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POTENTIAL ALTERNATE DOMESTIC HEATING FUELS

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March 1982

For presentation to the Combustion Institute, Canadian Section, 1982 Spring Technical Meeting, Banff, Alberta, May 1982

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
REPORT ERP/ERL 82-28(OP)

POTENTIAL ALTERNATE DOMESTIC HEATING FUELS

by

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ABSTRACT

Three potentially renewable liquid fuels are considered for domestic heating in those areas of the country where conventional energy sources are either too expensive or unavailable. They are two vegetable oils, canola and sunflower, and methanol. One attractive feature of these fuels is that they might be burned in furnaces or boilers equipped with conventional pressure atomizing oil burners fitted with flame retention heads, with little or no modification to the system.

However, due to its high viscosity and fatty acid composition, canola oil is not satisfactory in blends greater than 10% with No. 2 oil. Sunflower oil performs much better, and an optimum blend of 50:50 in No. 2 heating oil offers potential for future use.

Methanol, when fired in a furnace quipped with a retrofit condensing heat exchanger designed for use with gas, offers a major end-use energy advantage, with steady state efficiencies over 94%, and seasonal efficiencies in the 90% range, when compared to conventional furnaces fired with oil or gas, which operate below 60% over the heating season.

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INTRODUCTION

The realization that conventional crude oil reserves in Canada are relatively small, and that the cost of such fuels in the marketplace is increasing rapidly, has sparked an interest in replacing the No. 2 oil now used in domestic heating. Conversion to alternate fuels, such as natural gas, propane and wood is now being supported by the Federal government in the Canadian Oil Substitution Program (COSP). In those areas of the country where natural gas is not available, retrofit of existing oil-fired systems with flame retention heads to improve efficiency (1) is being subsidized in a similar program.

In the longer term, other new fuels which might offer potential for domestic heating are certain vegetable oils and methanol. One attractive feature of these new heating fuels is that they might be burned in conventional pressure atomizing oil burners fitted with flame retention heads, with little or no modifications to the system.

FUEL PROPERTIES

In Canada, two major oilseed crops are canola and sunflower. Properties of these two vegetable oils, methanol and conventional No. 2 oil are presented in Table 1.

Canola and sunflower oil have similar properties, except for their fatty acid compositions. Their specific gravities are about 10% greater than for No. 2 oil, yet because of their oxygen content, their higher heating values are some 10% less.

Methanol has five times the oxygen content of canola oil and only half the energy content. At the same time its hydrogen to carbon ratio (H:C) is twice that of the other fuels. Its viscosity is very low, about one-tenth that of No. 2 oil, and almost two orders of magnitude below the vegetable oils.

COMBUSTION PERFORMANCE

All experiments were carried out at CCRL using a conventional warm air oil furnace with a concentric tube heat exchanger, fired by a high pressure gun-type burner with flame retention head. Both steady state and cycling trials were carried out, with flue gas properties measured with continuous analyzers for carbon dioxide, oxygen, carbon monoxide, nitrogen oxides, unburned hydrocarbons and particulates, along with gas and metal temperatures using shielded thermocouples. For the condensing furnace, condensate was collected over specific timed intervals and analyzed for acidity and ion composition. A brief summary of the results follows.

Canola Oil

Due to its high viscosity and fatty acid composition, pure canola oil cannot be burned in on-off cycling systems, due to severe ignition problems. However, blends of up to 50% canola in No. 2 oil yield fair performance, if significant amounts of fuel preheat and pressure augmentation are used. The emissions due to incomplete combustion are higher than for No. 2 oil. At levels higher than 10% canola in No. 2 oil, there was evidence that coking and the nozzle or the head could lead to failure over the heating season.

Sunflower Oil

Sunflower oil performs much better than canola. It can even be burned "neat" (i.e. without blending), although emissions are high. Miscibility with fuel oil is good; performance in blends with No. 2 is most satisfactory. An optimum blend of 50:50 sunflower in No.2 oil offers good potential as a domestic heating fuel (2). Efficiency is high with emissions of carbon monoxide, hydrocarbons, nitrogen oxides and steady state particulates at or below the levels for No. 2 oil. Only transient particulate emissions are somewhat higher, and techniques are being examined to improve this condition. From Table 2, it is seen that if the fuel pressure and fuel temperature are adjusted, cyclic particulate emissions vary only between 3 and 6 g/kg for blends from 10% to 100% sunflower oil in No. 2 oil.

Methanol

Methanol, which can be produced from wood, coal or natural gas, can be fired in retention head burners. However, because of its low lubricity and corrosion potential, minor modifications to the pumping system are required to ensure satisfactory long term operation. Although much publicity has been given to the use of alcohols in automobiles, it may well be that their most effective contribution to transportation fuel economy is as a substitute for No. 2 oil in domestic heating, freeing up needed middle distillate for fuel efficient automotive diesels.

Using a flame retention head burner, methanol can be burned in conventional oil furnaces, at low excess air levels yielding steady state efficiencies at the 80% level. Because of its low lubricity and corrosion potential, work must continue to find a pump suitable for long-term operation.

Because of methanol's high hydrogen-to-carbon ratio, a large amount of energy is tied up in the form of a latent heat (hydrogen) loss (3). A stainless steel condensing tertiary heat exchanger with induced draft fan has been produced for CCRL under contract. This unit is designed to be retrofitted to existing natural gas-fired furnaces or converted oil furnaces to raise their efficiency to that of the new condensing furnaces. Firing methanol into one of these units yields high levels of condensation and operational efficiencies over 90%. A schematic of this condensing unit is presented in Figure 1.

From Table 3, it is seen that methanol yields three times the condensate in the retrofitted condensing furnace than did propane. At the same time, efficiency was increased from 91% to 94% on a steady state basis. Since this type of furnace has a seasonal efficiency on the same order as its steady state efficiency, while a conventional oil or gas furnace has a seasonal efficiency more than 20 percentage points below its steady state level.

CONCLUSIONS

1. Sunflower oil shows potential in a 50:50 blend to displace large quantities of No. 2 oil as a heating fuel in those areas where alternative conventional sources are either unavailable or too expensive. Specifically, it may well allow the agricultural community to come nearer to energy self-sufficiency.

2. Firing methanol in a furnace equipped with a retrofit condensing heat exchanger offers major increases in end-use efficiency, along with very low emission levels.

3. Canola oil, either neat or in blends, does not seem to be a satisfactory fuel for domestic heating systems.

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Table I - Fuel properties

	Canola	Sunflower	Methanol	No. 2 Oil
Ultimate Analysis, g/g				
Carbon	.778	.776	.375	.864
Hydrogen	.119	.109	.126	.133
Oxygen	.103	.115	.499	-
Sulphur	-	-	-	.003
Hydrogen:Carbon Ratio	.153	.140	.336	.154
Higher Heating Value				
MJ/kg	40.5	39.0	22.7	45.5
Flash Point, [C	213	227	11	50
Specific Gravity	.917	.924	.798	.846
Viscosity, cSt at 40[C	35	34	0.58	7
Fatty Acid Composition				
16:0 Palmitic	4	6		
18:0 Stearic	2	5		
18:1 Oleic	60	18		
18:2 Linoleic	20	64		
18:3 Linolinic	10	1		

Table 2 - Cyclic particulate emissions for sunflower oil

Blend with No.2 oil	10	25	50	75	100
Fuel Pressure, psig	100	120	170	190	190
Fuel Temperature, [C	22	83	69	75	83
Cyclic Particulates, g/kg	6.65	4.02	6.86	6.01	3.20

Table 3 - Performance of condensing furnace with propane and methanol

Fuel	Excess Air, %	% Condensed	Efficiency %
Propane	98	18	91
Methanol	54	57	94

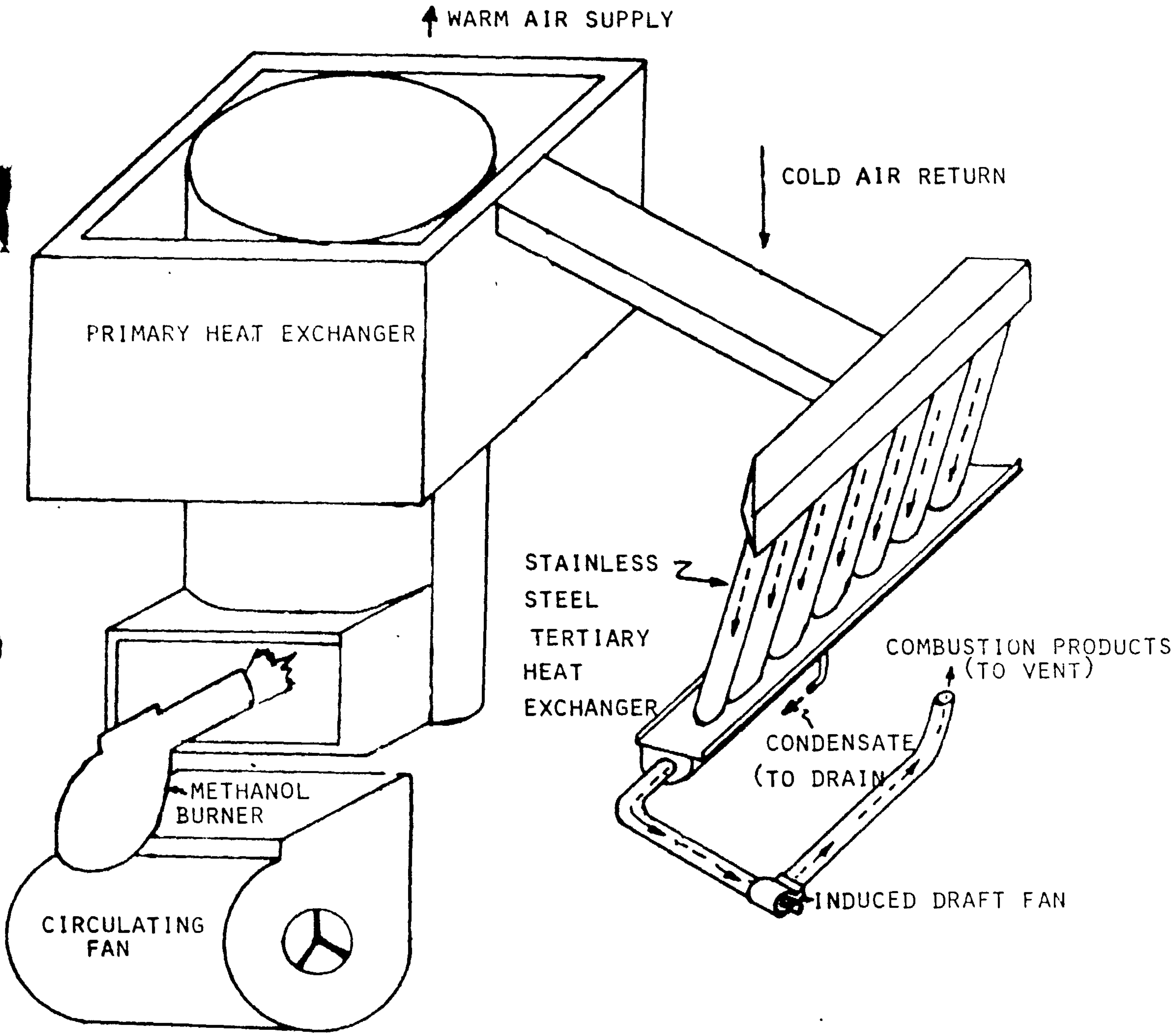

Figure 1. Methanol-fired condensing flue warm air furnace.