Understanding Stoves

Dr. N. Sai Bhaskar Reddy, CEO, GEO
http://e-geo.org

Contents

Although there are various methods of testing the stoves, the most important testers are the users. The multiple factors for a successfully adopted stove in time and space also vary. In the last two months, I have done about 100 tests for some of my stoves, followed WBT 4.1.2 methodology. Since last 7 years, had been designing stoves, testing them, training on stoves, getting the community (user) feedback etc., some of my experiences, observations and insights into the stoves are as such.

Testing the stoves involves not only following the standard procedures but also the tester having the experience. Apart from the values, the testers experience would help a lot in designing good stoves.

Fuel wood

Size of fuel wood: It was observed that for fuel many testers chose thin sticks. In our region people chose wood of 1.5 inches to 2.5 inches diameter. The wood is never split perfectly into square cross sections, as usually one uses during the testing of stoves. Splitting the wood into thin size say 2 cms x 2 cms is very difficult and consumes energy and time. The length of the wood is usually about 1.5 feet to 4 feet. Bundling and transportation of the cut wood is not convenient if the wood length is too short. Sometimes the wood carried by head loads is very long say about 5 to 8 feet in length. The women / men balance the wood on their heads, to carry it. In a tribal area, people use trunks of wood without cutting as fuel wood, they are often 6 to 12 feet in length and nearly 4 inches to 12 inches in diameter. The trunks of wood as fuel is a common practice for many institutional stoves. Such usages are commonly found in the habitations located in the forest areas / in forest fringe areas.

Type of wood: Different types of wood are available such as Neem, Accacia Nilotica, Prosopis Juliflora, etc.

Wood moisture: In many tropical and semi-arid environments on a dry day the wood moisture varies between 12 to 18%.

Very thin wood <1 cm is used for kindling. Sometimes kerosene is used (about 5 to 10 ml). Thin wood is not preferred by communities for cooking (except for kindling). Thin wood burns conveniently with very less smoke, but sometimes they yield soot. The stove users does not like soot deposit on the utensils and on their walls. The bark of the wood although good for fire but sometimes leads to excess sooth emissions. The kerosene added for starting the fire, leads to conspicuous soot emission.

Size of the stove:

In our region, 8 inches height of the stove is ideal. Any stove too high about 12 inches or more is inconvenient. Women prefer sitting comfortably on the floor and cook. Many of the activities done by women in the rural areas are by sitting. Especially while making rotis, they prefer the low height of the stove. Scientifically the chimney effect would help the smoke to burn in tall stoves. But, as per the ergonomics and local practices, it is not convenient to the user. Sometimes a scientist is successful in the lab, but fails at the community level. Often the pan for making rotis is about 10 to 12 inches in diameter. In a 4 inch diameter stove, the stove should be operated in high power for the flames to spread underneath the pan for complete burning of a roti. The diameter of the stoves about 7 inches is ideal for different types of the utensils used in the region.

Two of my stove designs were a failure due to small diameter of the stove and also being tall. As a designer there is a need to balance between the science and user requirements (including ergonomics and many other factors).

Stove life and efficiency

The thermal efficiency is also dependent on the mass of the stove. The light weight metal stoves are thermally more efficient, especially during the cold start phase. During the hot start phase they show slight improvements in thermal efficiency. Heavy stoves are thermally less efficient during the cold start phase. During the hot start phase of testing, heavy stoves having the retained heat, show better efficiencies. A compact stove is more adoptable then, the stove with more movable or removable parts. It costs more to make stoves with two or more materials.

Insulation and refractory are two important factors in a stove design. Getting a material which has both the properties is of great value. The refractory material available in the markets (aluminum and iron based bricks) are heavy and bad insulators. But the life of the stove is guaranteed for even 10 years. The thermal efficiency goes down. The cost of the stove goes up because of the cost of refractory bricks and excess weight of the stove. Heavy stoves are difficult to facilitate. The volume of the stove and the surface area of the stove increases relatively for more durable stoves. There ought to be loss of heat due to radiation for durable stoves.

Air is the best insulation material. Even by using the thin metal sheets for combustion chamber (with air holes - side air / secondary air hole features), the life of the combustion chamber can be increased. For safety another thin sheet can be used as external wall. The surface area of contact between the hot parts and other parts of the stove should be least. By using pointed or thin screws, ceramic watchers, the heat transfer to the outer body can be reduced. Often between the inner and outer walls insulation material is filled. The contact between the grate and the stove body should be least. This can be achieved through pointed supports for the grate.

For facilitation to wider geographies, the convenient weight of the stove is around 2 to 4 kgs. The stoves weighing more than 10 kgs, are the most difficult stoves to sustain as an enterprise. It is even more difficult to sustain the facilitating team, if the stoves weigh more. The stoves facilitated through subsidies / stoves facilitated through the schemes are often heavy. Majority of the stoves available in the market and sold on a large scale (although inefficient) are always light. These stoves being light also cost less and are also less durable.

In heavy stoves, it is convenient to sustain the simmering test as compared to light weight stoves.

Removable grate:

The holes in the grate should be small and at the same time should not affect the life of the grate. Too much primary air / too little air underneath the grate affects the stoves performance.

Capacity of the domestic stove:

A domestic stove often serves on an average about 5 members in a family. The same stove should also support if there are more number of guests on occasions say 10 members. It is very difficult for many families if they can’t have this flexibility of cooking. The range of cooking pots used are of 1 to 5 liters capacity.

Charcoal in the stoves

Many stoves achieve higher efficiencies because of continuing to consumption of charcoal in the stoves (including the TLUD stoves). However during the testing of stoves, one of the most difficult tasks is weighing the charcoal as the water reaches boiling point. Dousing the flames is convenient when the wood is pushed into the sand. Scrapping all the charcoal from the wood is a difficult task. Some time is lost in the process of weighing the charcoal, weighing the wood and the water in the pot after boiling.

Charcoal yield

The charcoal yield from Magh 3G stove is around 15% by weight. For TLUDs the yield is about 25%.

Cooking conditions

In the semi-arid region, cooking is often done is semi-ventilated conditions. The cooking pots are closed with the lid while cooking. Sometimes for stirring / during simmering of rice, etc. the lid is opened or semi-closed. While making Rotis the pan is completely exposed. Utensils used for cooking vary: i.e., pots are cylindrical, taper from mid way of the pot, semi-spherical, or bowl shape, etc. For the WBT test, cylindrical utensil of about 3 to 3.5 liters capacity is used.

Time of testing

If the tests are conducted at the transition phase of sun rise / sun set, the air temperature changes are very fast. Sometimes chill effect will be there on the stove and the pot. The places selected for testing are not completely closed, so there could be influence of the local weather and other environmental conditions. The ideal time for testing the stove could be other than those two timings.

Flame

The observation of the flame is very important, for which the photographs would be more useful then the videos. In a dark room the observations about the stove performance can be more convenient. Blue flame is best visible in the dark conditions.

Rushing and dancing flame

There are two types of flames, rushing flame (as in rocket stoves) and dancing flame (say as in Magh 3G stove). Rushing flames are common where there is chimney effect and also due to chimneys. In the rushing flame stoves, although the flames appear dynamic and impressive, but the conduction of the heat to the pot is low. Where as in dancing flame stove, there is through mix of air with the combustible gases, and the flame takes its time without rushing to combust the gases underneath the pot. Therefore the heat conduction to the pot is high.

Color of flame

The reddish color flame yields more soot. The yellowish-red color flame is common. The bluish-yellowish-reddish flame is good. (Observing the flames is the best experience, one could spend hours just watching the flames, because the color is energetic and flames are dynamic change their form continuously),

Air for combustion

There are three sources of air possible for a stove : - Primary air, Side air and Secondary air.

Primary air

This air is mainly from the bottom of the grate / underneath the wood. Excess of air flow will, lead to excess / uncontrolled combustion. Primary air is always required in less quantities. If this air is preheated before reaching the wood it will make the stove perform better. The embers at the bottom of the grate, sometime after preliminary combustion are very much useful for preheating the primary air.

Side air:

In majority of the traditional stoves this is the only source of air. From the fuel feed opening this air gushes. In three stone stoves from all the three sides this air gushes. Too much of this air in open air conditions has dampening effect on the flames. Controlling gushing side air is also important. If the mouth of the fuel feed is completely closed due to over feeding of the stoves by wood in traditional stoves, sometimes leads to extinguishing of the flame and release of excess smoke. Using side air shutters is a good idea. Using simple small holes on the sides, as given in Magh 3G, would also help. In efficient stoves the fuel feed opening should be reduced, as already primary air facility is given.

Secondary air

For all TLUDs this is an important feature. This feature can also be given to the domestic stoves (as compared to TLUDs, few holes can be given), which helps in complete combustion of any smoke otherwise left. In the efficient stoves without chimney effect, this is a very useful feature.

Note: It is convenient to use a stove in open air conditions with all the three air features (primary, side air and secondary air), as compared to other stoves.

Gap between the grate and bottom of the stove

In the domestic stoves, the gap between the grate and the bottom of the stove could be around 1.5 to 2 inches. Seldom people remove ash while cooking, and ash being a good insulator, it protects the bottom of the stoves. The embers falling beneath the grate helps in preheating the primary air. In any case the movement of the primary air should not be blocked.

Who can test the stoves?

Anyone can test the stoves. One need to have some experience of preparing the kindling wood, lighting the stove, tending the fire, taming the flames, choosing the wood, feeding the wood, observing the fire, all that is needed apart from cooking which means nearly 10 ways of preparing the food. (Roasting, frying, boiling, steaming, mashing, simmering, etc.). For WBT tests one should know only Boiling and simmering. Biomass stoves are different as compared to other stoves. The most difficult stoves to learn and operate are biomass stoves. Sometimes cooking on biomass stoves is like caring babies.

Best way to learn cooking is to start with the three stone stoves. Anyone who can reach thermal efficiencies of around 30% with a three stone stove (in closed conditions) is an expert. Everyone need not be an expert for testing stoves. Patience and interest are the two most important factors in stove testing. Best way to learn cooking is by observing and learning from the experienced people. Operating a stove professionally for the first time using a manual is difficult.

Highest thermal efficiencies are achieved in lab conditions and only by the experts. Most often highest thermal efficiencies achieved are reported by the stove facilitators. But thermal efficiencies achieved by operators with different experiences and conditions are not reported. Sometimes, stoves reported by a producer are so high, but they fail to pass through a countries specific test. Rating the stoves by “stars” is important, because people buy different types of stoves for various reasons.