Troika™ Bingwa™ TLUD-ND Stove: Simplified Construction

Prepared by Paul Anderson "Dr TLUD" 10 Feb 2014

The previous document entitled *Troika TLUD Stove: First Look* (dated 27 Nov 2013, available at www.drtlud.com/troika-tlud-stove) introduces the Troika series of TLUD stoves. This current document is specific about the simplified construction of one natural draft design, called Bingwa, the Swahili word for "Champion".

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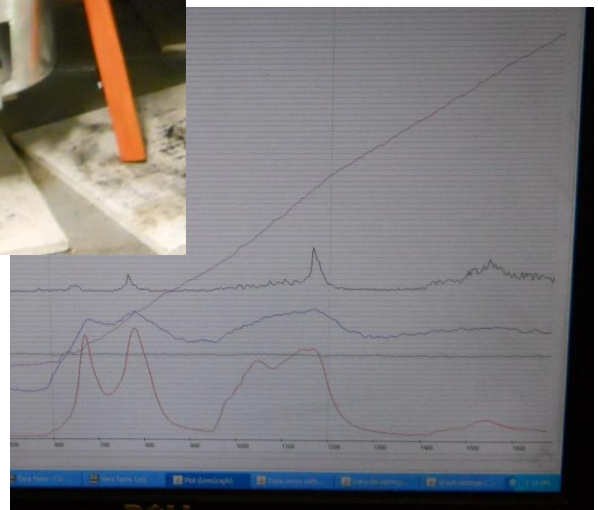
This PowerPoint file is intended to be read as a document either printed on paper or on a personal computer screen. It is not prepared for projection except to show the images.

Expect additional Troika documents during 2014. Updates will be available at: www.drtlud.com/troika-tlud-stove

At left: Troika Bingwa being tested at Aprovecho Open House 28-31 January 2014.

Below: Screen capture of first emissions testing of Bingwa TLUD . Slope line is increasing water temp.; Black is PM reading; Blue is CO2 (power level); Red is CO emissions level.



Description and Parts List for the Troika Bingwa TLUD-ND

Basic description: The Troika™ Bingwa ™ is a natural draft (ND) TLUD reactor (gas and char producer) that consists of a central (inner) fuel container (with bottom and with air inlets), and a concentric outer cylinder that are both supported by a tripod that attaches to the upper and lower areas of the outer cylinder. A "burner head" or combustor is placed on top during operation. Described here is only one of the literally hundreds of combinations of materials and configurations to accomplish the construction of a Troika TLUD. **SHOWN ARE ONLY SIMPLE ASSEMBLIES OF PIECES** made in Uganda in January 2014.

Tripod support structure:

1. Legs (3) of wood (usually 3 to 5 cm longer than the height of the outer cylinder)
2. Upper Support Ring (diameter matching Outer Cylinder, w/ 3 brackets for legs)
3. Under Support "Y" bracket

Cylinders and air control:

4. Outer Cylinder (open bottom) with side opening for access to primary air inlet.
5. Inner (fuel) Cylinder, with closed bottom and a primary air inlet
6. Primary Air entrance
7. Top or Upper Ring that joins the two cylinders
8. Grate (not visible in most of the pictures)
9. Other parts: Screws, bolts and nuts, paint for legs, serial number tag (optional), furnace cement (only used if air leaks are too big).

Draft creation:

10. To have sufficient natural draft (ND), a concentrator lid plus a 3 – 4 inch riser (such as a cylinder 5 – 7 inches in diameter) is needed. It can be attached to the stove structure as in the tripod pot support of the Champion TLUD built by Servals. Or the upper part (combustor) of a Quad TLUD stove can be used with its attached pot rests, as seen in the photo on page 1.

1. Legs

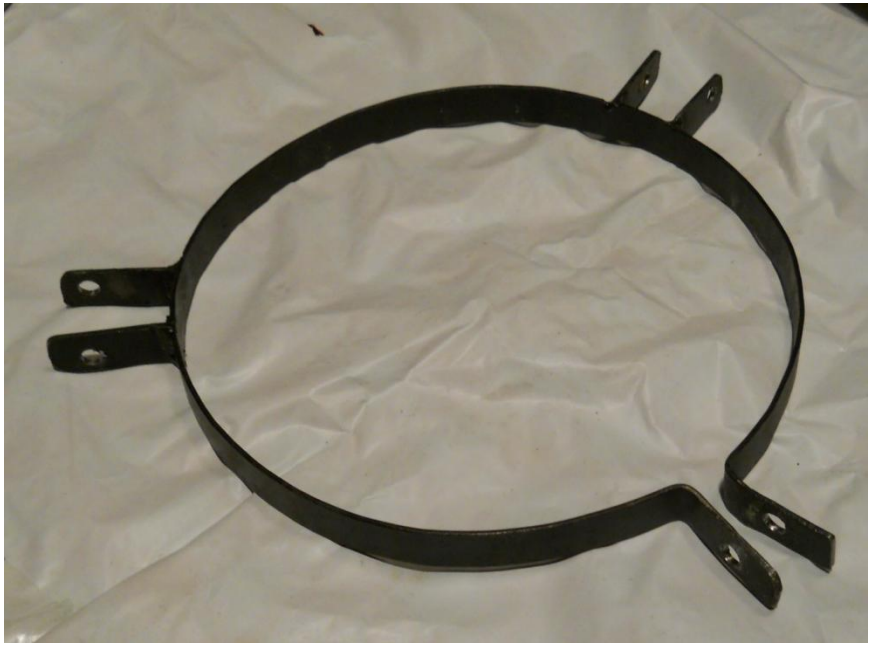
Photos below:
Round or square dowels, with suggested size of 1 x 1 inch (25 x 25 mm).
*** Cut to desired length. 48” dowels yield 3 legs of 16 “ each. 36” dowels yield 2 legs of 18” or 3 legs of 12 “.
Square wood should be shaped for hand holding comfort, using plane, knife or shaping tool (shown as yellow tool).

Photos left and below:
Wooden legs drilled and with bolt and nut for attachment to brackets on Upper Support Ring.

Photo below:
One example of legs assembled with the Upper Support Ring with brackets, plus Under Support of the cross-member style.

2. Upper Support Ring, with 3 brackets for legs.

Left Photo : The Upper Support Ring can be made of flat steel bands of heavier metal (1.0 mm thickness minimum) that could be welded. Width should be 0.75 to 1 inch (18 to 25 mm). Aluminum can be used, which is lighter, but may be too flexible to provide adequate support for use with heavy pots (to be determined). See the "*First Look*" document for other suggestions.



Right Photo: The gap between the two arms of each bracket should be approximately 3 mm (1/8th inch) wider than the wood to be inserted there. This slight flexibility helps avoid the difficulties of precise alignment of the drilled holes through the metal and through the wood. The hole diameters need to be appropriate for the diameter of the bolt or long rivet that passes through them.

Note: Instead of using a bolt and nut, craftsmen could possibly use a rivet that is essentially a thick nail, with the nail head on one side and a cut-and- flattened nail-end at the other side. This gives substantial cost savings.

3. Under Support Bracket

This Under Support bracket in the form of a “Y” attaches to the bottoms of the three legs and provides a base for both the outer cylinder structure and the fuel chamber. The shown design is made from 1mm sheet metal cut into 25 mm (1 inch) wide strips (4 ft long), and then folded 90 degrees to make an angle-iron with 12 mm on each side.

One piece 40 cm long (16”) is cut on one side in the center and bent 60 degrees (forming a 120 deg angle). A second piece 20 cm long is welded at the midpoint to form the third leg. The end of each leg is cut approx 18 mm (3/4 inch) on the fold to allow one side to be folded downward approx. 80 deg., leaving two tabs at each end for attachment to the wooden legs (right photo) via screws through drilled holes.

Note that in the final assembly, the “flat” surface is upward, contacting the bottom of the fuel chamber, to which it is attached via screws (see holes in the left photo and later photos.).

Cylinders

The two cylinders are the most important components, and they can be made in any reasonable way, as described in the introductory document *Troika TLUD Stoves: First Look* .

About the dimensions:

Height of the standard Troika Bingwa cylinders is 300 mm (almost 12 inches) before 5 to 10 mm of the long edges (top and bottom of the cylinder) are bent under for strength and smoothness. However, height can be varied as long as the height dimensions are the same for the two cylinders and the three wooden legs. The legs could be up to 5 cm longer than the height of the cylinders, depending on the total height preferences of the stove producer and the stove users.

Diameter of the outer cylinder of the standard Bingwa TLUD is 8.75 inches (222 mm), resulting in a circumference of 700 mm (27.5 inches). Commonly 20 additional mm are added to the length of the flat sheet metal to allow for overlap for making the joint in the cylinder, whether a lap joint by a tinsmith or a simple overlap with screws or rivets or spot welding to secure the ends together.

Therefore, the starting sheet metal for the outer cylinder is a rectangle measuring 300 x 720 mm.

The inner (or fuel) canister starts with sheet metal 300 mm high and with the following lengths for the corresponding diameters:

7.5 inch diameter = 600 mm + 20 mm overlap = 620 mm.
6.25 inch diameter = 500 mm + 20 mm overlap = 520 mm.
5.0 inch diameter = 400 mm + 20 mm overlap = 420 mm.

4. Outer Cylinder / canister, sheet metal material

The sheet metal can be cut and rolled into a cylinder (as shown) by a tinsmith.

The size of the rectangular opening is approx. 3 x 4 inches to allow easy passage of the primary air duct.

The outer cylinder can get quite warm, but not hot enough to damage the metal. Therefore, thin galvanized mild steel should be sufficient for many years of usage.

5. Inner Cylinder (also called Fuel Chamber)-- With Bottom

The inner cylinder needs a well sealed seam or joint and also a bottom, becoming a fuel chamber or canister. It will have direct exposure to pyrolytic temperatures of 400 to 650 deg C, so it should be of gauges such as 24 or as thick as 20 gauge. The thinner gauges (such as 24 or 26 or 28) are easier for fabrication, have lower price, and are highly appropriate for making initial units.

The sealed bottoms can be of several types. You can attach a bottom mechanically (as in making tin cans) or with tinsmith skills.

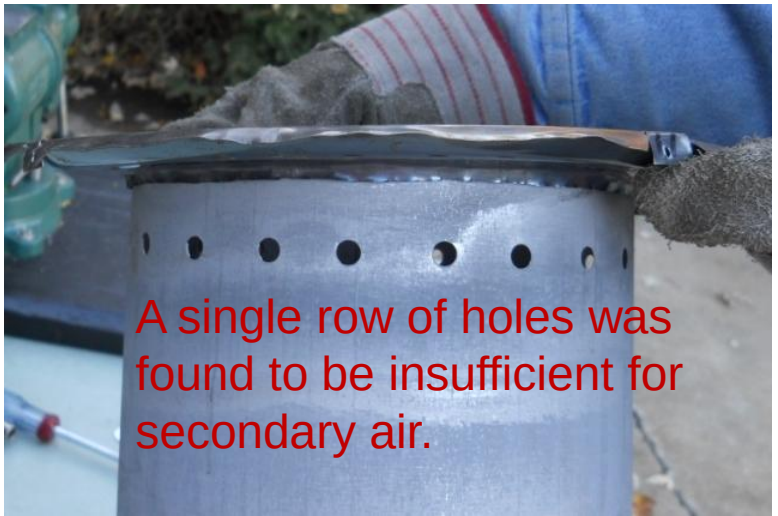
For proper functioning to control the intensity of the pyrolysis and the fire at the top, it is **very important that the fuel chamber does not allow leakage of air.**

We discuss the bottom again
concerning the Entrance for Primary Air (#6).

5. Inner Cylinder (Fuel canister) – Entrance of Secondary Air

One type of entrance for secondary air into the fuel chamber can be by holes (shown in two photos to the right.) Diameter and number of holes are topics of research, but 6 – 8 mm diameter spaced at 2 to 3 cm is generally reasonable. Note that the upper edge of the inner (fuel) cylinder Is bent over to form a better seal with the ring.

A second type of entrance for secondary air is by creating a gap between the top of the fuel chamber and the horizontal connector (ring or plate) to the outer cylinder, as done with the Quad TLUDs shown below. Note in the upper photo that the metal tabs are downward from the horizontal plate, and in the lower photo the tabs are upward from the top of the fuel cylinder. Either way works fine. Approx. 1.5 mm gap works well.



6. Primary Air Entrance

The entry of primary air into the fuel chamber and under the grate can be accomplished in many different ways. The most simple is merely a hole, as in the Champion TLUD by Servals (upper left photo). Other ways are sliders (on Mwoto stoves), box-snouts (on Quad stoves), and pipes. It is optional but highly desirable to be able to adjust to allow varying levels of air into the chamber.

Shown are ways to block the in-flow of primary air (clockwise from upper left): Disk on rod; slider on fuel chamber; slider on snout; and snout with blocker piece.

6. Primary Air Entrance (continued)

For purposes of production and for repairs, we desire that the fuel canister is able to be inserted and removed from the top of the stove. This requires that the entrance passageway of the primary air is short enough to be able to be pass inside the outer cylinder. One preferred method is to have short “box” or pipe that is firmly (and air tight) attached to the fuel chamber. If necessary, extension pieces can be attached when the fuel chamber is in place.

In the photos below, the short box should actual be lower, even touching the bottom of the fuel chamber, and secured with a screw or two through the bottom plate and the bottom of the box.

Furnace cement is useful to assure no leakage of air through joints.

7. Top or Upper Ring or Plate

The Upper Ring connects the Outer Cylinder and Inner (fuel) Cylinder. (Quad stoves use a plate.)

These rings are used for capping the secondary air chamber.

Similar rings can be used for the “Concentrator disk” that is needed in the Natural Draft (ND) versions of the Troika stove. This disk forces the secondary air to mix with the up-welling combustible gases, with the resultant flame and heat exiting through the concentrator ring.

Two half-rings (not shown) that slightly overlap allow the placement and removal of the ring or fuel canister during maintenance.

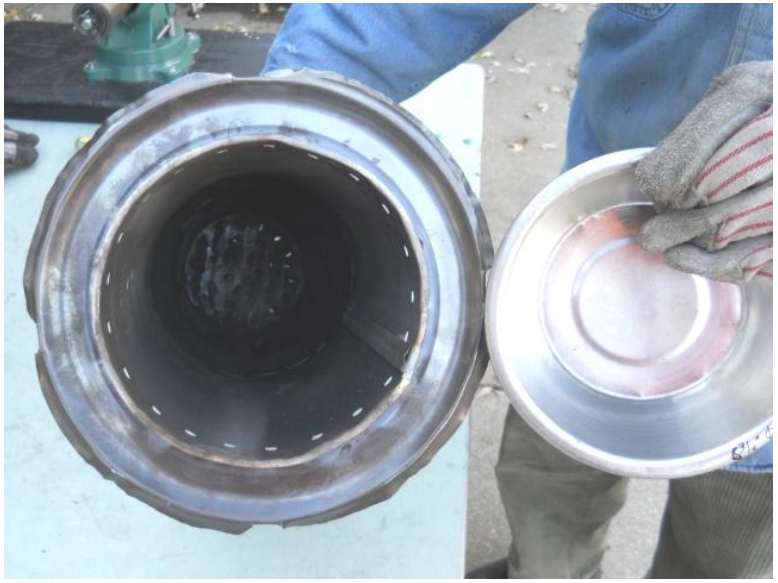
Note that to have a Troika TLUD-ND with different fire power (as determined by the diameter of the fuel canister) requires only the changing of the upper ring and fuel canister.

8. Grate (Inside the Inner Cylinder)

The grate at the bottom of the Inner Cylinder can be made from a variety of materials. Simple grates of mild steel will need to be replaced occasionally, but can be very suitable if the char is emptied soon after pyrolysis finishes. (photo on right)

However, if Bottom Burning (TLUD-BB combustion) is intended (See *Micro-gasification Terminology* at www.drtlud.com/resources) consider using stainless steel as a more long-lasting alternative,. Some highly appropriate SS items are dinnerware of plates and bowls. Refer to comments and photos in the *Troika…: First Look* document at www.drtlud.com/troika-tlud-stove .

Holes can be made with a hammer and chisel, a metal punch, a drill press, etc. Hole size, number, and placement need to insure that sufficient primary air can enter, but fuel should not fall through the holes.



9. Other parts

Screws: Used for various purposes: attaching legs to supports, attaching metal covers to the outer cylinder, securing the forced-air unit to the outer cylinder, etc.

Bolts and nuts: Used for various purposes: attaching support rings to the outer cylinder, brackets to support rings, legs to brackets, etc.

Paint for legs: Shown in some photos is an orange-colored paint that identifies gasifier stoves in Uganda.

Serial number tags: If serial numbers are desired, these can be stamped/embossed or created by an outside company and added to the stove.

Furnace cement: Furnace cement is used where needed to seal cracks and gaps. In a final design, it may or may not be necessary, depending on the precision of the tools and workers available to join the metal components.

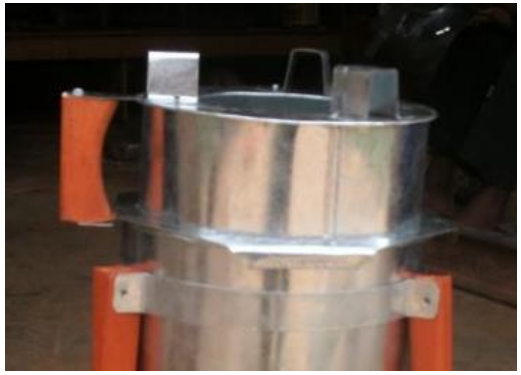
Assembly of Inner Cylinder (with Upper Ring, Grate and Primary Air Entrance) into Outer Cylinder.

The grate and the primary air inlet (and air controller) need to be attached to the Inner (Fuel) Cylinder. The difference between the two diameters is the maximum length of the pipe or box so that the pipe or box plus Inner Cylinder can enter into the Outer Cylinder and pass through the hole in the Outer Cylinder. This arrangement places half of the primary air pipe outside for access for controlling the airflow.

Using tabs and screws allows secure attachment and also the ability to easily change the entire inner fuel chamber and top ring for maintenance or to exchange different sizes of fuel chambers. This is especially useful when developing new configurations of inner cylinders, grates, materials, etc.

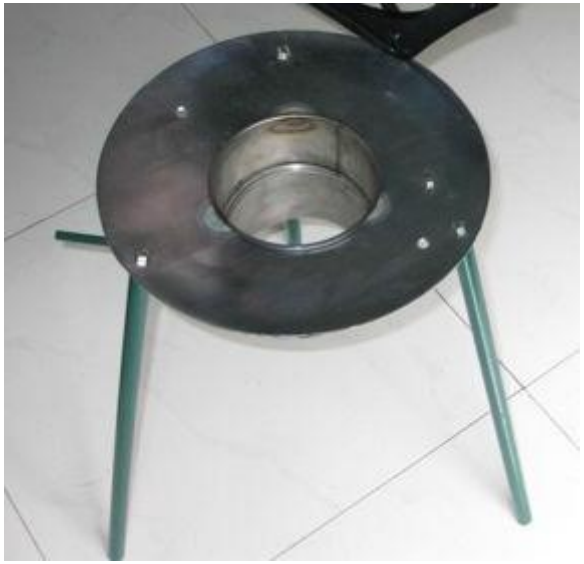
10. Riser for Natural Draft (ND) Operation

The Troika Bingwa is a TLUD-ND stove that uses a concentrator lid plus a 3 – 4 inch riser (such as a cylinder 5 – 7 inches in diameter) to provide sufficient draft.



The upper part (combustor) of the Quad stove can be used, and it has pot rests, as seen in the photo to the right.

Also the riser can be attached to the stove structure as in the tripod pot support of the Champion TLUD built by Servals, shown below. Note that it the lower half can slide up and down to facilitate the placement and removal of the TLUD reactor below it. The concentrator can be placed onto the reactor, or can be attached to the riser.



Conclusion

The Troika Bingwa TLUD is an evolutionary step in the development of micro-gasifier cookstoves.

This document will be updated with the various improvements of the Troika, and placed at:
www.drtlud.com/troika-tlud-stove

The Troika™ and Bingwa™ names are copyrighted only to prevent their usage with products that are not faithful to the basic concepts of the Troika Bingwa designs, which are freely given for Public Domain usage.

Stove developers are encouraged to contribute their experiences and improvements for the benefit of others. Please send comments and photos to Dr TLUD (Paul Anderson) at:
psanders@ilstu.edu

Troika™ Bingwa ™ Summary Description:

(In a format compatible with Roth's 2014 revision of the *Micro-gasification* manual.)

Model : Troika Bingwa TLUD-ND The Troika Bingwa model is an addition to the "Champion Family" of TLUD cookstoves that include Champion (2005 & 2009), Mwoto (2010), and Quad (2012). All five stoves have the same basic dimensions and performance, but with distinct constructions. (Bingwa means champion in Swahili.)	
Target area:	In-country fabrication anywhere.
Fuel type:	Any chunky dry solid biomass, including wood segments.
Designed by:	Dr TLUD (Paul Anderson)
Retail price:	Local variations estimated to be US$13 to $30, depending on materials and labor at each production site.
Numbers sold:	None; Designs are available.
Start of production:	December 2013.
Manufactured by:	Cooperating producers in each country, including Awamu in Uganda.
Contact:	Dr. Paul S. Anderson (Dr TLUD) psanders@ilstu.edu

Photo Source: Dr TLUD

Address:	Juntos Energy Solutions NFP 227 South Orr Drive, Normal, IL USA 61761 Phone: +1-309-452-7072 Skype: paultlud
Production capacity:	Depends upon capabilities of cooperating producers. Scalable upon demand.
Short Description:	All of the fundamental TLUD characteristics, plus evolutionary enhancements. Can have "pot on top" (like Mwoto & Quad) or "pot supported separately" (like Champion). Component pieces for easy local assembly and maintenance. Can be enlarged beyond residential cookstove sizes, including for biochar production.
Features:	Three legs (wooden) for greater stability and cool handles. Stainless steel "bowl-grate" can permit continuous TLUD-BB operation
Handling/operations:	Virtually the same as for Champion, Mwoto and Quad TLUDs.
Char-making ability:	Yes, with increased control of airflows that can impact biochar characteristics.
User feedback:	Not available yet.
Accidents reported:	None so far.
Performance data:	Equal to or improved over other TLUD-ND stoves. Expecting Tier 3 and 4 ratings.
Further info: Go to www.drtlud.com/troika-tlud-stove for the latest information and reports on usage.	
Other comments: Dr TLUD makes the Troika(TM) designs available to all who participate in transparent further development. "Fair play" is expected. Cooperative efforts are encouraged. Stove Camp training for fabrication, household usage, and charcoal or biochar production can be arranged.	