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# Vegetable Oil as an Emergency Fuel

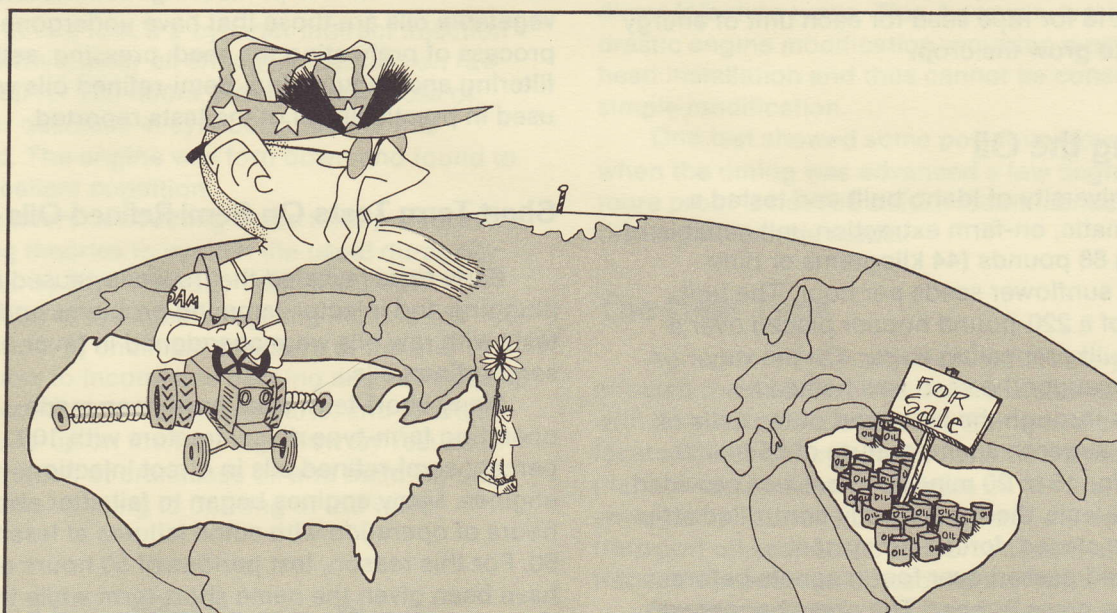
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The unstable world political situation combined with the fact that a large amount of the world's oil reserves is located in the Middle East means we must continue to search for an alternate fuel source for our agricultural machinery. It is well-known that there is a limited amount of fossil fuels and even with no world political problems the

demand will exceed supply in the not-too-distant future. The United States currently imports fossil fuels because we use more than we produce. Vegetable oils are a renewable resource. They offer a means of keeping our agricultural equipment operating in an oil emergency.



## What are Vegetable Oils?

Vegetable oils are extracted from corn, soybean, peanut, sunflower, rape and other less common oil seed crops. The energy content of these oils varies somewhat but is generally comparable to that of diesel fuel. However, because of their high viscosity, vegetable oils will not flow as easily as diesel fuel, especially during cold weather, and this is a major problem.

Vegetable oils are composed of long molecular chains of carbon, hydrogen and oxygen. Technically they are called fatty acids. These oils will burn in internal combustion engines at a much

slower rate than propane, gasoline or diesel fuel because the vegetable oil molecules are larger than those of these standard fuels.

However, vegetable oil molecules are fractured into smaller ones when they react with alcohol, forming glycerol and esters. Once extracted, the esters burn much like regular diesel fuel.

Vegetable oils are widely used in food and industrial production and many extracting facilities are located throughout the country. These facilities are not always utilized to their maximum capability and could produce more oils if the oil seeds were available.

## Production of Oil Seed Crops

Soybeans, corn, rape and sunflower seeds are Kentucky crops from which vegetable oil can be extracted for fuel production. Kentucky farmers currently have the technology and experience of growing corn and soybeans. Rape and sunflowers are adaptable to the Kentucky climate but have not been grown on a large scale because of the lack of a market. However, with some experience they could be grown. Soybeans, sunflower seeds and rape seeds have a greater potential for oil production than corn because their oil yield can be as high as 20, 30 and 41 percent respectively, while the oil yield of corn is only 4.3 percent. Another consideration in growing these crops is the energy required to produce the crop compared to the energy found in the oil. Illinois researchers found that on non-irrigated land the energy units from the oil was 4.09 for soybeans, 3.5 for sunflower seed and 4.18 for rape seed for each unit of energy expended to grow the crop.

## Extracting the Oil

The University of Idaho built and tested a semi-automatic, on-farm extraction unit capable of processing 88 pounds (44 kilograms or nine gallons) of sunflower seeds per hour. The unit consisted of a 220-pound hopper placed over a specially built preheating auger. On the way through the auger the seed was heated by conduction through the inner and outer walls of the special auger to a temperature of 85 to 130 degrees F for 15 to 20 minutes. Heat was provided by four 750-watt, thermostatically controlled strip heaters in a closed, forced-air system.

The seed passed over four magnets before entering the press hopper. The press hopper was kept full with the use of a photo cell. Pressure on the seed was manually adjusted to maximize the oil flow. The oil was pumped into a holding tank and allowed to settle for 48 hours. The oil was then forced through a 3-stage filter unit consisting of a recleanable prefilter 20 microns thick, and then through a 4- to 5-micron throw-away filter. Oil was then degummed by hydrating with steam or hot water. Degumming was necessary on all seed except rape.

The unit was 78 percent efficient for soybean and more than 80 percent efficient for rape seed. They found no significant oil breakdown during aerobic storage of 140 to 200 days.

The unit cost approximately \$10,000 to build in 1982. It required 0.6 kilowatt hours of electricity per gallon of oil processed.

Commercial plants that extract vegetable oils for food and industrial markets process more efficiently than on-farm units. These facilities remove about half of the oil from seeds with mild pressing and remaining oil is extracted with solvents.

## Diesel Engine Test Results

Tests using vegetable oils as a substitute for diesel fuel have been run in the United States and some foreign countries. These tests have been run with raw oils, semi-refined oils, blends (semi-refined oil mixed with diesel fuel) and esters.

For the purposes here, **raw vegetable oils** are those in which the oil has been pressed out of seeds with no further processing. **Semi-refined vegetable oils** are those that have undergone a process of preheating the seed, pressing, settling, filtering and degumming. Semi-refined oils were used in practically all of the tests reported.

## Short-Term Tests On Semi-Refined Oils

Early tests revealed that raw oils caused filter-plugging and injector-jamming problems and so tests with raw oils were abandoned in favor of semi-refined oils.

Many short-term tests have been made operating farm-type diesel tractors with 100 percent semi-refined oils in direct injection engines. Many engines began to fail after about 50 hours of operation with some failures at less than 50. For this reason, test periods of 50 hours or less have been given the name short-term while tests of more than 50 hours are called long-term.

Toward the end of the 50 hours all direct injection engines became hard to start. The internal carbon build-up became so great that the engines had to be torn down and thoroughly cleaned. In all engines, the vegetable oils caused oil dilution in the crankcase at a faster rate than diesel fuel.

Other tests with farm tractors have shown that vegetable oils can be used successfully with the above limitations as long as the oil is changed frequently and the injectors are removed and cleaned regularly.

## Long-Term Tests On Semi-Refined Oils

Many long-term tests with vegetable oils as a diesel substitute have been conducted in the United States and foreign countries. The results are quite different making it difficult to draw definite conclusions. In Europe, where there are more indirect injection engines than in the United States, some tests indicate much longer and more satisfactory engine performance when these types of engines burn vegetable oils. It seems likely that indirect injection systems could utilize vegetable oils better than direct injection engines.

In general, direct injection engines become impossible to start after 150 to 200 hours. They also show a high percentage of power losses, and tear-down reveals scoring of cylinder walls, stuck top rings, high carbon build-up and other difficulties such as contamination of the injector nozzle.

Yet in one test, a 2-cylinder indirect injection engine with regular oil changes operated on raw linseed oil for 200 hours. No noticeable loss of power or decrease in cylinder pressure was detected. The engine was torn down and found to be in excellent condition.

Engineers conducting these tests put forth the following theories to explain the usual durability problems: 1) high viscosity results in poor atomization at the injectors giving incomplete combustion, 2) chemical structure of the oils contributes to incomplete burning and adhesion to interior combustion chamber parts, and 3) after some build-up on the top ring, blow-by results in contamination of crankcase oil and build-up on valve stems, leading to burning of the valve surface.

## Short- and Long-Term Tests on Blends and Esters

Many tests have been run on blends of diesel fuel and vegetable oil. In general any mix above 20 percent semi-refined vegetable and 80 percent diesel oil eventually caused some kind of durability problem. Several tests of 400 to 600 hours on 10-90 blends were considered satisfactory. Nearly all 50-50 blend tests had to be stopped after 10 to 40 hours of operation.

Straight esters of vegetable oils appear to give performance nearly as good as regular diesel fuel with crankcase oil changes twice as often as with diesel fuel. The big drawback is processing costs. In one test, processing cost about \$3.30 per gallon. Also, this process is highly technical requiring a

person knowledgeable in chemistry and highly sophisticated equipment. At this time processing esters cannot be considered as an on-farm operation.

## Engine Modifications

Some tests show that engines can use vegetable oil successfully with no modifications. However, from a summary of all test results it appears that frequent oil changing is imperative and an attempt should be made to operate the engine at 75 percent power or less to reduce carbon deposits. Some method of heating the fuel in the fuel tank and lines leading to the injector pump would reduce the viscosity problem.

It also appears that indirect injection diesel engines offer superior performance and durability in the burning of vegetable oils, when compared to direct injection types. This, however, is a rather drastic engine modification requiring a new type of head installation and thus cannot be considered as simple modification.

One test showed some power improvement when the timing was advanced a few degrees but more proof is needed before recommendations in this regard can be made.

## The Next Time

Agriculture production will be severely affected the next time the United States is faced with a shortage of petroleum. Some farms may be located close enough to a vegetable oil processing plant to secure some vegetable oil for fuel in an emergency. However, most farmers will need to transport oil seed to a commercial plant and to transport processed oil back to the farm.

Another option would be to organize a community press with equipment and capacity larger than on-farm units. This will involve purchasing expensive equipment and training personnel to operate the facility. Owners of such a facility could afford sophisticated fractioning equipment so that long-term operation in farm-type diesel engines would be safe and practical. The by-products of these facilities might be used as animal feed or fertilizer. This would help reduce the cost of operation.

It is obvious that on-farm units, at this time, are not practical. Research is badly needed to make them efficient and easy to operate. In the meantime, farmers as well as policy-makers need to think now about food production during the next, inevitable, fuel emergency.

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