The UBI Hollow Core Fired (HCF) Biochar Oven

A number of people have requested information on low tech biochar production. This communication concerns the UBI Hollow Core Fired biochar oven design that UBI/MoBI have begun working on. I have included a few pictures and brief comments on them to give the reader an idea of the design and its use.

I use the term **BIOCHAR OVEN** (or simply 'oven' in context) to designate a simple, low tech pyrolysis apparatus dedicated primarily to the production of biochar, usually with a feedstock capacity of 50 – 5,000 l. There is no intentional admission of oxidizer into the feedstock chamber during pyrolysis in a biochar oven.

We focus on ovens because they are more efficient and environmentally friendly than adaptation of more traditional methods of low tech charcoal production. The reasons for our focusing on low tech units in this size range will be readily apparent on reading a brief summery of the UBI concept that can be found on this web site.

'Biochar stove' or 'kiln' have also been used for these types of units. However, biochar stoves (and stoves in general) primary are for cooking and heating with biochar as a co-product. They are usually of smaller capacity as well. Kilns can be of very large size and often have internal burning, particularly when used in charcoal making. 'Retort' is another word that is sometimes used, but they can be of very large size and the word is not familiar to the general public.. We often deal with the general public and one advantage I see is that 'oven' is readily associated by them with what the apparatus is designed for. A biochar oven is used to bake feedstock into biochar in the same vain as a bread oven bakes dough into bread. For all of these reasons I would encourage the use of the term 'biochar oven' for these sorts of units.

1. Hollow Core Fired (HCF) drum with lateral core arms design (KJF '08).

This design has an outer drum (here a 200 l oil drum) with an inner core (formed by a large diameter pipe seen here removed, standing to the right of the drum and fitted with lateral arms). When in place the core opens through the ends of the drum.

2. In this design gas ports in the core were enlarged enough to loosely hold horizontal, open ended hollow pipes (core lateral arms).

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3. These lateral arm pipes were arranged in an ‘X’ pattern with a whole cut in them at mid length that faces up the core when the oven was placed in the firing position. (The drum is inverted for loading and thus the mid-length lateral arm holes cannot be seen in this picture.) The loose fit of the lateral arms in the core pipe holes allows for pyrolysis-gas (p-gas, which is generated at a positive pressure) to enter the core and burn there. Although the initial design function of the lateral arms was to distribute heat outwards through simple conduction, the open ends and hole at the middle also allowed for generated p-gas to be carried from the periphery of the drum into the core for burning. The upward rushing air in the central core should cause a pressure decrease as well as it moved around the horizontal pipe and its central, upward facing hole. This should draw hotter gas generated nearer the core out towards the periphery. We saw no evidence that this drew O2 into the biomass chamber from the holes in the core pipe.

Firing is carried out with the drum in the vertical position with the open-able end down and the sealed end up while situated in a heat retention cowling. Pyrolysis is initiated with an auxiliary fire beneath the drum.

4. The design is insufficient to cause good charring throughout a load of sawdust because of the sawdust's strong insulation properties.

5. For a further trial the drum was partitioned into vertical thirds. One each was filled with sawdust, ‘paddock’ (winter camp, packed) manure and field dried manure. As before, the sawdust was not charred completely through, nor was the paddock manure. However, the field dried manure was well charred throughout.

The paddock manure had been broken up into small pieces (though not as small as sawdust) to facilitate drying but still was not well dried. Both factors (dampness & packing) would impede heat penetration. However, the field dried manure was well dried and of relatively large size making for large pore size between pieces which facilitated heat penetration.

6. Another trial was run with a drum load of commercially available larch stove wood with a few pieces of thick larch bark. The wood and bark were well charred. A great deal of clean burning flame exited the top of the cowling during the burn indicating that there was insufficient O2 entering the core at the height of pyrolysis to allow for complete burning of the p-gas there.

LESSONS & THOUGHTS

The UBI HCF design: It seems this design is adequate for making biochar of dry feedstock that does not pose the heat penetration problems of sawdust. However, a number of design innovations may make it more efficient or practical.

Oil drums: "Oil drums" (and the similar type with removable clamp lids) are made of fairly thin gauge metal and cannot be expected to stand up to long repeated usage. However, where available they can be inexpensive and readily adaptable and may still be more economical or practical than similar ovens constructed from scratch using heavier gauge metal. It would not be necessary to have a tightly fitting clamp lid if the lid is situated at the bottom of the drum during firing and slightly recessed within the end of the drum, as any escaping p-gas or oil will be burned either by the initiating fire under the barrel or swept into the hollow core by the updraft during operation. This means that standard bung type drums for containing liquids could be used by simply cutting free the lid and using the resulting disk as the bottom, held in place during firing by removable and/or fixed pegs.

Cylindrical polygons: Where metal 'oil' drums are either not economical or unavailable, oven drums can be fabricated from desired gauge metal. If equipment is not economically available to fabricate round cylindrical drums and hollow cores, then cylindrical polygons of 4 or more sides could be made by either break bending metal sheets or welding together rectangular panels. A removable lower end need not be epically tight fitting if it is slightly recessed for reasons described above.

Cowling: The cowling or oven housing is used primarily to improve heating efficiency. However the structure can be relatively expensive and make production operations cumbersome. With fire primarily concentrated in the hollow core, the cowling could be reduced to light insulation integral to the outer wall of the oven. This should decrease initial expense while increasing mobility and ease of production operations.

Increasing heating efficiency: In the dry larch wood trial especially, a great deal of smokeless flame was seen immediately above the hot gas vents of the cowling at the height of the pyrolysis process. This indicates that the oxygen in the air being drawn into the hollow core was insufficient to fully burn the p-gas being vented there. It would seem that a series of channels could be designed immediately external to the outer drum wall that could draw down this hot p-gas, passively charge it with additional oxygen rich air and have it burn along the outer sides of the drum while being drawn back up through a corresponding set of channels. Keeping it low tech in this way would be preferable to using some sort of forced draft which would add to operational expense and be difficult in rural areas where electricity or fuel for auxiliary engines might be hard to come by.

Gas tight lateral arm fittings: Drawing the hot p-gas being generated nearer the core into the outward lying biomass should enhance heat penetration efficiency. This might be facilitated by sealing the connection between the horizontal pipe and the core. This could be done by either mating them with a screw fitting or welding them together. If the latter were done with the originally designed through-pipe with upward facing exit port, advantage could be taken of the greater pressure differential. A more even distribution of heat through the biomass load might be achieved by connecting each horizontal cross pipe to a feeding ring around the inside of the wall of the drum with inlet ports sized and distributed appropriately around the circumference.

Up-sizing: Fabrication of the drums would free us to increase drum volume through our size range of interest (50 – 5,000 l). Merely making the drum longer would probably have little effect on the other details of design except for accommodating the oxidation of the greater volume of p-gas generated. This might require increasing the diameter of the core (and capacity of the outer channels if they are used). However, increasing the diameter of the drum would also require adjusting the diameter of the hollow core for adequate heat penetration of the biomass. Perhaps it would become necessary to switch to a pattern of multiple hollow cores within the drum as the diameter increases.

Horizontal burning: We have begun testing this design with the drum stood vertically for the expediency of simplifying a makeshift cowling design. With fire confined primarily to the hollow core (and 'draw down' channels if they are incorporated) and a properly designed cowling, it should be possible to operate the oven in a horizontal or near horizontal position which might facilitate biochar production operations, especially with longer drums.

Adaptation for sawdust: Although the current design was inadequate to completely char a load of sawdust, the design should be adaptable to sawdust by adjusting the diameter of the hollow core to the degree of heat penetration achievable by the burning of p-gas generated and any auxiliary fuel that is economically available for an auxiliary fire. However, this would decrease the volume of the load, though perhaps a second or third concentric drum could be added with the firing occurring between them.

Analysis of performance: In addition to testing some or all or the modifications alluded to above we plan to characterize the performance of these designs, including temperature profiles in various regions of the drums during operation, as well as characterizing biochars produced from various feedstocks.

Open source designs: To the extent that these designs are not covered by priority or patents unbeknownst to me (I conceder the UBI Hollow Core Fired designs original work), I conceder the designs "open source" and invite their use and improvement, asking only that I be kept informed. I hope to continue to work on improving the design and to make available the results, including detailed data, on the UBI and other web sites. I would like to invite all interested to collaborate in creating a data pool on the UBI Hollow Core Fired design, its construction, operation, maintenance and the characteristics of the biochars produced. You can contact me at pattamo_kop@yahoo.com.

For more information on the UB International program and the UBI concept please see our web page at: http://www.biochar-international.org/regional/ubi

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