The Versatile Stove-A Preliminary Report

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This report summarizes some preliminary tests regarding a stove that I have designed called the Versatile Stove, as it gives the user many options for use. This report also outlines my thinking for the stove. Finally, the report gives some plans for future work.

Motivations

The Versatile Stove is designed to be user friendly. It is not particularly designed to be clean and efficient, as I believe that user friendly features will lead to better adoption than stoves that are clean and efficient but not practical.

I believe the features most desired in a stove are power (first and foremost) and then in no particular order the ability to burn whatever wood is at hand (including large pieces and wet wood) the ability to burn for a long time with little attention, the ability to use pots of many sizes, the ability of the user to see the fire, and the ability to contain the fire (for both burn safety and as protection against wind). Having a stable stove and a stable pot within the pot supports are also good features that the stove provides. Being able to heat 2 pots at once is a feature the stove provides, though in some places this may not be very important.

Stories from the field have convinced me that many people use large pieces of wood because that is all they have, then often try to burn the wood without any kind of combustion chamber. They build huge fires because that is the only way to keep the wood burning, and the bulk of the fire is nowhere near the pot so it does little to heat the pot. Parts of the large pieces of wood smolder continuously, with large amounts of smoke and wasted wood. Since most of the fuel they have is larger pieces, stoves with small combustion chambers just don't work.

Design Features

The main design feature is that the stove has a very large combustion chamber. This allows the user to burn large pieces of wood. This also allows the user to burn a lot of wood at once, making the stove almost a batch load stove. Depending on the size of the wood and how it is arranged, one can get a fairly uniform fire for a long time that is not too big or too small with little tending. The current combustion chamber is 37 cm front to back, 20 cm wide, and 20 cm tall, with about 2.5 cm of this being below the grate. The back of the stove is closed, and the front of the stove is fully open to allow wood to be inserted. A front covering to reduce heat loss was tried but seemed to be ineffective.

The stove currently has 2 conical pot supports, a larger one in the back of the stove and a smaller one in the front of the stove. Each conical pot support has the actual pot supports inside the sheet metal cone, and no matter what the diameter of the pot, and no matter whether the pot is flat or round on the bottom, a gap equal to the height of the pot supports is present between the edge of the pot and the cone. This gap is currently 12.7 mm, and this seems to be about optimum. The photos below show the stove.

Photograph 1: Prototype Versatile Stove without the insulation and without pots. The back on the stove (on the right) is closed, and the front of the stove (on the left) is open.

Photograph 2: The pot supports with 2 pots and insulation. For prototype tests aluminum foil makes adequate insulation.

The slope of the cone is about 45°, such that the pot supports grip the pot. The pot is very stable within this “nest” of pot supports. The larger cone has 5 pot supports while the smaller has 3. Probably 5 is the optimum number.

The smaller pot support is in the front where the fire is usually weaker, and can handle pots up to 20 cm in diameter. The larger pot support is in the back, and can handle pots of up to 30 cm diameter within the cone, or if really large pots are being used, it can sit on the top ends of the pot supports. With the pot sitting on top of the pot supports, it is no longer nested and the stability feature is lost. This is shown in the photo below. Typically, such a large pot would be so heavy that it would be stable simply due to its weight.

Photograph 3: This pot is 37 cm in diameter. While is does not sit within the pot supports and is not as stable as a smaller pot, this system could be used for a pot of any size with either a round or flat bottom. Note that the small burner is covered for this test, since it won't be used.

Summary of Results

Here is a quick summary of the results against the design objectives. At the time of this writing 8 tests have been done with the Versatile Stove as seen above, and 15 preliminary tests were done with single pot stoves with similar large combustion chambers. Details of the test methods are given later.

The stove is powerful! Five liters are typically brought to a boil in around 15 minutes.

The stove can burn big wood, up to 8 cm has been burned, along with smaller wood. Photograph 4 shows some of the big wood that has been burned in the early version of the stove, and photograph 1 shows some wood off to the side that was burned in the stove.

The stove takes little tending. A test has been conducted with a pot with a lid where the stove was tending once during the modified water boiling test (described later) and another test without a lid where the stove was tending twice. Four times (with pot lids) to six times (without pot lids) is more typical

however, and of course it depends on the wood available and the user's technique. At least some larger wood, 3 cm or more, is needed to give long steady burning and keep the tending requirements this low.

The stove can heat 2 pots at once, one up to 30 cm in diameter and one up to 20 cm. The front (smaller) burner is much lower in power than the rear, but is enough to maintain the large pot at simmer if it has a lid, and is enough to bring a small pot to a boil while the large pot is simmering.

The stove has conical pot supports that make the pot very stable within the stove.

The wide base of the stove makes for a very stable stove.

The stove can heat very large pots, but under these conditions the pot is not as stable. See photo 3.

The stove can burn at least a fraction of wet wood. In some preliminary tests, wood was burned that had been pulled out of a river the previous day, in conjunction with some drier wood. In the best test with wood measurements, 33% of the wood was at 32% moisture content, and the fire ran well. This feature is still being explored, and it's likely that the stove will be able to burn higher fractions of wet wood.

Turndown ratio is a function of how the wood is managed, but the turn down ratio can be very good. In one test, 1697 Watts was delivered to the large pot up to the time of boiling, and afterwards an average of 507 Watts was delivered (the pot was simmering with a lid) for a turndown ratio of 3.3:1 based on heat delivered to the pot. The turn down ratio based on the fire power was not measured, but was probably similar. One could probably achieve better turndown by tending the stove more frequently with a large number of small sticks.

The wood typically does not burn back past the door, so if a fire is left unattended with a long piece of wood sticking partially out of the stove, the part outside the door is usually not consumed. See photo 4. Thus, very long pieces of wood can be used without cutting or splitting.

After the test there is typically 50-100 g of charcoal burning in the stove. In one test 6 liters of water was heated by 30°C after the main test was concluded.

Wood use is high. Typically about 1800 g of wood is used (more if some of the wood is wet) to complete a 2 pot cooking task. This includes bringing 5 liters to boil and simmering for 45 minutes, and bringing a smaller pot to boil. With a little more tending, the fire can be managed such that the wood use is as low as 1200 g if the pots have lids. With constant tending and with a large number of small sticks, the wood use could probably be brought down further, but this is typically not what users would do.

Thermal efficiency is low, typically about 18%. This seems to be mostly independent of the number and size of the pots.

Smoke is a strong function of fire size and the wood being burned. A large fire will usually produce black smoke, and a weak fire or a fire with wet wood will produce white smoke. This seems to be similar to other stoves I've worked with.

In the Eye Nose Test (described in the next section, basically a test to see if the eyes and nose sting while over the stove) sometimes the stove performs well, other times poorly. It can perform poorly in the Eye Nose Test even when no visible smoke is being produced.

Photograph 4: A previous similar stove at Stove Camp in Oregon. The wood on the left is 8 cm, and the wood on the right was pulled out of the river the day before this test. Note that the larger piece of wood has stopped burning at the edge of the door of the stove. The original length of this piece was over 1 meter, and was consumed over the course of 3 tests.

Test Methods

Typically, I do a modified water boiling test in which I bring about 5 liters of water to boil as quickly as reasonably possible in a pot of about 25 cm diameter, then simmer the water for 45 minutes. I do tests with and without lids because both situations are common, and I maintain simmer by maintaining at least a weak simmer, because that is what the users would do. Preliminary tests on a gas range say that to maintain a simmer in such a pot without a lid takes about 1000-1100 Watts, maintaining a simmer with a lid takes about ¼ of this. (Holding the temperature constant at 3-6 degrees below boiling, as is commonly done, takes about 575 Watts without a lid.)

I typically measure wood use and calculate efficiency for the entire test from wood use and the energy into the water, without accounting for remaining char. I measure time to boil and correct to the standard

conditions of 5000 g and 80° temperature rise. If I'm using wet wood I measure that separately. Some oven drying tests were done early in the season to measure wood moisture content. Usually the wet wood is dry wood that was dunked in water before the test, and the water weight gain is measured. In short, I have at least an estimate of the moisture content of the fuel. Efficiency calculations include a factor reducing the energy content of the wood for moisture.

I don't have the capacity to measure pollutants, and I believe most users don't much care anyway. I make visual observations of smoke and I also do an "Eye Nose Test" where I put my face over the fire and see how much it stings my eyes and nose.

One unique aspect of my tests is that I measure and note the number of times I need to fuss with the wood during the test, either because the fire is too weak to do its job, or because the fire will be difficult to stoke if I let the fire die down any more. The last situation is common when simmering with a lid, where very little fire is needed to maintain simmer.

Some testing has been done with a very large pot, and a significant number of tests have been done with 2 pots, one of 25 cm diameter holding about 5 liters and one of 19 cm diameter holding about half this amount. If more than one pot is used, the efficiency is based on the energy into both pots. For a time to boil, only the number for the larger pot is given.

At present, the stove has only been tested with liquid fire starter, either lighter fluid or alcohol. The time to get the fire going is included in the time to boil, but is usually short due to the liquid. In time, tests will be done with fatwood, plastic bags, or paper as fire starter.

Options for Use-Why is the Stove Versatile

Here is a summary of some of the options for using the stove.

Any size wood up to very large and very long. Of course, some smaller wood must be used to start the fire.

Two burners, of which the smaller one can be used or covered. The cover for the small burner is shown in photo 5, and this cover is effective is holding heat in the stove when the front burner is not needed.

The large burner can handle up to very large pots, and on either burner flat or round bottom pots can be used.

Large pots, at least up to 25 cm diameter, can be placed on the small burner and simmered if they have a lid, while another pot can use the large burner.

The user can load the stove with large pieces of wood for a slow steady fire that takes little tending, or the user can feed the stove with smaller sticks to get fine control of the fire with better turndown. With the right mix and placement of large and small sticks, a powerful fire can be created that lasts until the pot starts to boil, then turns itself down as the small wood is consumed and the larger pieces are left to provide a slow steady fire for simmering.

The wood can be placed more under the larger burner or the small, to give more or less heat to one burner or the other.

It is possible to switch burners in the middle of the cooking task. For example if one merely wants to bring a small pot of sauce up to a boil, just before the big pot is done cooking it can be moved to the less powerful front burner, and will maintain simmer if it has a lid and there is substantial fire. The sauce pot can be put on the more powerful rear burner, which it will achieve boil in a few minutes.

After boiling starts, it is possible to pull some of the wood to the edge of the stove, reducing the fire power. Typically, the wood outside the stove does not burn. Some smoke escapes from the door of the stove when this is done.

Typically, at the end of the cooking task there is a significant amount of charcoal left. A large pot of wash water can be put on the stove and it will heat significantly, with no further attention to the fire or coals. This could also be drinking water to be pasteurized.

When covered, the front burner can be used as a food warmer or a wood drier.

Photograph 5: The prototype cover for the small burner. Even this crude prototype prevents most of the heat from escaping from the front burner.

Future Modifications and Tests

Both pot supports will be the same size, able to accommodate 28 or 30 cm pots, though not necessarily 2 30 cm pots at the same time.

An ash removal tray will be added.

A version of the stove will be tested without a grate, using ridges in the ash removal tray to serve as a semi-grate.

The cover for the low power burner will be better and will serve as a food warmer or fuel drier.

A number of ideas will be tried to try to make the stove more efficient by changing the design of the sheet metal cone and pot support.

Tests will be done with other, simpler, method of starting the fire. The time to boil will probably be greater.

A 2-pot meal will be cooked.