The TDI-SVO controversy

http://journeytoforever.org/biodiesel_TDI.html

We've said there are doubts about running DI (Direct Injection) diesels on vegetable oil using the usual two-tank pre-heating systems. Others say so too.

Yet others say it's not an issue, it works fine.

Which is right?

Pro

"There is no issue with DI's and SVO. I'm convinced that DI engines on a heated 2-tank system are reliable. At 170 deg F, different types of oil don't display large differences in operation. Unlike cold oil."
-- Steve Spence, Webconx
http://www.green-trust.org

Greasel in the US says of their two-tank kit: "Ready-to-install kit that will allow you to run any diesel on waste vegetable oil. The key to running a diesel on vegetable oil is heat. This is done by a special tank and fuel line, heated with the hot coolant your engine is already producing."
http://www.greasel.com

"Recent DI engines are best being run on two tank systems as vegoil might either destroy the piston or get between cylinder & piston as unburned particles or because of bad spray of the injectors (which then hit the rim of the piston or the cylinder wall). When the vegoil is warm, there is no problem with DIs. So far for a short overview..."
-- Stephan Helbig
http://people.freenet.de/sthl/

"For dual tank vegetable oil fuelled operation, with heated tank & if COLD, fuel line, I would recommend ANY diesel engine providing that the oil is hot before it hits the injector pump and is purged before shutdown. The problems with DI diesel engines seems to be mostly associated with carbon build-up on injectors and that can be reduced significantly if not eliminated by use of heated veg-oil."
-- Tony Clark, President of the Western Australian Renewable Fuels Association
Inc.
http://www.shortcircuit.com.au/warfa/warfa.htm

Con

Today's DI and TDI diesels are efficient, clean-burning engines. The fuel injection technology is highly sophisticated:

"... Siemens, Delphi and Bosch all are ramping production of sophisticated new injectors that can handle today's sky-high fuel pressure, and inject infinitesimal fuel droplets so quickly that upcoming diesels may at times employ as many as five distinct injections for each cylinder's combustion 'event.'

"... the most promising advantage of common-rail technology is the ability to deliver extremely high fuel pressures on the order of 23,000 psi (1,600 bar) or more. This type of pressure means that in microseconds, astonishingly tiny fuel droplets can be injected; these droplets more effectively mix with the induction air, boosting power production and reducing emissions.

"Only Volkswagen AG, Europe's diesel volume-sales leader, has resisted the common-rail development path, instead relying on its unique 'unit injector' system that combines each injector with an integral fuel pump, energized by its own lobe on the camshaft. This system develops pressures of up to 29,300 psi (2,020 bar)..."
-- From "**Super Diesels!**", Ward's Auto World, September 1, 2001
http://industryclick.com/magazinearticle.asp?magazineid=50&releaseid=8418&magazinearticleid=118355&siteid=26

"The latest multi-jet direct injection system with fuel supply by 'common rail' at a pressure of 1600 bar is another noteworthy feature. Fuel supply to the five-hole nozzles is controlled via an ultramodern solenoid valve. The fuel injection system's response time is less than 20 millionths of a second, ensuring extremely fine metering of the fuel and up to five injections per working cycle." -- **The Opel Eco-Speedster**
http://www.autointell.com/News-2002/October-2002/October-2002-1/October-02-02-p5.htm

Five distinct injections for each cylinder's combustion "event"... fuel pressures on the order of 23,000 psi... astonishingly tiny fuel droplets... five-hole nozzles... millionths of a second...

With such technology, fuel viscosity and combustion characteristics would have to be critical. "At 170 deg F (76.6 deg C), different types of oil don't display large differences in operation." True?

This is from a recent study:

The properties of canola oil and diesel are very similar, except a significant difference in viscosity, with canola oil having 12 times the viscosity of diesel. Even after heating to around 80 deg C it is still six times as viscous as diesel. This leads to problems with flow of oils from the fuel tank to the engine, blockages in filters and subsequent engine power losses. Even if preheating is used to lower the viscosity, difficulties may still be encountered with starting due to the temperatures required for oils to give off ignitable vapours. Further, engines can suffer coking and gumming which leads to sticking of piston rings due to multi-bonded compounds undergoing pyrolyses. Polyunsaturated fatty acids also undergo oxidation in storage causing gum formation and at high temperatures where complex oxidative and thermal polymerisation can occur.

To date there have been many problems found with using vegetable oils directly in diesel engines (especially in direct injection engines).

1. Coking and trumpet formation on the injectors to such an extent that fuel atomisation does not occur properly or is even prevented as a result of plugged orifices,
2. Carbon deposits,
3. Oil ring sticking,
4. Thickening and gelling of the lubricating oil as a result of contamination by vegetable oils, and
5. Lubricating problems.

Other disadvantages to the use of vegetable oils and especially animal fats, are the high viscosity (about 11 to 17 times higher than diesel fuel), lower volatilities content which causes the formation of deposits in engines due to incomplete combustion and incorrect vaporisation characteristics... At high temperatures there can be some problems with polymerisation of unsaturated fatty acids, this is where cross-linking starts to occur between other molecules, causing very large agglomerations to be formed and consequently gumming occurs.

Although some diesel engines can run pure vegetable oils, turbocharged direct injection engines such as trucks are prone to many problems.

-- From "**Research into Biodiesel Kinetics and Catalyst Development**", by Adam Karl Khan, Department of Chemical Engineering, University of Queensland, 17 May 2002 -- Acrobat file, 432Kb:
http://www.cheque.uq.edu.au/ugrad/chee4001/CHEE400102/Adam_Khan_Thesis.pdf

With the current injector technology, what would "large differences in operation" mean, exactly?

A well-known French study found large differences, using a DI engine:

"Fuel structure and characteristics have been shown to have great influence on engine performance and emission behaviour. One of the most important parameters is the spectrum of fatty acids. Length of carbon chains and number of double bonds in the fuel molecules affect low temperature suitability, spray formation and carbon residue. Net calorific value and density also affect the energy content of cylinder charge.

"It is possible to preheat the oil up to 150 deg C where it attains the same viscosity as the diesel oil. Atomisation tests showed that at 150 deg C the performance of the rapeseed oil are comparable with that of the diesel oil."

That's double the temperature the two-tank systems use.

The ACREVO study found that the temperature could be reduced by adding ethanol:

"It has been established that an addition of 9% of ethyl alcohol (95%) brings a great benefit regarding the pre-heating oil temperature. In fact, the presence of alcohol allows a reduction in the inlet oil temperature from 150 deg C to 80 deg C. Moreover, the combustion of the emulsion produces less soot and, at the exhaust, the amount is almost one half less than that produced by the combustion of rapeseed oil (almost 40% less soot than diesel fuel)."

But we haven't yet heard of anyone using an ethanol additive with two-tank heated SVO systems on a DI diesel. There has been some discussion of thinning the oil with "white spirit", which can mean different things in different places, but it seems inconclusive.

"**Advanced Combustion Research for Energy from Vegetable Oils (ACREVO)**":
http://www.nf-2000.org/secure/Fair/F484.htm

In the early 1980s, the German company Elsbett developed an advanced all-new DI car diesel engine which had true multi-fuel capabilities -- it could run on vegetable oil as well as petrodiesel. This engine was the forefather of the modern DI car diesels in production today.

Elsbett modifies diesels, including DI diesels, to run on vegetable oil, with new injectors, glowplugs, heat exchangers and more -- with full warranty. Diesels modified by Elsbett will run on SVO, petro-diesel, biodiesel, or any blend of the three, without dual tanks or switching fuels for start-up and shut-down.
http://www.elsbett.com/

Elsbett supplies D-I-Y kits, but not for DIs. "For direct injection diesel

engines, the technical requirements for the modification are quite sophisticated," Klaus Elsbett told us. "For passenger cars we still prefer to do the job in our workshops."

Can DI diesels run safely on two-tank heated systems? "Two-tank systems definitely do not work for DI diesels," Elsbett said. "The main engine breakdown reason is related to the lube oil, especially on turbocharged engines."

While Stephan Helbig said DI engines are best run on two-tank systems, he was perhaps comparing it with "just put it in and go" without heating and only one tank, as some people in Germany do that, or claim to. Maybe they get away with it with older Mercedes IDI diesels.

Stephan also said this: "Problem with TDIs is: If used with cold vegoil (which happens mostly just after cold starts) the injectors might get clogged or sooted and they can spray onto the rim of the piston or the cylinder wall. The piston might be burned away or particles might remain on the cylinder wall and cause a seizure. So two-tank system would be recommendable until further improvements are found... There have been several people who broke down even with 'ordinary' Bosch VE pumps -- not yet with TDIs. But as TDI pumps have still smaller spaces at their pistons the danger is much higher. Most recent theory is: This vegoil causes a much higher pressure on top of the pump piston. This gets compressed, widens and so gets stuck or seizes in its cylinder. As it is revolving at the same time the strain is tremendous. What helps is either a two-tank system or an instant heater to get vegoil with a low viscosity as soon as possible. And always avoid high revolutions. A distributor pump piston does twice as many strokes as the engine speed (2000rpm = 4000 strokes). So increasing the pressure might not be recommendable IMHO. Some of our pumps have done 20 or 30,000 km (12,500-18,500 miles) and then broke down because of that one common failure."

Stephan's website says this:

Newer Diesel Injection Systems:
All newer diesel engines are direct injectors. Direct injection comes with a much higher fuel pressure than pre-combustion engines. Mostly the fuel is sprayed into a hollow on top of the piston. A correct adjustment of the injection/ignition timing is very important to avoid the fuel be sprayed onto the rim of the piston or even the cylinder wall. Both can cause severe damages. Also use only heated vegoil to prevent the injectors from getting clogged up which can cause a wrong spray pattern as well.
Direct injector engines can be equipped with in-line pumps, distribution pumps or one of the other systems, mentioned in the next paragraph.

1. Pump injector units:
A single piston on top of every cylinder is driven by the camshaft (engine) and a solenoid nozzle opens the (hole-type) injector at time of ignition. Up to now there are only a few experiences with this system, but the principle suggests that it could be resistant to vegetable oil. As they produce a very high pressure of up to 1200 bar, the fuel gets hot and a heat exchanger is used to cool it down. One could make use of it to heat the vegoil and so lower its viscosity.

2. Common Rail Systems:
A high pressure is generated by fuel pumps and stored in a common injector rail. A solenoid nozzle opens the injector at the time of ignition. The pressure in the pipes is always at the same level, controlled by a regulator valve. Problems are likely to arise from the high pressure pump and the regulator valve. Again, I haven't heard about any long time experiences by now.

Vegetable oil instead of diesel- an alternative fuel?
http://people.freenet.de/sthl/poel/VegFAQ.htm

So far this has mainly been about using new oil, but Greasel and others say "any diesel on waste vegetable oil", which is a different matter.

This is what Ed Beggs of SVO system supplier Neoteric Biofuels Inc. in Canada said about it:

Re TDI: I get a lot of people, especially in the USA, determined to run brand new TDI's and PowerStrokes on WVO!

I tell them not the best idea. They insist. Fine, free country, I guess, but at least go two-tank, and get the best WVO you can find, and then also thin it out 10% or so with a suitable solvent blending agent. That's the best advice I can give to somebody who insists on doing this.

For the TDI crowd, well, if you really insist on doing this, then get that oil clean, get it thinned out a bit per ACREVO, and use a 10-micron filter, then get the oil hot, on a two-tank setup.

Your car is already very fuel efficient, and very clean. If you can afford a newer diesel, you can afford either new SVO, diesel, or good biodiesel, and if you run biodiesel, we'll still gladly sell you a VEG-Therm inline fuel heater for the winter!

So, would I myself run one of our kits on a coveted TDI of my own, one of these days, when I can afford one?

Yes I likely will, but it will be when the engine is out of warranty, the car has 100,000 km on it already and is depreciated, and it will be very good used Canola oil only, two tank, heated, and thinned, and I'll use the 10-micron filter. That much of a chance I'll take, but personally, not more than that.

-- Ed Beggs, **Neoteric Biofuels Inc**
http://www.biofuels.ca/

Conclusion

There is an "issue" with using straight vegetable oil in a DI diesel, especially waste oil. We don't say "Don't do it!", but we don't recommend it either. On the other hand, we'd like to encourage it, because unless people are prepared to take intelligent risks and experiment we'll never know what works and what doesn't. But, it is a risk, you're on your own, no guarantees.

Also, the more people use straight vegetable oil, with whatever system, good or bad, the more likely it is that the car manufacturers will start to take some notice and begin to realize that there is a market for true multi-fuel capability diesel engines, and put some R&D effort into it at last.

Here's someone who's using SVO with his DI and seems to be doing well, so far:
http://home.t-online.de/home/strutzberg
See "Salatöl - Tdii" (with English page)

He seems to be using more than just the usual two tanks and heating. "Over 60,000km..." -- 37,000 miles, good going, but still not very much for a diesel. When he makes it to 250,000, he'll have proved something, if he keeps proper records, but still not that much: that engine, under those conditions, with that system, using that oil. But it'll help.

If a lot more people do that, and keep records, then we'll eventually have enough data to make some confident assertions. But in establishing what works and what doesn't work, some are likely to be left with the remains of what didn't work. They'll be heroes in the cause of real straight vegetable oil diesel motors, that anyone can use, not just enthusiasts -- manufacturer-made, supplied and warranted diesels that can run on petro-diesel, biodiesel or straight vegetable oil, in any blend, without any fuel-switching or fuss: fill 'er up, switch on and go, stop and switch off, like any other car. Currently only Elsbett does that.

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Is ethanol energy-efficient?