of vegetable oils as biodiesel fuel was started by Rudolf Diesel when he first used peanut oil for demonstration of his newly developed compression ignition (CI) engine in year 1910 [6]. Today, there are more than 350 potential vegetable oil crops, depending upon the climate and soil conditions, are being used as the main conventional feedstocks for biodiesel production such as soybean and canola in Canada, sunflower oil in Europe, soybean oil in

US, palm oil in Malaysia and Indonesia, coconut oil in Philippines, etc.[7-9].

Another group of feedstock for biodiesel production is fats derived from animals. Vegetable oils and animal fats are of two types of biological lipid materials, made up mainly of triacylglycerols (TAGs) and less of diacylglycerols (DAGs) and monoalkylglycerols (MAGs) [10].

Another group is of waste oils which is collected from households, cafeterias, restaurants, etc which is then recycled and filtered. Using a waste oil as biodiesel is also gaining attention nowadays as it utilises a waste products.

So,in the experiment we have choosen one from each category i.e. soyabean, mahua, beef tallow and waste frying oil.

The conversion of feedstocks to biodiesel can be carried out by incorporating any of the following methods:

1. Direct use and blending of oils
2. Micro-emulsification
3. Pyrolysis
4. Transeterification

Out of the four methods, transesterifcation process is most commonly used method. Transesterification of vegetable oils has emerged as most viable and effective method for the purpose. The reaction yields ester with viscosity and volatility characteristics similar to diesel. The modified vegetable oil called biodiesel is biodegradable, nontoxic, free from sulphur, and renewable.

First step in the production of biodiesel is to neutralize FFA by adding correct amount of KOH (catalyst).The pH of the samples is kept between 8 and 9.A solution I of 1% KOH was prepared and another solution II of 10ml of methanol is prepared with 1 ml of sample oils.In order to get Ph between 8 and 9 equivalents quantity of KOH is determined which will neutralize FFA in the oil which is carried out by adding drop by drop adding solution I to solution II.

After that, batches of 10 liters of soyabean, WFO, beef tallow and mahua are collected and they are converted into biodiesel one by one. The oil were heated at about 55-60^oC to avoid evaporation of methanol from the solution. The of KOH need for reaction is determined by adding FFA neutralization to a standard KOH solution.

Another solution is prepared with this KOH for 10 liters of oils which is filtered and poured into a container fitted with electric heater, thermostat, and a stirrer.The heating at constant temperature of 55-60^oC and stirring is carried out for about 1.5 hours. After that,the entire solution is poured into the separating flask situated below of the reaction container.The solution is kept for about 8 hours in order to separate glycerol and feedstock methyl ester layer wise due to density difference. Major amount of glycerol is separated by opening the valve but there were some traces of glycerol in the oil which us removed by washing with hot distilled water and finally by filtration. This process is repeated for all four feedstock and then their properties are analysed and compared with each other.

During the course of experiment following reaction takes place:

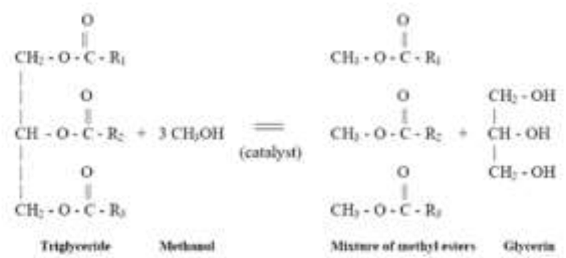

Figure. 1

3. EXPERIMENT

The biodiesel from the feedstock is produced via trans esterification process as discussed .After that, various properties of produced biodiesel such as pour point, cloud point, flashpoint, viscosity, calorific value, etcare determined experimentally in the Department of Chemical Engineering, AMU, Aligarh, India.

3.1 DETERMINATION OF POUR AND CLOUD POINTS

CLOUD POINT: All diesel fuel as contained dissolved paraffin wax as the temp of the fuel decreases, the solubility of the wax in the fuel also decreases. At some point, the wax crystal will begin to precipitate. That point is known as the cloud point. If enough wax precipitate, the crystal can block fuel flow through screens and filters.

POUR POINT: The pour point of a liquid is the temperature of which it becomes semisolid and loses its flow characteristics. A high pour point is generally associated with a high paraffin content.

The oils are also kept in a specimen and the specimen is allowed to cool inside a cooling bath. The temperature at which haziness starts appearing is called cloud point. The cloud point is reported at intervals of 1˚C.The temperature at which fuel loses its flow characteristics is called pour point and its checked after every 3˚C.

3.2 DETERMINATION OF FLASH POINT

Flash point is the lowest temperature at which fuel can vaporise to form an ignitable mixture in air.

The flash point is determined only for safety during transport, storage and handling. A low flash point can be fire hazard. During transport of fuel in closed tanks, the disturbance in the fuel increases due to motion of automobile. As a result, the friction between fuel and tank will increase. Thus, the temperature starts rising. So, a flash point gives an estimation up to which temperature is safe to transport.

The oil is kept into the cup which is heated and at intervals a flame is brought over the surface. The temperature at which vapor starts forming will be a flash point.

According to ASTM D6751-12, flash point of biodiesels should be above 130^{o}C.

3.3 DETERMINATION OF ASTM DISTILLATION TEMPERATURE

In this a 100ml sample is taken in a cup and is heated in a heated bath. The vapor is then distilled through cooled water kept outside the tube. The distillate is then taken in another jar and the temperature of distillate after every 5ml.

The significance of ASTM distillation lies in the fact that it determines the boiling range of a petroleum product. Also the distillate value gives us the temperature at which 95% of the fuel gets evaporated.

According to ASTM D6751-12, distillation temperature of biodiesels can be maximum 360^{o}C.

3.4 DETERMINATION OF VISCOSITY

Viscosity of the fluid is a measure of its resistance to gradual deformation by shear stress.

A high viscosity fuel oil leads to improper atomization which in turn leads to incomplete combustion.Thus.it is important to have the value of viscosity in right range.

The viscosities of the feedstocks and biodiesel were determined using rheometer.

According to ASTM D6751-12, kinematic viscosity of biodiesels should lie in the range 4.5-6 mm²/sec.

3.5 DETERMINATION OF CALORIFIC VALUE

It is a very important fuel property. It gives the amount of heat energy released after combustion of one unit of fuel. Higher the calorific value, higher is the heat released, better will be the biodiesel.

Calorific value is determined experimentally using a bomb calorimeter. Calorific values of biodiesel are obviously lower than that of diesel.

4. RESULTS

4.1 VARIATION OF DENSITY

Fig. 2 shows the variation of densities for different feedstock and their biodiesels. It can be observed from the figure that the density of feedstock decreases after converting into biodiesels. The largest decrease in density is observed for soyabean biodiesel and least for beef tallow. It is also readily observed that the density of soyabean biodiesel is quite close to diesel while that for beef tallow has largest. Mahuanad WFO biodiesels have intermediate densities.

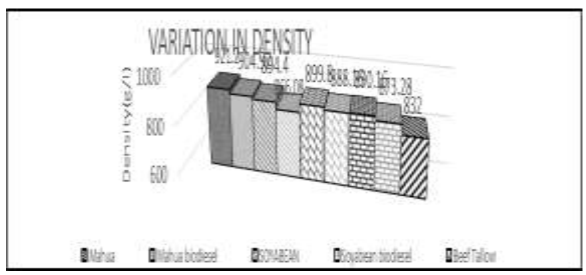

Figure.2

4.2 VARIATION OF POUR POINT

Figure 3 shows the variation of pour point of feedstock and their biodiesels.It can be readily observed that there is a decrease in pour point in feedstock after biodiesel conversion.This is due to the conversion of densed fatty acids into mono alkyl ester which was earlier give a higher pour point.It can be observed from the figure that the soyabean biodiesel has pour point close to diesel and beef tallow anfmahua biodiesel has quite high pour points.

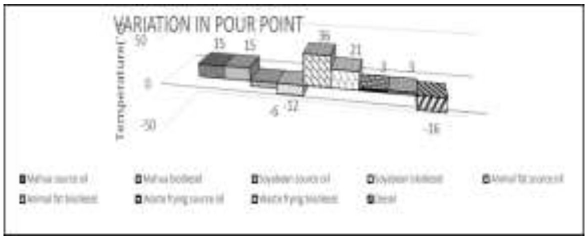

Figure 3

4.3 VARIATION IN VISCOSITY

Figure 4 shows the variation of viscosity of different feedstocks and their biodiesels. It can be observed that there is an appreciable decrease in viscosity after transesterification process except for mahuaoil. It can be readily observed that soyabean and WFO biodiesels have comparable viscosities with diesel. Decrease in viscosity is due to the elimination of viscous glyceride portion from feedstock, which was very viscous initially.

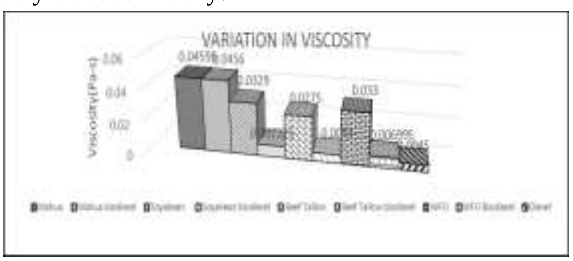

Figure4

4.4 VARIATION IN CLOUD POINT

Figure 5 shows the variation of cloud point of feedstocks and their biodiesels.The trend of cloud point variation is same as that for pour point as pour and cloud point are related to each other.

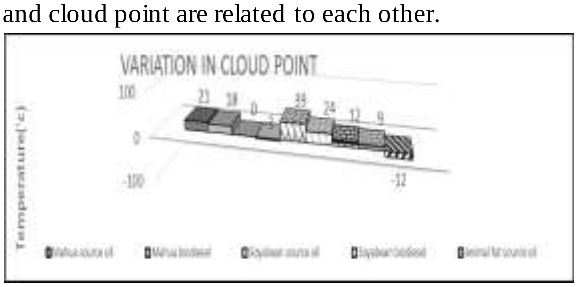

Figure 5

4.5 ASTM DISTILLATION TEMPERATURES

ASTM distillation temperatures (in degree Celsius) are observed as 340,360,340,340, and 275 for Mahua, soyabean, beef tallow, WFO biodiesels, and diesel respectively.

4.6 CALORIFIC VALUE

The calorific values (in MJ/Kg) for biodiesels are 32.8, 38.5, 34.6, 35.7, and 45 for Mahua, soyabean, beef tallow, WFO biodiesels and diesel respectively. Soyabean biodiesel has best calorific value and close to diesel and mahua has least calorific value.

4.7 FLASH POINT

Flash point of all the biodiesels is found to be greater than 180ºC.

5. DISCUSSION

The use of biodiesel as an alternative fuel has been proved to be a good choice. The conversion of different feedstock to biodiesel has been carried out and quite significant change in fuel properties were observed, especially soyabean biodiesel has shown the best properties as per ASTM D6751-12 standards and very close to mineral diesel. Beef tallow and mahua biodiesel although showing decent properties still they require some secondary treatment process in order to enhance their properties. WFO biodiesel also show quite satisfactory results as per ASTM standards and can be used as a diesel substitute.

6. CONCLUSION

Biodiesel ia a domestic fuel substitute and can be very useful in the present scenario of energy crisis. Biodiesel is an increasingly attractive, cleaner, nontoxic, biodegradable fossil fuel substitute that can be produced from various sources. Soyabean has a very good potential to be used and a substitute for diesel. Other produced biodiesels also proved to be a satisfactory alternative. Biodiesel will reduce the demand of conventional fossil fuels to some extent.

REFERENCES

[1] Roser M. Energy Production & changing Energy Sources. Our World Data 2014

[2] Energy BSR of W. Statistical Review of World Energy 2014; 2014.

[3] CIA World factbook. 2013. Jon H. Van Gerpen, Charles L. Peterson, Carrol E. Goering, Biodiesel: An Alternative Fuel for Compression Ignition Engines, for presentation at the 2007 Agricultural Equipment Technology Conference

Louisville, Kentucky, USA 11-14 February 2007.

[4] Asadullah Al Galib and Md. Roknuzzaman, March 2009 ‘Biodiesel from Jatrofa oil as an alternative fuel for Diesel Engine’, KUET, Khulna, Bangladesh.

[5] Navindgi MC, Dutta M, Kumar BSP. Performance evaluation, emission characteristics, and economic analysis of four non-edible straight vegetable oils on a single cylinder CI engine. J EngApplSci 2012;7(2):7.

[6] Smith EG, Janzen HH, Newlands NK. Energy balances of biodiesel production from soybean and canola in Canada. Can J Plant Sci 2007;87(4):793–801..

[7] Vega EV. Cleaner Production Opportunities for Improvement of Carbon Saving in the Production of Coconut Biodiesel.Int J Chem Environ Eng 2011 Available from.

[8] Abdul-Manan AFN, Baharuddin A, Chang LW. A detailed survey of the palm and biodiesel industry landscape in Malaysia. Energy 2014;76:931–41.

[9] No S-Y. Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: a review. Renew Sustain Energy Rev 2011;15(1):131–49