16

Urban Energy Technical Note

Gasifier Stoves

Gasifiers produce wood gas which is a syngas fuel which can be used as a fuel for furnaces, stoves and vehicles in place of petrol, diesel or other fuels. During the production process biomass or other carbon-containing materials are gasified within the oxygen-limited environment of a wood gas generator to produce hydrogen and carbon monoxide. These gases can then be burnt as a fuel within an oxygen rich environment to produce carbon dioxide, water and heat. One of the main uses of wood gasification has been to power internal combustion engines. Wood gas stoves are actually wood gasifiers designed to produce heat which is ideal for cooking and meeting other heating needs.

There is a broad range of existing gasifier stove designs and development is on-going. In the ever-increasing areas where charcoal and firewood are becoming scarce and/or expensive, gasifiers will be of growing relevance as an option for the clean burning of alternative biomass fuels. The wood gas or gasifier stove is a simple and reliable solution for bringing down fuel costs. It is an advanced version of other biomass based improved cookstoves (ICS) and converts solid biomass into clean combustible gas (producer-gas) by means of a process known as thermal gasification. Gasifier stoves approach the concept of generating heat from wood and biomass in a completely different way, separating the generation of combustible gases from their subsequent combustion to create cooking heat. Gasification advantages have been known for a long time but only recently could they be reliably accomplished at the sufficiently small and micro-scales appropriate for household stoves.

Gasifier stoves that use the natural draft principle can be designed in two ways.

1. Single Unit Stove where one cooks first with pyrolytic gases which are normally created on the spot from dry biomass using the TLUD (Top-Lit Up Draft) technology. In the process, charcoal is formed which is then dumped into a charcoal stove for one to continue cooking.
2. Two Unit Stove combines TLUD pyrolytic gasifiers (which make charcoal) and charcoal stoves (which consume charcoal). The stove starts with almost any type of dry biomass as fuel for gas-style cooking while making hot charcoal that is subsequently burned to continue the cooking on a charcoal stove that is the base of the bottom unit.

Fig. 01: **How a gasifier stove operates**

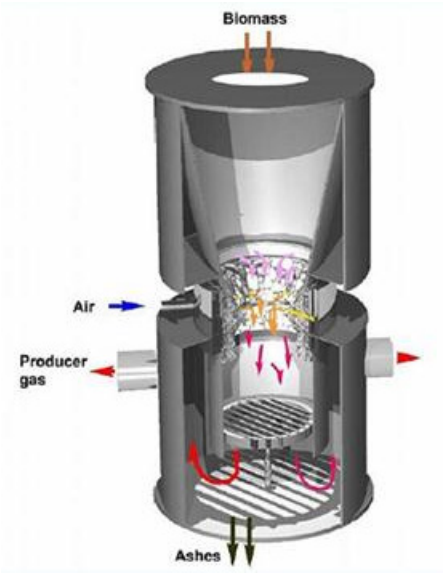


Fig. 02: **Field demonstration of a gasifier stove in Uganda**

Operation of a Gasifier Stove

The term Top-Lit Up-Draft (TLUD) denotes the two key characteristics of these types of gasifiers. TLUD technology utilises a vertical container with dry biomass fuel ignited at the top, causing the twin processes of pyrolysis (thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen) and carbonization (conversion of organic substance into carbon or a carbon-containing residue through pyrolysis or destructive distillation) to progress steadily downward. The gases move upwards and as they exit the stove they are combusted in a flame appropriate for cooking. In TLUD gasifiers, the fuel does not move (except by shrinkage when pyrolyzed). Instead, a "pyrolysis front" moves downward through the mass of fuel, converting the biomass to char. Unique

among the gasifiers, TLUDs do virtually all of the biomass pyrolysis or wood-gasification before doing appreciable char-gasification. The transition between the two phases is quite distinct, changing from a characteristic yellow-orange flame (from burning tarry gases) to a smaller bluish flame that denotes the burning of carbon monoxide. The hot charcoal accumulates in the container until the batch has ended, when it should be transferred to a charcoal stove for continued cooking, or to a container where it is extinguished.

Operating 2-unit Stove

The lower part of a 2-unit stove is called a base unit or bottom unit." It is a charcoal burner that has sidewalls to contain charcoal over a grate which provides air inlets from underneath.

The upper part of a 2-unit stove is called the top unit or the gasifier. It is normally a vertical cylinder to hold dry biomass fuel so that it can be ignited at the top in typical TLUD fashion.

The biomass is loaded and ignited at the top as in standard TLUD stove operations. The fuel is carbonized by a descending pyrolytic front, which is the most distinctive characteristic of TLUD technology. Being a batch operation with user-determined conditions including fuel type, fuel quantity, and air control, the simultaneous processes of pyrolysis and carbonization occur while there is an appropriate flame from combusting "woodgas" delivering heat to the cooking pot.

When the woodgas flame ends, the top unit can be carefully lifted off and the charcoal created spread within the T-Base unit, which is then used as a charcoal stove to continue the cooking. Additional charcoal can be added as needed. Because the wood gas stoves operate in two distinct phases; (a) as a TLUD device with pyrolysis while saving char; and (b) as a charcoal stove that consumes char, the emissions are very low compared to other stoves used in households. This is primarily due to the following;

1. The charcoal is already hot and combusting when the charcoal phase starts.
2. The time period of charcoal burning is much shorter.

The 2-unit stoves have emissions significantly lower than existing charcoal stoves, making them (and other TLUD stoves) the only currently available, low-cost, solid-biomass-fuel stoves that could be acceptable for urban and rural use in the developing countries.

- Establish a progress report as the scientific basis for future adjustments.

Advantages of Gasifier Stoves over other ICS

- Biomass is burnt more cleanly (much less soot, black carbon and indoor/outdoor air pollution);
- They are more efficient due to more complete combustion (less total biomass consumption;
- They use a wide variety of small-size biomass residues (no need for stick-wood or charcoal);
- Biomass fuels are often within the immediate area of the users;
- They can create gas from dry biomass with very simple, inexpensive technology directly in the burner unit;
- They can create charcoal, which may be used for energy purposes or to improve soil productivity;
- Easy lighting allows cooking to start within minutes compared to the slowness of using charcoal.

Components of Gasifier Stove

The gasifier stove consists of the top and the base units. The base unit can either be a charcoal stove or a metal container (steel bucket, flat bottom steel cooking pot, or galvanized cylinder with flat bottom) to trap and save the charcoal at the end of the gasifier phase. The top unit consists of four basic parts; the inner cylinder (a sheet metal tube which functions as the fuel holder as well as the combustion chamber which allows air to get into the chamber through secondary vents made on top for combustion to be possible); the outer cylinder (another sheet metal tube with diameter usually 5 cm or larger than the inner cylinder which serves to pre-heat secondary air, act as a heat shield, and improve stove stability); the upper cowling (a sheet metal ring that fits snugly against the inner and either snugly against or overhanging the outer cylinder. It is secured to the cylinders by friction and/or other attachment method at or near the top of the stove), and; the lower cowling (a sheet metal ring that fits snugly over the inner cylinder near the bottom, which either fits snugly inside the outer cylinder or extends past it, depending upon the base geometry and primary air flow regime. It is secured to the cylinders by friction and/or other attachment method. A wider lower cowling will make the stove more secure until it overhangs the edges of the base).

1. Inner cylinder sizing, thickness and material

The heat output of a given fuel increases with an increase in the diameter of the inner cylinder. As the height/length of the cylinder increases the burn time increases (and the heat output may drop due to increased air resistance). Inner cylinder diameters of 10-25 cm are reasonable. Height/length could range from 30 cm for denser fuels and shorter burns, to 76 cm for lighter fuels (like peanut shells) and longer burns. Very long/tall stoves may need additional structure of some kind for safety/stability. The inner cylinder gets very hot, especially near the bottom at the end of the gasifier phase. Thicker steel sheet metal will increase durability. Galvanizing may also help, but the zinc will melt during stove operation and may not increase life much. Stainless steel would be more durable but probably too expensive. 24-gauge sheet steel is used.

2. Outer cylinder sizing, thickness and material

Length will depend on the inner cylinder and base geometry. Diameter would normally be 2-4 in. (5-10 cm) more than the inner cylinder. The outer cylinder could be thinner than the inner cylinder. Galvanized steel sheet should be used to enhance durability and appearance. If it is too thin it is easily dented/bent. 28-gauge galvanized steel is used.

3. Concentrator ring thickness and material

A minimum of 24-gauge minimum iron sheet should be used. Galvanizing may

extend life; stainless steel is preferable for durability.

4. Upper cowling thickness and material

The upper ring can fit snugly between the inner and outer cylinders or overhang the outer cylinder with attachments. It can be flat, or domed or ridged for greater stiffness. Iron sheet gauge 24-30 is recommended. The use of galvanized steel is optional.

5. Lower cowling thickness and material

The lower cowling needs to fit snugly against the inner cylinder. It needs to fit snugly against the outer cylinder or extend past it. It can be flat, or domed or ridged for greater stiffness. 22-28 gauge is recommended, while the use of galvanized steel is optional.

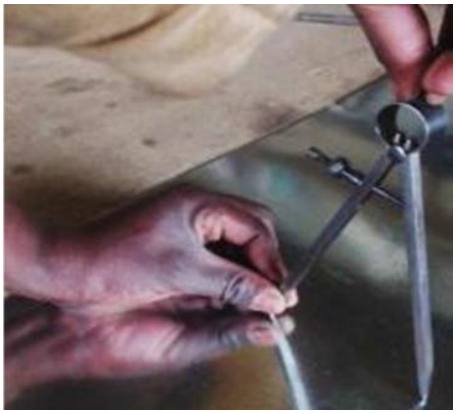
The Future of Gasifier Stoves

The challenge during recent years has been a slow penetration of the technology to the larger population. Meanwhile, TLUD developers have consistently pointed out the charcoal-creating aspect of those stoves, but with two drawbacks. First, the dumping out of the hot charcoal is somewhat inconvenient and creates safety concerns. Second, leaving the charcoal to burn in the TLUD structure is inefficient in terms of heat transfer (the pot is too far above the glowing charcoal), and the high heat of the charcoal seriously shortens the life of the metal in the lower parts of TLUD stoves. The 2-unit innovation provides a better utilization of the TLUD technology because charcoal created stays in the base unit, which is specifically designed to withstand the higher heat and accomplish cooking with charcoal.

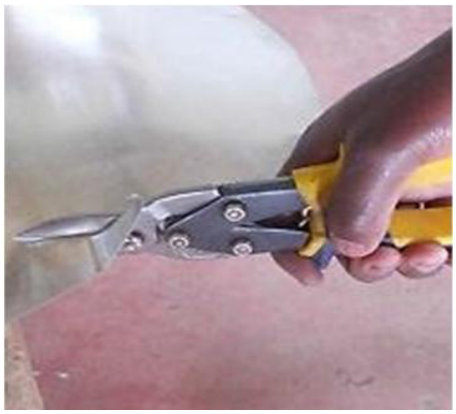
In essence, regular charcoal is usually made in distant places far from the end-user, and all the heat generated in the carbonisation process is lost while releasing into the atmosphere considerable greenhouse gases (GHG). In contrast, a TLUD stove is operated locally by the end-user of the biomass fuel. The useful energy value in the pyrolytic gases emitted in the charcoal-making process is used for cooking in the TLUD phase, applying the low-emission principles of a "gas-burning stove" that makes its own gases from dry biomass fuels. Then the TLUD-made charcoal (that could be called TLUD-char) is burned in the base unit of the 2-unit stove.

Construction of a Gasifier Stove

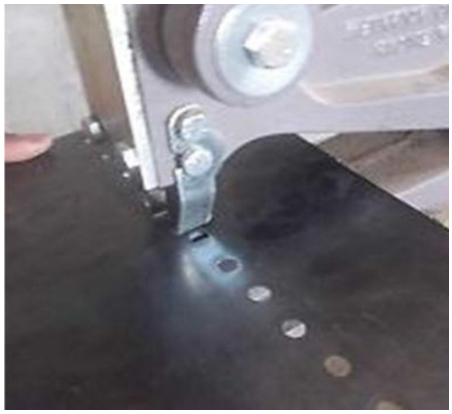
The following steps are followed in the construction of a gasifier stove.



Step 1: Mark out the dimensions of the various stove pieces.



Step 2: Cut out the pieces carefully using the right tool. Use gloves whenever you are dealing with sharp edges.

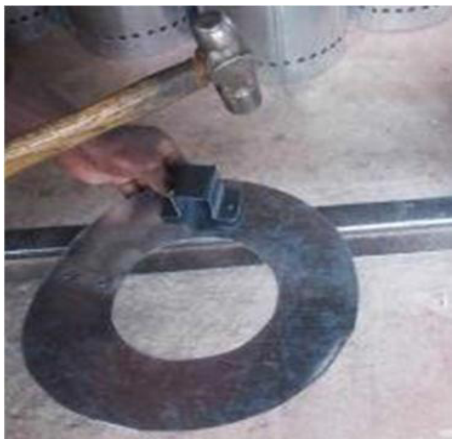


Step 3: Punch the holes in the sheet metal.

Step 4: Roll up the fuel chamber to form a round shape using a slip roll. The outer cowling will form a rounded cylinder without requiring any tool. Bring the two ends together.

Step 5: The 2 ends of the fuel chamber are joined as well as the cowling. The lap seam requires riveting as well. Steel rivets should be used.

Step 6: Put a seam around the inner edge of the bottom cowling and then join it to the cylinder using the single bottom seam.

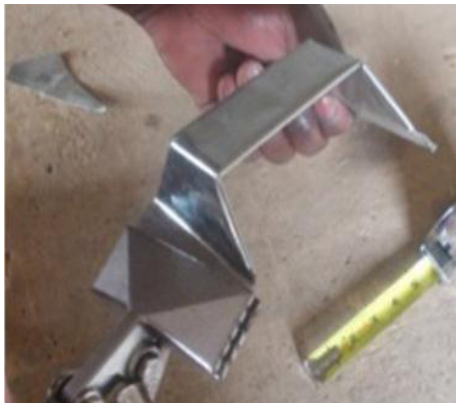


Step 7: Put a seam around the inner edge of the top cowling and then join the pot stands to the cowling using steel rivets.

Step 8: Fold the top edge of the fuel chamber and slip it through the top cowling. It should go through the bottom cowling until the fold overlaps the top cowling.

Preparing a meal using the gasifier stove in Kampala, Uganda. It can be used to prepare matoke (banana plantain) the local staple food.

Step 9: Join the upper cowling to the cylinder using the single bottom seam.



Step 10: Make handles using the folding tool according to your preferred design and join as below.

REFERENCES

1. Practical Action (2009): Energy Poverty: The Hidden Energy Crisis. Practical Action, Rugby
2. Waithaka,D., 2014. Step-by-Step Assembly of Gasifier Stoves. Wisdom Stoves of Ol Kalou.
3. www.renewableenergyworld.com/rea/tech/why
4. www.solarcooking.org/newsletters/scrmar08.htm
5. www.undp.org/content/undp/en/home/ourwork/environmentandenergy/successstories/improving_cook_stoves_and_access_to_energy/
6. www.practicalaction.org/improved-cooking-stoves
7. www.aepc.gov.np/index.php?option=com_content&view=category&layout=blog&id=73&Itemid=94
8. www.gvepinternational.org/sites/default/files/factsheet_ics_web_final.pdf
9. www.crtnepal.org/?option=technology&tid=3734323436
10. www.newdawnengineering.com/website/library/Papers+Articles/HERA-GIZ%20microgasification%20manual%20V1.0%20January%202011.pdf

Executed by UN-Habitat with the support of GEF and UNEP

For more information, please contact:

The Urban Energy Unit
Urban Basic Services Branch
United Nations Human Settlements Programme (UN-HABITAT)
P. O. BOX 30030 - 00100 Nairobi, Kenya
Vincent.Kitio@unhabitat.org
www.unhabitat.org/urban-themes/energy/