SUNFLOWER OIL RESEARCH PROJECT*

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Sunflower production in North Dakota in 1981 is approximately 2,250,000 acres. Most of the sunflower seed produced is processed into cooking oil.

Farm production in North Dakota has been hampered by occasional shortages of petroleum fuels. Sunflower oil has been suggested as a fuel that would serve as an alternative to diesel fuel during periods of petroleum shortage. Sunflower oil used as fuel could insure a supply of agricultural products if petroleum supplies are unavailable.

Substitution of sunflower oil for diesel fuel is not recommended at present because effects that the oil might have on engine parts have not been determined. A second reason that sunflower oil is not now recommended for fuel is its high cost. Engineers at NDSU have initiated engine testing programs using sunflower oil for fuel, and farm operators will be advised when results of the tests are available.

Technology for commercial extraction of oil from seed is well developed. Processes are largely mechanical and involve types of equipment familiar to farm people, so on-farm production of the oil is conceivable. A second suggested concept is to locate processing plants as cooperative or privately-owned businesses in communities close to the region where the oil will be used. Approaches of this kind would keep transportation problems at a minimum.

Most existing oil extraction plants include auger-type expeller units. These machines are designed with an auger in a perforated housing. The center shaft of the auger increases in size from the inlet to the outlet until at the outlet end the shaft is the same diameter as the flighting. As seed moves through the auger, it is compressed until it is forced between the outlet shaft and

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the auger housing. Oil is forced out of the seed as it is compressed and flows from the machine through the perforations in the housing. Friction caused by the process provides heat so the oil will flow well. Seventy-five percent of the oil from sunflower seed has been extracted by this process.

In most commercial extraction plants, the meal from the auger expeller is exposed to a spray of hexane. This is a solvent that dissolves the remainder of the oil and removes it from the meal to increase the oil yield. Over 99 percent of the oil can be removed from the seed when the process is used. Hexane is then evaporated from the oil and reused. The complexity of the solvent extraction process makes it undesirable for small on-farm processing plants.

Filtration is a necessary step in processing oil as a fuel for diesel engines. The filtration is necessary to prevent fouling of the engine fuel systems.

Further refining may be desirable to alter the oil characteristics so it will perform well in engines. Commercial extraction plants remove gums by treating the oil with water and then processing it in a centrifuge. Waxes are removed by cooling the oil. Treating the oil with methyl ester will produce a methyl ester which also may be used as a fuel. Engine testing is needed to determine if these or other treatments would improve the sunoil as a fuel.

Meal from processed sunflower shows promise of being a useful feed supplement for livestock. Dr. W.E. Dinusson is conducting a research program in the Department of Animal Science to evaluate this meal. He reports that the protein content for solvent extracted dehulled seed is above 40 percent. This compares favorably with that of other oilseeds such as soybean meal, cottonseed meal, and rapeseed meal.

Dr. Edward J. Deibert is evaluating the meal for possible use as a fertilizer. The nutrient content (nitrogen, phosphorus, and potassium) of the whole seed meal and dehulled seed meal would have an approximate value, based on current fertilizer prices, of $29.40 and $51.72 per ton respectively.

Dr. D.L. Helgeson and Prof. L.W. Schaffner are conducting economic analyses on processing sunflower oil and on use as fuel. Oil costs have been estimated based on commercial costs of production and a current market value for the meal. Production costs include value of the seed, labor, and equipment. Seed costs at 7.58 cents per pound and a meal value of $86 per ton gave an estimated cost of production of $2.07 per gallon of oil. Labor and equipment cost estimates were included in the analysis.

Dr. H.J. Klosterman of the Biochemistry Department and Dr. D.C. Zimmerman, a biochemist with USDA, have recommended chemical modifications that might be made to the sunflower oil to make it more manageable as a fuel. They are evaluating reports from researchers in the Union of South Africa on the conversion of the oil to methyl ester to provide improved fuel. Viscosity of the methyl ester is improved over that of sunflower oil, but they begin to freeze at temperatures around 32° Fahrenheit.

Engine Testing

The potential for success of this system of using sunflower oil as a fuel for diesel engines depends on the performance of the sunflower oil in engines over a long period of time. Potential hazards include varnish buildup, sticking of piston rings, carbon buildup on injectors, excessive stresses on fuel pumps, and contamination of crankcase oil. Tests are needed to determine if these hazards exist and to determine what adjustments might be made to correct the hazards.

The energy content of sunflower oil has been measured at around 130,000 btu/gallon. This compares well with the energy content of diesel fuel at about 138,000 btu/gallon. Sunflower oil is 30 times more viscous than diesel oil at 32°F and therefore will not flow as well. The cetane rating of sunflower oil is 37, which compares favorably with the cetane rating of diesel fuel at 48. For comparison purposes, the cetane rating for gasoline is reported to be about 15 and that of ethyl alcohol is about 7. Sunflower oil weighs 7.7 pounds per gallon and diesel fuel weighs 7.0 pounds per gallon.

A series of short term tests were conducted using a Ford 7000 tractor and an Allis-Chalmers 7010 tractor. Tests on the Ford 7000 with 100% diesel fuel, a mixture of 50% diesel fuel - 50% sunflower oil, and 100% sunflower oil indicated that respective horsepower outputs were 81.4, 79.6, and 75.5. Respective horsepower hours per gallon (Hp hr/gal) were measured at 15.55, 15.02, and 14.8.

A complete testing program is under way to determine the effects of several hundred hours of operation when sunflower oil is used for fuel. Allis Chalmers and the Agricultural Engineering Department at NDSU are cooperating on the work. Testing is being done in the research laboratories of the Allis Chalmers Engine Division at Harvey, Illinois.

In the tests, a 4 cylinder, 3.3L, turbo-charged and intercooled diesel engine is being used. Five hundred hours have been run on diesel fuel as a baseline and then 600 hours with a 50/50 blend of alkali-refined sunflower oil and #2 diesel fuel. These tests were started in January 1981 before the Engine Manufacturers Association (EMA) came out with a recommended test cycle. A two-point test cycle of high idle (3 minutes) and peak torque (10 minutes) was used at that time. This test cycle gave a load factor similar to the load factor of the EMA test cycle. As a result of these tests, no trouble was encountered while operating on diesel fuel, but complications developed while operating on the blend. While using the blend, problems with fuel filters plugging and injector coking occurred continually. Filters were changed daily and the longest service life produced by a set of nozzles was about 100 hours. Originally, the sunflower oil was filtered through a 5 µm filter, and later a 3 µm filter. At the conclusion of the 600 hours of operation with the 50/50 blend, the engine was inspected. The #2 ring was stuck on all pistons and there was excessive carbon build-up on all intake ports. Problems with crankcase oil thickening was not encountered. The oil was changed every 50 hours to circumvent this problem. A series of tests using the EMA test cycle will soon be initiated. Dr. Everett Pryde, Research Leader, Oilseed Crops Laboratory, Northern Regional Research Laboratory, USDA, Peoria, Illinois is cooperating on these tests. The EMA Alternate Fuels Committee is monitoring these tests.

Twelve tractors are also being operated in North Dakota fields on blends of sunflower oil and diesel fuel. Flower Power, Inc., P.O. Box 26, Grand Forks, ND 58201, is sponsoring the project and NDSU is providing the data analysis. John Deere, Allis-Chalmers, and J.I. Case are the manufacturers represented in the program. The tractors range in power from 120 hp to 250 hp. Six tractors are being run on a 25% blend of sunoil and diesel fuel. The remaining tractors operate on a 50% blend. A lubrication oil sampling program is in progress and daily log sheets are kept by the individual cooperators. Periodic dynamometer checks indicate the performance of the engine.

Inspection of the individual engine components will take place at the completion of the 1981 growing season. Injector coking has been observed, but the carbon is soft and seems to burn off when the engine is operated under a heavy load. Damaged cylinder liners have been found in two of the tractors operating on the 50/50 blend.

Average sunflower seed production in North Dakota approaches 1400 pounds per acre. Oil content of the seed with hull is about 40%. If 75% of the oil can be extracted, oil yield is about 55 gallons per acre. The fuel required to produce one acre of sunflower in eastern North Dakota averages just over 9 gallons. One acre of sunflower can produce fuel for 6 additional acres of sunflower under these conditions. It has been estimated that one unit of energy is required to produce and process sunflower oil that contains 6 units of energy. The oil therefore appears to be an energy efficient source of fuel.

Most factors related to the use of sunflower oil as a fuel for diesel engines are encouraging. Results of tests on the long term effects of the oil on engines must be obtained and will determine if the practice can succeed or not.