Biodiesel: A New Alternative Fuel and Energy Source

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Abstract— Due to depletion in Fossil Fuel new alternative energy sources are becoming popular. Electric Vehicles and Equipment are becoming more recognized. The new alternative fuels will provide a bridge between the traditional fossil fuel to the electric equipment and automation. Biodiesel is now looked upon as an alternative energy source since it is mainly produced from vegetable oils and animal fats. Also, because it is non- toxic by nature. Energy generation and Pollution reduction are the two main concerned reasons for Biodiesel distribution and development worldwide. Complete [1] substitution of petroleum derived fuels with biofuels or biodiesels is impossible. Use of biodiesel along with the petroleum fuels is possible and will also help in prolonging the depletion of the fossil fuels. Corrosion, carbon deposition and wear and tear of the fuel supply part of an engine system are some of the challenges we need to overcome. The best solution for this is to come up with a different Engine System which is compatible for Biodiesel. Here, we will discuss all the possible factor comparing the traditional petroleum fuel with the biodiesel. Also, we will discuss the advantages, disadvantage and some production methods for biodiesel.

Keywords: Biodiesel, Engine System, production

I. INTRODUCTION

Fossil Fuels are used for almost all the transportation purposes, but due to a non- stop demand and supply, these fuels are now depleting. A solution to the problem of fossil fuel depletion is the realization that people need to rely on new fuel sources that are developed from replenishable sources [2]. It is necessary to know alternative energy sources which will fulfil the demand and, also will satisfy the combustion characteristics. Biodiesel is the methyl or ethyl ester of vegetable oil. It is clean burning fuel hence, a perfect substitute for the existing compression engines. It can be used as a pure fuel in the diesel engines or we can blend it with the petroleum fuels in any percentage. [6] Biodiesel being extracted from vegetable oil is a best example for the replenishable source. As long as the crops used for the production of the vegetable oil are in cultivation, we will have an unending supply for the biodiesel.

As an alternative for the conventional fuels like petrol and diesel, biodiesel will be a very crucial option for reducing the environmental problems. Here are two major reasons why biodiesel is a suitable alternative:

1) No engine modifications are required if we replaced diesel with biodiesel.
2) It reduced Greenhouse Gas emissions.
3) It improves the lubricity.

The above are some reasons which make biodiesel a more acceptable and adaptable option. Also, usage of biodiesel will boost the rural development as well as economy as the industry will shift from petrol to agricultural- based fuel. [1]

However, using biodiesel do come with its own challenges like coking of injectors, carbon deposition on the piston and engine head, corrosion, wear and tear of the engine system. To overcome these challenges, we have to develop a methods of extracting biodiesel from trans-esterified vegetable oils. [3-5]

For biodiesel to be a new alternate fuel source it is necessary for its properties to fit in with the existing fuels.

II. CHARACTERISTICS OF GOOD FUEL

The fuels used in an engine or for any combustion processes, it is important for the fuel to have some define characteristics. If the fuel is able to successfully have all the required characteristics, then it is listed as a Good Fuel.

Here are some characteristics that are taken into account before categorising any combustible fluid as fuel:

A. High calorific value
B. Moderate ignition temperature
C. Low moisture content
D. Low non-combustible materials
E. Moderate rate of combustion
F. Knocking
   1) Octane Number
   2) Cetane Number

A. High Calorific Value

The calorific value of a fuel is amount of heat liberated by its complete combustion. For solid and liquid fuels, calorific value is expressed in kJ/kg, whereas for gaseous fuels it is expressed as kJ/m3 where m3 is normal cubic metre measured at NTP conditions i.e., at 0°C temperature and 760 mm Hg barometric pressure (1.01325 bar). Sometimes, calorific value of gaseous fuels can also be expressed as kJ per cubic metre expressed at STP conditions. STP (standard temperature and pressure) conditions are taken as 15°C and 760 mm Hg barometric pressure (1.01325 bar).

A fuel consists of one or more combustible components like carbon, hydrogen, carbon monoxide, hydrocarbons, sulphur etc. Of the above, mentioned combustibles sulphur is not a desirable ingredient due to corrosive properties of SO2 formed by its combustion. The above mentioned combustibles liberate heat by their combustion, but to evaporate the water formed by combustion of hydrogen or hydrocarbons as well as to evaporate the moisture content of the fuel, its sensible heat from temperature to the saturation temperature at combustion pressure and its latent heat and superheat, if any, have to be supplied to bring it to the temperature of the products of combustion.

It can also be defined as calorific value of a fuel is the total quantity of heat liberated from combustion of unit mass of fuel in air. The heat liberated by the combustion of the fuel, neglecting the heat required to evaporate the water is called the Higher Calorific Value of the fuel (HCV). Higher

calorific value is the maximum heat energy liberated by the complete combustion of the fuel. This is also called as the gross calorific value of the fuel. If we subtract from the higher calorific value, an amount of heat required to evaporate the water formed, we get Lower Calorific Value (LCV) or Net Calorific Value (LCV) or Net Calorific Value of the fuel.

Hence, we can infer that higher is the Calorific Value, the amount of heat and temperature liberated is high. It is an important condition for a fuel.

B. Moderate Ignition Temperature

The lowest temperature to which the fuel must be pre- heated so that it starts burning smoothly is called Ignition Temperature of a Fuel. Now this is one of the peculiar condition, where the ignition temperature is required to be moderate the reason is that for fuels with Low Ignition Temperature there is a very high risk factor. Those fuels are very dangerous as the temperature to ignite them is very low. Such fuel must be handled with a great caution. Because of this the storage for such fuels is very difficult and hazardous.

Now when we take into consideration the fuels with High Ignition Temperature there is a possibility that the fuel will cause problems during ignition and cannot be used for the tasks where the ignition temperature is moderate, like an IC Engine. These fuels have an advantage of storage as well as safety but not suitable for quick burning.

As a result, a fuel should have a moderate ignition temperature.

C. Low Moisture Content

Moisture Content of any fuel is very important aspect. Moisture in fuels reduces its heating value as a result, the fuel is not able to burn completely and thus, can damage the parts where the combustion takes place. For example, during a rainy day if some water manages to get inside the fuel tank, after- sometime the vehicles stops to respond to acceleration; reason- moisture reduces the heating value and in turn causes the engine to seize therefore, stopping the vehicle.

Also, from an economical point of view we can say that we are paying money for moisture at the cost of fuel. Because of this we can say that low moisture content is very beneficial.

D. Low Non- Combustible Material

Non- combustible materials by name suggests that substances which neither burn nor give flammable vapour. After the combustion of fuel, these substances remain in the form of ash or clinker. As the don't support combustion the remain in the whole mixture and reduce the heating value.

The main disadvantage of such material is that by reducing the heating value these materials reduce the effective temperature. Because of these reasons it is suggested to have a fuel which produces very less non-combustible materials.

E. Moderate Rate of Combustion

This is another peculiar condition where the combustion rate of the fuel is required to be moderate.

At low combustion rate, the heat generated during or after the combustion gets radiated, which results in very less temperature increase. As a result, high temperature value is not achieved. for fuels with very high combustion rate, the combustion reaction may get out of control and cause a lot of damage and if, the fuel with a high combustion rate is used in a cylinder like casing for combustion there is always a possibility of explosion. To avoid such harmful accidents the fuels with moderate rate of combustions are usually used for controlled combustion purposes.

F. Knocking

1) Ignition temperature: The minimum temperature at which the combustion reaction is self- supporting is called the ignition temperature. It is also known as Spontaneous Ignition Temperature (SIT).
2) Compression ratio: For an Internal Combustion Engine the compression ratio is the total swept volume of the cylinder with the piston at bottom dead centre (BDC), divided by the total compressed volume with the piston at top dead centre (TDC). The power output and efficiency of an IC Engine are dependent on this factor.

Air- fuel mixture inside the engine cylinder get heated up to a temperature which is greater than the ignition temperature due the compression. As a result, a spontaneous combustion occurs before the spark is introduced to the mixture. This results into a shockwave which dissipates its energy by hitting the walls of cylinder and the piston causing a rattling sound to emit. This is called Knocking. Consequences of knocking are:

1) Power output and efficiency of the engine decreases.
2) The wear and tear of the engine parts take place rapidly.
3) The overheating caused by the knocking causes mechanical damage.

To avoid the knocking it is necessary for the fuel to have anti- knocking properties. The anti- knocking quality is given by Octane Number.

Octane Number is given by the percentage of volume of iso-octane (2,2,4 Trimethyl pentane) in a mixture of n-heptane and iso-octane. Iso Octane having the maximum anti- knocking quality its octane number is 100 while n-heptane having minimum anti- knocking quality its octane number is 0.

To increasing the Octane rating of any fuel some anti- knocking agents are added to it. An anti- knocking agent is a gasoline additive used to reduce engine knocking and increase the octane number of the fuel by raising the temperature and pressure at which auto- ignition occurs. TEL (Tera Ethyl Lead) + Ethylene Dibromide is one of the effective additives. The Ethylene Dibromide in the mixture prevents the lead to deposit by forming volatile lead halides. TEL gets converted to very fine lead oxide particles. These particles then react with the hydrogen peroxide molecules that are formed in the engine cylinder. Slowing down the oxidation reaction and preventing knocking.

Considering a diesel engine, there delay period between the injection and ignition of diesel. If this delay period becomes large, too much of diesel accumulates in the cylinder and burn very rapidly, causing a diesel knock. The anti- knocking quality in diesels is given by cetane number. Cetane Number is given by the percentage of volume of n-hexadecane in a mixture of α- methyl naphthalene and n-hexadecane. n- hexadecane having the maximum anti-

knocking quality its octane number is 100 while α- methyl naphthalene having minimum anti- knocking quality its octane number is 0.

Cetane rating of a fuel can be improved by adding:

1) Amyl/ Butyl nitrate
2) Carbamates
3) Di-tertiary butyl peroxide
4) Metal Organic Compounds

The above all are the characteristics of a good fuel. Comparing these basic characteristics any fuel is rated.

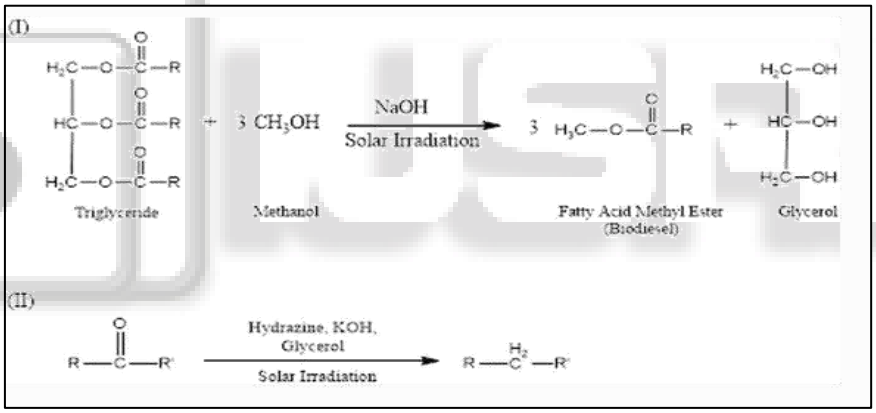
Characteristics	Petrol	Diesel	Bio- Diesel
Calorific Value (MJ/Kg)	45.8	45.5	37.27
Ignition Temperature (°C)	(Unleaded) 257.22 to 445	210	373.889 to 704.44
Octane Number	Regular- 87 Midgrade- 89 to 90 Premium- 91 to 94	N/A	N/A
Cetane Number	N/A	40 to 55 (Light Diesel) 35 to 50(Heavy Diesel)	46 to 52 (Vegetable Oil) 56 to 60 (Animal Fat)
Flash Point (°F)	-45 (Unleaded)	140	266

Table 1: Characteristic comparison of different fuels

From the above table we can infer that biodiesel fulfil most of the characteristics and hence, can be directly used for diesel engines with some modification or partially be used with petrol in any percentage.

To have a ample supply of biodiesel it is necessary to have a production process which produces minimum waste and the amount of biodiesel produced is also sufficient. By using a newly developed technique we will be able to produce less waste and sufficient biodiesel.

In this method [2] the generation of carbon dioxide waste during biodiesel production has been eliminated. Also, another concern for production of biodiesel was generation of waste by- product glycerol. A technique has been developed that incorporates the use of recovered biodiesel waste glycerol as the solvent system for Wolff-Kishner reduction reactions. The reduction of iso-butyryl chloride has been performed successfully using biodiesel waste glycerol as the solvent system and solar irradiation as the heat source for the chemical reaction. [7]



Glycerol is produced as a by-product in the synthesis of biodiesel. For every 3.8L of biodiesel produced, 476 grams of glycerol is produced. Pure glycerol having many applications as a solvent and preservative, it will be further refined and then used for different purposes. This method is an elegant solution for production of biodiesel. And in future this method will be in lead for mass production of biodiesel.

III. Advantages and Disadvantages of Biodiesel

Biodiesel has some advantages and dis- advantages, they are listed below: [5,8,9]

A. Advantages:

1) It is safer to handle, more biodegradable.
2) Biodiesel is cost effective as it can be produced locally.
3) The waste by- product generated during the production of biodiesel has many applications.
4) It is non- toxic by nature.
5) Engine modifications are not required for the biodiesels up to B20.
6) Biodiesel has flash point more than diesel.
7) The cetane rating of biodiesel is better than diesel.
8) Biodiesel has no need to be drilled or refined like diesel as it is produced by chemical reaction.
9) Biodiesel has fewer emission of CO_2, CO, SO_2 compared to diesel.
10) As biodiesel is produced by vegetable oil it will help in boosting the agricultural sector; thus, economically helping the rural areas.
11) Biodiesel has better lubricating qualities than the conventional fossil fuels.
12) It will act like a bridge to new technology for the developing nations.
13) It has far less tailpipe emissions.
14) It has a higher combustion efficiency.

B. Disadvantages:

1) Degradation of biodiesel might occur in the storage containers if the storage is prolonged.
2) It would cause carbon deposition on the piston head of the engine.
3) It causes excessive engine wear and tear.

4) It would cause coking of the injectors.
5) With calorific value less than petrol and diesel the engine using biodiesel will have less power output.
6) Biodiesel has a very high viscosity as compared to that of diesel because of large molecular mass and large chemical structure of vegetable oil, it will cause problems during pumping, combustion when used in a diesel engine.
7) It emits high amounts of NO_x as compared to diesel.
8) Biodiesel is corrosive in nature and will cause damage to the engine system and its parts like the injectors, pipes, hoses, etc.

IV. CONCLUSION

A forthcoming energy crisis when the fossil fuels will be depleted will cause a great economic setback. At those time a promising fuel like biodiesel will provide way to get us back on tracks. With the benefits that come with biodiesel, the economic and social developments of rural areas will sky rocket and will lay a path for progress.

For a growing demand of transportation fuel in the world, biodiesel will be a noteworthy candidate as very less modification will be required to use it on a commercial level. Considering all the pros and cons and fuel properties of biodiesel, using it as an additive for petroleum fuel and directly for diesel engine with little modifications, it will be a very reliable alternative fuel source. But the modification will increase the price, so it is necessary to develop a fully compatible and dedicated engine system for biodiesel.

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