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PERFORMANCE OF COMPRESSED WOOD BRIQUETTES IN WOOD STOVES: A PRELIMINARY EVALUATION

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FEBRUARY 1979

Prepared for Annual Meeting of the Canadian Wood Energy Institute

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
ERP/ERL 79-16 (OP)

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by

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ABSTRACT

This paper discusses preliminary test results on the relative performance of a representative dry hardwood, maple, and compressed wood briquettes in three wood stove types. Two airtight stoves and one non-airtight. Franklin stoves were used. In the airtight box stove, the briquettes tended to lead to greater hydrocarbon and carbon monoxide emissions than for the maple, indicating more incomplete combustion. In the airtight (Scandinavian) baffled stove, no significant performance difference was observed between the two fuels. A potential fire hazard arose with the non-airtight stove, with uncontrollably high flue gas temperatures. As a consequence, it is recommended that the briquettes not be used in a non-airtight stove.

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INTRODUCTION

The Canadian Combustion Research Laboratory (CCRL) is engaged in a program to develop a test procedure to measure the efficiency of wood-fired appliances. The procedure being followed is to measure the efficiency indirectly, by the instantaneous heat loss method, as described in Reference 1. This requires a detailed knowledge of the exhaust gases.

In the development of this test procedure, a number of generic types of wood stoves are being tested, under a variety of different control conditions and with different wood types.

This paper describes preliminary results for the performance of three types of stoves, a non-airtight Franklin, and two airtights- a box stove and a baffled stove, fuelled with air-dried maple and with compressed wood briquettes.

FUEL ANALYSIS

The maple burned during the trials was air-dried for two years and had a moisture level of 15% on a wet basis. The ultimate analysis of the wood, in per cent by weight, as well as the calorific value as represented by the higher heating value is given in Table 1.

The compressed wood briquettes as fired had a moisture level of 5% on a wet basis, with an ultimate analysis as given in Table 2.

Both analyses were performed by the Solid Fuels Analysis Laboratory, Energy, Mines and Resources, Canada Centre for Mineral and Energy Technology (CANMET).

TEST STOVES

The box stove used for the trials was airtight, with no internal baffle. Hence, it was possible for the flames to reach the furnace exit. A schematic of this stove is given in Figure 1.

The baffled stove used was also airtight with a single horizontal baffle of the Scandinavian type. In this type of stove it is extremely difficult for flames to reach the furnace exit. A schematic of this stove is given in Figure 2.

The third stove, the Franklin was not airtight. Even with the doors shut and the combustion air control completely closed off, there is a large amount of air leakage in the area of the combustion zone, due to poor fitting doors, wall plates, etc. A schematic of this stove is given in Figure 3.

TEST PROCEDURE

The method used to evaluate the performance was the instantaneous heat loss method (1). All of the components in the exhaust stream, as well as the weight change of the wood, are measured and recorded simultaneously on magnetic tape throughout the burning cycle. Afterwards analyses of the data are carried out on the computer for each instant of time, and the profiles throughout the burning cycle are plotted. Flue gas components measured and the technique used for each are given in Table 3.

TEST RESULTS

The results of the tests are summarized in Figures 4 to 16. For the box stove, Figures 4 and 5 show the cycle results for stack temperature and carbon dioxide (CO_2), carbon monoxide (CO) and hydrocarbons, respectively, with air-dried maple at 15% moisture as the fuel. Figures 6 and 7 show the same variables, with the densified wood as the fuel. Stack temperature and carbon dioxide are somewhat higher for the maple, while CO and hydrocarbons are significantly lower, indicating more complete combustion for the maple than for the briquettes, even though the maple was operating at a lower excess air (i.e. higher CO_2) level.

For the baffled stove. Figures 8 and 9 show the cycle results for stack temperature and carbon dioxide (CO_2), carbon monoxide (CO), and hydrocarbons, with maple as the fuel. Figures 10 and 11 show the same variables with densified wood as the fuel. In this stove there seems to be no significant difference between the performance with the two fuels.

For the Franklin stove, Figures 12 and 13 show the cycle results for stack temperature and carbon dioxide (CO_2), carbon monoxide (CO), and hydrocarbons using dried maple, while Figures 14 and 15 show the same variables with the briquettes as fuel. Even though the Franklin was run with the doors shut, and the combustion air controls almost shut, the carbon dioxide levels with the maple are much lower than seen for the previous airtight stoves, indicating significant leakage. In fact, there was about ¼ in. clearance below the bottom of the doors of the stove so that proper air control was impossible. Peak temperatures with maple after refuelling were between 315°C and 370°C, much higher than for the other stoves. On the other hand, CO and hydrocarbons were low on a volumetric basis, due to dilution at the high excess air level.

When using the briquettes in the Franklin, a potentially catastrophic problem occurred. Because of insufficient air control, the fire "ran away with itself", and extremely high temperatures were experienced. At the standard measuring port for flue gas temperature, six feet downstream from the stove, the stack temperature was 510°C. At the stove exit, the temperature of the flue gases was an extremely dangerous 750°C, constituting a fire hazard. (Figure 16). Interestingly enough, at the same time as the peak temperatures were occuring, carbon dioxide and even carbon monoxide also peaked. As well, immediate whitening of the stove casting occurred, as did severe oxidation of the galvanized flue pipe test section, at all points where the flue gas temperature exceeded 540°C.

CONCLUSIONS

Although the test results reported herein are preliminary in nature, the following conclusions appear justified.

1. Even though densified wood may appear to offer advantages in the transportation and supply of wood as a fuel, more work is required to determine its suitab-lity in present wood stove designs.

2. In particular, use of the densified wood in airtight box stoves might lead to increased emissions of carbon monoxide and hydrocarbons, due to incomplete combustion.

3. Airtight baffled stoves appear to be able to burn the densified wood without significant problems.

4. Non-airtight Franklin stoves, as well as other non-airtights where combustion air cannot be completely controlled would appear to constitute a definite fire hazard when fuelled with the densified wood.

5. It is recommended that packages of the densified wood carry an easily visible label recommending against their use in non-airtight stoves.

6. Because of the possibility of flue gas temperatures from wood stoves exceeding 540°C under certain conditions, and the oxiddizing effect this can have on galvanized pipe, with resultant potentially harmful zinc emissions, galvanized flue pipe should not be used with wood stoves.

7. For more general use of densified wood in domestic heating, new stove/furnace designs are likely required.

REFERENCES

1. Hayden, A.C.S., "Efficiency of Wood-Fired Appliances", Canadian Wood Energy Institute Course on Wood Heating, September 1978, ERP/ERL 78-82 CANMET, Energy, Mines and Resources, Canada 1978.