Either acidic or basic catalysts could be used for the transesterification, but best results were obtained with potassium hydroxide.

Good progress has been made in answering some of the questions posed earlier, but definitive answers for all of the problems are not yet available, and there is need for continuing testing of modified fuels and evaluation of engine design factors.

Farm-Scale Recovery and Filtration Characteristics of Sunflower Oil for Use in Diesel Engines[1]

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ABSTRACT

The "Hander," new Type 52 oil expeller was evaluated to determine its performance in expressing sunflower oil for use in diesel engines. Strain gauges were mounted on the barrel of the expeller and were used to give a relative indication of barrel pressure. Relative barrel pressure was then used as the independent variable in determining performance. Filterability of four commercial sunflower oils and blends of these oils with No. 2 diesel fuel were determined at various temperatures and pressures. Oil extraction efficiency ranged from ca. 56% to 84% at low and high relative barrel pressures, respectively. The greatest oil extraction rate was 12.3 kg/hr at a feed rate of 40 kg/hr with an extraction efficiency of ca. 80%. Dewaxed sunflower oils and blends filtered much better than nondewaxed oils and their blends. Increasing temperature, pressure and percentage of diesel fuel in the blends increased filterability of dewaxed sunflower oil.

INTRODUCTION

America's view on energy availability and costs is very different today to that a decade ago. Today, almost 45% of our total energy is derived from oil and 40% of this is imported. The majority of this oil comes from an international oil pool controlled by OPEC. It is now clear that the United States must solve its energy problem at home. Various alternative liquid fuels are being considered, with much attention being given to vegetable oils.

The diesel engine application is widespread in agriculture, and increasing numbers and used in automobiles and trucks. Various researchers have demonstrated that sunflower oil has potential as an alternative fuel for diesel engines (1).

The practicality of an alternative farm fuel is dependent on the amount of land required to produce the crop. The average sunflower yield in the United States is 1390 kg/ha. The oil content of the seed is ca. 40%, which can all be recovered in a commercial solvent extraction operation to get 604 L/ha of sunflower oil. The on-farm fuel required to produce one hectare of sunflower or small grain in North Dakota ranges from 56 to 84 L. Under these conditions, one hectare of sunflower could produce enough fuel to grow 7-11 hectares of small grain or sunflower (2). Further, it may be possible for the farmer to reduce costs compared to commercial processing by recovering the oil from the seeds with a screw expeller and then processing the oil as necessary. There are two major differences between commercial processing and on-farm processing. In the latter, the hulls are not removed and solvent extraction is not utilized. The meal will be high in fiber content and will contain 12-18% oil on a dry weight basis, and efficiency of oil recovery will be less than in a commercial process.

After recovery, sunflower oil is clarified through one or more processes to remove most of the solids (primarily small seed particles). The large solids can usually be screened off or settled out. Before the oil can be considered for use as a fuel, the fines must be removed. This can be accomplished by using one or more of several processes including settling, screening (stationary or vibrating), centrifuge, filter press or vacuum filtration. For on-farm processing, gravity settling followed by the use of a filtration system appears quite attractive. Gravity settling requires very little capital investment and virtually no operating expense.

It was recognized that filtration would be required or at least be desirable in several locations in the total fuel supply system, i.e., prior to delivery to the storage tanks, or prior to delivery to the engine fuel supply tank, or prior to the injection pump in the fuel system of the diesel engine. The pressure differential across the filter would range from relatively low to relatively high values. Oil temperatures at the time of filtration would also vary from low to high. Additionally, sunflower oil samples from various sources were quite different in visual appearance and turbidity, which would affect the filtration characteristics of the oils.

The objective of this research was to evaluate the performance of an on-farm type screw expeller for recovering sunflower oil for use in diesel engines. A further objective was to determine filtration rates of some commercially available sunflower oils and blends of these oils with diesel fuel at various temperatures and pressures.

EXPERIMENTAL PROCEDURES

Sunflower Oil Recovery

Capacity of an oil extraction unit may be given in terms of the mass of seed or in terms of mass or volume of oil produced per unit of time. Oil recovery efficiency is the ratio of the oil produced to the total oil content of the seed.

The unit under study was the "Hander" oil expeller, New Type 52, made by CeCoCo of Osaka, Japan, rated at ca. 50 kg/hr of dehulled sunflower seed, and powered by a 2.2 kW electric motor. This unit is similar in form to all oilseed screw presses (3). It is simply a screw conveyor with decreasing volumetric displacement from the feed inlet end to the point of discharge of the press cake, which revolves within a drained barrel. The decreasing volume of the screw applies increasing pressure to the seeds as they move through the length of the barrel, causing the oil to be "squeezed" from the seed and expelled through the barrel. Additionally, the screw fits into a tapered ring at the discharge point of the press cake. The screw can be adjusted axially relative to this ring to change the pressure applied to the seeds. Varying the applied pressure will influence the feed rate, oil capacity,

[1]Work on this project is supported by North Dakota Agricultural Experiment Station Project 1439.

cake thickness and extraction efficiency. The friction of the seeds against the screw and barrel results in the production of heat. The production of heat is perhaps desirable, since commercial extraction of oil utilizes heat to increase extraction efficiency.

For on-farm operations, it would be desirable to minimize adjustments to the machine to optimize processing and extraction capacity and extraction efficiency. The simplest and most probable adjustment to make on the "Hander" expeller is to change the screw position relative to the position of the tapered ring, thereby changing the pressure exerted on the seeds.

With this in mind, it was of interest to determine machine performance at various pressure settings on the unit. Strain gauges were mounted on the barrel housing which surrounds the tapered ring. The strain gauges give a "relative" indication of pressure as the screw is moved farther into or out of the tapered ring.

A series of tests were run using oil-type sunflower seeds which had been cleaned with a fanning mill. Tests were run using seeds at an initial temperature of ca. 20 C. Indicated barrel pressure was used as the independent variable (Table I). As barrel pressure increases (more pressure is exerted on the seeds), the feed rate and meal thickness decrease, while the oil extraction efficiency and barrel temperature increase. The oil recovery rate increases with increasing pressure to ca. 110 MPa and then starts to decrease with a continued increase in barrel pressure.

Sunflower Oil Clarification

A standardized filtration test was developed to permit the comparison of the filtration characteristics of sunflower oil from various sources and of blends of these oils with diesel oil.

A 208-L drum of partially refined sunflower oil was obtained from each of four different sources; two samples had been dewaxed and two had not been dewaxed. The filter apparatus consisted of an oil reservoir which could be pressurized using nitrogen gas. The reservoir was connected to a 70-mL Spectra/Por laboratory filtration cell. Because many tractor filters are ca. 5 μm nominal, 4 μm absolute filter paper (Filpaco No. 1812-28) was used. The outlet from the filter was directed to a container on a digital electronic balance. Tests were run with 100% sunflower oil and with blends of 50/50% and 25/75% sunflower oil and No. 2 diesel fuel, respectively. Accumulated weight of filtrate passing through the filter for the sunflower oils and blends was determined at pressures of 34, 138, 276 and 414 kPa and temperatures of -5, 10, 25 and 40 C (Figs. 1-5). These figures indicate that the addition of diesel fuel increases the filterability of each of the oils. Filterability of oils A and D, both of which were dewaxed, increased in direct proportion to the amount of diesel fuel added. Oils B and C,

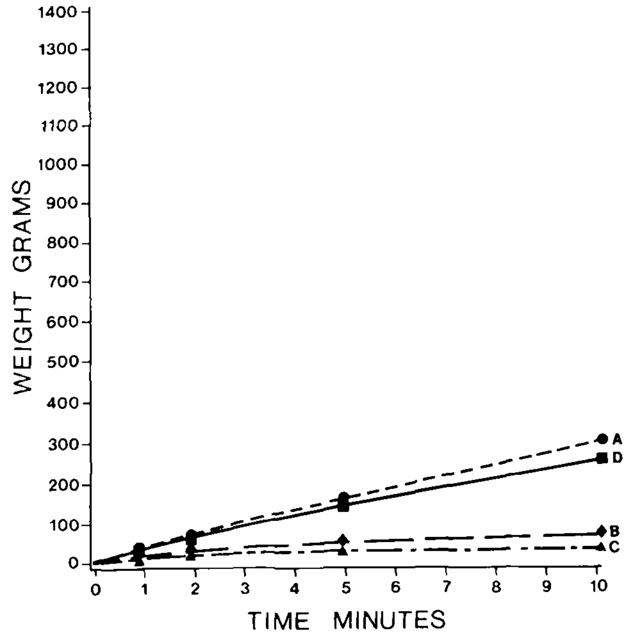

FIG. 1. Accumulated weight of filtrate vs time for 100% sunflower oil at 25 C and a pressure of 34 kPa.

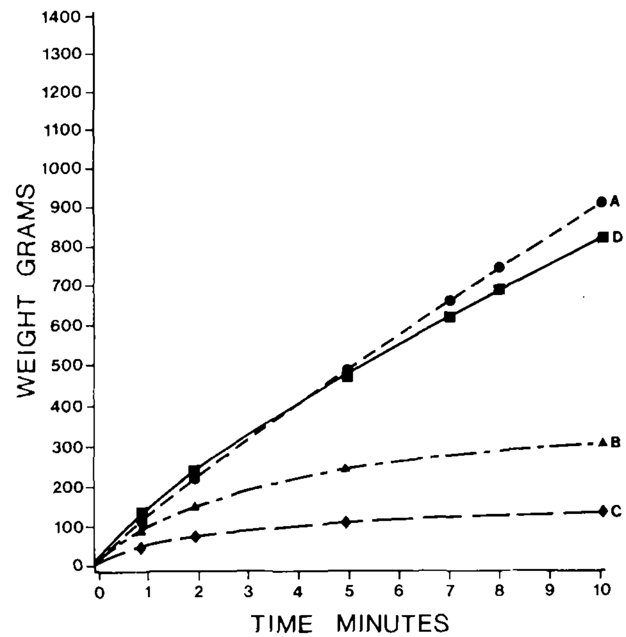

FIG. 2. Accumulated weight of filtrate vs time for blends of 50% sunflower oil and 50% No. 2 diesel fuel at 25 C and a pressure of 34 kPa.

TABLE I

Effect of Barrel Pressure on Various Parameters

Relative indicated barrel pressure (MPa)	Feed rate (kg/hr)	Oil recovery rate (kg/hr)	Oil recovery efficiency (%)	Meal thickness (mm)	Barrel temperature (C)
85	47.5	10.11	55.8	0.790	65.8
90	47.0	10.54	57.8	0.770	67.9
95	46.2	11.16	62.5	0.740	70.1
100	44.8	11.78	68.0	0.695	72.4
105	42.7	12.21	74.0	9.645	75.0
110	40.0	12.30	79.5	0.585	78.2
115	36.3	11.80	84.0	0.510	81.9

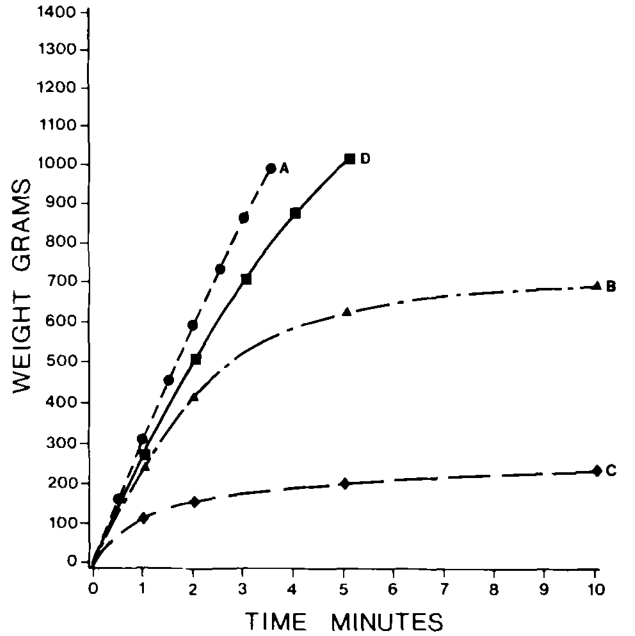

FIG. 3. Accumulated weight of filtrate vs time for blends of 25% sunflower oil and 75% No. 2 diesel fuel at 25 C and a pressure of 34 kPa.

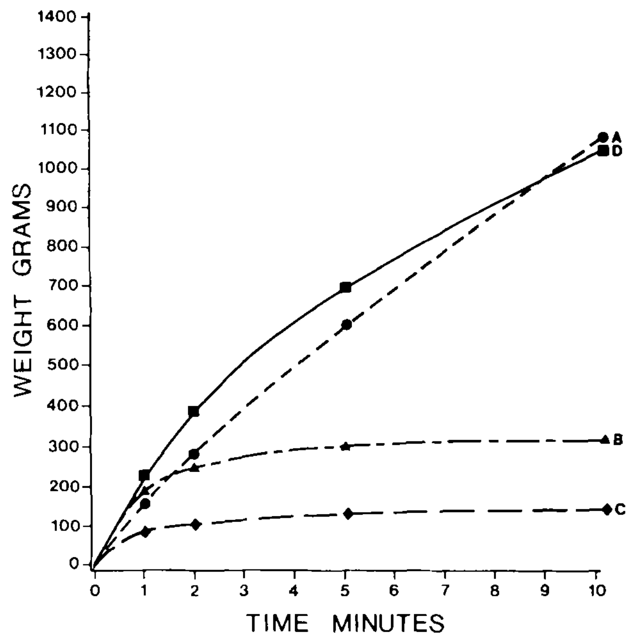

FIG. 4. Accumulated weight of filtrate vs time for blends of 50% sunflower oil and 50% No. 2 diesel fuel at 40 C and a pressure of 34 kPa.

neither of which were dewaxed, responded slightly differently. Filterability of oil C and its blends changed very little, while the filterability of oil B and its blends increased slightly in each case but then soon plugged the filter. Filterability of oils A and D and their blends increased proportionally with an increase in temperature from 10 C to 25 C. Filterability of oils B and C and their blends increased much less dramatically with the same temperature increase and again plugged the filter after the initial increase. Again, the filterability of oil C and its blends responded much less than that of the other oils. Increased pressure also greatly increased the filterability of all the oils and blends except for oil C and blends with the oil.

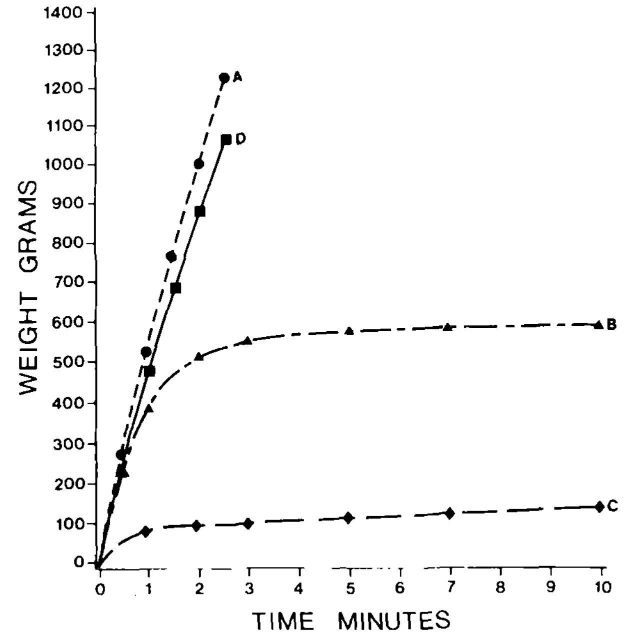

FIG. 5. Accumulated weight of filtrate vs time for blends of 50% sunflower oil and 50% No. 2 diesel fuel at 25 C and a pressure of 414 kPa.

DISCUSSION

The recovery of oil from sunflower seed by using the screw expeller is a simple, easily understood process that would be easy for relatively unskilled labor to operate. There is little danger of fire or explosion because highly volatile solvents are not used. Since chemicals and water are not required for the process, danger of freezing in the winter is eliminated and there should be no pollution potential from the process. A press of the size tested has the potential for extracting several thousand gallons of oil per year, and the meal from the process has the potential to replace high protein supplement currently being purchased by farmers. Oil extraction efficiency ranged from ca. 56% to 84% at low and high barrel pressures, respectively. The greatest oil extraction rate was 12.3 kg/hr at a feed rate of 40.0 kg/hr with an oil extraction efficiency of ca. 80% and at relatively high barrel pressure. A further increase in barrel pressure increased efficiency by ca. 4% but decreased both feed rate and oil recovery rate.

A standardized filtration test using four different commercial partially refined sunflower oils, two dewaxed oils and blends of these oils with No. 2 diesel fuel showed that the flow-through rate was much better than with the nondewaxed oils and their blends with diesel fuel. Increasing temperature, pressure and percentage of diesel fuel in the blends all greatly increased the filtration rates of the dewaxed oils. Although the same parameters increased the filtration rate of the nondewaxed oils to some extent, the filter soon plugged after the initial increase in flow rate. To minimize filter plugging, sunflower oil for fuel should be dewaxed.

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