Smoke-free Cook Stove (mud)

This project was inspired by a situation observed in Guatemala. While visiting the refugee village of El Gorrion, I found myself gagging on smoke drifting from a nearby kitchen door.

A woman was cooking on a masonry bench over an open fire with no chimney, but there was an opening in the roof where smoke could exit – prevailing winds permitting. I had seen such cooking arrangements in various parts of Mexico as well.

Next to this was a larger stove with an expanse of steel plate and a vented chimney. This was not being used because it required too much firewood. I had earlier spotted a propane stove in another room that was likewise not being used. In that case, they could not afford the propane. Here we have two well-meaning solutions to a very serious and widespread health hazard that are not being employed because of economics.

Upon returning to the States I began to define what it would take to solve this problem:

1. It must be smoke free, or nearly so.
2. It must require the same or a lesser amount of firewood.
3. It must use materials that are cheap and locally available.
4. It cannot be larger than the existing cooking area.
5. It must require little or no modification of existing cultural practices.
6. It must be perceived as desirable to the target population.
7. Tooling requirements must be cheap, and accessible in the target area.

I built a 21” square box from scraps of plywood on hand, and packed it with earth. This mass was then sculpted internally to create a burn chamber, channels for combustion air and exhaust flow, and a dual-function cooking surface. The resulting prototype serves the above criteria in a variety of ways:

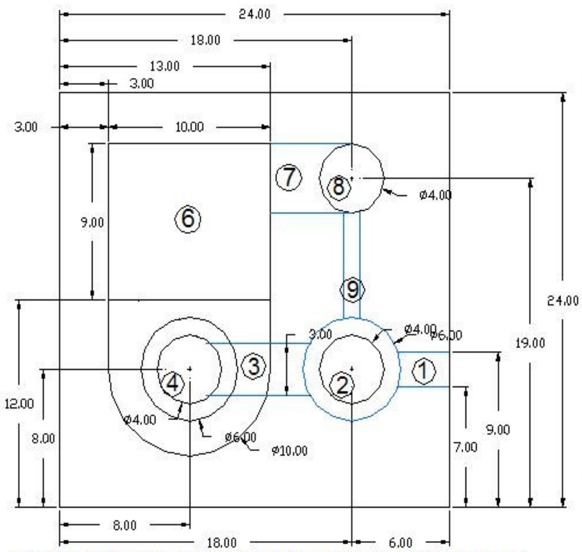
1. Typically, slightly more than 40% of the energy in firewood is in the form of smoke. By burning the smoke, less firewood is needed.
2. The fire is completely contained within the structure, so less energy is lost to convection and radiation.
3. The flue gasses are contained and directed against the bottom of a cooking vessel, rather than being free to wander around it and be wasted.
4. This exhaust then flows across the bottom of a steel plate, so that tortillas etc may be prepared while food is being boiled. Doing both of these at once instead of in sequence per tradition, shortens the amount of time that the fire is needed.
5. The fire itself is well served by small twigs and other scraps not normally useful as firewood. This greatly increases the amount of locally available fuel.
6. In addition to these five techniques for reducing expense, an externally vented flue eliminates what may remain of the smoke.
7. The prototype was sculpted from earth – available anywhere but downtown. About 10’ of 4” single-wall flue pipe is required, and also a small plate of steel.
8. The area of the top surface of this prototype is smaller than any cook surface I’ve seen in the homes I’ve visited, but scaling upwards by a few inches should be no problem.
9. This stove could be sculpted from an existing cooking bench. This would insure economy, size, and minimal impact upon cooking practices.
10. There is no way to predict the acceptability of this stove with any certainty. It may need to be demonstrated or otherwise marketed before cultural acceptability can be ascertained.

In this top view, the 4” hole on the lower left opens out to a 6” diameter burn chamber a few inches below the surface. The overall depth from the top surface is about 14”

The exhaust from this burn is taken from the bottom of the burn chamber and directed upward through the 4” hole rising in the pit in the upper part of the photo (You can see the terracotta coloring lining this hole resulting from the firing of the earth by the high-temperature exhaust).

When the plate in the upper left is placed over the pit, a pot covering the hole receives the full benefit of this blast. The flue gasses then pass under the plate and exit into the flue which is inserted in the 4” hole at the lower right.

For the benefit of any interested, I am including drawings showing the approximate dimensions of this unit. I also add a few additional notes and comments.



TOP VIEW OF STOVE SCULPTED FROM MUD
THE DIMENSTIONS ARE NOT CRITICAL

SMOKE CONTAINS APPROXIMATELY 40% OF THE TOTAL ENERGY AVAILABLE IN WOOD.

IN ORDER TO BURN THIS SMOKE YOU NEED A BRIGHT ORANGE FIRE, AND PLENTY OF AIR.

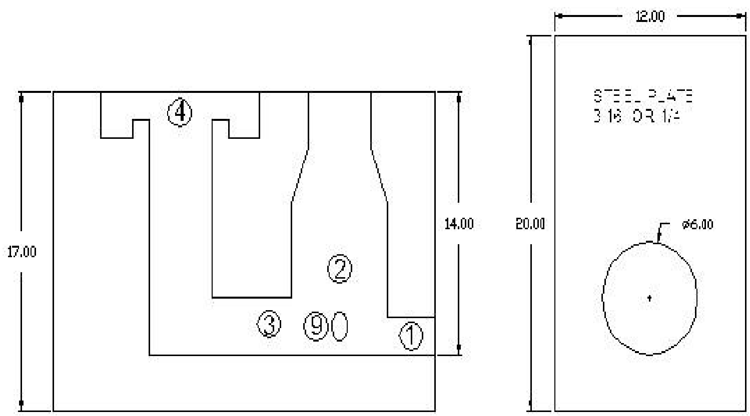
A DRAFT OF AIR IS PROVIDED BY ATTACHING A 4" (10cm) DIAMETER FLUE AT LEAST 8' TALL AT ⑧

WOOD IS FED INTO THE BURN CHAMBER THROUGH A 4" OPENING ②
THE CHAMBER BELOW ENLARGES TO ABOUT 6" AND IS ABOUT 14" DEEP
AN OPTIONAL AIR SUPPLY MAY ENTER THE BASE OF THIS CHAMBER ①

A 3" DIAMETER TUBE EXITS THE BOTTOM OF THIS CHAMBER ③ AND THEN RISES TO THE COOKING SURFACE. ④

A CHAMBER ⑥ DUG DOWN TO 10 OR TWELVE INCHES SO THAT ADDITIONAL THERMAL PROCESSES COULD BE ADDED. THESE WOULD INCLUDE SUCH THINGS AS CERAMICS, TUBING FOR HEATING WATER, AND MIGHT EVEN SERVE AS AN OVEN BASED UPON RESIDUAL HEAT WHEN THE FIRE IS OUT.

FIANALLY, THE FLUE EXITS THE BOTTOM OF THIS CHAMBER THROUGH ⑦ AND ENTERS THE FLUE.



A STEEL PLATE COVERS THE COOK SURFACE. AND PROVIDES A SEAL SO THAT THE SUCTION FROM THE FLUE CAN DRAW AIR INTO THE BURN CHAMBER.

THERE MAY BE A HOLE IN THIS PLATE DIRECTLY ABOVE THE INPUT PASSAGE. THAT WOULD BE COVERED BY A POT. OR A PIECE OF METAL

A SMALL PASSAGE ⑨ ANGLES UPWARDS FROM THE BOTTOM OF THE BURN CHAMBER DIRECTLY INTO THE FLUE. THIS IS TO GET THE DRAFT STARTED. AND CAN BE CLOSED WITH ASHES AS THE FIRE BUILDS. ALTERNATIVELY. A SMALL FIRE COULD BE STARTED DIRECTLY UNDER THE FLUE.

SECTION THRU COOKING SURFACE AND BURN CHAMBER

Adjustments:

The photos above are of my very first attempt at this type of stove. Although it seems to work very well, there is currently no base of application experience (other than a test that showed it could boil water faster than our modern gas stove in the kitchen).

Materials

This original was made from earth far more suited to gardens than structures. I would recommend trying a mixture of coarse sand, clay, and maybe some dried grass mixed in – here's my reasoning:

1. Without some clay, the soil will crumble too easily, even when completely dry.
2. If it is pure clay, the thermal stresses and drying will create cracks, and possibly explode pieces off from the insides of the chambers and passages.
3. The grains of sand will not expand and shrink with temperature changes as much as the clay, and changes in moisture will not affect them at all. This will help stabilize the mixture.
4. Cracks attempting to propagate through the mass will be frustrated by constant detours around the grains of sand.
5. I am uncertain as to the optimum ratio of sand to clay, but feel it should be just enough to glue all the grains of sand together. I don't think the ratio is very critical, but I would expect that

about three parts sand to one part clay would be an acceptable starting point – almost anything would be better than the garden soil I used.
6. The dried grass would permeate the mass with small tubes as it decayed, and was burnt out. This would increase the insulating properties, relieve thermal stresses, and terminate cracks. This could be very important when higher ratios of clay are used.
7. Perhaps a higher percentage of clay with a small amount of cement added would be a good as a plaster for hardening the top surface.

Tooling

In seeking to verify the simplicity of this project, I filed a chisel edge on a 2-foot length of 1/8" X ¾" mild steel to use as a sculpting tool. It was quite effective. I also used a simple screwdriver to define internal passages. The entire project could be well served by these simple tools.

Skill and patience could have created the nice round holes you see in the photos above, but having neither, I designed and fabricated the 4" diameter auger that actually produced them. It may sometimes be desirable to sculpt such a stove from an existing cooking platform. I was able to drill my auger through a well-dried experimental block of one-part clay to two parts sand, and use the chisel mentioned above to sculpt a well defined notch in it. This approach appears to be quite practical. In cases where an existing cooking platform is brick or concrete, a hammer and a tool-steel chisel may be required.

Although the auger was only about two-feet long, the shaft was made of ½' all-thread, topped by a handle that could be unscrewed. This enabled me to add extensions if I ever needed a deeper hole. A stove-related application of this could involve boring down through a common 3'- thick adobe wall. Care must be taken however to adequately cap such a chimney so that water could not enter and deteriorate the wall.

Principles

In order to burn the smoke (and render the additional 40% of the available energy I mentioned), you need a bright orange fire, and plenty of air. Therefore a stack of at least eight or ten feet is essential to create a strong enough draft.

This must also be coupled with a good seal between the burn chamber and the flue. Air leaking under the edges of the steel plate, and from around the pot or plate sitting over the hole in the plate can significantly reduce the stove's effectiveness.

During the burn it would be well to cover either the hole above the burn chamber, or the vent that comes in from the side (the top could be covered by a second cooking vessel for that matter).

In the photos and drawings you can see that the pit is shallower on the end where the flue gasses enter. This is to force them closer to the bottom of the pot. By creating a raised ring around this opening (visible in the drawings but not in the photos), the pressure against the gasses can be relieved immediately after their application to the bottom of the pot. This allows for a better draft.

The intent of the pit is to allow for further options and experiments – consider:

1. I have already been able to fire a simple clay structure in a second prototype with a larger pit. Any household using such a stove could also dabble in ceramics.
2. If the deep end of the pit were 14" X 10" X 7", you might be able to fire a brick 12'X6"X4" (30cm X 15cm X 10cm) every time you cooked. By the end of a year just one brick per day would give you a wall a meter high by at least three meters long. A community project could doubtless be served within weeks.
3. Bricks of this size could span the pit, creating thermal storage and insulation that would allow the pit to serve as an oven after the fire was out. Indians of the Southwestern United States

would cook their bread by building a fire in a clay oven, then removing the ashes, and inserting the dough.

4. A fire could be built in the pit itself to roast meat in a vented barbeque.
5. Piping could be installed to heat water in a tank elevated adjacent to the stove – a primitive kitchen with hot running water!
6. A Stirling-cycle engine could be run off this scavenged heat to produce enough electricity for modest lighting – enough! I'd better stop before I get too far out of hand, but I still have a lot more ideas.

I am certain that needs and local inspiration in the field could contribute much to this project, and I would be quite eager to hear of anything related to this that may occur in any part of the world. I am also quite interested in discussing appropriate technology needs that may arise from any quarter.

In closing

It is ironic that while in the United States we are seeking to wean ourselves of a petrochemical addiction, the poor in developing nations might leapfrog past us to a high quality of life, while maintaining a locally sustainable infrastructure. This might also become an option for our homeless.

This cannot happen unless attention is given to growing fuel locally. This stove can effectively use twigs unsuitable for current cooking fires, and it can thereby decrease the wait between planting and harvesting of fuel. In this case, it would make sense to fill in fence rows and any unused spaces with fuel plants.