SOURCES AND USES OF BIODIESEL FUELS

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Introduction

Interest in renewable energy has heightened due to the uncertainties of the supplies and prices of the fossil/petroleum fuels. Using vegetable and animal oils as a source of diesel fuel provides an alternative solution. The production of biodiesel in the US is becoming increasingly more available. The biodiesel fuels have properties different from petroleum diesel fuel which are both positive and negative with respect to engine performance.

Since most modern diesel engines were designed for the petroleum fuel, some problems would be expected when using biodiesel fuel due to small differences in properties. But these problems can easily be overcome with minor adjustments in engine operation and maintenance and handling of the fuel.

Background

When Rudolph Diesel designed the compression (diesel) engine in 1897, he used peanut oil as the fuel. As the petroleum fuel market evolved with the production of various fuels e.g. gasoline, heating oil and kerosene, the crude oil was refined to produce fuels with traits meeting very specific needs of their final use. Since the time of Diesel's development, the compression ignition engine and diesel fuel properties together have evolved to improve the performance of the engine and to meet environmental air quality requirements.

As environmental air quality requirements become more restrictive, the challenges of designing new engines and modifying fuel properties become greater. The fuel delivery systems on diesel engine were designed and manufactured with greater precision requiring improved lubricating properties of the diesel fuel. As a result the fuel is metered more accurately to the engine cylinders producing more efficient engines and fewer contaminants in the engine exhaust.

To meet environmental air quality requirements, the composition of the fuels was also modified. Sulfur is one of the principal components of concern. The sulfur is very important in determining the lubricity, lubricating ability, of the fuel which became more important with the more precisely manufactured fuel systems.

All these modifications were made without consideration for the biodiesel properties. As these fuels gained more interest, their properties must be compared to the present day petroleum fuels. For some properties the biodiesel fuel has an advantage. For other properties the biodiesel fuel has disadvantages but they can be addressed by using proper fuel additives and properly maintaining and servicing the engine.

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Biodiesel Production and Ssources

Biodiesel can be produced from a variety of sources including algae, discarded cooking oil and agricultural crops. In 2002, the primary world source of biodiesel was canola/rapeseed at 84%. Sunflowers were second at 13%; soybeans and palm oil each contributed 1% to the world market. The eastern European countries appear to be the leaders in biodiesel production with approximately 550 million gallons in 2002 (Biodiesel, 2006). The production of biodiesel in the US primarily from soybeans has been increasing dramatically each year since 2001, Figure 1. The production from 1999 to the present has nearly doubled each year.

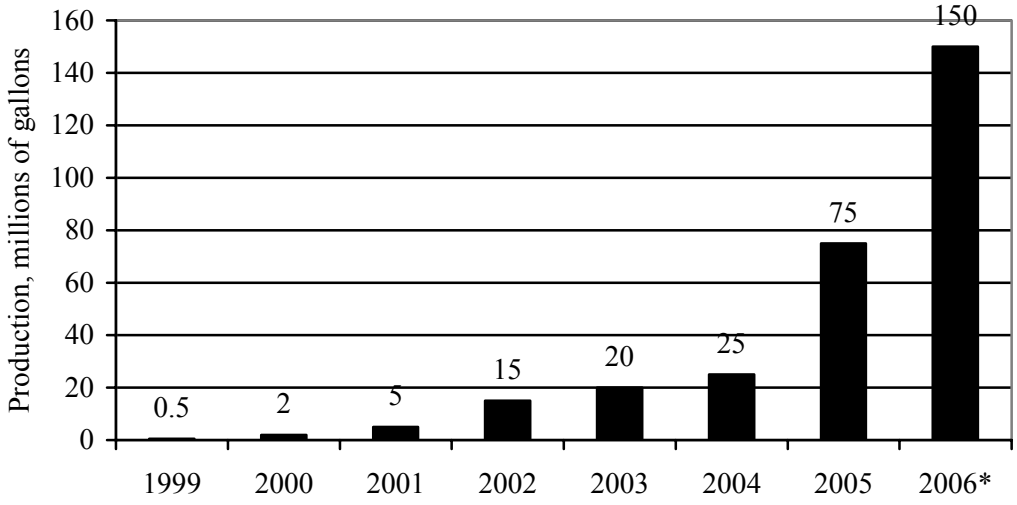

Figure 1. Production of Biodiesel Fuel in the US (*2006 estimate).

The primary Midwestern US and Central Canada crops considered for production of biodiesel are canola, sunflowers, safflowers and soybeans. This discussion will include corn because the oil is a potential by-product of the ethanol process or other processes.

Oil production per acre will be dependent on the seed yield and the oil content of the seed and will vary from year-to-year. Using average yield data, canola produces the greatest quantity of oil per acre (127 gallons) followed by sunflowers, safflowers, soybeans and corn in that order, see table. Corn has the lowest production per acre (18 gallons), Figure 2 (Kurki et al. , 2006).

Differences Between Biodiesel and Petroleum Diesel

The biodiesel produced from crop oil has characteristics which provide several advantages over the petroleum diesel fuels. Examples of these characteristics are lubricity, cetane rating and environmental pollutants. Although the biodiesel fuels has some disadvantages with regard to petroleum fuels, many can be overcome with the use of additives or the use proper fuels storage and handling and proper maintenance and service of the diesel engines. Examples are cloud point temperature, water contamination and solvent properties. In other cases differences are small, e.g. energy content, especially when blends of biodiesel are used.

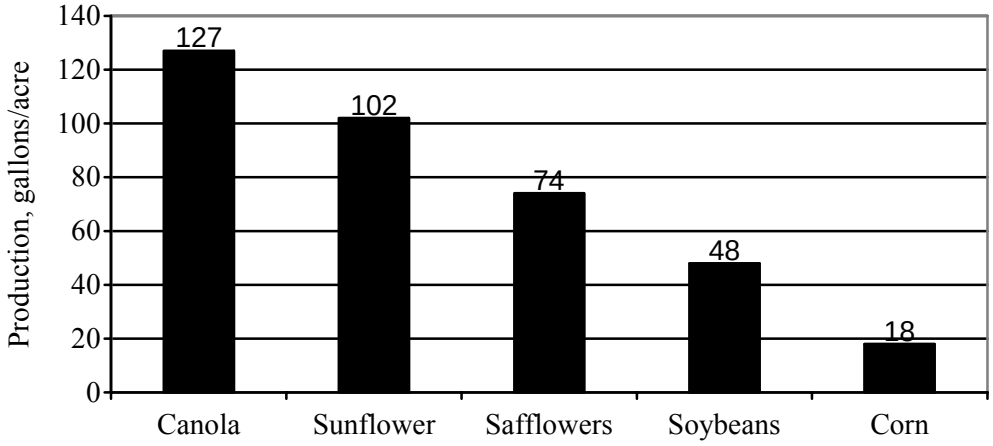

Figure 2. Production of oil in gallons per acre.

Lubricity is the ability of the fuel to lubricate which is especially important in the fuel pump and injectors where clearances between parts are very small and pressures may be rather high. Sulfur in the petroleum diesel fuels provides improved lubricity, which is indicated by the scar diameter produced during a ASTM D6079 standard test called Ball on Cylinder Lubricity Evaluator (ASTM, 2006). A larger scar diameter indicates lower lubricity. The sulfur in the exhaust contributes to environmental problems.

For petroleum diesel fuels number 1 and 2 the lubricity diameters are 670 and 540 microns respectively, Figure 3. Adding 1 to 2% by volume of biodiesel to petroleum diesel fuel significantly improves the lubricity of diesel fuel, Figure 3 (Lubricity, 2006). Increasing the biodiesel blend beyond 2% has very little impact on the diesel fuel lubricity improvement, see Figure 3. Also the biodiesel has a greater impact on diesel fuel number 1. One of the agriculture equipment manufactures recommends a maximum of 450 micron in the new tractors. The fuel produced from crops reduces the need for sulfur to obtain the desired lubricity characteristics.

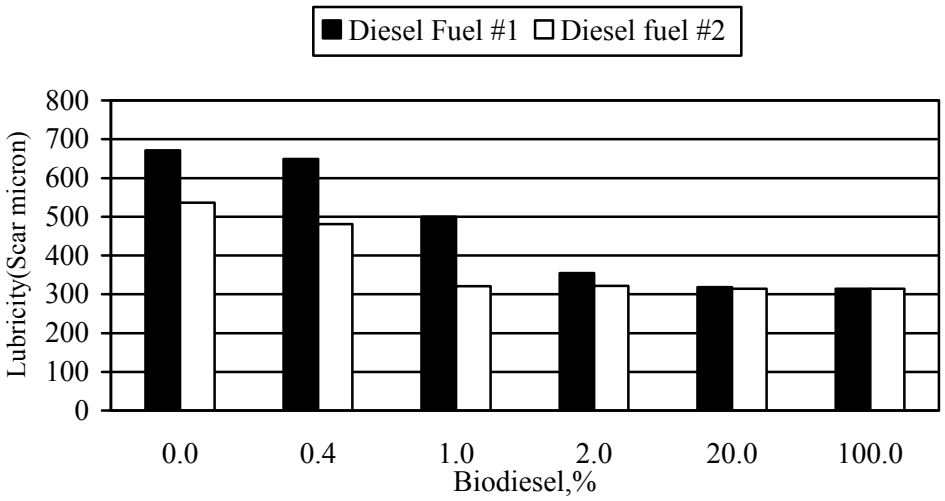

Figure 3. Lubricity for diesel fuel and blends of biodiesel.

The biodiesel blends have reduced emissions of some pollutants but other may increase. Sulfur, aromatics and hydrocarbons emissions will be less but the nitrous oxides will increase slightly. The most important pollutant would be the sulfur because the biodiesel reduces the need for sulfur to insure the lubricity needs of a diesel engine.

During cold weather fuel clouding or wax separation may occur, especially with higher blends of biodiesel which is referred as the cloud point. This may lead to fuel filter clogging and hard starting. This should not be a problem with blends of five percent biodiesel but is a concern at higher levels. One tractor manufacturer recommends the cloud point should be 10°F below the coldest temperature. The pour point is the temperature where the fuel is no longer pumpable, resulting no fuel being delivered to the engine, leaving it inoperable. Sunflower oil exhibits the highest cloud point, 45°F, see Figure 4 (Kurki et al., 2006).

If 100% biodiesel is going to be used, at least two solutions are available to address the cloud and pour point problems. Heating the fuel to a temperature about 10° above the cloud point will reduce the problem but would require modifications to the engine and its fuel tank. Additives are on the market for lowering the cloud and pour points of diesel fuel. The additives may be referred to as pour point depressants or antigels. Based on market information on fuel additives, there appears to be some additives developed specifically for the biodiesel fuels.

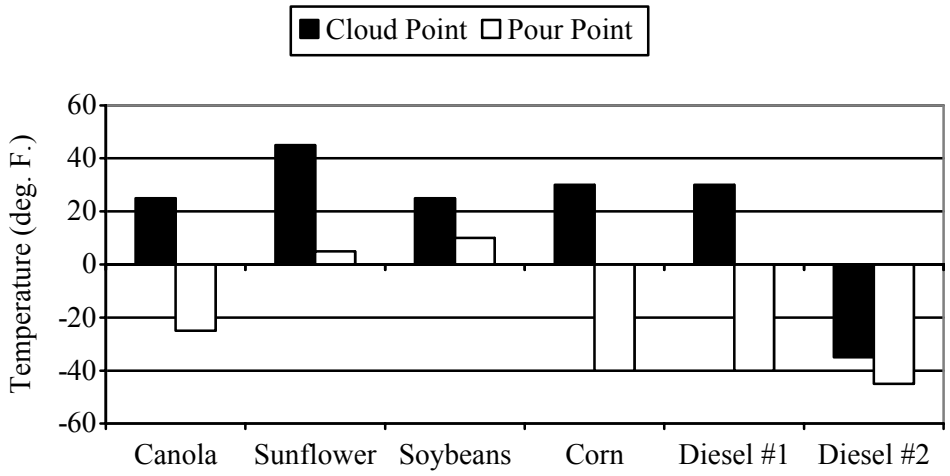

Figure 3. Pour and Cloud points for several diesel fuels.

Cetane rating describes the ignition characteristics of diesel fuel. Using a diesel fuel with a cetane rating lower than the manufacturers' recommendation can be detected by the diesel knock produced. The comparable gasoline property is octane rating which is referred to anti-knock rating. Fuels with higher ratings will cause an engine to operate more efficiently and will tend to start more easily. Most petroleum diesel fuels on the market range from 40 to 55. The biodiesel fuels have higher ratings than the standard petroleum diesel fuels (Figure 4), noting the differences are small, with canola being slightly higher (Kurki et al., 2006).

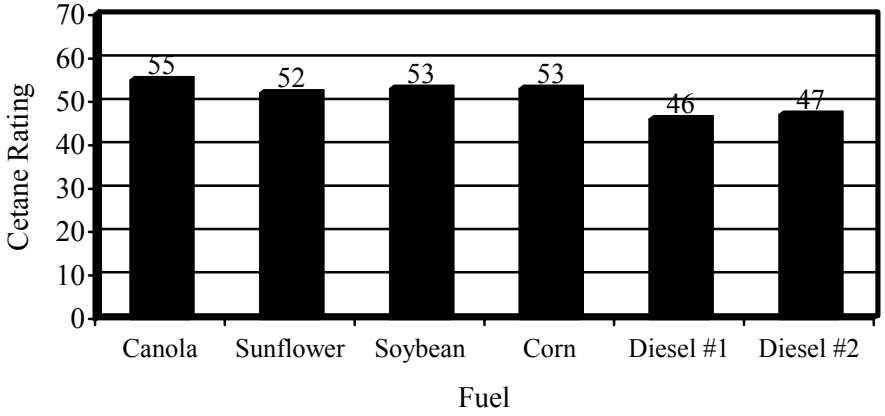

Figure 4. Cetane rating of diesel fuels from various sources.

For older engines, a minimum cetane rating of 40 is frequently recommended. For modern tractors, one manufacturer recommends a minimum cetane rating of 45 but 50 is preferred. The ratings for biodiesel are above the preferred rating which should not create a problem. Operators of diesel engine powered equipment should check the operator's manual for the recommended cetane number. For some older equipment the recommended cetane may not be listed in the operator's manual.

Other issues regarding biodiesel fuels include moisture absorption and some seal and material compatibility. All these issues become more important when using higher blends of biodiesel. Nonetheless, at the 5% level several normal recommended practices should be used. With moisture absorption, there is an increased risk of microorganism growth in the fuel tank which may lead to an increased clogging of the fuel filters. Any steps to reduce the potential of water entering the fuel system should be followed. Examples include insuring fuel caps are properly installed, more frequently draining the water from the water trap on an engine, keeping tanks filled, including storage tanks, and adding a water trap on the fuel storage tank to separate the water from the fuel as it is drawn from the storage tank.

When changing from diesel to biodiesel, more contaminants will be present in the fuel initially because the biodiesel acts as a solvent. In the fuel tanks, the biodiesel will breakdown some of the contaminants adhering to the inside wall of the tank. Therefore fuel filters may need to be changed more frequently immediately after changing to the biodiesel. The filters can be changed at the normal recommended interval after several filter changes. One manufacturer recommends changing at one half the normal intervals for the first several filter changes.

The energy available in each pound of biodiesel fuel is eight to ten percent less than petroleum diesel fuel. For canola and soybean derived biodiesel, lower heating value is about 17,900 and 17,400 BTUs per pound respectively, (Auld et al., 1982). For petroleum diesel fuel it is 19,300 BTUs per pound. The density of biodiesel is about four to five percent greater than the petroleum diesel fuel. Therefore the difference is less when considering the energy in a gallon of fuel but the biodiesel fuel is still slightly less. Under normal engine loads and at 20% or less for biodiesel blend, the operator will not likely perceive a difference in engine performance when switching to biodiesel.

Selecting a Biodiesel Source

Diesel engine manufactures specify the fuel for use in their engines must meet standards set by American Society for Testing Materials (ASTM). The current standard for diesel fuel (ASTM D975-06b, 'Standard Specifications for Diesel Fuel Oils') is specified in new engines (ASTM, 2006). This standard is used by engines manufactures to address warranty issues. If the biodiesel blend meets this standard, the fuel will not cause a warranty to be voided.

ASTM has a standard that is specifically for biodiesel fuel blend stock. 'Standard Specifications for Biodiesel Fuel Blend Stock' (ASTM 6751-06a) is designed for the 100 percent biodiesel that is blended with the petroleum diesel fuel (ASTM, 2006). The standard consists of numerous ASTM methods for determining characteristics of the fuel. Examples of characteristics specified by the methods are cetane rating, cloud point, sulfur, water, sediment and glycerin.

To ensure fuel quality, the National Biodiesel Board established a Quality Assurance Program Requirements for the Biodiesel Industry called BQ-9000. This voluntary program provides an opportunity for biodiesel producers to be gain accreditation by meeting requirements for providing quality fuel and the fuel meets the ASTM 6751 specifications. In addition the board has a program voluntary program for certifying marketers who meet the requirements regarding the handling and storage of biodiesel.

Summary

Biodiesel oils from the various crops are very similar with respect to efficiency, cetane rating and lubricity. Some of the biodiesel fuels have higher cloud and pour points, making them more undesirable for Wisconsin operation unless additives are used or engines modified. The greatest difference among the various sources of biodiesel fuel is the production per acre, where canola is the highest. The importance of these differences will be impacted by the uses of by-products from the manufacturing of the biodiesel fuel and the availability of the crop. Biodiesel blend of 20 percent or less can be used successfully in Wisconsin weather conditions using proper storage and appropriate engine maintenance practices.

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