Mandeleo improvement (abridged) in Rongai, Kenya

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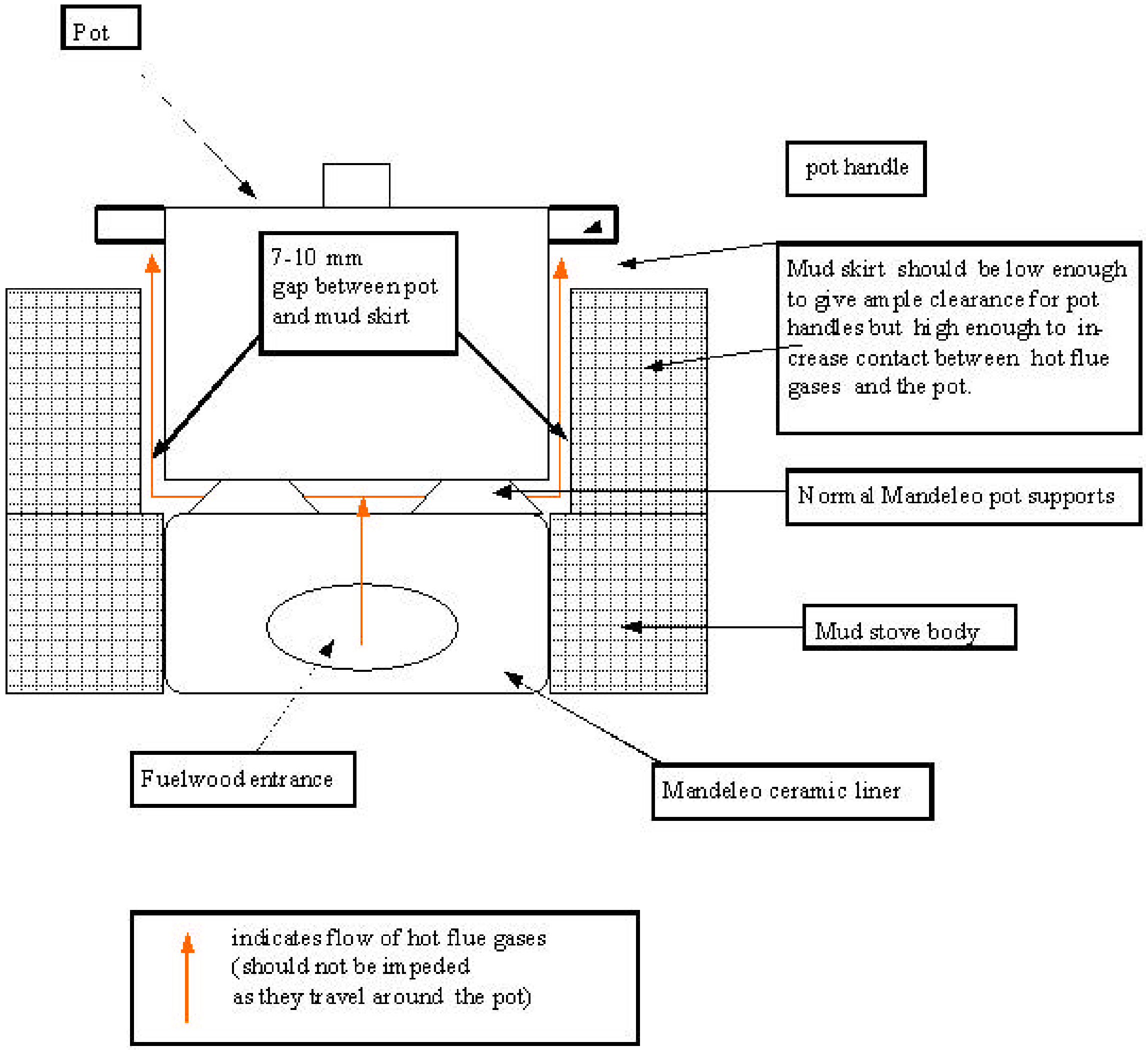
3.0 Improving the Mandeleo

As we discussed during my presentation the simplest way to improve the efficiency of the Mandaleo – at least for installed (non-portable version) is to design the stove so that the **pot is submerged into the stove**.

Our research has shown that a shielded fire can reduce fuel consumption by half. In our tests, in which we compared a traditional 3 stone fire to the simple shielded fire (shown above) made from anthill soil, PHU efficiencies increased from 15.5% to 31.2%. By forcing the hot flue gases through a narrow gap between the pot and the stove body, more of the heat is forced into the pot. This stove doesn't require a ceramic liner (it can be made with straight anthill soil) but if one were to be used, it would look something like this:



A few things need to be considered when submerging the pot into a mud-stove skirt

1. The mud skirt, which the pot will sit into, should be designed for the largest, most common pot. Smaller pots, will fit into the stove an receive some benefit, but will not have the high fuel efficiency that the larger pot will have.
2. The gap between the mud stove skirt and the largest most common pot should be approx 7 – 10 mm
3. It is very important that the flow of hot air is not impeded. Sometimes people think that they should seal the top of the skirt, mistakenly thinking that it will "trap heat". This is not the case. It will merely stop the stove from working. Convective flow is necessary for the stove to work!
4. The stove body should be made from anthill soil. To prevent cracking the mixture should be as dry as possible while still being workable. Some shrinkage is inevitable so it is important to make one prototype, measure the stove after it has dried, and then calculate total shrinkage. Then shrinkage can be accounted for in future stoves.

5. The stove body should be allowed to dry for at least 2 weeks before use. It should be covered with cloth or plastic for the first week and then uncovered for the last week. This is assuming 'normal' humidity conditions; during the wet season drying times should be increased.
6. The stove walls should be wide enough to resist breakage. 3-10 cm should suffice but some experimentation might be necessary. A 3 cm thin wall will steal less heat from the fire but will not be as rugged as a 10cm thick wall .

This configuration will decrease fuel consumption by about 50% as compared to an unshielded Mandeleo. It will not reduce emissions in and of itself - to do that you would need a rocket combustion chamber - but it will decrease emissions on a per MJ delivered basis (i.e. it will use less fuel so decrease exposures).

Improving the ceramic liner

Different groups have worked for more than twenty years on the clay liner. The problem of working with different clays is that each clay has different properties (various amounts of silica, magnesium, iron, feldspar etc) so although a certain recipe may be successful in one area, there is no guarantee that it will work in another region that uses a different clay. That said, I would suggest a starting point of using 75% clay, 25% grog and 5 % sawdust. (Yes this adds up to 105%!)
The clay should be dried, pounded and then sifted through a 2 mm screen . The grog should be fired, pounded and sifted through a 2 mm screen. The sawdust should also be put through a 2 mm screen. This recipe has proven very successful in Zambia.

4.0 Rocket Stove Prototypes

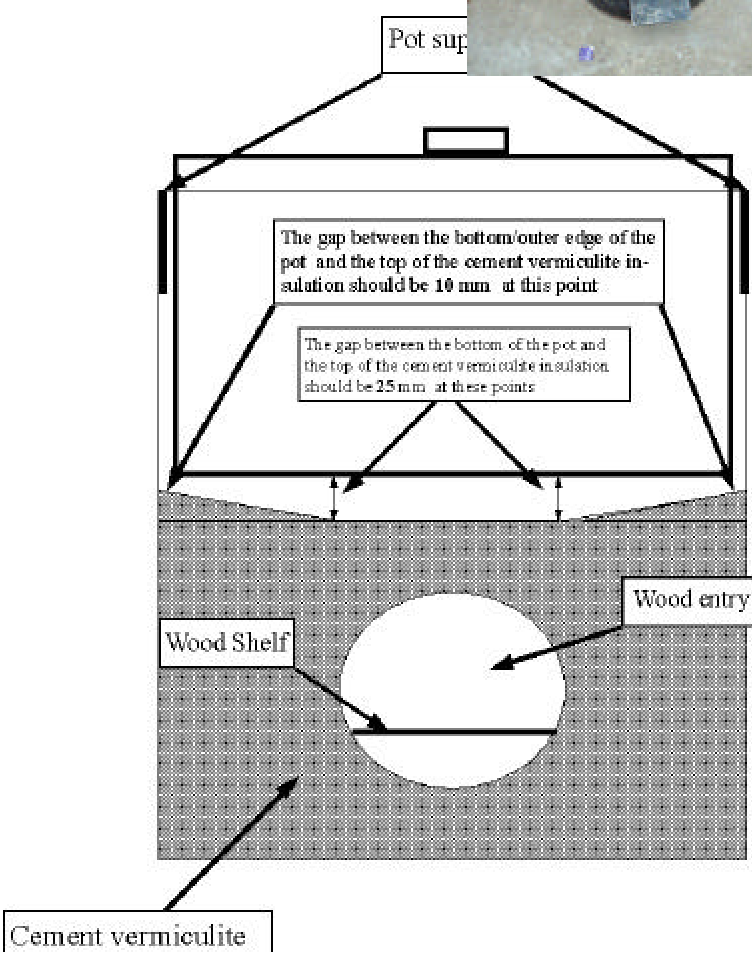
4 stoves were built for the women of Rongai

3 of the stoves were made from sheet metal and the fourth stove (far left) was made from a used paint bucket. Note the 6 pieces of 8mm bar that are welded on to the inside of the stove. The stove could be made from metal or from ceramic. Obviously there wasn't sufficient time to make ceramic bodies but the metal prototype will give a sense of how the stove will function.

The stoves were designed to fit one size pot.
Just as with the Mandeleo, the stove can be designed to precisely fit the largest, most common pot while allowing other smaller pots to also fit inside but with a slight loss of efficiency compared to the larger pot.

This stove would be suitable for households and for market vendors who use the same pot everyday, all day to cook chips or other non roasted food items. These vendors spend a minimum of 50Shillings /day so have an added incentive to purchase a fuel saving stove.

Notice how the 8mm pot supports create a consistent gap around the pot which allows for the even flow of hot flue gases around the pot.



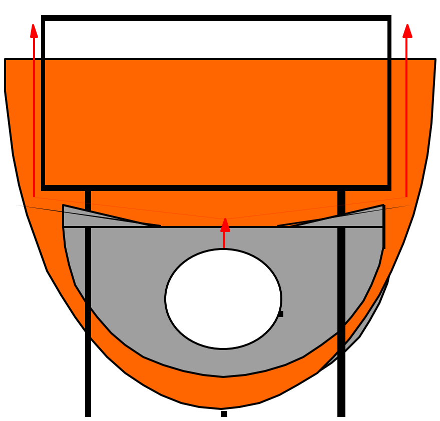
This is a schematic of the inside of the stove. The traditional rocket stove has a taller combustion chamber that increases combustion efficiency
(and decreases smoke production). This is a simpler version that is designed for optimal heat transfer **not** combustion efficiency.
Ideally this stove would be used outside or in a semi enclosed structure

The combustion chamber is made using the cement/ vermiculite that is lightly tamped around a 100 mm pipe. The pipe is then removed, thus forming the fuel magazine and combustion chamber. In other countries we have used a ceramic body made from sawdust/clay for the combustion chamber/ feed chamber

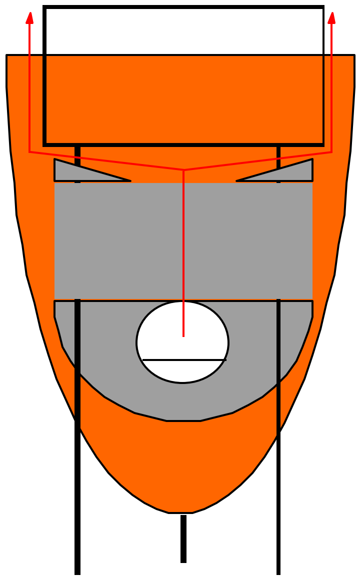
4.1 ceramic body Rocket stove

Instead of using metal for the outer stove body, it could be made from terracotta/bisque fired pottery with a refractory clay/sawdust or cement/vermiculite insert. This would have a number of advantages to the existing Mandeleo - higher fuel efficiency, longer life span and less smoke.

One of the challenges of the Mandeleo liner is that it requires building a kiln that can fire to 950C. From my conversations with Daniel and James I understand that it has been difficult for these kilns, especially the un-insulated ones to reach that temperature throughout the inside of the kiln. Using a lower fired clay liner with a cement/vermiculite inside would help to mitigate this problem.



Here is a schematic of the terracotta Rocket stove body with the refractory liner/combustion chamber shown in gray. As with the metal version , this stove would be ideally used outside or in a semi enclosed structure



Here is the same stove concept but with a taller combustion chamber. This stove is optimized for combustion efficiency and heat transfer and so it could be used both indoors and outdoors. Obviously its greater height and larger refractory liner would increase the cost of the stove in comparison to the shorter version.

<u>Institutional Rocket Stove</u>

Old CWWC kitchen

New two pot rocket stove

I thought that one of the best ways to demonstrate the potential for improving the Mandeleo stove was to leave a couple of models (institutional and household/portable) behind so that people could actually see the benefits of the rocket principle. I could imagine that without seeing functional examples it would be less inspiring to invoke a new design concept at any level. If CWWC is impressed with the institutional stove once it has been proven in the kitchen then the move to take the concept and apply it in some form to the household stove is quite simple.

Please see the attachment for design specifics.

The retail price of this stove was estimated at approx US$100-200.
The orphanage spends approx US$ 200 /month for fuelwood
In other countries in Sub Saharan Africa, users have reported a 50-93% reduction in fuelwood. This would suggest that the stove could pay for itself in one to two months.

At the very least this institutional stove will demonstrate the fuel savings that can be realized by submerging the pot into the stove.

The Fireless cooker

I was impressed with the Fireless cooker design. It had all of the features that I would recommend: scrap wool insulation, a protective plastic liner and a locally produced basket. My only concern was that the price (800 Shillings) was quite high. More research needs to be done to decrease the price of the raw materials for the cookers. This could involve having the CWWC women's group make their own baskets instead of buying them or use a cheaper fill material. Because they are using a heavy plastic liner that will protect the insulation, they have a wider option of materials that they could use. They could, for example, use banana leaves or even newspaper, instead of wool.

On a positive note , if the women of Rongai will pay 800 Shillings for a fireless cooker than one would assume that they would pay more than 250 Shillings (the current price for the Mandeleo) for a super fuel efficient improved stove that optimized combustion and heat transfer efficiency