The Hybrid Rocket Stove and Biochar

Biochar

Biochar is charcoal intended to be used as a soil admix rather than to be burnt. There are 2 main reasons for this;

1, To improve crop yields by increasing the soil's nutrient holding capabilities, increasing moisture retention, reducing acidity and increasing the amount of soil micro organisms.
2, To stabilise the carbon in biomass and thereby sequester atmospheric carbon dioxide.

There are environmental and economic advantages to producing your own biochar as a by-product of cooking or generating domestic heat and hot water. It is important not only to make biochar yourself or to obtain it from a known local source, but also to ensure that it is made in such a way that the heat produced is used efficiently.

Issues of peak oil and climate change mitigation mean that we should be looking for alternative energy sources to fossil fuels. If we are to wean ourselves off our fossil fuel addiction, we are going to have to use biofuels very wisely. We can not afford to be wasteful with wood, even if that wood is seen as a 'waste' resource.

Rather than building up an industry which produces, packages, transports and sells biochar, it would be better with regard to environmental concerns to develop domestic heating and cooking systems which burn wood gases and leave biochar unburnt to be used by the person who produced it or sold or given to local neighbours.

There is a rapidly growing market for biochar and new industries are emerging which produce, package and sell biochar. For several reasons I believe that it is better to produce your own biochar or to buy biochar produced locally from a known source.

1, The feedstock from which biochar is made may not be known or regulated. Biochar may include soot and other byproducts from the incineration of plastics or other environmentally hazardous substances.

2, The CO_2 and other environmental pollutants released from burning fossil fuels to produce, package and transport biochar may be greater than the CO_2 sequestered by the biochar.

3, The biochar may be produced while wasting the heat resulting from burning the pyrolisis gases.

4, It is possible that commercial scale biochar production could result in unsustainable woodland management, deforestation or even land grabbing (practices that have been seen with other biofuel production.)

5, Purchasing enough biochar in a large enough quantity for it to have any noticable effect in terms of soil improvement may prove prohibitively expensive.

6, Poor biochar production techniques (such as the use of charcoal kilns or poorly designed retorts) may result in particulate emissions (unburnt smoke) which contribute to global warming.If we are not careful, biochar industries may well waste wood and contribute to atmospheric CO_2 levels.

Keep production local!

I have combined design features of rocket stoves and anila stoves to produce what I call a modified rocket stove. This stove is operated in a similar way to a rocket stove but has the advantages that it produces more heat than a rocket stove and it produces biochar.

The pyrolysis cookstove technology which is being implemented across various developing countries demonstrates efficient, intelligent use of wood as a biofuel. However nobody has yet looked into ways of implementing the principles of this technology in the developed world.

Before going on to propose a heating system which is suitable for use in the developed world and which produces biochar, I am going to briefly introduce 3 simple stove designs. The tlud and anila stove are worth mentioning because, when used as biochar producing cookstoves, they demonstrate the efficiencies and benefits mentioned above.

I mention the rocket stove because, although it is not a biochar producing stove, it has design features which allow efficient combustion and efficient heat retention.

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The tlud

Designed by Paul Anderson, the top light upward draught (tlud) gasifying cook stove works on more than just one level. It is a very efficient cook stove, producing a lot of heat from a small amount of wood. It is smokeless and it produces biochar. Paul Anderson has also been instrumental in getting these stoves distributed and used in developing countries where wood or charcoal is otherwise used in conventional fires for cooking. By being more efficient, less wood is needed. By being smokeless, diseases and deaths caused by smoke in living spaces are reduced. By producing biochar, subsistence growers are able to mantain soil fertility and improve soil structure, biological activity and moisture holding capacity. Atmospheric carbon is also being sequestered by the use of these stoves.

Tlud stoves are basically a container with restricted air input to the bottom of the container, filled with biomass which is lit from the top, and forced air blown through holes at the top of the container. This air mixes with the rising smoke (wood gas) causing it to combust.

When the flame from the combusting smoke (wood gas) dies down, charcoal sticks are left in the stove. These have to be quenched with water to prevent them from burning up before they can be used as biochar.

The Anila Stove

Designed by R V Ravikumar, the anila stove consists of a combustion chamber surrounded by a second chamber, the retort. The retort has a removable lid or base so that it can be filled with biomass such as wood chip. A fire is built and lit at the top of the inner combustion chamber. This fire causes the wood chip in the retort chamber to heat up.

Because there is not enough air in the retort for combustion of the wood chip, pyrolisis occures instead. Pyrolisis is when something burns when deprived of oxygen. It can't produce a flame, so smoke (producer gas) is given off.

There are holes in the bottom of the combustion chamber. The only place where the wood gas from the retort chamber can go is through these holes into the combustion chamber, where they combust.

The retort can then be opened to empty out the biochar and refill with wood chip.

The Rocket Stove.

Rocket stoves, developed by Larry Winiskari, are very simple in terms of design; they consist of an elbow of pipe surrounded by heat resistant insulation. They have two features which have made them of interest;

1, They are efficient in terms of combustion.

2, They allow for efficient heat capture.

Efficiency of combustion also equates to clean, i.e. smokeless combustion. Smoke is unburnt particles.

There is little point in having efficient combustion if that heat is not also captured efficiently. Because the stove is insulated, it does not rely on having an insulated flue pipe to generate air flow. It is therefore possible to direct the flue gases horizontally and through a thermal mass.

Rocket stoves do not produce biochar. I have included this description of rocket stoves here because I have used the rocket stove design but introduced two design changes in order to enable it to produce biochar.

The advantages of efficiency of combustion, ease of heat capture and ease of lighting are retained in the modified rocket stove.

The Biochar Rocket Stove

It is my belief that the principles of biochar cook stoves can be applied to developed as well as developing countries. This would help us to reduce our ecological footprint, sequester CO2 and produce a greater proportion of our food locally. The modified rocket stove is clean, easy to light, does not require charcoal to be quenched, can be fitted with a self filling hopper and auger and is more suited to domestic use in developed countries than are the anila or tlud.

A rocket stove can be hybridised with an anila stove by replacing the insulation of a rocket stove with biomass such as woodchip.

These stoves have 2 advantages over rocket stoves;

1, These modified rocket stoves produce more heat than conventional rocket stoves because, as well as the combustion of the sticks in the combustion chaber, the wood gases also combust.

2, They produce biochar.

Like anilla stoves, the only place for the wood gases produced in the retort to go is through the holes in the bottom of the combustion chamber where they then combust, adding to the heat being produced.

These stoves also have 3 advantages over anila stoves;

1, By feeding the combustion chamber from the bottom, the top of the stove is left free to be attached to a heat exchanger.

2, They are easier to light than anila stoves. Any smoke produced when first lighting is directed away from the living space up the flue.

3, They can be allowed to burn after pyrolisis has finished, running as a rocket stove.

The diagram (Fig. 1) shows dimensions which have been shown to work. These dimensions can be scaled up but this size is suitable, for example, as a small scale domestic water heater.

The stove shown in the diagram is the basic version, a hopper and removable bucket can be fitted (ensuring the retort remains air tight) in order to make filling and emptying easier.

A fan has been fitted which forces air into the combustion zone, immediately above the point at which the pyrolisis gases enter.

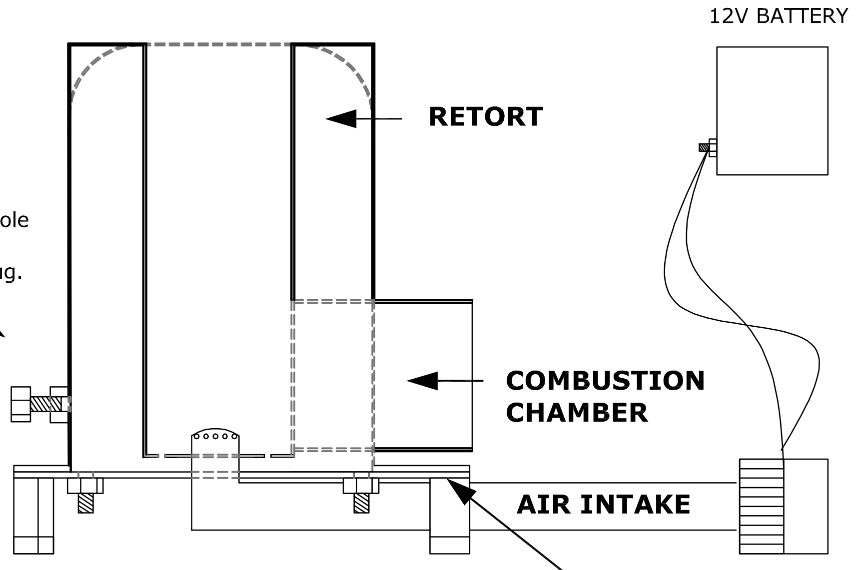
Although the stove will burn and produce biochar without the aid of a fan, the flames produced are orange in colour, indicating unburnt soot or carbon.

Unburnt carbon released into the atmosphere is a contributor to climate change.

The heat output of the stove is significantly increased with the forced air, as the particles are then fully combusted (the flame should turn white).

Biochar Rocket Stove.

Lots of heat and biochar



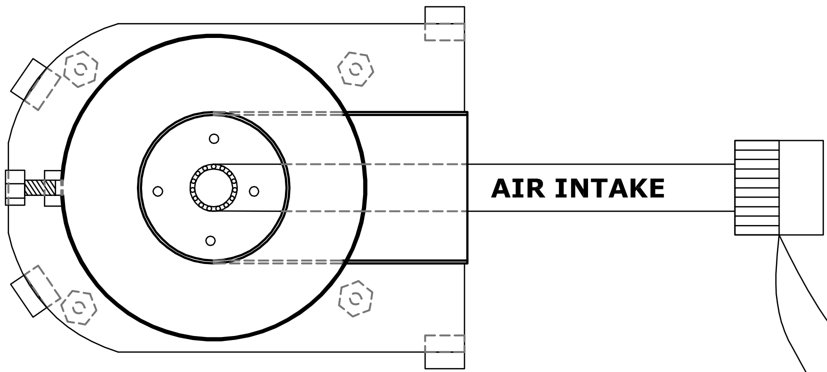
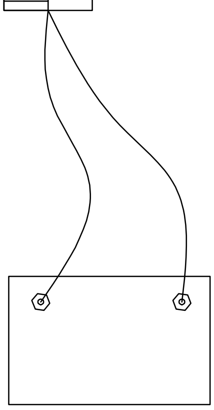


Fig. 1



Firing

The 4 nuts attaching the base plate need to be removed and the base plate taken off,wood chip or any other suitable biomass is then fed into the retort chamber.The base plate is replaced. The stove can then be placed back under the flue or heat exchanger ready to be lit.
A fire is simply lit in the elbow of the combustion chamber.Turning the fan on makes lighting the stove easier.
Putting a hand full of dry wood chip into the combustion chamber makes it easier to light.

The aim is to establish a small pile of charcoal in the combustion elbow. Around 3 sticks of wood at a time can be fed into this charcoal, end grain first.
After around 10 to 15 minutes, the flame should noticeably increase in size. The fire should be maintained and the fan turned on until this flame dies down (30 to 60 minutes depending on the biomass used).
It is good to continue running the stove as a normal rocket stove for at least a further 10 minutes in order to ensure complete pyrolisis.
The fan only needs to be on when there is a flame present, the aim is to maximise the efficiency of combustion.
The stove can be left for a couple of hours before being removed and the biochar emptied. This will ensure a more complete pyrolisis and will result in less smoke being emitted when emptying the stove.

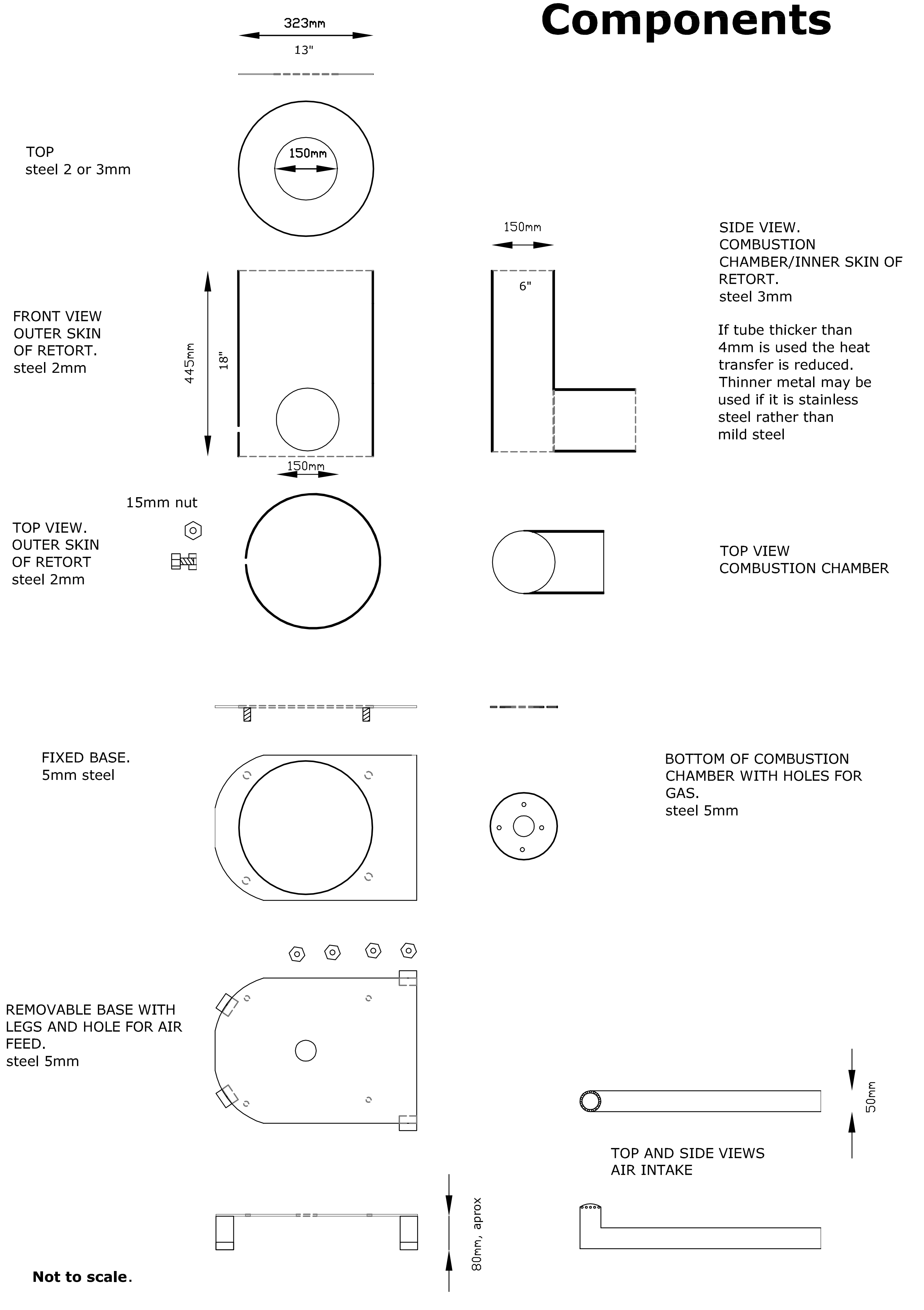
Other Considerations.

It is important that the biomass in the retort as well as the sticks used in the combustion chamber are properly dried.
Moisture in green or wet wood will cool down the combustion resulting in wasted heat, Increased emissions, Possible incomplete pyrolisis.

Woodchip that has not been dried will not store and will rot.

Design Ed Revill.
Drawing Diane Holness 2011
Open source technology

Components



Not to scale.