Technologies For Biomass Utilization

PART 5

Combustion Gasification & Propulsion Laboratory

Department of Aerospace Engineering

Indian Institute of Science

Bangalore 560 012

Stove performance indicators

- Reference features used for comparison

1. Heat utilization efficiency – standard water boiling test (and cooking test, if possible)
2. Is there awareness of moisture and size effects
3. Operability - start up time, variation in power on demand, and shut down time
4. Acceptability of a variety of bio residues with minimum preparation.
5. Life and first cost of the stove

Phillips stove – recent development – Feb 27, 2006

When properly used the woodstove typically reduces fuel consumption up to 80% compared with traditional, three stone fires……The secret to many benefits of this stove is an electronically controlled fan forcing air through the stove, leading to higher temperatures and a better fuel to air ratio. This results in cleaner burning and more efficient use of fuel. A thermoelectric generator using the heat from the burning wood generates electricity for the fan….. Philips Research also optimized the construction of the stove for low thermal mass and good insulation. This ensures that the stove takes less energy to heat up, decreasing the time to get to cooking temperature, and makes sure the stove loses less of its heat to the surroundings.

Phillips stove - observations

- The fire in the stove appears as a diffusion flame with tongues of soot – nearly all the time
- The firewood size is uncontrolled as is visible – remember the golden rule – $1/6^{th}$ to $1/8^{th}$ size is violated substantially. It is not obvious moisture effect is paid attention to.
- The poor combustion quality is consistent with the firewood sizing.
- No statements on water boiling efficiency.
- Other aspects like using thermoelectric effect for getting electricity are options for which more economical solutions like a rechargeable battery powered fan exist.

The Aprevecho stove designs

THE WINIARSKI ROCKET STOVE

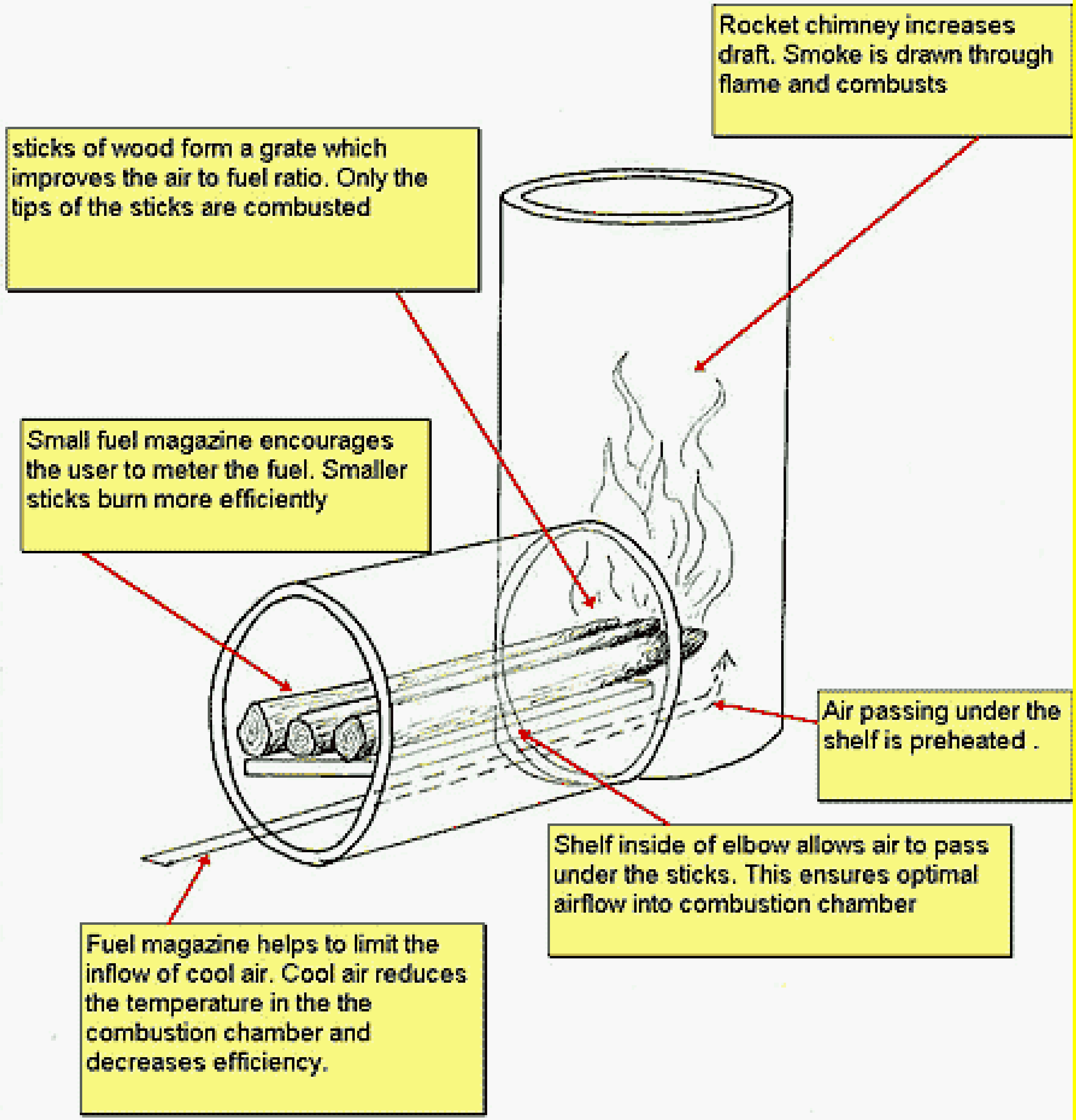
In the last 13 years, variations of the Rocket Stove were built in over 20 countries.

- Efficiency: 12-42%. The efficiency depends on type of a heat exchanger used.
  Construction: Simple to construct with a number of different materials. The simplest Rocket Stove can be built with thick tin cans and wood ash (5,000 of these were built in refugee camps in Zaire).
- Material costs: $0-$20 US. In Honduras we made a simple refugee version of this stove for approximately $1.50 US in material costs.
- Life expectancy: Is 2 weeks to ten years depending on the materials used.
- The Rocket elbow can be made from different materials to improve its durability – sand/clay (Lorena), pumice/concrete, heavy steel pipe, 430 stainless steel or special heat resistant eramic. Currently all the stoves in Honduras are built with this type of refractory ceramic.

(From their website obtained by google searching for Aprevecho stoves)

The Rocket Stove

(from their web page)



Aprevecho stove - efficiencies

Three stone fire **1** pot = 11%, Rocket stove = 13%

Rocket Stove /Partial skirt = 23%, Rocket stove full skirt = 36%

Lorena **1** pot = 5%, **5** pots **= 1**0%, Estufa Justa **1**pot = 5%, **3** pots = 16%, **5** pots = 20%

Estufa Justa de dos hornillas **1** pot = 10%, **3** pots = 23%, Justa profunda **3** pots = 35%

Test Protocol:

Use two pounds of dry wood. FIll pots 2/3 full, in this case each held 5 pounds of water. Assume that two pounds of of dry wood contains 17,200 Btu's. Measure the effect of the burning by measuring both sensible and latent heat. Latent heat is measured by weighing water after the test. The percentages shown above are the percent of toatal Btu's released from from the wood that warmed and boiled the water in the pot(s).

Aprevecho stove - Observations

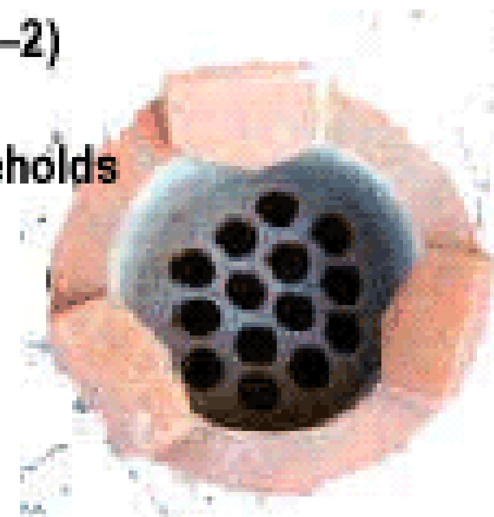
- The combustion process is direct.
- There is not air-to-fuel ratio control on the combustion process.
- Heat conservation is what that has been attempted with understanding

Considering the fact that they have been in the development and dissemination for a long time, I think they could benefit from improved designs substantially. Also, on the question of cost, while it is true that it should be minimized, there are communities that can afford to pay a price that can bring in efficiency.

Traditional Cook Stove

Lao Bucket Stove – TLBS

Material	:	Metal covered baked clay
Production	:	Semi manual
Size	:	Multi size
Specification	:	Portable (weight 3 – 8 kg)
Price	:	2,000 – 8,000 riels (US$ 0. 5 –2)
Usage rate	:	40%
Main users	:	Urban and peri-urban households
Fuel	:	Charcoal
Efficiency	:	25%
Dissemination	:	Commercialization



Laos stove

- Charcoal stoves should be able to deliver much higher efficiency.
- Heavy stoves tore more heat (Aprevecho web site discusses this considerably)
- The process of getting charcoal is inefficient.
- One could do with torrified biomass rather than charcoal (torrified biomass – white charcoal obtained by cooking biomass at 200 to 250 C for several hours)
- These observations are relevant for several other stoves in Africa also.

Experiment in Japan

Japan makes itself unpopular worldwide by throwing away 130 million pairs of disposable wooden chopsticks per DAY!!! -- made out of other people's forests, not their own. Some countries are being seriously deforested because of Japan's throw-away chopsticks. The Japanese are not unaware of the problem, but not a lot gets done, beyond tokenism (such as a disposable chopsticks wrapper from one of the ubiquitous convenience stores, bafflingly labelled "Ecology Earth Effort")......

We propose burning them in an improved cookstove. Preferably it should be a stove that a school class could make in a few hours, preferably out of "tincanium" (millions of waste tin cans in Japan, they get recycled but it's a good part of the lesson) -- but this isn't essential, it's more important to have a design that works well. If too difficult for a class to make, it could perhaps be supplied in kit form. Mainly it has to work without fail, and without gassing everybody while cooking the rice for a school lunch.

Experiment in Japan, contd

Work so far

We used Tom Reed's basic two-coffee-cans design as a starting point, but scaled down. See **A Wood-gas Stove For Developing Countries**, T. B. Reed and Ronal Larson (268k Acrobat file)

We're still not sure whether such stove designs can be scaled down effectively this way, but this first design was beginner's luck -- very rough-and-ready, just to see if we could do it, but it worked surprisingly well.

It was made out of two 400g tomato cans, one with lots of holes punched in the bottom and a primitive slider to control the air supply, the second can with bottom removed and fitted on top of the first can, with a small gap. It burned for half an hour, and left us with a nice pile of charcoal sticks.

Experiment in Japan, contd

….This stove works much better. It certainly burns well -- rather too well: flames roar up much higher than the rim of the top can. It takes 50 pairs of chopsticks, cut in half, weight 200 grams, standing vertically. It burns for 25 minutes to half an hour, and will boil half a litre of water from 15 deg C in four minutes. It leaves 20-25 grams of charcoal.

But it smokes a bit, sporadically, obviously tars and CO are being released -- not healthy. The flame is yellow-orange, tinged with blue. The jet from the centre pipe seems to work best, with more of a blue flame mingling with the yellow-orange from the heated air coming in from round the side. It seems to work rather better as the fire progresses down the can towards the bottom. Near the bottom it works really well…….

I tried using a wick, inserting a smaller can into the top can, but didn't get anywhere with it, it didn't work at all.

Any advice would be very welcome indeed! Please send suggestions/comments to:
keith@journeytoforever.org

Keith Addison, ourney to Forever, Handmade Projects