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A REPORT ON THE IDAHO ON-ROAD VEHICLE TEST WITH RME & NEAT RAPESEED OIL AS AN ALTERNATIVE TO DIESEL FUEL

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SUMMARY:

Two diesel powered pickups are being tested on 20 percent biodiesel and 80 percent diesel. One is powered by a 5.9 liter turbocharged and intercooled engine. This engine is direct injected and is being run on 20 percent RME and 80 percent diesel. The other pickup is powered by a 7.3 liter, naturally aspirated engine. This engine has a precombustion chamber and is being operated on 20 percent raw rapeseed oil and 80 percent diesel. The engines themselves are unmodified, but modifications have been made to the vehicles for the convenience of the test. In order to give maximum vehicle range, fuel mixing is done on-board. The biodiesel fuel tanks are heated with engine coolant circulation.

KEYWORDS:
Biodiesel, Rapeseed, Rape Methyl Ester, On-Board Fuel Mixing, On-Road Vehicle Test.

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ABSTRACT

Biodiesel is among many biofuels being considered in the United States for alternative fueled vehicles. The use of this fuel can reduce U.S. dependence on imported oil and help improve air quality by reducing gaseous and particulate emissions. Researchers at the Department of Agricultural Engineering at the University of Idaho have pioneered rapeseed oil as a diesel fuel substitute. Although UI has conducted many laboratory and tractor tests using raw rapeseed oil and rape methyl ester (RME), these fuels have not been proven viable for on-road applications. A biodiesel demonstration project has been launched to show the use of biodiesel in on-road vehicles. Two diesel powered pickups are being tested on 20 percent biodiesel and 80 percent diesel. One is powered by a 5.9 liter turbocharged and intercooled engine. This engine is direct injected and is being run on 20 percent RME and 80 percent diesel. The other is powered by a 7.3 liter, naturally aspirated engine. This engine has a precombustion chamber and is being operated on 20 percent raw rapeseed oil and 80 percent diesel. The engines themselves are unmodified, but modifications have been made to the vehicles for the convenience of the test. In order to give maximum vehicle range, fuel mixing is done on-board. Two tanks are provided, one for the diesel and one for the biodiesel. Electric fuel pumps supply fuel to a combining chamber for correct proportioning. The biodiesel fuel tanks are heated with a heat exchanger which utilizes engine coolant circulation.

Agricultural Engineering Department developed a small pilot plant system for rapeseed methyl ester production (Peterson et al. (1991).

Several individuals and organizations have reported tests with on-road vehicles on vegetable oil and vegetable oil blends. For example, Pischinger et al. (1982) reports on tests with the Passat diesel indirect injection engine which was run 8,640 miles on a 30-70 soybean oil-diesel mixture and then 10,800 miles on 100 percent peanut oil. They found the combustion chambers to be relatively clean but reported the following problems:

1. High viscosities render some modifications to the fuel system necessary.
2. With peanut oil they found deposits on intake valve stems.
3. Cold starting was harder.
4. The smell of exhaust gases was unbearable.

The University of Missouri has fueled a Dodge diesel pickup with soydiesel. They have added a fuel tank to the bed of the pickup and use a fuel transfer pump to transfer fuel from the biodiesel tank to the existing diesel tank (Schumacher, 1992).

There are several examples of dual fueled diesel engines with ethanol. For example, Goering, 1992; Griffith, 1988; Jarret, 1987 developed a fumigation system which injects ethanol through the airstream using the primary fuel system.

No on-board mixing systems with vegetable oils were found.

OBJECTIVES

1. Test a blend of 20 percent RME, 80 percent number two diesel (D2) and a blend of 20 percent raw rapeseed oil 80 percent D2 fuel in a 30,000 mile per year on-road vehicle test.

2. Design an on-board fuel mixing system to maximize the travel range for each pickup and at the same time keep the fuel from congealing.

3. From dynamometer testing, determine the percent difference in horsepower, opacity, economy, and exhaust temperature compared to that of D2.

4. Conduct pending ASAE fuel standard tests for 20-80 RME, 20-80 neat rapeseed oil, 100% D2, and 100% RME.

METHODOLOGY

Pickups

Research in the past has concentrated on the use of stationary engines under controlled conditions and loading. This project will produce results which will simulate day to day service. Two diesel-powered pickups are being tested on 20 percent biodiesel and 80

performed after each dynamometer test. With the smoke sensing meter located just above the vehicle's smoke stack the driver rapidly accelerates the engine three times, with the transmission in neutral. The driver then repeats the snap idle test three times while the meter measures the maximum opacity. The average of the three maximum readings is the percent opacity for the snap idle test.

Each pickup will have a log book to keep daily and long-term records. Each data entry will include the following: date, ending mileage of trip, ending hour meter reading of trip, oil added, fuel added, driver, and destination. Also, a maintenance record book is being kept for each vehicle, which includes the oil samples, dyno test data sheets, and any other scheduled or unscheduled maintenance.

Oil Samples

Oil samples are taken at each oil change which is 3,000 miles for the biodiesel pickups and at the owners discretion of the control vehicles. The oil samples are analyzed at a commercial oil analysis laboratory for wear metals, and physical tests will be performed, including antifreeze, fuel dilution, water, and viscosity. An infrared analysis for soot, sulfur, nitration, and oxidation will be conducted.

DEVELOPMENT

While the engines of the test vehicles are unmodified, the vehicles themselves have been modified for convenience of running the test. For example, it is known that esters will deteriorate rubber components over a period of time, so the fuel lines were replaced with viton hose. Some modifications were made on the fuel storage and delivery system to provide the on-board mixing of the fuels and for the convenience of the tests and the operator. A 56-gallon fuel tank for the biodiesel has been placed in each pickup bed. The vehicles as outfitted can travel over 4,000 miles between each fill up of biodiesel using the 20-80 blend. Electric fuel pumps supply fuel to a combining chamber for correct proportioning.

Mixing System

Two on-board fuel mixing systems have been tested. The first fuel mixing system consisted of a timing circuit which controlled the simultaneous operation of the two fuel pumps. The biodiesel was pumped through a precalibrated precision needle valve to obtain the desired 20-80 mixture. When the fuel reached a preset level in the combining chamber, a reed-relay float switch would close, activating the timing circuit. The time was adjusted to fill the one quart combining chamber. This was in operation for the initial 15,000 mile period.

A second generation circuit was recently installed on the pickups which uses a larger combining chamber. Three floats are used to control the mixing ratio. The principle of mixing is based on a known volume between each float. The first float starts the diesel pump and fills the combining chamber with diesel fuel until the second float switch is closed which turns the diesel pump off and the biodiesel pump on. As the biodiesel fills the chamber an adjustable float is activated which turns the pump off. This recent upgrade has logged only 2,000 miles on the Ford and was recently installed on the Dodge.

Ford

The Ford has accumulated 18,565 total miles with 16,900 miles and 368 hours on the blend. The fuel milage for the first 1,670 miles was 17.8 mpg using 100D2. The average mileage for the blend is 18.2 mpg. A total of 731 gallons of diesel and 197 gallons of raw rapeseed oil has been consumed.

Oil Sampling

The engine oil is sampled at each oil change interval which is every 3,000 miles. The check vehicle for this test changes oil every 2,000 miles and both use Delo 15-40 engine oil. Iron for the check pickup has been high since the beginning of the test while all other elements are at acceptable levels. Wear data for the biodiesel pickup are at acceptable levels without any significant differences between sample reports see figure 2.

Dynamometer Testing

As of June 17, 1993, two dynamometer test have been completed. The snap idle test was not implemented until the second dyno test. An abbreviated summary is presented in Table 2.

Table 2. Ford Dynamometer Test Results.

	1262 Miles		*10400 Miles*	
	Blend	*Diesel*	*Blend*	*Diesel*
Max Hp @ 3000 rpm	*117*	*121*	*137*	*133*
Economy mpg @ Max Hp	*6.35*	*6.52*	*6.38*	*6.38*
Snap Idle Test % Opacity	*NR*	*NR*	*12.4*	*NR*
% Opacity @ 2800 rpm	*10.2*	*13.1*	*10.2*	*13.1*

The injectors and compression were tested at 1666 and 10517 miles. Injector valve opening pressures varied as much as 50 psi and there were no differences noted between the cylinder compression tests.

The check vehicle has been dynamometer tested twice. At 38,671 miles a horsepower rating of 124 at 3,000 rpm and 11.7 percent opacity of for the snap idle test was recorded. The compression was comparable to the biodiesel and the injector VOP was 200 psi lower.

Heating

The biodiesel heating system was tested under non-driving conditions with the ambient temperature in the teens. Figure 3 is the test results for the Dodge pickup. The engine block heater was acting as the heating source for the engine coolant.

CONCLUSIONS

The on-road vehicle tests are progressing on schedule. No major maintenance or operating problems have been encountered. One objective of the study was to develop an on-board mixing system to increase the travel distance and a heating system for the biodiesel fuel. Continuous improvements to the mixing system have been made. A second generation mixing system should provide a more accurate mixing ratio. The heating system performed well during the cold winter months, keeping the biodiesel at 60 degrees fahrenheit.

At the 10,000 mile dynamometer test the Dodge pickup had a 36 percent decrease in opacity and 4.5 percent less horsepower at the 20-80 blend compared to 100 percent diesel. With 100 percent RME there was a decrease in opacity of 63 percent and 9 percent in horsepower compared to that of 100 percent diesel.

Also at 10,000 miles the Ford developed 22 percent less opacity and 3 percent less horsepower with the 20-80 blend compared with 100 percent diesel.

The vehicles are now at 20,000 miles and the next set of dynamometer tests and engine inspections will be completed in the near future.

Acknowledgements

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Disclaimer Statement

This report contains a summary of research results. This is not to be construed as a recommendation for the use of any alternative fuel mixture mentioned. The engine operator is responsible for all decisions concerning use of alternate fuels. Production of the ester involves the use of certain hazardous materials, the competence of the personnel involved and suitability of available equipment must be considered before attempting to reproduce this work in any form.

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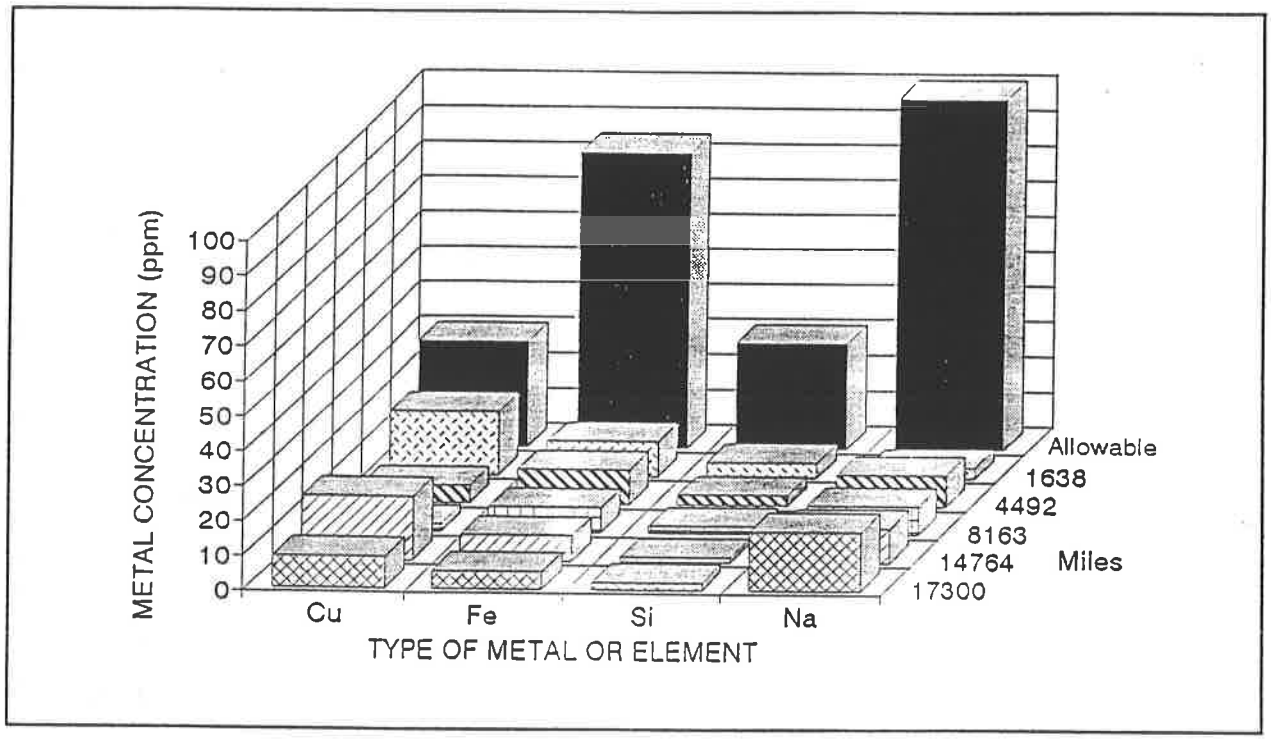

Figure 1. Average Metal Concentrations for Dodge Pickup

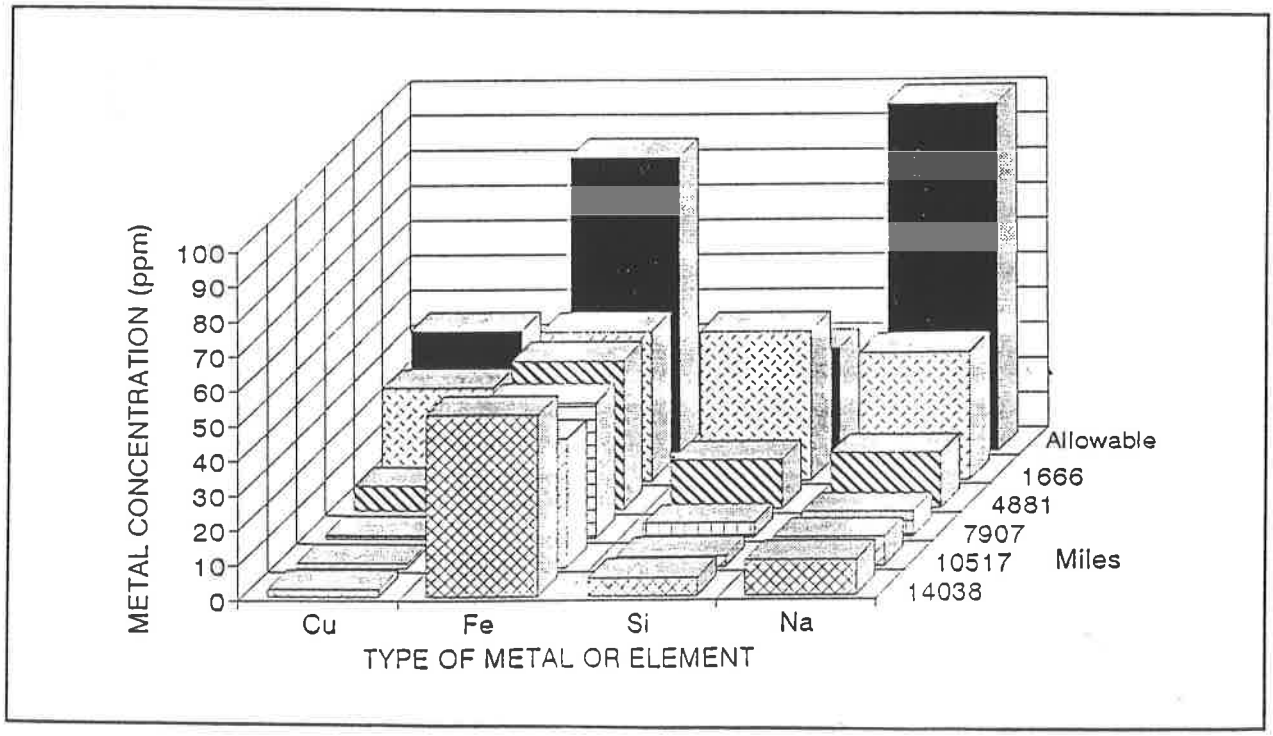

Figure 2. Average Metal Concentrations for Ford Pickup