A review: Advantages and Disadvantages of Biodiesel

Shafaque Firoz1,*

1UG Student, School of Mechanical Engineering, KIIT University, Patia, Bhubaneswar, Odisha -751024

Abstract - The present paper gives a complete idea on the prospective technology for the production of clean energy in the form of biodiesel. The fast growing society needs energy which should be clean in all the aspects and this can be fulfilled by biodiesel. Due to increasing use of petroleum fuels in automobiles and industrial sectors, in the past few years, the world has started facing severe problems like environmental pollution, ozone layer depletion, global warming. Due to good oxidation characteristics and lubricating nature, Biodiesel is attracting the world to its side as the alternative fuel. Therefore, many scientists from different parts of the globe are carrying out research to find an alternative source in order to replace the existing one. Biodiesel can replace the present energy crisis and further help in reducing global warming. Utilization of biofuels results in the reduction of global warming and also helps in maintaining the demand and supply levels of fossil fuels. The present paper gives an idea of different types of fuels available along with comparison of properties of different fuels and their advantages and disadvantages.

Key Words: biodiesel, Diesel engine, transesterification, performance, emission

1. INTRODUCTION

Energy has the capability to do work and has become a key factor for a process to occur. An energy resource is something that can produce heat, power, life, move objects, or produce electricity. Matter that stores energy is called a fuel. Human energy consumption has grown steadily along with population and final reached a stage of extinction[1]. In today's society, humans consume as much as 110 times of the energy consumed by early human i.e. the developing society needs energy for its running. Most of the energy we use today come from fossil fuels. But fossils fuels have a disadvantage that they are limited in nature, and cause other potentially harmful effects on the environment[2].

1.1 Renewable Resources

Renewable resources are that resources which can be replenished by the environment over relatively short periods of time. This type of resource is much more desirable to use because it can be compensated by the nature. Some examples of renewable energy sources are solar energy, wind energy, hydropower, geothermal energy, and biomass energy[3].

1.2 Non-Renewable Resources

In contrast to renewable resources, non-renewable resources are resources that are not easily replenished by the environment. Earth minerals and metal ores, fossil fuels (coal, petroleum, and natural gas) and groundwater in conditions are considered non-renewable resources.

2. FUELS

In our day to day life we see many machines running around us, for running them some form of energy is required which is provided by the help of fuel. A fuel is any material that can be made to react with other substances so that it releases chemical or nuclear energy as which can be utilized directly or can be converted into work. Fossil fuels were rapidly adapted during the industrial revolution because they were cheap and efficient[4]. They have become a major part of our society but they have also imputed to pollution. Currently people are more inclined towards usage of renewable fuels such as biofuels.

Biofuels are fuels which are derived from biomass, they can be in solid, liquid and gaseous form. Biomass can be used directly for heating or power or it can be processed to get the maximum benefit from it. Biofuel can be produced from any carbonaceous material. Many different plant derived materials are used for biofuel manufacturing. Ethanol is also a biofuel because it is made from corn[5]. Biodiesel is vehicle fuel made from vegetable oil.

3. ENERGY FROM DIFFERENT FUELS

The amount of energy from different types of fuel depends on the stoichiometric ratio, the AFR ratio and its Specific energy, the energy per unit mass. Air–fuel ratio (AFR) is the mass ratio of air to fuel present in a combustion process such as in an internal combustion engine or industrial furnace.
5. OILSEED CROPS FOR BIODIESEL PRODUCTION

Biodiesel can be produced from a wide variety of oilseed crops and animal fats. In Europe, rapeseed oil is the major biodiesel feedstock[7]. In the United States soya beans are major biodiesel feedstock. Algae contains 90% of biodiesel contain in it.

5.1 Different oil seed crops for biodiesel production are

- Soybeans
- Mustard
- Rapeseed and Canola
- Camellina
- Sunflower
- Karanja
- Mahua
- Neem oil
- Rice bran oil
- Jatropha

In addition to oil seed crops, biodiesel can be produced from:

5.3 Used and waste oil

Waste oil and grease can be collected from restaurants to produce biodiesel. Whereas the processing costs of this urban source are higher per gallon than the processing costs of virgin vegetable oils.

5.4 Animal Fats

Animal fats are low cost biodiesel feed-stocks. However, there are also some drawbacks and challenges to animal fat feed-stocks[4].

5.5 Algae

Microalgae have long been considered as potentially good sources for biofuel production because of their relatively high oil content and rapid biomass production[5].

6. SELECTION OF FEEDSTOCK FOR BIODIESEL

In general, seeds and nuts should be selected considering all the outcomes and shortcomings, it should be stored in cool and dry conditions, and processed quickly to avoid degradation. The seeds should be processed close to the time when the oil will be processed into biodiesel. Before processing the seeds must be cleaned, screened, and, in some cases, hammered or dehulled[9]. The meal or cake in some cases must be heated to deactivate toxic components before use. Biodiesel is not the same as straight vegetable oil or animal fat. A normal diesel engine will eventually be damaged through the use of straight vegetable oil or straight animal fat fuel. Vegetable oils or animal fats must be converted into biodiesel by reacting the oil or fat with an
alcohol and a catalyst. This process is referred to as "transesterification[4]."

7. MAKING BIODIESEL

Biodiesel is made by reacting vegetable oil or animal fat with an alcohol (methanol or ethanol) and a catalyst. This process separates the glycerin from oil or fat. Thus resulting in biodiesel which is thinner than the original oil or fat and works better in diesel engine[10]. Biodiesel production is the method of producing the biofuel, biodiesel, through the chemical reactions such as transesterification and esterification. This involves vegetable or animal fats and oils being reacted with short chain alcohols (typically methanol or ethanol). The alcohols used should be of low relative molecular mass, ethanol is most commonly used because of its low cost, however greater conversion into biodiesel can be done using methanol[7]. The method of production is base catalyzed transesterification, this process is chosen because it consumes less time and also the cost of catalyst is low. This process is cheaper than the acid esterification[11]. However alkaline catalyst has the disadvantage of high sensitivity to both water and fatty acid present within the oil.

7.1 Transesterification

Animal and vegetable oils are composed of triglycerides, which are esters of three free fatty acids and glycerol. In the transesterification process, the addition of alcohol and alkali de-polymerization occurs, making it a stronger nucleophile. It can be seen that the reaction did not have other inputs than triglycerides and alcohol. Under normal conditions, the reaction will proceed very slowly, so heating is used to accelerate the reaction using a catalyst (acid and / or base). Common catalysts for transesterification include sodium hydroxide, potassium hydroxide and sodium methoxide[6].

The most economical process for processing virgin vegetable oil, which only requires low temperature and pressure and produces more than 98% of the crop. However, biodiesel made from different sources or in other ways may require acidic catalysts, which are much slower[12]. Due to the dominant technique for production almost all biodiesel is made from virgin vegetable oil using basic catalyst techniques because it is action on an industrial scale, only the base catalyzed transesterification method is discussed below.

7.1 Base-catalysed transesterification mechanism

The transesterification reaction is the base catalyzed. Strong bases capable of deprotonating the alcohol can be used, but sodium and potassium hydroxide are generally selected due to their lower prices. The presence of water causes undesired base hydrolysis, so the reaction must remain dry[6].

In the transesterification mechanism, carbonyl carbon from the starting ester (RCOOR1) undergoes a nucleophilic attack by an inlet alkoxy (R2O-) to provide a tetrahedral intermediate, which returns to the starting material, or passes to the transesterification product (RCOOR2). Various species exist in equilibrium and therefore the product distribution depends on the relative energies of reactant and product.

![Chart-1 Transesterification reaction](image)

8. DIFFERENT PRODUCTION METHODS

- **Ultra and high shear in line and batch reactors**

Ultra and High Shear Reactors inline or in batches enable continuous, semi-continuous and biodiesel production in batch mode. This drastically reduces production time and increases production volume[4].

The reaction is carried out in the highly energetic zone of the Ultra and High Shear mixer, reducing the size of the incompressible liquid droplets, such as oil or fat and methanol. Therefore, smaller the drop size larger the surface area, which will allow larger catalyst action.

- **Supercritical process**

An alternative, catalyst-free methodology for transesterification uses supercritical methanol at high temperatures and pressures during a continuous method. In the critical state, the oil and methanol are in a single phase, and reaction happens spontaneously and quickly[7]. The process can tolerate water within the feedstock, free fatty acids are converted to methyl esters rather than soap, thus a wide variety of feedstocks may be used. And also the catalyst removal step is eliminated.

- **Ultrasonic reactor method**

In the ultrasonic reactor methodology, the ultrasonic waves cause the reaction mixture to produce and collapse bubbles uniformly. This cavitation at the same time provides the space for blending and heating required to carry out the transesterification process. Thus, using an ultrasonic reactor for biodiesel production drastically reduces the reaction time, reaction temperatures, and energy input. Therefore the method of transesterification will run inline instead of using the time consuming batch processing. Industrial scale ultrasonic devices allow the commercial scale processing of thousands of barrels per day[6].

9. PRODUCT PURIFICATION

Products of the reaction include not only biodiesel, but also byproducts, soap, glycerol, excess alcohol, and trace amounts of water. All of these byproducts must be excluded for perfect blend of biodiesel, but the order of removal is process-dependent. The density of glycerol is greater than that of biodiesel, and this property difference is the key to separate the bulk of the glycerol coproduct. Residual methanol is typically recovered by distillation and reused[13]. Soaps can be removed or converted into acids. Residual water is also removed from the fuel[6].

10. BIODIESEL AS A REMEDY TO CURRENT ENERGY CRISIS

10.1 Biodiesel as a fuel

Biodiesel meets both the biomass-based diesel and overall advanced biofuel demand of the Renewable Fuel standard. Biodiesel is a liquid fuel usually stated as B100 or neat biodiesel in its pure, un homogenised form. Like petroleum diesel, biodiesel is used as fuel in compression-ignition engines. How well biodiesel performs in weather condition depends on the blend of biodiesel[14]. The smaller the proportion of biodiesel within the mix, the better it performs in cold temperatures. Regular No. 2 diesel and B5 perform the same in cold weather.

<table>
<thead>
<tr>
<th>Physical Characteristics of Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
</tr>
<tr>
<td>Kinematic viscosity at 40 degree celsius</td>
</tr>
<tr>
<td>Cetane number</td>
</tr>
<tr>
<td>Higher heating value, Btu/gal</td>
</tr>
<tr>
<td>Lower heating value, Btu/gal</td>
</tr>
<tr>
<td>Density, lb/gal at 15.5 deg celsius</td>
</tr>
<tr>
<td>Carbon, wt%</td>
</tr>
<tr>
<td>Hydrogen, wt%</td>
</tr>
<tr>
<td>Oxygen, by diff. wt%</td>
</tr>
<tr>
<td>Boiling point, deg celsius</td>
</tr>
<tr>
<td>Flash point, deg celsius</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
</tr>
<tr>
<td>Cloud point, deg celsius</td>
</tr>
<tr>
<td>Pour point, deg celsius</td>
</tr>
</tbody>
</table>

Not all the light-, medium-, and heavy-duty diesel vehicles are technically "alternative fuel" vehicles, several are capable of running on biodiesel. Biodiesel that is most frequently used as a blend with regular diesel fuel can be used in several diesel vehicles without any engine modification. The most common biodiesel blend is B20, which is 6% to 20% biodiesel blended with petroleum diesel[4]. B5 (5% biodiesel, 95% diesel) is commonly used in fleets[7]. Before using biodiesel, it’s necessary to check the engine’s warranty to make sure that higher-level blends of alternative fuel do not void or have an effect on it. Biodiesel improves fuel lubricity and raises the Cetane number of the fuel. Diesel engines depend upon the lubricity of the fuel to stay moving components from wearing untimely. Federal regulations have step by step reduced allowable fuel sulfur to only fifteen parts per million, that has often resulted in lower aromatics content in diesel fuel. One advantage of biodiesel is that it can impart satisfactory lubricity to diesel fuels at blend levels as low as 1%.

10.2 EFFICIENCY

According to a recent study, an average farm consumes fuel at 82 liters of oil per hectare of land to generate one crop. However, a mean crop of oilseed makes oil at an average rate of 1,029 L/ha, and high-yield oilseed fields turn out about 1,356 L/ha. It is clear to notice the ratio of input to output in these cases which is roughly 1:13 and 1:16. Photosynthesis is known to have an efficiency rate of about 3-6% of total solar radiation[6]. Therefore, if the whole crop mass is used for producing energy, the general efficiency of this chain is currently about 1%.

10.3 Comparing emissions

Our testing showed that emissions from the biofuels were the same or better than from regular diesel by most measures. None of the four fuels generated significant amounts of carbon monoxide. Cooking oil produced less smog-causing NOx than regular diesel, while our B100 produced a little more.
11. ADVANTAGES OF BIODIESEL FUEL

- Easy to use: No vehicle modification or any fueling equipment needed.
- Power, Performance and Economy: Proven power generation, performance and cost efficiency made biodiesel a useful fuel.
- Effect on environment: Biodiesel is helping in reducing pollution and improve health by lowering the emission of CO2 which reduces the effect of global warming.
- Biodiesel reduces the use of foreign oils.
- Biodiesel is safer to handle because it is less toxic and easy to store than petroleum.
- Biodiesel helps communities by keeping energy dollars at home.

12. DISADVANTAGES OF BIODIESEL FUEL

- At present, Biodiesel fuel is about one and a half times more expensive than petroleum fuel.
- It requires energy to produce biodiesel fuel from soya crops, plus there is the energy of sowing, fertilizing and harvesting.
- Another biodiesel fuel disadvantage is that it can harm rubber houses in some engines.
- As Biodiesel cleans the dirt from the engine, this dirt can get collected in the fuel filter and clogging occurs. So, filters should be changed regularly.
- Biodiesel fuel distribution infrastructure needs improvement, which is another of the biodiesel fuel disadvantages.

13. CONCLUSION

Biodiesel provides energy security as it protects the environment, and also boosts the economy. Today, biodiesel turning as the growing alternative fuel not only in America, but other parts of the world as well. One of themain reasons behind transition to biodiesel fuel is energy security. Is that the nation’s dependence on foreign oil get reduced, use of locally available sources is enhanced. Thus a country finds energy security in biodiesel fuel without a decrease in greenhouse gas emissions. Although the total energy balance is still a debatable issue, but clearly the energy security due to biodiesel fuel is enhanced. It has been observed that properly managed biodiesel fuels have the prospective for strengthening the security of supply and can also help in generating different energies[7].

References:


