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Alternate Fuels Demonstration Project

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Introduction

High fuel prices and the threat of shortages have caused many farmers and agricultural leaders to consider using other fuels in farm engines. Ideally, farmers should be able to produce alternate fuels on the farm from farm products and use the fuels in minimally modified engines.

Various research is being done on the use of vegetable oils, biogases, and distilled fuels—all agricultural crop products or residues—as alternates to gasoline or diesel fuel. In the north central area of the United States, ethanol and sunflower oil are regarded as two of the most promising alternates. Both fuels can be produced on the farm and burned in farm engines with a minimum of modification.

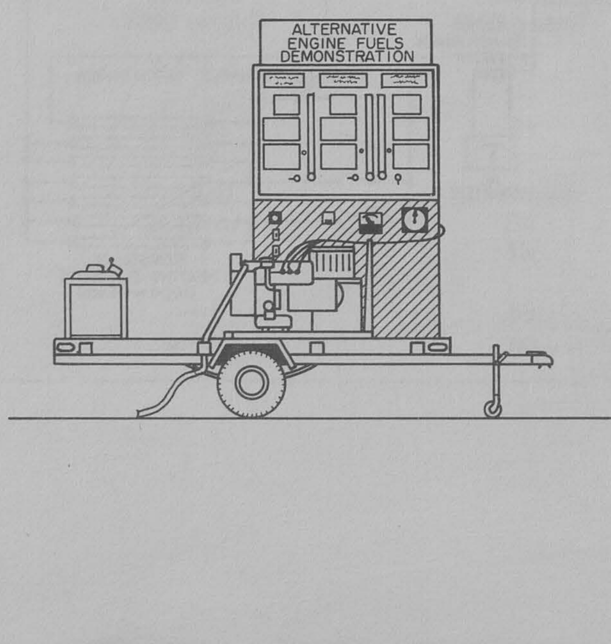
Many myths and misconceptions exist concerning alternative fuels. While the relationship of specific fuel consumption, fuel heating values, heat of vaporization, engine thermal efficiency, etc., are understood by most engineers, they are not understood by the consuming public. Demonstrations using alternate fuels in engines can provide an opportunity to discuss these relationships.

To help the public become more aware of the use of alternate fuels, the Agricultural Engineering Department of the University of Minnesota built two demonstration engines to show fuel consumption and power available when alternate fuels were burned in engines designed for gasoline and diesel fuel. Each engine, mounted on a trailer for easy movement to public demonstration sites (see Figure 1), was directly coupled to an electrical generator. Resistance heating elements, mounted behind the display panel, provided a load for the engine through the generator. The generator was connected in series with a display meter to reflect the engine power. A frequency meter indicated engine speed, and a timer measured the fuel consumption runs. Fuel tanks were mounted high on the demonstration unit to provide gravity flow to the engine or to the graduated burettes used to measure fuel consumption.

Spark Ignition Engine

The spark ignition engine was an Onan Model 2.5 LK L-head type rated at 5 horsepower with a 5.5:1 compression ratio and a fuel-load fuel consumption of 0.55 gallon of gasoline per hour. An optional cylinder head used with natural gas fuel was installed that gave a compression ratio of 7.2:1. An adjustable needle valve in the carburetor controlled fuel flow. Modifications included removal of the fuel pump, addition of a gravity fuel system and addition of a 25-foot flexible metal exhaust hose and muffler. No special provision was made to heat either the fuel or combustion air for operation on ethanol.

Figure 1. Side view of alternative engine fuels demonstration.



After four months, the stamped steel carburetor bowl and zinc die cast carburetor body were severely corroded and the rubber gasket sealing the bowl had expanded so that it no longer fit. The carburetor parts were replaced with resistant materials. (Copper, soldered copper, brass, and stainless steel are acceptable corrosion-resistant materials).

Compression Ignition Engine

The diesel engine was an Onan Model 6.0 DJE, four-cycle, two-cylinder with pre-chamber, rated at 12.2 horsepower. The compression ratio was 19:1 and full-load fuel consumption was 0.64 gallon per hour. The fuel pump was removed and a gravity fuel system installed. Separate fuel filters were installed for the three fuels used. The fuel return was looped back to the intake side of the injector pump. A bleeder valve was used in this return line to start the system; there were no subsequent problems when running, restarting, or changing fuels. Provision was made to feed the three separate fuels through the filters and to the fuel injectors. A carburetor was added to the air intake tube to allow the addition of liquid fuel to the intake air to supplement the injected fuel.

Figure 2. Wiring diagram for alternative engine fuels demonstration.

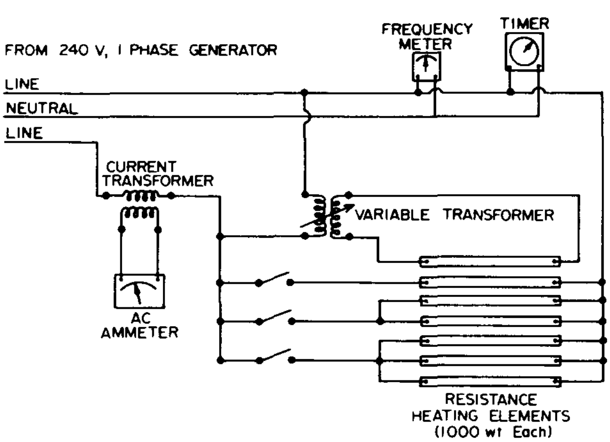
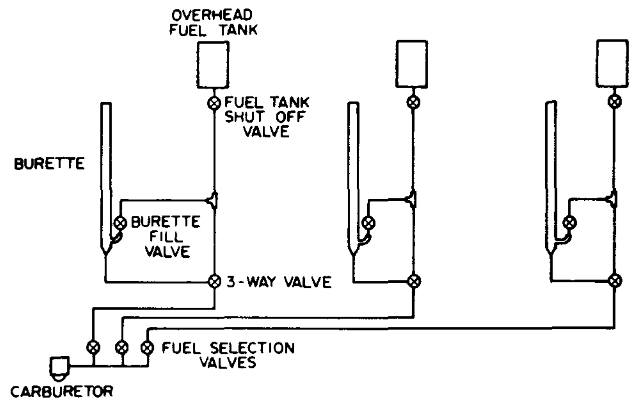


Figure 3. Fuel delivery system for ethanol demonstration.



Ethanol Fuels

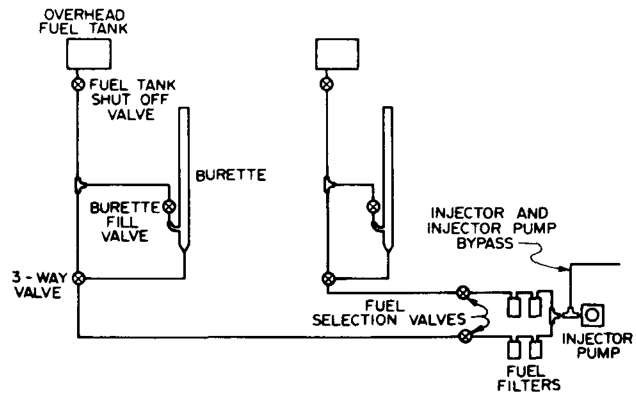
Two ethanol fuels were compared to gasoline in the spark ignition engine. Fuels with 95% ethanol-5% water (190 proof) and 80% ethanol-20% water (160 proof) were used. The 160 proof fuel is similar to that produced in on-farm ethanol production plants.

The engine was started, warmed up on gasoline, and peak power was recorded. Then, at slightly reduced power to assure a constant power for all fuels, the fuel consumption was measured. After the gasoline test, the gasoline valve was turned off at the carburetor and the 190 proof ethanol valve turned on. When the old fuel was consumed from the carburetor and the new fuel entered the engine, the speed of the engine dropped rapidly and, unless the needle valve was adjusted to correct the air-fuel ratio, the engine stopped. With the proper air-fuel ratios the engine attained the same peak power with all fuels, although fuel consumption varied with the heat content of the fuel. The Btu's required for each horsepower-hour of work were similar for the ethanol fuels and for gasoline.

Diesel Engine Fuel

The compression ignition engine demonstration used #2 diesel fuel, refined (degummed) sunflower oil, and 50-50 mixtures of diesel oil and sunflower oil. In addition, ethanol could be added to the intake air. No difference in engine operation was detectable when fuels were switched, since the injector system provided more fuel as needed to meet the load demand. Peak power and fuel consumption were similar for both diesel oil and sunflower oil. The addition of ethanol to the intake air reduced the amount of injected fuel in proportion to the heat energy (Btu's) added in the ethanol.

Figure 4. Fuel delivery system for sunflower oil demonstration.



Significance of the Demonstrations

The demonstrations show that alternate fuels can be burned in engines now used on farms. However, a change from the basic fuel for which the engine was designed does impose some limits. A variety of fuels have been used in spark ignition engines over many years, including varying grades of gasoline, natural gas, LP gas, and kerosene. Each fuel required a different compression ratio, ignition timing, carburetion, and operating temperature. The same is true of ethanol. A gasoline engine will run on ethanol with only a carburetor change to enrich the air-fuel mixture, but other changes would make the engine use ethanol more efficiently.

Ethanol fuels function well with compression ratios up to 13:1. This increase will improve engine efficiency. Ignition timing can be advanced slightly to allow for slower burning, and heat should be added to the intake manifold for starting and running at temperatures below 65°F. However, these changes render the engine unsuitable for burning gasoline.

During the summer when these demonstrations were made, the sunflower oil burned well in the compression ignition engine on its own and mixed with diesel oil. Research at North Dakota State University showed a 5 percent loss in engine effi-

Table 1. Typical Results from Fuels Demonstrations

	Gasoline	*Ethanol (190 proof)*	*Ethanol (160 proof)*
Peak power (Hp)	5.0	5.0	5.0
Fuel consumption (gal/hr)			
at 4.7 Hp	.46	.65	.81
	#2 Diesel Oil	*Diesel/ Ethanol*	*Sunflower Oil*
Peak power (Hp)	13	13	13
Fuel consumption (gal/hr)			
at 8 Hp	.55	—	.56
at 10 Hp	.60	.54/.19	.60

ciency when burning all sunflower oil compared to diesel oil. Other research stations have shown fouled injector tips, stuck rings, and solids in the crankcase from burning sunflower oil-diesel oil mixtures. Sunflower oil is much thicker than diesel oil at low temperatures and heat is required to thin the fuel during cold weather.

While ethanol and sunflower oil each can be burned in farm engines, some modification of the engine should be considered for anything more than casual use; and currently, costs and complexity of producing the fuels on the farm makes them noncompetitive with gasoline and diesel fuel.

The most immediate problems show in the fuel properties in Table 2. Ethanol has a much higher flash point than gasoline and requires additional heat in the air-fuel mixture for starting when air temperatures get below about 65°F.

The sunflower oil is similar in Btu content to diesel oil, but has a higher viscosity (is thicker) at low temperatures and will not flow through fuel lines and filters.

In addition, long-term effects on the engine are not fully known. The sunflower oil caused deposits on the injectors in some tests and a thickening of crankcase oil in another. These problems may be alleviated by rigorous maintenance programs, but the reliable, care-free performance expected from present fuels is not assured.

Table 2. Fuel Properties

	lbs/gal	*Btu/gal*	*Octane No.*	*Flash point*
Gasoline	6.1	125,000	88	−44°F
Ethanol (200 proof)	6.6	83,000	98	55°F
	lbs/gal	*Btu/gal*	*Cetane No.*	*Viscosity mm²/sec at 32°F*
#2 diesel oil	7.07	140,000	48	6.4
Sunflower oil	7.70	130,000	37	187.7

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