

## Using Biodiesel Fuel in Your Engine

### Introduction

Biodiesel is an engine fuel that is created by chemically reacting fatty acids and alcohol. Practically speaking, this usually means combining vegetable oil with methanol in the presence of a catalyst (usually sodium hydroxide). Biodiesel is much more suitable for use as an engine fuel than straight vegetable oil for a number of reasons, the most notable one being its lower viscosity. Many large and small producers have begun producing biodiesel, and the fuel can now be found in many parts of Pennsylvania and beyond either as “pure biodiesel” or a blended mixture with traditional petroleum diesel (e.g., B5 is 5 percent biodiesel, 95 percent petroleum diesel).

The process of making biodiesel is simple enough that farmers can consider producing biodiesel to meet their own needs by growing and harvesting an oil crop and converting it into biodiesel. In this way, farmers are able to “grow” their own fuel (see the Penn State Cooperative Extension publication *Biodiesel Safety and Best Management Practices for Small-Scale Noncommercial Production*). There are many possible reasons to grow or use biodiesel, including economics, support of local industry, and environmental considerations.

However, there is also a great deal of concern about the effect of biodiesel on engines. Many stories have been circulating about reduced performance, damage to key components, or even engine failures that are blamed on biodiesel. Some manufacturers are wary about honoring their warranties on engines if biodiesel is used, while others are encouraging the use of biodiesel. Given the wide array of confusing reports, understanding the truth of the matter is not easy.

Fortunately, quite a bit of careful research exists and continues on testing the performance of biodiesel in engines, both in laboratory conditions and in real-world operating conditions. These controlled studies clear up much of the confusion about using biodiesel and can be used as a reliable guide to the real performance of biodiesel fuel in engines.

### Engine Performance Using Biodiesel

While we don't know everything about its performance, it is safe to say that good-quality biodiesel fuel generally performs well in engines. Several of the more important points to keep in mind are as follows:

- Engine power: engine power and torque tend to be 3 to 5 percent lower when using biodiesel. This is due to the fact that biodiesel fuel has less energy per unit volume than traditional diesel fuel.



- Fuel efficiency: fuel efficiency tends to be slightly lower when using biodiesel due to the lower energy content of the fuel. Typically, the drop-off is in the same range as the reduction in peak engine power (3–5 percent).
- Engine wear: short-term engine wear when using biodiesel has been measured to be less than that of petroleum diesel. While long-term tests have not been published, engines are expected to experience less wear in the long run when using biodiesel.
- Deposits and clogging: deposits and clogging due to biodiesel have been widely reported but are generally traceable to biodiesel that is either of low quality or has become oxidized. If fuel quality is high, deposits in the engine should not normally be a problem.
- Pollution from engine exhaust: biodiesel results in much less air pollution due to its higher oxygen content and lack of both “aromatic compounds” and sulfur. The one exception to this is nitrogen oxide (NO<sub>x</sub>) emissions, which tend to be slightly higher when using biodiesel. Proper tuning of the engine can minimize this problem, however.
- Cold-weather performance: similar to petroleum diesel, engines tested in cold weather typically experience significant problems with operation caused primarily by clogging

of the filters and/or coking of the injectors. The use of flow-improving additives and “winter blends” of biodiesel and kerosene has proved effective at extending the range of operating temperatures for biodiesel fuel. Pure biodiesel tends to operate well at temperatures down to about 5°C (this varies noticeably depending on the type of oil used). Additives typically reduce that range by about 5 to 8 degrees, while winter blends have proved effective at temperatures as low as -20°C and below.

### **Biodiesel Quality Is Vital**

It is important not to confuse the performance of high-quality biodiesel with the performance of low-quality biodiesel. The difference can be tremendous, and producers that do not pay careful attention to their process are almost guaranteed to end up with poor-quality biodiesel. Proper fuel quality and care are vital for all engine fuels, and this is certainly true for biodiesel.

The most common problems with fuel quality are (1) the biodiesel may contain some “unconverted” vegetable oil (incomplete processing), (2) traces of chemicals from the making of the biodiesel (e.g., methanol, lye) can remain in the biodiesel, (3) products of the reaction (e.g., glycerin, soaps) may not be completely removed from the biodiesel, (4) excess water that is used to “wash” the fuel may be left in the biodiesel fuel, and (5) the fuel can polymerize/oxidize due to long-term storage or exposure to moderate to high temperatures.

The impact of poor-quality biodiesel will probably not be immediately noticeable in the operation of your engine, but over time deposits, corrosion, and damage can accumulate until your engine catastrophically fails. It is not easy to detect the difference between good- and poor-quality biodiesel, and the laboratory tests that are required are quite expensive. Some low-cost test kits are commercially available, and while they are not as accurate as a test from a qualified laboratory, they show promise for providing a low-cost alternative. The primary standard for biodiesel fuel quality in the United States is ASTM standard D6751, which requires that the fuel pass a wide array of tests before it is deemed to be satisfactory. If you purchase biodiesel commercially, you should insist that the fuel be certified to meet the standard. Small-scale producers should at least consider investing in a test kit.

### **Possible Engine Problems When Using Biodiesel**

Many problems have been reported by people using biodiesel fuel. Careful investigation indicates that most of these difficulties can be attributed to poor-quality biodiesel fuel and are almost identical to the problems caused by low-quality petroleum diesel. However, some of the problems (primarily cold-weather problems) are not due to poor fuel quality but are related to the inherent properties of biodiesel fuel. Fortunately, most of these problems can be avoided or

minimized. Common engine problems when using biodiesel, their possible causes, and their solutions are presented below. This list is not meant to serve as an exhaustive repair manual but rather to give a sense of some of the performance issues related to biodiesel fuel.

**Problem:** Deposits on injectors affect fuel spray pattern.

The most common symptoms are misfiring or hard starting. This is most likely caused by either cold-weather operation with partially solidified fuel, or by fuel that was not completely transformed from oil to biodiesel. Vegetable oil has a tendency to form deposits on the injectors, especially when the engine is running at part load.

**Solution:** Have the injectors cleaned by a qualified mechanic—the precise nature of injectors makes these parts difficult to clean unless you have specialized training and equipment. Low-temperature flow-improving additives can be used to improve the fuel’s operation in cold conditions and to help avoid this problem in the future. You should also check to make sure the fuel is free of contaminants and has been fully transformed from oil to biodiesel.

**Problem:** Deposits in injector pump (varnish and gums) affect performance. The most common symptoms are hard starting, decreased power, and misfiring. This can be caused either by biodiesel fuel that has been incompletely transformed, or by biodiesel fuel that has partially oxidized.

**Solution:** Have the injector pump cleaned by a qualified mechanic. As with the injectors, this job is not practical for the home mechanic due to the precise nature of the pump’s components.

**Problem:** Lubrication oil becomes diluted, leading to rising oil levels, loss of oil pressure, and/or worn bearings. This is often due to excessive blow-by in the cylinder from a poor fuel spray pattern and/or worn rings.

**Solution:** Monitor your lubrication oil regularly, and take corrective action if any signs of dilution occur.

**Problem:** Engine either refuses to start in cold weather or runs only a few seconds after starting. The filter has probably become clogged with particles of solidified biodiesel.

**Solution:** You could wait for springtime to arrive, or possibly try warming the fuel filter—12-volt jacket heaters are available. “De-icer” additives for petroleum diesel can be used for biodiesel as well. If you live in a cold climate, you should consider either using an additive designed to improve the fuel’s cold-weather properties, or else install a “preheater” to warm up your fuel tank and filter. It may be necessary to winterize your fuel by blending biodiesel with either kerosene or winter-grade petroleum diesel during the coldest months

of the year. Experience at Penn State's farm has been that if tractors are stored in a warm garage (above freezing), they tend to start easily and operate well throughout the day, even when outdoor air temperatures are quite low.

**Problem:** Fuel leaking from fuel line. Biodiesel is a very effective solvent for some materials, including certain types of elastomer (e.g., Buna Nitrile rubber).

**Solution:** Before using biodiesel fuel in your engine, confirm that the engine is "rated for biodiesel use," which means that the materials are all compatible with biodiesel fuel. Otherwise, you will need to locate all materials in the engine (i.e., seals and hoses) that can be degraded by biodiesel and replace them with biodiesel-rated components. This can be quite a chore. Usually, components that are made from "fluoro-elastomers" (e.g., Viton or Teflon) can be considered safe for use in a biodiesel engine.

**Problem:** Fuel filter clogs, but not due to cold weather. There are three main possibilities: your biodiesel fuel quality is low, leading to formation of resins or gels in the fuel system; algae are building up in your tank; or the biodiesel is "scouring" older deposits out of the sludge that typically builds up in the bottom of old fuel tanks. Operators who switch from petroleum diesel to biodiesel are more likely to experience this problem since older vehicles that have used petroleum diesel for many years are likely to have quite a bit of deposits in the fuel tank.

**Solution:** If the problem is caused by low-quality fuel, correct this problem by using only ASTM-certified fuel. If the problem is caused by algae, an algaecide additive can be helpful. Also, simple measures such as filling your fuel tank at the end of the day can reduce moisture levels in the fuel and inhibit the growth of algae. If you are just switching to biodiesel after years of using petroleum diesel, you will need to change filters often at first, as the biodiesel loosens deposits from the inside of your fuel tank and engine. In extreme cases, you may need to have your fuel tank thoroughly cleaned or replaced before adding the next tank of biodiesel.

### Does Engine Type Matter?

Not all diesel engines are the same. Each manufacturer's design includes some unique features that may affect its performance when using biodiesel. This issue is not clearly understood at present. However, modern diesel engines are sufficiently similar in that the differences in performance are expected to be minimal, provided that the materials used in the engine are all compatible with biodiesel.

The same, however, may not be true of older engines, especially those that do not use the common-rail ignition systems that are almost universally used today. Some tests

have indicated that old, indirect injection engines experience fewer difficulties when using biodiesel fuel and even show promise for running on straight vegetable oil that has not been chemically processed into biodiesel. The potential may exist for examining older engine designs for clues as to how to best create engines for biodiesel use. Some older engines use seals and hoses manufactured from "Buna N" rubber, which can be dissolved by biodiesel. Be sure to check on this and replace if necessary before switching to biodiesel.

### Engine Care When Running on Biodiesel

Generally, biodiesel fuel should be able to be used interchangeably with traditional diesel. However, some manufacturers recommend that you reduce the maintenance interval (often by 50 percent) to ensure that filters remain unclogged and the lubrication oil remains in good shape. However, it is important to consult the manufacturer of your engine for specific recommendations.

Also, because of biodiesel's tendency to oxidize, you should exercise care if you are planning to store your engine for any period of time. It may be appropriate to drain the engine of all fuel before storage, change back to petroleum diesel before storage, or alternately add a fuel stabilizer.

### Summary

High-quality biodiesel fuel that is properly cared for should result in a lifetime of excellent performance. In general, it can be used in exactly the same manner as petroleum diesel fuel. The one notable exception is during cold-weather conditions, when biodiesel tends to "gel up" sooner than traditional diesel fuel. Many additives are available on the market that can help safeguard the quality and improve the cold-weather performance of biodiesel, and their use is one option for improving the performance of the fuel when using biodiesel. However, using a "winter fuel blend" is the recommended approach for the severe winter conditions experienced in Pennsylvania.

The quality of the fuel is extremely important, however, and poor-quality fuel can have many negative effects on an engine. To protect against this, any biodiesel fuel that you use should comply with the appropriate standard for use (i.e., ASTM Standard D6751).

For additional information, please refer to the following Penn State Cooperative Extension fact sheets and reports:

- *Biodiesel: A Renewable, Domestic Energy Resource*
- *Renewable and Alternative Energy Fact Sheet: What's So Different about Biodiesel Fuel?*
- *Making Your Own Biodiesel: Brief Procedures and Safety Precautions*
- *Biodiesel Safety and Best Management Practices for Small-Scale Noncommercial Production*

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