

A Comparative Study of Latest Mechanical Design of Biodiesel and its Fuel Properties

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Abstract: This paper presents a study on latest mechanical design of biodiesel and its fuel properties.

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1. Introduction

Biodiesel has other eco-friendly features. Biodiesel can be defined as "carbon neutral" as the key benefit. In other terms, the gasoline does not contain a net carbon emission in the form of carbon dioxide (CO₂). It is because when the oil crop is produced, it consumes the same volume of CO₂ as when the fuel is combusted. In reality, this is not entirely true because CO₂ is emitted during fertilizer development needed to fertilize the oil fields. The processing of fertilizer is not the primary cause of emissions related to biodiesel development. Other causes include esterification method, oil solvent extraction, manufacturing, drying and transport. Both such processes need either the energy input as electricity or as a fuel, which usually contribute to the release of greenhouse gases. To better assess the effect of all such channels, a method called life cycle review must be used. Our LCA segment discusses this topic more closely. Biodiesel is easily biodegradable and completely un toxic, which ensures that handling is much less dangerous than fossil fuel spills. Biodiesel has a trigger point higher than conventional fuel and so is better when a collision happens.

Output of biodiesel:

Biodiesel can be produced from direct vegetable oil, animal oil / fat, tallow and waste oils. As described above. There are three basic routes for the manufacture of biodiesel from oil and fats:

Catalyzed base oil transesterification. Clear acid catalyzed oil transesterification. Simple acid Transformation of the oil into the fatty acids and then into biodiesel.

Nearly all biodiesel is processed by base catalyzed transesterification as it is the cheapest method that requires only low temperatures and pressures and that produces a conversion rate of 98 per cent. That is the sole explanation why this phase is highlighted in this article.

The method of transesterification is the transfer of an alcohol-based (fat/oil) triglyceride to esters and glycerol. A triglyceride has three long chain of fatty acids as its basis. The

attributes of the fat are defined by the composition of the glycerine fatty acids. The characteristics of biodiesel can in effect be influenced by the fatty acids. In the esterification phase, triglyceride in the presence of a solvent, normally a solid alkaline such as sodium hydroxide, reacts with alcohol. Alcohol reacts to the monoalkyl ester or biodiesel and synthetic glycerol by way of fatty acids. Alcohol (methanol generates methyl esters, ethanol creates ethyl esters) is used in most processing of methanol and is the main catalyst in either potassium or sodium hydroxide. Potassium hydroxide has been identified to be more suitable for the production of ethyl ester biodiesel. Rape Methyl Ester (RME) produced from raw rapeseed oil reacted with methanol is a typical product of the transesterification phase. The following table indicates the chemical cycle for biodiesel methyl ester. The reaction from fat or oil to alcohol is a reversible reaction, meaning that the alcohol must be applied to the reaction to the right to insure complete conversion. The reaction components are biodiesel and glycerol itself.

2. General

Biodiesel and its chemistry

Advantages:

A large amount of glycerol is produced by the transesterification process used in biodiesel processing. Glycerol was historically produced from petroleum extraction which typically needs a dedicated manufacturing plant. Glycerol may be extracted and used as a by-product in transesterification. Glycerol is used in many sectors, including the manufacturing of soap and other household goods. Glycerol is still commonly used in cosmetics because it avoids damage to the consumer from untreated crystalline structures. Glycerol from biodiesel processing was found to be an economic benefit. Combined with the anaerobe fermentation cycle, this cheap by-product of glycerol.

Disadvantages:

Although there are many benefits to utilizing biodiesel as a source to gasoline, there are several drawbacks. Based on the biodiesel mixture's chemical properties, cold temperatures appear to induce coagulation in fluid that prevents engine fuel injection (Knothe, 2010). Biodiesel has a cloud stage where the

fuel starts to solidify into a layer like rubber. The gasoline becomes completely Wax-like and unusable in the car once it hits a few degrees below this temperature (Dogpatch, 2015, using biodiesel). As certain semi-trailers transfer heavy loads in cold climates coagulation presents a serious challenge to their service. This temperature restriction has proven to be a barrier in the introduction of biodiesel instead of petroleum fuel.

Another important issue is the dispute between fuel and food. The major reactant in biodiesel output is fat or grease. These oils are derived from crops that may otherwise be used as a food source. The small number of productive ground is a restricted volume of property for cultivation. The turning of rising crops into fuel has a detrimental effect on the food supply.

The method of biodiesel processing uses methanol as a fuel. It is claimed that biodiesel is not 100% "bio" regardless of the more popular sources of methanol (Knothe, 2010). Methanol can conveniently be derived from natural gas, a non-renewable fuel. Methanol can, however, also be generated through a variety of renewable reagents, but not normally.

Biodiesel vs. Petroleum Diesel:

Biodiesels are both identical in density and lower fuel volume (LHV), which is not the latent fuel heat vaporization metric. The flash point and octane number are almost identical with the exception of peanut oil. Which vary from standard diesel with lower LHV and higher flash points in both oils. A fuel has to have sufficient storage electricity, and a fuel with the lowest LHV is the best energy supply.

Energy intake is commensurate with the fuel's volumetric energy density dependent on LHV. LHV represents temperature variations during combustion and the heat of the water vaporisation. While the energy content of various biodiesel forms is quite high, both produce around 10% less heat than petroleum diesel (Alternative Fuels Data Center 2015).

Different Sources and their Characteristics:

Owing to their abundance and variety from olive oils to animal fat, various forms of biodiesel from oils are used all over the world. Biodiesel is primarily produced from soybean oil in the United States (Martinez, Sanchez, Encinar & Gonzalez, 2014). Various oils produce varying levels of fatty acids, which results in a somewhat different formula.

Twelve specific biodiesel feed stocks, primarily composed of fatty acid methyl esters (FAME), were contrasted by means of a major analysis by transesterification. We tabulated and measured a variety of characteristics, including the amount of cetane, the viscosity, the intensity, the magnitude of heating, the point-of-flash, the average carbon chain frequency, the average degree of in saturation and oxidative power.

The American Society of Testing and Materials (ASTM) has established characteristics criteria for appropriate biodiesels. Cetane number is an ignition time metric for diesels with higher cetane numbers that result in greater combustion easiness and is widely used as a standard fuel efficiency indicator. A minimum cetane number 47 for biodiesels is defined in ASTM

specification D6751. Biodiesels made of the most-used feedstocks often surpass this amount, while more cetane is preferable.

While the heating value of biodiesels is not subject to requirements, the higher heating value (HHV) is another significant feature used in the assessment of biodiesel efficiency. HHV is the only element.

The fuel energy is readily transformed into thermal energy taking into consideration the radiant power of water vaporisation. Biodiesel produces on average 11 per cent mass oxygen and much fewer mass methane and hydrogen than conventional fuel. Biodiesel thus has nearly 10 percent lower HHV by weight than petroleum-based diesel, while its capacity is only 5-6 percent lower than that of petroleum diesel (Hoekman et al., 2012).

The fuel density and viscosity volatility, or properties that influence fuel efficiency at low temperatures, are strongly dependent on the fuel cloud location. Viscosity, the resistance to flow of liquids, is an essential factor that influences fuel efficiency. High-viscosity carburizers are weaker because of decreased atomization and vaporization problems, contributing to low combustion and higher pollution. Viscosity is strongly temperature based, indicating that most problems induced by fuel viscosity often arise in the low atmospheric temperature and cold start engine conditions (Hoekman et al., 2011).

Cloud point is commonly used as a cold-flow measure. It is the temperature at which waxes in the fuel solidify and fog the FAME mixture which, because of filter blocking and fuel injectors (Hoekman et al.,

(2011)). The average degree of insaturation or the average amount of double-bond equivalents (amount of twins and aromatic ring) in a fuel was found to interact negatively with the cloud point and to increase cold weather efficiency at higher levels of insaturation. The following are feedstock outlets and related properties (Demirbas, 2008).

Emissions:

Biodiesel has been shown to have an advantage over petroleum-based diesel in terms of Composition of pollution. Biodiesel burning generates little to no SO₂ pollution, fewer polyaromatic hydrocarbons, soot, and carbon monoxide. Combustion output is described as the combustion-released energy ratio to the fuel's higher heating value. This performance can be improved by adjusting the air inlet to the burner, which will also affect the final process

Composition of pollution (Durrenberger, 1983).

Combustion performance often relies on the combustion temperature and the CO₂ emissions. Large CO₂ emissions suggest that the combustion is complete and the bulk of the fuel is absorbed. The stack temperature is explicitly associated with

Volume of soot built-up and heat transmission surfaces size. With stronger soot deposition,

The surface rate of conductive heat transfer decreases and the stack lacks more usable power (Durrenberger 1983). It is necessary for these reasons to change burners to optimize CO₂

rates in the stack while minimizing the amount of smoke generated.

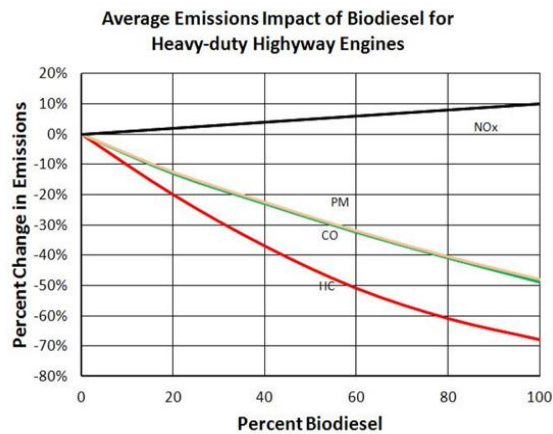


Fig. 1. Emission Changes with Percent Biodiesel

Figure 1 displays the expected trends when combusting mixtures of diesel and biodiesel.

Nitrogen Oxides:

Nitrogen Oxides (NOx) are a category of extremely reactive gasses that contain nitrous and nitric acid compounds. Such chemicals are primarily introduced into lorries, vehicles, power plants and off-road exhaust systems (O. US EPA, OAQPS 2014). As air nitrogen and oxygen behave at incredibly high temperatures and pressures inside a combustion chamber of up to 4000 ° F and 300PSI, the NOx gasses shape (Johnson 2015). Fuel is pumped into the cylinders by direct injection diesel motor and creates small droplets. Oxygen interacts with the fuel droplets on the boundary surface of the soil, increasing the concentrated temperature in the fuel droplet needed for NOx gas formations.

Usually elevated oxygen rates and high temperatures contribute to strong NOx production. Such factors are commonly seen in diesel engines since the air-fuel combination is lean and the compression ratios are strong. Diesel fuel releases fewer NOx than gasoline through combustion, but diesel engines emit more NOx emissions to the air through the usage of catalytic converters on gasoline driven automobiles ("Automobiles Emissions Air Pollution Town Diesel LPG CNG," 2015).

$$\frac{d[NO]}{dt} = \frac{6 \times 10^{16}}{T^{1/2}} \exp\left(\frac{-69,090}{T}\right) [O_{2,eq}]^{1/2} [N_{2,eq}] \text{ (moles/cm}^3 \text{ - sec)}$$

Fig. 2. Kinetics of Reaction Equation (d [NO] / dt)

Effects of NOx:

If NO2 is broken into NO and O in the atmosphere by UV radiation from the sun that mixes with the air-borne oxygen produces ground level ozone, a poisonous pollutant and strong greenhouse gasses. NO2 is oxidized into nitric acid by an ammonia reaction that in effect reacts to create acid precipitation with water vapor. The actual quantities of NO,

NO2 and NO3 are challenging to assess, because of the quasi-equilibrium of the identical oxygen atomic molecules ('Nitrogen Oxides (NOx)' 2015).

High concentrations of nitrogen in bodies of water, especially in coastal estuaries, will disrupt the normal chemical equilibrium that keeps the ecosystem of the environment intact and intensify the cycle of eutrophication, which ultimately contributes to reduced oxygen rates and fish stocks.

NOx emissions lead to a broad range of health issues including: breathing irritations, vomiting, pulmonary emphysema (chronically weakened lungs), damaged lung defenses, lung edema, eye inflammation, lack of appetite and dental decay. Young children and asthmatics, as well as persistent bronchitis, emphysema or other recurrent ailment, are among the most affected categories. NOx emissions

NOx pollution constituted 6% of the greenhouse gas pollutants in the United States. NOx gases remain in the environment for 120 years before being eliminated or transformed through chemical processes. NOx gases have a greenhouse impact about 300 times greater than carbon dioxide gas pollutants (C. D. American EPA, 2014).

Once NO2, Ultraviolet light in the atmosphere by the sun is broken to create NO and O and reacts with airborne oxidation to produce ground-level ozone, a poisonous pollutant and a strong greenhouse gas. NO2 oxidizes into nitric acid through an ammonia reaction, which, in effect, interacts with the water vapor to create acid rain.

Taking Measurements:

Prior to any tests, the tip of the probe was positioned in order to locate the intake hole in the water. The sampling tube was sufficiently wide to occur without disrupting the flow substantially. Measurements have been made in the middle of the tubing.

Exhaust Ventilation System Modification:



Fig. 3. Ventilation System

To sample emissions for calculating pollution amounts, the ventilation device had to be changed. A 6-inch metal channel was found to be wide enough to mount the flue gas analyzer device while the exhaust stream was fitted to the overhead ventilation shafts. The above is installed on fixed steel braces with the aid of the unit managing director and technician Tom Partington and a 6-inch pipe tea was fitted to trap condensing water vapor. It was attached to a funnel-shaped pipe fitting and fed into an aluminum shaft about 1 1/2 inch in diameter, which

connected to the boiler. For tests, a tiny hole was bored into the surface of the 6-inch conduit. This hole was attached while not in use with a bolt.

The image of the updated exhaust device for this project is shown in Figure 3. This system was built with the assistance of the machinist on the campus to ensure a good air flow. The bolt used to tightly cover the ventilation is just below the end of the assembly panel. This is omitted to calculate using the check meter.

In fact, the vacuum pressure imposed on the combustion chamber must be modified to minimize the ventilation system. This was achieved by using the slide button. The Tee vent connection was mounted in order to trap concentrated water that does not enable the combustion chamber to flow back into it.

Process of Producing Biodiesel at WPI:

Production:

The WPI Device Laboratory is able to build and purify biodiesel using an ion exchange resin. Now senior students in chemical engineering develop the biodiesel for the Unit Operations Class in an experiment. Two computer-controlled reactors are used. Methanol and potassium hydroxide as a solvent are known as alcohol. In the first reactor flask, methanol and potassium hydroxide are mixed together, and canola oil in the second vessel is cooked. When the methanol-catalyst mixture exceeds a predefined temperature, it is injected into the second vessel in which the reaction happens. It is achieved in automatic hot water baths at a steady temperature of approximately 55 ° C and 60 ° C. When the reaction has been finished, it will cool for a number of days after which two phases develop. The heavy layer of glycerol pure is then removed from the bottom of the bottle and the lighter layer of biodiesel is regenerated. Usually, it takes about 2 hours, generating roughly 400 mL of unclean biodiesel (Belliard, Carcone, Swalec, & Zehnder, 2014).

Students from the Chemical Engineering Operations Unit course at WPI 's Unit Operations Laboratory in Goddard Hall developed bio-diesel for this analysis.

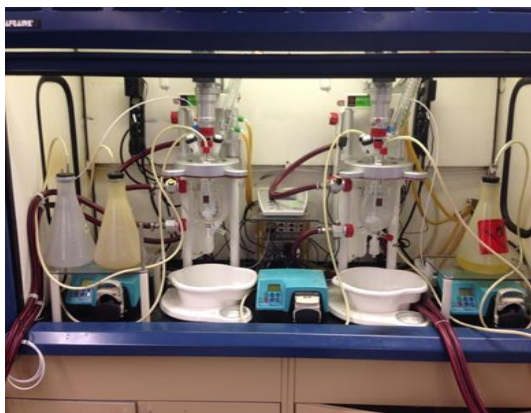


Fig. 4. WPI Biodiesel Production Setup

Fig. 4, demonstrate the set-up in the WPI Unit Operations Lab to manufacture biodiesel. The following cycle description

involves the two reactors and the two reaction source sources for an overall biodiesel receptor. The machine program manages the two reactors of the system: The Catalyst Reactor and the Cycle Reactor. Throughout the phase reactor the contents of the catalyst storage reactor are pumped. System reactor samples can be collected and then tested for glycerol material. Acetone is used to disinfect the reactors in operations.

A methanol, glycerol and biodiesel mixture must be produced and then filtered to extract both methanol and glycerol. Approximately 300-400mL of available organic diesel is generated per run (about 40 minutes). The lots made in the laboratory class were all prepared using canola oil, but biodiesel with other types of oils can be created.

Purification:

Thanks to low pressures and temperatures of about 65oC, the remaining methanol in the biodiesel process is evaporated. The rich form of biodiesel is then treated by an ion exchange resin. The resin is used to wash biodiesel by adding glycerol, methanol and catalyst. The method is built to avoid the injection of water into biodiesel, which is otherwise regarded as dry-washing. Dudalite DW-R10 Ion Exchange Resin, which has been assumed to have greater adsorption rates than other resins, is commonly used in this process. While rigorous studies have not been performed to confirm this, we assume that refined biodiesel can conform with the ASTM biodiesel requirements (Belliard et al. 2014).



Fig. 5. Two Phase Separation and Resin Column

Figure 5, demonstrates the two-phase glycerol and distilled biodiesel distinction. The dark orange-brown process, a mixture mainly of glycerol and biodiesel trace amounts is added and the almost pure biodiesel above is omitted. The compound for ion exchange is seen on the bottom.

3. Conclusion

This study investigated the use of KM micromixer in the

production of biodiesel from waste vegetable oil. The effects of methanol/oil molar ratio, catalyst concentration, volumetric flow rates, and the presence of a co-solvent on the transesterification reaction were examined. The study proved that the reaction can be completed giving higher percentage yield of biodiesel that reached 97%.

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