Saving Energy With a Biomass Cook Stove Using a Well-Designed Pot

Introduction

People who design biomass cook stoves know that a well-designed stove can save a significant amount of fuel when properly used. It is also possible to save significant amounts of fuel if a well-designed cook pot is used for cooking meals. Although the maximum fuel saving will only be possible if the fuel saving pot is used with the well-designed stove, it is possible to save fuel with the fuel saving pot when used with any stove design.

Figure 1 below shows the standard pot used in the water boiling tests at the Aprovecho Research Center.

Figure 1. Standard test pot

This pot measures 25 cm in diameter and is 16 cm high. Our study of the heat losses from this pot during the simmer phase of the cooking cycle shows that approximately 80% or 4/5ths of the heat loss is due to evaporation of water.

Evaporation is a common process that occurs whenever a body of water is exposed to air. Water evaporates from the ocean, from lakes, rivers and streams. Evaporation removes heat from the water or any other liquid where it occurs and tends to lower the temperature of the liquid. Even a small amount of evaporation can remove a significant amount of heat.

The rate of evaporation is controlled by the temperature of the water, the surface area of the pot as well as the amount of moisture in the air and the air temperature. As the water

temperature increases, the rate of evaporation increases very rapidly. For example, when the pot shown in Figure 1 is used for simmering at 2 – 3^{o}C below boiling, as much as 1 liter of water is lost each hour. This represents a large amount of heat loss that has to be replaced by heat supplied by the fuel. If a pot is designed that would minimize this heat loss, than a significant amount of fuel can be saved.

One way of reducing the heat loss due to evaporation is to decrease the surface area of the water by decreasing the diameter of the pot. If the diameter of a standard pot is decreased than the volume of water that it can hold is also decreased. Figure 2 shows a pot design that decreases the surface area without decreasing the water capacity.

Figure 2. Experimental cook pot

The diameter of the top of the pot measures 12.5 cm or ½ of the diameter of the standard pot. Thus the surface area of the water in the pot when it is filled up to the narrow neck is ¼ that of the standard pot. This means that the heat loss due to evaporation is also ¼ that of the standard pot. In addition this pot has a wide base that maximizes the heat transfer between the cook stove and the pot.

Test Results

Comparison tests were done with the pot shown in Figure 1 and the pot shown in Figure 2 to demonstrate the savings that can be had by using the experimental pot.

The table below summarizes the results of these test runs.

	Standard Pot	Experimental Pot	Savings
Evaporation to Boiling (gm)	235	42.5	82%
Energy to Simmer 30 min (kw-hr)	0.38	0.13	66%
Evaporation to Simmer 30 min (gm)	490	103	79%

The water lost due to evaporation to bring the water to boiling is 82% less for the experimental pot. The water lost during simmering is 79% less for the experimental pot and the fuel savings for simmering 30 minutes is 66%. The water lost in the initial boiling and subsequent cooking process is 4/5ths less when using the experimental pot. This is a significant savings.

Cooking Oil Effect

The research done relating to this work also revealed another way to save even more fuel. If cooking oil is added to the pot so that it forms a layer completely covering the water surface, than the evaporation normally happening during the simmering phase will be completely absent. In other words the oil layer keeps the water from evaporating. For the pot shown in Figure 2 this requires 2 tablespoons of olive oil. For other cooking oils this may vary.

Given this result, when the oil is present the fuel saving is 87% of that required for the standard pot. In addition there is no loss of water during cooking.

Retained Heat Cooking

An additional method for saving fuel is to use the new pot as a retained heat cooker. Test runs were done in the following way: The experimental pot was filled with water. Next cooking oil was added sufficient to cover the water surface. The pot of water was then brought to boiling and immediately removed from the heat source. Next a bath towel was used to completely cover the pot. Figure 3 shows how the water temperature varied over the next 3 plus hours.

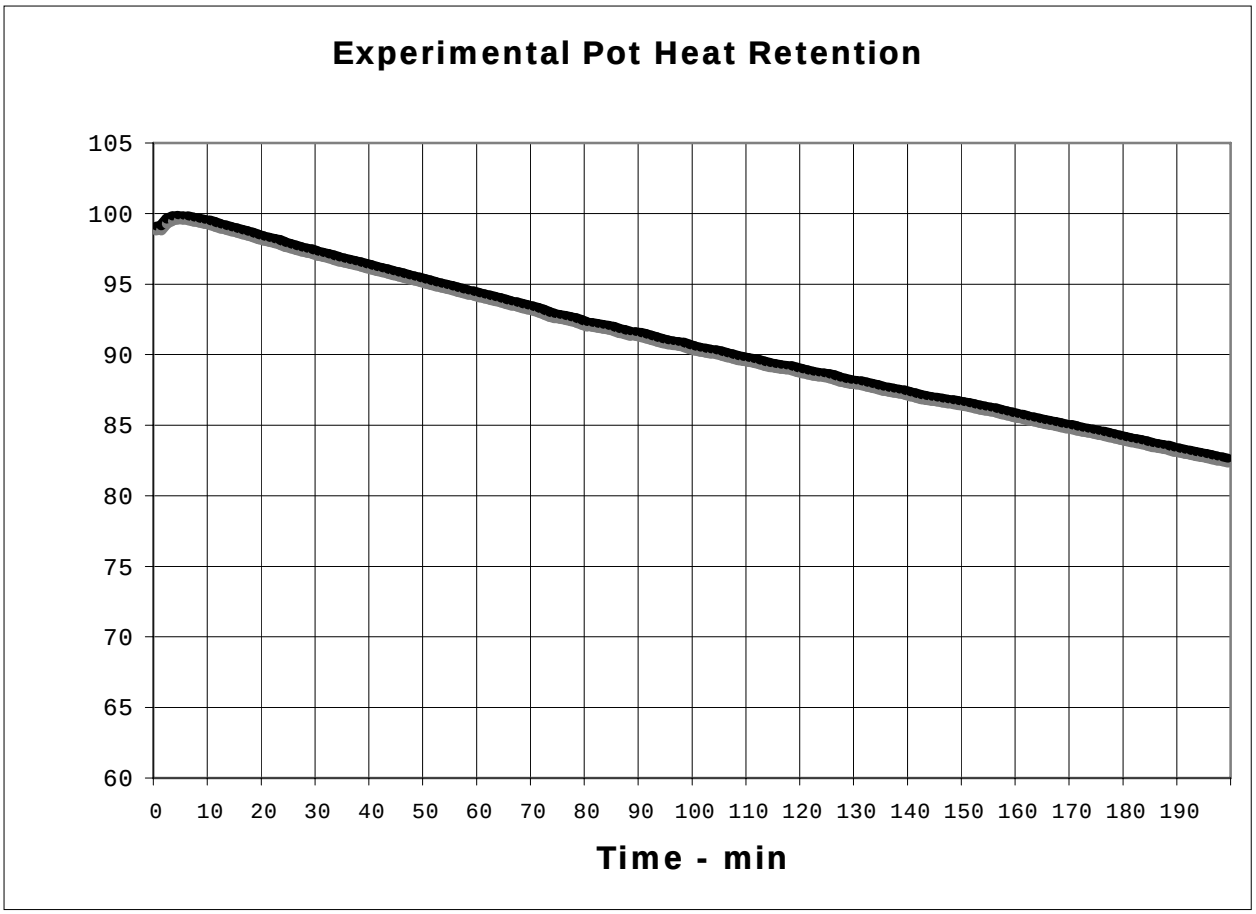

Figure 3. Experimental pot as a retained heat cooker

The water temperature in the pot remained above 90^{o} C for almost 2 hours. This was sufficient to cook a pound of pinto beans.

Cooking With Residual Hot Coals

The final method that was used to save fuel was the following:
The water in the experimental pot was covered with a thin layer of cooking oil. A Rocket stove was then used to bring the pot to boiling. The unburned wood was then removed but the hot coals were left in the combustion chamber. A cover was placed over the air inlet that limited the air supply so that there was just enough air to keep the coals burning. The water temperature in the pot was then recorded for the next 45 minutes. The average temperature of the water over the 45 minute interval was 99^{o} C.

Savings with a Lid

All of the data obtained using the experimental pot was done without a lid, however the standard pot was run with and without a lid. The results were as follows:

1. The evaporation loss with the lid on the standard pot was less than that for the experimental pot.
2. The fuel savings during the simmer phase was identical for the standard pot with a lid as for the experimental pot without a lid.

3. The evaporation loss during the simmer phase was less for the standard pot with a lid than for the experimental pot without a lid.

Summary

1. A cook pot with a wide base and a narrow neck can save significant fuel usage as well as water by minimizing heat loss due to evaporation.
2. A layer of cooking oil covering the liquid surface will eliminate evaporation completely.
3. The experimental cook pot shown above can be used as a retained heat cooker by simply using a towel as an insulator.
4. If a Rocket stove is used to bring the above mentioned pot to a boil and the unburned wood is removed, the residual hot coals will maintain cooking temperatures for at least 45 minutes.
5. The standard pot with a lid experienced less of a loss due to evaporation in all runs than the experimental pot without a lid.
6. The standard pot with a lid used the same quantity of fuel for simmering as the experimental pot without a lid.