FC Trough Char-Maker of Corrugated Roofing Sheets (CRS)

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http://www.drtlud.com/resource/prt16820

Introduction:

"Flame Cap (FC)" is a relatively recent term which describes a PROCESS that successfully produces pyrolytic char (or charcoal) by using flames (which consume oxygen) to shield the created charcoal underneath the new fuel that is placed on top. Various writings often use different descriptive terms for the devices:

A. As a SHAPE, referring to cones, inverted pyramids, pits, trenches and troughs. The most distinctive characteristic of all FC devices is that they are "cavities" with open access to air on the top only, but in many different shapes and dimensions. They are all "cavity char-makers". A few have tops, hoods or covers.

B. As a closed PHYSICAL STRUCTURE, such as a "kiln" or "oven". The Wikipedia definition of a kiln: *"A kiln … is a thermally insulated chamber, a type of oven, that produces temperatures sufficient to complete some process, such as hardening, drying, or chemical changes."* [https://en.wikipedia.org/wiki/Kiln] A kiln or oven is a device which utilizes an enclosed chamber. In contrast, Flame Cap (FC) devices are very open, which means that they are not accurately called kilns and ovens.

Therefore, I prefer to use the designations of "Flame Cap" or "FC" and words like "char-maker" or "device" or "FC pyrolyzer." Inconsistent use of terminology is likely to continue and possibly be debated.

The Flame Cap (FC) technique has been described in the following writings along with some of the FC different devices. This is not a full review of the available information. An Internet search of key words will yield numerous references; here are only a few that caught my attention:

A. Japanese farmers have used cones for char making for decades or perhaps centuries.

B. Interest in cones in 21st Century: Kelpie Wilson's work at http://www.greenyourhead.com/cone-kiln

C. Pyramids: http://www.thebiocharrevolution.com/blog/making-and-operating-pyramid-cylinder-flame-shield-kilns-in-northern-california

D. Large cones of the Kon-Tiki style: https://www.biochar-journal.org/en/ct/39

E. Biochar in portable containers - 55 gallon and 80 gallon kilns: https://www.youtube.com/watch?v=lOSDwp20EKM

F. Pits to make biochar: https://www.biochar-journal.org/itjo/media/doc/1434748327997.pdf

G. Simple trench method: https://www.youtube.com/watch?v=I1jAo7qd_Q8

H. FC Tub Char-makers: http://www.drtlud.com/resource/prt16810

I. FC Trough Char-makers: http://biocharproject.org/charmasters-log/new-biochar-ideas (See parts 1 and 2.) (This is highly recommended and is preparatory information to this current writing.)

J. FC Troughs of roofing sheet metal: http://www.drtlud.com/resource/prt16820 (This item is presented here below.)

Experimental FC Trough units with corrugated metal roofing sheets:

For months I have been interested in the use of corrugated roofing sheets (abbreviated to be CRS) for making FC troughs. My inquiry to the innovators of FC troughs, Dr. Karl Frogner and Dr. Michael Shafer (authors of item "I" above), prompted a response in July 2016 that was not encouraging about CRS:

Second [in addition to considering barrels], we have also played around a lot with roof sheet. We have two big problems with it.

(1) It is plated and when hot the plating goes, emitting not nice gasses.

(2) Once the plating is gone, it rusts through really fast. In our early machines, we dealt with this by making pop open frames that permitted the easy replacement of sheets. This required working to the form factor of the sheets, but this was no big deal. In the end, however, it just proved too cumbersome.

The other thing to remember is that useable sheet steel (and also square box and angle iron) are readily available in recycling yards. The sheet steel needs to be patched together, requiring extra welding, but at a few cents a kg it is much less expensive than [new] roof sheeting.

Their experiences and comments are quite valid. However, the short-term, low-cost use of these sheets continued to be attractive to me.

In August and September, I had two opportunities (actually self-imposed "requirements" or promises to the hosts and participants) to make FC troughs with limited funds, short time-tables, and without easy access to welding equipment. At both locations there were small stacks of previously-used corrugated roofing sheets that were free for me to use. The general size measurements were decided for convenience, with actual measurements decided during fabrication. No measurements stated below are intended to be precise.

Circular body with barrel ends: August 2016. During the Stove Camp and Char Production Gathering held at Aprovecho Research Center, Oregon, USA: (Main assistants were Cynthia Jasman for construction and Paul Taylor for operation.)

Two roofing sheets measuring approximately 180 cm (~6 ft) were laid side by side with 2 (maybe 3?) undulations overlapping and then screwed together to create a width of about 120 cm (~4 ft).

Corrugations make difficult the sealing of the ends. So an easy solution was to use 10 cm (4 inch) end segments of a 200 L (55 gallon) drum, as shown in Figures 1 and 2.

Figure 1: Two views of an FC Trough with circular profile of corrugated roofing sheets and end segments from a 200 L barrel.

Figure 2. Detail showing reinforcement with angle iron nested into one of the corrugations and bolted to the end cap and sheet.

Usage was somewhat problematic, with the fire tending to be in the center or favoring only one end. Fuel pieces were thrown in. The char accumulation was estimated, not measured, to be 12 to 16% of the fuel weight. A GAC test of adsorption (provided later by Dr. Hugh McLaughlin) showed quite good adsorption capacity.

Note: The sidewalls are curving inward, quite different from most FC cones, FC pyramids and other FC troughs. Inward curving is considered to be undesirable, but that is not yet scientifically proven.

Trapezoid body with sheet metal ends: September 2016

During a 5-day Gasification and Biochar Workshop at Las Cañadas, Veracruz, Mexico. (Assisted by many, including Alejandro Lopez M. and Bernardo Courtade for fabrication and Camilo Vallejas for operation.)

Fabrication: We had our pick from perhaps 20 sheets of used corrugated roofing, choosing two about 180 cm (6 ft) long and with matching corrugations. With overlapping for fastening together (with self-tapping screws and a power drill for easy assembly), the assembled piece was 160 cm (63 inches) wide.

The end pieces were 61 cm (24 in) (being half of the width of the flat 24-gauge metal sheet, to avoid waste) by 1 meter long (39.5 in). Approximately 5 cm (2 in) were allowed for the bottom and two sides to be folded 90 degrees to give overlap over the corrugated sheets for fastening together with screws.

The desired final shape was decided while holding the pieces together to create sufficient but not too much of a flat base, which turned out to be 30 cm (12 in) wide. This left 130 cm for the two sidewalls (about 65 cm (25.5 in) each on the slant to reach the straight vertical height of 56 cm (22 in)). (Figure 3.) The steep sidewall shape is advocated by the developers of the Kon Tiki design of FC cones.

Figure 3: FC Trough of Corrugated Metal Sheets

When the shape and bottom width were decided, three men easily made by hand a firm crease (bending together) along

Figure 4: FC Trough of corrugated roofing with sheet metal ends and re-bar support / handles, with details of folded edges and screws.

a corrugation for each edge of the bottom. The ends of each corrugation were snipped (about 3 cm) and then folded inward 90 degrees to provide additional surfaces for attachment to the end pieces with screws (or nuts and bolts). (Figure 4.) If available, some furnace cement could be applied to further seal the sides to the ends.

The resultant top opening was approximately 91 cm (3 ft). For additional strength and to give "handles" for carrying the FC trough, two lengths (about 3 meters or 10 feet each) of previously used re-bar (steel rod) were inserted through holes in the upper corners of the end pieces. Thicker rod would have been stronger (but was not available). The rod can be secured to the sidewalls with wire loops.

Operations:

Three small fires were lit for initial combustion in the FC trough. After a few minutes they were merged and additional fuel was placed on top. As with all Flame Cap char-making devices, attentive nursing of the fire is important until sustained flames are over the entire top surface.

Figures 5 – 8: Building a fire in an FC trough char maker.

Figures 9 and 10: A few hours later, the FC trough is nearly full. Capacity is over 600 Liters. Note the bamboo fuel visible in the trough and behind. Ended in the evening. Apart from the learning experience, essentially only one man was needed part time to do the char making.

Figures 11 – 14: Emptying the FC trough char onto a spare roofing sheet.

Figures 15 and 16: Char spread on a metal roofing sheet for inspection and partial cooling, then partially doused with water, and then placed into a drum and sealed. The corrugated sheet bends easily and greatly assists when putting char into barrels.

Char characteristics and fuel observations:

This was my first opportunity to have virtually unlimited supplies of dry bamboo. It is an excellent biomass for conversion into charcoal in FC and TLUD pyrolyzers. The resultant char is not "oily", and it easily breaks apart into desired sizes. Abundant mulberry branches under 3 cm diameter were also a successful fuel with very nice char.

Conclusions:

1. Compared with my other (still limited) experiences with Flame Cap (FC) devices, the FC troughs are especially convenient when the biomass fuel tends to be a meter or more in length and under a meter in breadth (bushiness), which is a very common size for low-value "waste" biomass.

2. FC char is created by pyrolysis in an oxic (O_2 present and flame present) environment, resulting in moderate to high temperatures for carbonization. The resultant chars have relatively low content of volatiles and are seen as favorable for use as biochar into soils.

3. We are only at the beginning of understanding the processes and methods of Flame Cap pyrolysis for char production. The methods are not complex, and the devices can be of very low cost. We hope that many people will try FC char making in many devices and report their results, both pro and con.