Document: Shields-E450c first documents (by Paul Anderson) 7 October 2013 --

Stovers, especially the ones concerned about HOW to test char-making (and batch loaded) stoves.  
  
Frank Shields has proposed an **alternative method for efficiency testing of stoves that make charcoal** (including the batch loaded ones.)     His comments were made in 3 or 4 messages on the Stoves Listserv starting on 3 October 2013 under the subject of:         Re: [Stoves] Efficiencies for the rich and poor.  
  
Below I have snipped the key parts and put them into chronological order so that you can see the development of Frank's thoughts.   And I give a quick summary here of what I call the Shields E450c method (proposed):  
  
1.  Char-making stoves (including the TLUDs) do their cooking (or provide data for efficiency testing) with the energy from combustion of the pyrolytic gases produced inside the stove from raw biomass.   Factors of moisture content (MC) need to be taken into account (as is already required in the other testing of cookstoves, eg standard WBT).  
  
2.  The temperature of 450 deg C is measured and established as solid base temperature for the completion of the most of the making of pyrolytic gases.  Actually, between 400 C and 550 C there is not a great deal of variation, and that variation could be entered into the calculations IF that variation is considered to be significant and IF the stoves reach that or higher temperatures for sufficient and extended time in the pyrolytic process.    
  
[We note that in current discussions about revisions to the WBT regarding char-making stoves, there is NOT a discussion (that I know of) of whether the chars taken out and weighed were created at 400 or 500 or 600 C or whatever temperatures.  If the temperature is not crucial for that version of testing, the temperature of char creation is probably not too critical as long as it is in the 450 degree range or above.   This could be discussed by the experts IF the Shields method gains interest.]  
  
3.  Therefore, in a stove efficiency test where there is reasonable consistency in the yield of charcoal on a weight basis from a known biomass, it is possible to determine the "Energy of the combusted pyrolytic gases created when temperatures were about 450 C or above".   Frank calls this    E450c    .   And this is the energy that is available to do the "work" of cooking.   Some goes into the pot, and some is lost, yielding an efficiency percentage.   When you know the starting weight of a particular fuel (with known MC), and you will know the potential E450c energy available.   It is directly related to the already carefully determined energy content of so many types of biomass.    And that pyrolytic fraction (the E450c energy) has been released when the pyrolytic process ends (very clearly seen in these char-making stoves) and noted as number of minutes.   If you note the time that the boiling temperature is reached, divide that by the total time and you have the percentage of E450c energy that was expended to attain the boil.  
  
4.  There is no attempt to assign a value (of energy or monetary or social or climatic impact) to the produced char.    
  
To Frank I say "Thank you!!".   Now the measurement experts can read below the original messages and offer their comments.  
  
Note:  Frank and I and Ron Larson and Hugh McLaughlin and Thomas Reed and several others with interests in char-making stoves will be together on 13 to 17 October (a week from now) at the North American Biochar Symposium at Amherst University in Massachusetts.  The Shields E450c approach to measuring efficiencies might be a topic for side discussions there.  But the real debate is within the IWA technical committees.  
  
Paul

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On Oct 3, 2013, at 3:54 PM, Frank Shields <[frank@compostlab.com](mailto:frank@compostlab.com)> wrote:

Greetings Stovers,

 Tom

Reed coauthored a book tilted An Atlas of Thermal Data (link below)

that explains the results of Thermogravimetric data on a wide variety of

biomass under different conditions. The results show a rapid decrease

in weight that then stabilizes around the 400c and mostly completed at

450c. Using Thermogravimetric analysis (TGA) on biomass can separate the

fuel into two distinct and repeatable fractions. The one fraction

between ambient temperature to 450c we know will be used during cooking

as once this restively low temperature is reached it has volatilized. It

needs no oxygen from outside and gets it all from the fuel to form a

gas then secondary air to completely combust.  The fraction of fuel left

above 450c contains energy that may be used or left after cooking. To

compare efficiencies of stoves it seems to me we just need to use the

energy of the biomass fraction we know will be used and use that value

as the energy provided. If a stove is designed to use some char as added

energy all the better for that stove. We do not need to determine the

char left in the stove. We need to decide to use HHV or LHV but since we

are not testing for hydrogen and just using an agreed upon value it

doesn’t matter – as I see it.

**From:** Stoves [mailto:stoves-bounces@lists.bioenergylists.org] **On Behalf Of** Ronal W. Larson  
**Sent:** Thursday, October 03, 2013 8:57 PM  
**To:** Discussion of biomass cooking stoves  
**Subject:** Re: [Stoves] Efficiencies for the rich and poor.

 Frank:

    The folks working with char-making stoves are not going to understand this sentence at all:    *'We do not need to determine the char left in the stove.*'

     That

is as simple a measurement as you can find.   Granted that most of the

weight loss is before 450 C,  the weight is NOT constant as you keep

going higher in temperature   You will have a fair shot at the

temperature achieved by measuring the weights in and out.  But temp is

not the only variable, there is also the time at temperature, the size

of the fuel etc.  See material in the Gaur-Reed Chapter 8.

 [Anderson interjects: I recognize Ron's concerns, but I believe   
that the impacts will be minor compared to the overall accuracy of   
the measurements.  
  Ron continues: I know people are trying hard to determine the peak pyrolysis

temperature from the characteristics of the char - besides weight

differences, there is density, water-adsorbing properties, pH, and

electrical conductivity in the "simple" (poor man) category.  Some big

changes in conductivity can occur above a certain temp.   Many people

would like to know the CEC characteristics, but I know nothing on that

measurement.

 I guess I am saying that the stove itself might serve as the "pipe"

you are describing [FOR USE IN LABORATORY MEASUREMENTS OF ENERGY IN BIOMASS].  If you have a good guess at the temperature of the

produced char, you have a reasonable estimate of its remaining energy

content, which is what I guess you are after.   I don't have much hope

that any test with a "pipe" is going to tell you much about a particular

stove. [ANDERSON: But it will tell you about the particular fuel and be totally independent of the stove type or trying to boil water in the test.]

On 10/4/2013 12:45 PM, Frank Shields wrote:

**\*This I think important\***

**I’m thinking when we test stoves we should start with knowing the weight of a pile of biomass. Then test and determine the total energy450c (E450c) dry weight of the pile. Weigh the remaining pile after each test to determine the amount of E450c used for the task(s). Using this volatile fraction as the measured energy input (not total energy of the fuel) we can then determine the amount of E450c it took to cook a pot of rice without the need to subtract the energy in the char left over. Once the biomass pile has been used up, the sum of the E450c used should add up to the total [E450c] in the starting biomass. The char left over for the garden has no E450c so there is nothing to subtract from the total E450c value of the starting biomass. But if you want to know how much E450c was required to produce it, just add up all the E450c used for the completed tasks that left the char behind. All we need to do is make sure the stove it [is] at or above 450c when the task is completed so to make sure all E450c in the fuel has been used. So simple…..  (I think!).**

**Thanks**

**Frank**

Frank wrote in his next message:

**There are two purposes to do a lot of testing to measure many things including efficiency:**

**1)    Is to learn about stoves, how they work, what chemistry is taking place, where, why and for how long so improvements can be made.**

**2)    The sole purpose of comparing one stove to another. Money and sales are at stake. Must be done right, cheap, with few variables.**

**It seems EPA and past procedures are doing all the testing for purpose one as much as purpose two. I am just concentrating on purpose two. A stove has many factors that increase (or decrease) efficiency. Using the E450c fraction as a measure we have things like; insulation, size of pot, pot gap, secondary air AND ability of the stove to use some char to help aid in the task. If that happens it shows up in better efficiency. We center around the E450c energy value and do things that improve on it.**

**I think purpose one is many different separate studies so to control the variables. And certainly should not be muddying the testing of efficiency when $$ and reputations are involved.**

**Regards**

**Frank**

**Frank Shields**

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***[Frank >] The only thing that matters is us all being able to come up with the same number. If we all have a TGA and its calibrated we should be able to send a sample to a bunch of labs and they all report back the same number for E450c. It’s this value we give to the fuel.  If during the testing we use larger fuels pieces that take longer for them to reach 450c in the field it doesn’t matter. We go as long as the secondary flame is still there because when that goes out nothing happens no matter how much un-burned fuel is left. That just means the stove is designed for smaller pieces or different biomass or a re-design needed to handle the larger pieces. The efficiency goes down because of that. It’s the same as if the stove needs better insulation or a change in the gap.***

**In most situations char is of secondary concern with the first being what the task of the secondary flame is being used for. If your main concern is char and its quality, that is a different task. You want to know the efficiency of making the best quality char. Meaning the E450c used from the pile (weight) to produce good quality char. So you determine the E450c used for different configurations and compare the different chars produced for quality. Then determine the E450c needed to produce that best char (task).**

**Regards**

**Frank**