Construction of a

3 Billy Stove Gasifier

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Construction of a 3 Billy Stove Gasifier:

The Australian TLUD

Steve Ewings 2014

Contents

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1.0 Introduction

After many years of providing information about gasifiers through www.build-a-gasifier.com I thought it was about time I made my own.

So I have begun with the most basic of gasification principles, the gasifier stove. The Gasifier to power my car will have to wait until I retire (when will that be?) when I might be able to afford both time and materials… it will happen just a matter of time.

As an Australian I began searching for off-the-shelf materials to make a stove and went everywhere to find a cheap supply of materials including: Bunnings, general hardware stores, kitchen shops, Red Dot, $2 Dollar shops, Coles and Woolworths and “tip shops’ in my search. Nothing turned up in the search for what I needed, and that I could direct to others to find containers that would fit inside each other like Russian dolls.

It may well be that that in the future I will simply buy sheet metal and construct a purpose built Gasifier Stove but in the first instance I just wanted to make something that (a) didn’t cost a fortune, (b) worked and (c) was readily available.

The brain fart one Sunday afternoon was the idea of using “billy cans” that could be purchased quite cheaply in Australia. A Billy can is a simply a pot or type of kettle that is placed on an open fire to boil water to make a cup of tea or coffee.

The term billy or billycan is particularly associated with the Australian outback, but is also used in the UK and Ireland. The term as I understand is extended to a “billy tin” or “billy pot” in Canada so it is not just isolated to Australia.

The three Billy Cans below were purchased from a camping shop (BCF) for the sum of $AU37.00. They all fitted inside each other which meant there was an off-the-shelf design solution.

Figure 1: Three Billy Cans

2.0 What is a TLUD?

The acronym TLUD stands for Top Lit Up Draft Gasifier is a gasifier stove design which owes its origins to Thomas Reed. According to Paul Anderson who refers to himself as Dr TLUD, “In 1985 on a trip to South Africa, gasification expert Dr Thomas B. Reed awoke one night thinking of a very small gasifier for the domestic stove needs of impoverished people. For ten years he worked to develop what is now called the TLUD (Top-Lit UpDraft) natural draft gasifier stove. Indeed, he is the recognized originator of what is now called Top-Lit UpDraft gasification.” There are of course many permutations of this principle and the 3 Billy Stove is one of them.

The distinguishing feature of a TLUD Gasifier stove is combustion of the biomass (burning of woody material) occurs at the top of the fuel pile. It is quite different to a normal fire, and the woody biomass (chips, twigs, or pellets etc.) in a TLUD is pyrololised and the gas from the biomass is expelled (driven off) within the fuel chamber, drawn down and then burnt through a secondary chamber. The biomass itself is not entirely combusted through the top down burn process and leaves a torrefied material known as biochar which can be incorporated in any garden.

Figure 2: TLUD principle

This idea is counter intuitive and goes against the principle of lighting a campfire or where we light a fire at the bottom and the fire burns up. Think about the classic campfire, a tripod of sticks, size increasing outwards at the base and the ignition point is at the bottom of the stack like that below.

Figure 3: A traditional fire

The TLUD is very different to a traditional fire as the TLUD stove is designed to set alight the top of the fuel source and draw down the methane laden gases to burn through secondary portals. A TLUD stove burns down-through the biomass instead of up. In a traditional fire the biomass is burnt and the gases are driven off and this gas escapes and only a small portion forms part of the heat cycle.

3.0 Materials

I wanted to provide a construction method so any handy person could build a stove without having to master any fine skills. At the same time the stove needs to work properly as a true gasifier and I also wanted it to be atheistically pleasing. The 3 Billy Stove Gasifier stove design can be made with very few tools, no welding, screwing or riveting is involved.

- 3 Billy cans that will nestle inside each other
- Pair of tin snips
- Multi grips, pliers or similar
- Hammer (to panel beat drilled holes)
- 3mm and 5mm punch
- 50mm hole saw attachment (otherwise use tin snips)
- File to remove sharps and burs
- Stainless steel pot scrubbers
- Gloves for protection (jagged tin slices flesh very nicely)

4.0 Construction

4.1 Preliminaries

The first task is to remove the handles and holders on both the smaller Billies B and C as seen below. This will allow them to nestle inside each other. There is no need to remove the handle from billy can A, and in fact this is useful as a carry handle for the stove once the project is complete.

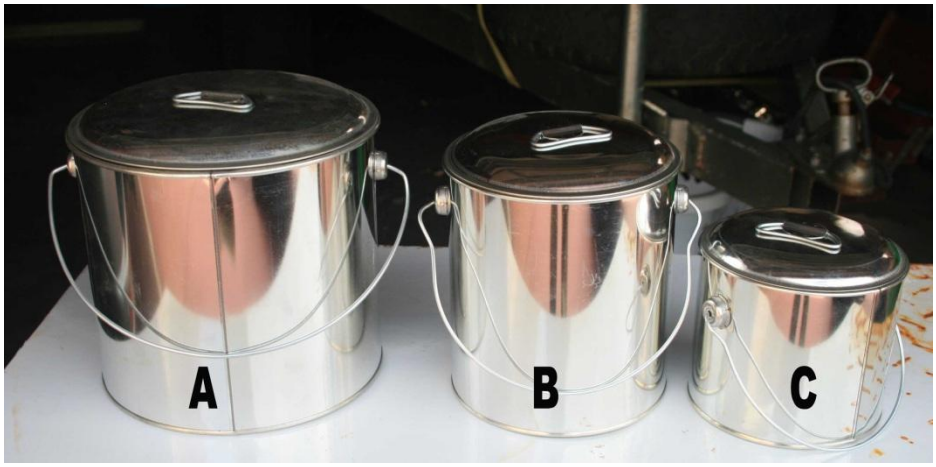


Figure 4: A, B and C Billy Cans

The easiest way to remove the handle holders is with a pair of multi-grips, pliers or other similar pinching device. Once the wire handles are removed, take your tool of choice and crush the holder then twist carefully until it is removed. Be careful not to tear the tin. If done properly there will be a few tiny pin prick holes.

Figure 5: Removing handles

Once the handle holders have been twisted off and removed you can use a hammer to flatten any raised and sharp tin around the small holes.

Figure 6: Handles removed from B and C

4.2 Cutting The Lids

The next step is to centre the Lid of Billy B in Billy Lid A. Use a permanent marker or scoring tool to mark out the circle of the lid. This line is to guide the cutting as seen in the next image.

Figure 7: Trace outline of Billy Lid B on Billy Lid A

Punch a starting hole using tip snips or a screwdirver and a hammer. The hole should be well away from the cutting line. If you haven't put on gloves then do so now! Once the hole is established you can begin to cut towards the line and then

you must follow this line carefully. This is because Billy B will be fitted inside this, effectively creating a ‘collar’ around Billy B and we want it to be as gas tight as possible.

Figure 8: Cutting the centre of Billy Lid A

There will be burrs and sharp edges inside the Billy Can A lid. Use a file to smooth off rough edges and clean up the profile. Now you can insert Billy Can B inside the lid of Billy Can A as seen in Figure 7. This must be a snug and tight fit as air (oxygen for pyrolysis) through Billy Can A must enter through the hole at the base of Billy Can B that will utlimately enter the base of Billy Can C (which is the fuel chamber).

4.3 Fuel Chamber Surround

At this stage you can also drill the 50mm (two inch) hole in the bottom of Billy Can B. This surrounds the fuel chamber. If you don’t have the 50 mm hole saw simply punch a hole and use tin snips to cut out the circular hole in the bottom of the Billy B.

Figure 9: Billy Can B inserted into Billy Lid A with 50mm hole in Billy B.

4.4 Fuel Chamber

The Fuel chamber (Billy C) has holes in the bottom and a row of holes around the top for the secondary burn. Turn the billy so the bottom is facing towards you and mark out for holes as per Figure 10. Use a 5mm punch (hollow or centre type) to punch evenly spaced holes as seen below.

Figure 10: Primary air holes in Fuel Chamber (Billy C).

To make it easier to keep the secondary burn holes consistently spaced from the top rim of the fuel chamber a piece of 18mm electrical tape was wrapped around the rim of the billy. Then using a Square a mark was made every 25mm around the fuel chamber.

Figure 11: Marking secondary burn holes in Fuel Chamber (Billy C).

Using a 3mm hole punch, the holes were made at the intersection of the mark and plastic tape. A hammer was then used to flatten burrs after the holes were punched through. Don't forget to remove the plastic tape!

Figure 12: Punching secondary burn holes in Fuel Chamber (Billy C).

We now need to prepare the fuel chamber which is Billy C so it will fit inside the lid of Billy B. As for the previous insert we need to trace the outline of the Billy C onto the lid of Billy B. Then you will cut out the lid Billy B with tin snips so Billy C can slip down inside the lid.

Figure 13: Fuel Chamber (Billy C) inserted into Billy B Lid.

4.5 Putting it all together

Now you can put your stove together. Below are the three components.

Figure 14: The 3 Billy Can

Place Billy Can B inside Billy Can A.

Figure 15: Billy Can B in A

Place Billy Can C (fuel Chamber) inside Billy Can B (which is already in Billy A).

Figure 16: 3 Billy Stove

The final should look like the above.

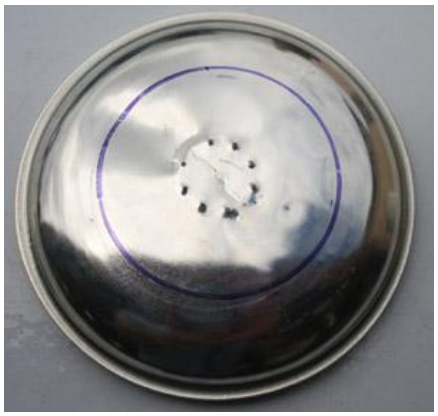
4.6 Pot Support

A pot or billy if placed on the stove opening will shut down (smother) the airflow so a pot support is necessary to lift the base of the pott off the stove opening. A simple pot support can be made from a piece of flat steel. Half way along each length cut a slot equal to the thickness of the steel strap. They can can then be fitted together to make the pot support.

Figure 17: 3 Flat steel with grooves cut

Figure 18: Finished pot support

5.0 Concentrator



If you have small pots the large open mouth of the stove can waste a lot of the heat as it flows up around the outside of the pot. A ‘concentrator’ can be made using the lid of Billy Can C that will focus the flame or concentrate the heat on a smaller area at the pot base.

Find a small circular object around 70mm diameter and mark a circle in the centre of Billy Can C lid. Then cut out the centre as per previous exercises.

Figure 19: Billy C lid

Figure 20: Concentrator on stove (left) and without (right)

The stove should be started without the concentrator and once it is burning the concentrator be put in place.

6.0 Operation

Place the 3 Billy Stove on a flat, inflammable surface (the base does get hot). In the bottom of the fuel chamber put one large or several small stainless steel pot scrubbers. This stops the wood chips from blocking the primary air holes at the bottom of the chamber.

Figure 21: Stainless steel pot scrubbers in base of fuel chamber

Feedstock for this design is around wood chips although twigs and broken biomass resemblimg the size of wood chips can be used. The range of wood chip sizes is from 5mm to 25mm.

Fill and pack the fuel chamber with wood chips just below the secondary burn holes at the top of the chamber. If you overfill the stove will generate a lot of smoke until it burns down below the holes. Place the X pot support on your stove before it gets too hot.

Place some light twigs on top of the wood chips so you can light the stove. If you are going to use a flamable liquid be careful. The most common cause of explosions is when the flammable gas or vapour is ignited in a confined space. The resulting rapid and explosive combustion may cause the stove, or parts of it, to blow apart due to the excessive internal pressures. (Note: it is actually the vapour and not the liquid that burns). DO NOT use petrol (gasoline) to light the stove. The vapour will drift below the wood chips in the fuel chamber then into the second chamber and exlode.

As the top layer of chips begin to burn there will be some start-up smoke. Once the layer is burning you may notice a pooling of ‘smoke’ (wood gas) within the chips. Then as the temperature rises the updraft between the the fuel chamber and walls of second billy will draw down the wood gas through the chips and smoking will stop. You should now begin to see flames appear from the ‘secondary burn’ at the top of the fuel chamber.

Once you see the stove is working you can place your cooking pot or billy on the stove. A litre of water in a pot using the ‘concentrator’ will take about 5 minutes to boil (depending on your elevation above sea level and the ambient temperature).

Even after the flames die down there will be significant amount of residual heat, enough to continue simmering whatever you are cooking. If the burn time isn’t sufficient (cooking various items) then there are a couple of options.

Firstly, you can empty the charcoal out into a container and start again. Take care as the billy stove will be very hot and the charcoal likely to be still glowing. Put this hot material in a metal container to cool down (then put it on your garden).

Or, secondly you can place a thin layer of wood chips on the existing burn. Don’t place too much on top otherwise you will stifle the updraft and the stove will begin smoking furiously.

Figure 22: Pot on the boil

7.0 Final Notes

7.1 3 Billy Stove

Some may wonder why I have used three billy cans when the stove could be made with just two. The primary reason was to make the stove a little safer. The fuel chamber and second pot generate a lot of heat and the third billy provides somewhat of a barrier. Secondly, a two billy stove would need legs made so the air intake hole wouldn't be obstrcuted. A appreciate the design could be changed so the air intake is from the side but I prefer the central bottom intake as the air is then evenly distributed upwards.

7.2 Blower Fan

The stove burns much hotter when air is forced through the bottom side inlet of the outside container, rather than just relying on the natural updraft. The next version will incorporate a small DC computer fan hooked to a battery and solar panel. A litre of water can take up to 9 minutes to boil, but intial experiments with a blower almost halved this time.

Figure 23: Smoke free burn under pot

8.0 References

1. Design of a Rice Husk Gasification Cook Stove for Rural Nicaragua, December 2010, Lockman, I et al., for Small Red Tile.

2. Le fourneau à gazéification Aaron, December 2013, Commission Européenne – Facilité Energie ACP-UE.

3. Micro-Gasification: What it is and why it works, 2008 Paul S. Anderson, Thomas B. Reed and Paul W Wever.

4. Micro Gasification: Cooking with gas from biomass, 2013, 2nd Edition, Christa Roth, published by GIZ HERA.

5. Primary Air Entry Gasifier Stove, October 2011, Mussie T., Lecturer at Mekelle University, Ethiopia.

6. Woodgas Camp Stoves, Renewable Energy Training Center, Morrisville State College, State University of New York.

7. Design Construction and Performance of a Stick-Wood Fired Furnace: For Residential and Small Commercial Application, October 1979, Hill, R.C., University of Maine, Unites States.

8. TLUD Handbook Revision 2010, Paul Anderson and Dr “TLUD” (Tee-Lud)

9. TLUD Construction Plans “Champion 2008″ Gasifier Cookstove, including operational instructions, Revised 2009, Paul Anderson.

10. TLUD Champion Gasifier Cookstove (Top-Lit UpDraft) Construction Plans, Ingenieure ohne Grenzen e.V., http://www.ingenieure-ohne-grenzen.org/

11. Troika™ Bingwa™ TLUD-ND Stove: Simplified Construction, February 2014, Paul Anderson, www.drtlud.com

All Referenced material is available on the Gasifier Stove download page at www.build-a-gasifier.com