From: alexis belonio <atbelonio@yahoo.com>
Sent: Wednesday, January 16, 2019 8:18 AM
To: Ronal W. Larson <rongretlarson@comcast.net>
Cc: Anderson, Paul <psanders@ilstu.edu>; Paul Olivier <paul.olivier@esrla.com>
Subject: Re: Fwd: [Stoves] Inquiry re blue flame from rice husk gasifeir

5. Air fuel ratio, superficial gas velocity, and specific gasification rate all affects the quality of gas from the gasifier. These all depends on the quality of rice husk used such as maturity, impurities, whether deteriorated or not, moisture content, etc.
6. The design of gasifier reactor and the burner also contributed in attaining blue flame color with rice husk as fuel. Properly design reactor having long but short diameter produces bluish flame.

In my experience, the maximum diameter of the reactor is about 250 mm. I have rice husk gasifier stoves and combusts even for micro gasifier for power generation that operates well even beyond 250 mm. It only matters on the way we introduce the air as well as in discharging the char in the case of a moving bed type reactor.

When the diameter is greater, this creates problems as tertiary air rushes in toward the middle. This can be minimized if a bigger plenum chamber between the fuel and the burner is provided. Another is to channel the gas into several burners to make use of it.

So when large diameters are required, multiple burners of a diameter no greater than 150 mm are placed on a lid, as shown here: (see attached info re multiple burner stoves.)
https://www.dropbox.com/s/mvje31ajn06uych/005.pdf?dl=0
https://www.dropbox.com/s/aln8m2ayft6rw3u/001.pdf?dl=0

Also, when the reactor is insulated capable of increasing the bed temperature and injecting hot air to the fuel, blue flame appears.

Heating both primary and secondary air is quite important. Yes, I agree!

The burner design on the other hand can also affects the color of the flame. Burner that can eliminate tars before the gas and properly mixed with hot air can also produce bluish flame.

Also I put a housing around the Belonio burner.
This makes an enormous difference. Yes! That keeps the heat concentrated into the pot. If we can design a burner that can release higher gas velocity, heat transfer can be further improved. I have a sample stove that work in this principle. See attached file.
The burner delivers heat to a pot with just about the same efficiency as a gas stove:
https://www.dropbox.com/s/uotkoyu5qq4eogb/020.jpg?dl=0
Long candlelight flames are replaced by many jets of tiny flames. This allows increased in the velocity of the flame which can improve heat transfer efficiency in the pot.
To get such a result, hot secondary air is directed horizontally at the base of the burner holes under a mild pressure created by the draft of the burner housing.
Then an intimate mixing of the two takes place.
The burner housing must not be too long, however.
If the burner housing is too long, the burner demands a lot of syngas, and there is not enough turn-down ratio for ordinary cooking.

7. Torrefied rice husks or even some biomass can produce bluish flame in gasifiers. I did test runs during my visit to one Company in India and also in Vietnam that torrefied rice husks and other biomass produced bluish colored flame when gasified.
One can torrefy and pellet, or one can pellet and torrefy. Torrefying before pelleting will require binder to form the shape we need. Pelleting before terrifying will

result to deform fuel. I used torrefaction of biomass for rice husk which is OK. For sugar cane bagasse it works fine since terrified biomass becomes hydrophobic which is an important factor in achieving good combustion. See attached info on sugar cane bagasse torrefyer I design and developed early last year.
Torrefaction is needed when the biomass is oily, as in the case of pine wood. Or loose and ground biomass to increase its energy content as well as to improve combustion/ gasification.
Torrefaction can be carried out by means superheated steam. what I did is to indirectly heat the biomass by conduction process inside a rotating cylinder.
One can boil in a pot above the gasifier and route saturated steam between the reactor and housing where it gets superheated. I do simply roasting of biomass to remove moisture and part of the volatile matter that do not combust.
One can also put a housing and heat changer around the boil pot to take advantage of heat rising up the sides of the boil pot.
See:
https://www.dropbox.com/sh/0nx4rwze4m605jz/AABi1sg5dK-OjoQMskHRAcoBa?dl=0
https://www.dropbox.com/s/c5fp15c3ppqypgy/001.pdf?dl=0
https://www.dropbox.com/s/feysn57b1x8vw6e/002.pdf?dl=0

8. Completely carbonizing biomass like sugar cane bagasse before gasifying will not help enough to produce bluish flame when gasified. This is with the exception of wood with sufficient amount of carbon present after carbonization.

9. Bluish flame in gasified rice husk can also be obtained by wet scrubbing or simply by spraying the gas with water in an enclosed chamber. However, when scrubbing hot gas during the process can increase the O_2 content of the gas which results into reduction of the heating value of the gas. From around 1,200 kcal/m^3 gas, it will drop down to around 800 kcal/m^3 once scrubbed.

Wet scrubbing will also reduce the temperature of the syngas - not ideal unless this heat gets recovered and used. Not only that, it also reduce the heating value of gas! The temperature of syngas coming out of the reactor prior to combustion is over 500 C. That is in the case of stove where measurement is don directly on top of the reactor. For gas channeled to a gas pipe and release to a separate burners or gas conditioning unit, it usually ranged from 150 to 300 C.

I would like to share with Alexis Belonio this text written by Alli Devlin.
She studied very carefully the efficiency and safety of the Lotus Fire Gasifier:
https://www.dropbox.com/s/ve7ppezks8c5far/Thesis%20Alli%20Devlin.docx?dl=0
Also, there is a more detailed explanation of how gasification and biochar fit into a larger strategy of waste transformation: Thanks that would be a help to all!
https://www.dropbox.com/s/wbarsaz89mvtglw/Summary.pdf?dl=0

Thanks Ron and Paul!

On Wednesday, January 16, 2019 10:29 AM, Ronal W. Larson <rongretlarson@comcast.net> wrote:

Alexis, cc Paul and Paul

It was not clear to me whether Paul O wanted this sent to the full stoves list - but I am sure he wants it to be sent to you. I will be glad to be in the middle, if both of you express approval of all or parts going to the larger stoves list audience.

I haven't looked at all of Paul O's cites, but guess some have already gone to the Stoves list - so we should try to avoid duplication.

Ron

Begin forwarded message:

From: Paul Olivier <paul.olivier@esrla.com>
Subject: Re: [Stoves] Inquiry re blue flame from rice husk gasifeir
Date: January 15, 2019 at 6:19:50 PM MST
To: "Ronal W. Larson" <rongretlarson@comcast.net>

See comments below.

On Wed, Jan 16, 2019 at 1:24 AM Ronal W. Larson <rongretlarson@comcast.net> wrote:
Paul:

Any comments (for me or the stoves list)?

Ron

Begin forwarded message:

From: "Anderson, Paul" <psanders@ilstu.edu>
Subject: Re: [Stoves] Inquiry re blue flame from rice husk gasifeir
Date: January 15, 2019 at 10:16:00 AM MST
To: alexis belonio <atbelonio@yahoo.com>
Cc: Discussion of biomass cooking stoves <stoves@lists.bioenergylists.org>
Reply-To: Discussion of biomass cooking stoves <stoves@lists.bioenergylists.org>

Stovers,

I thank Alexis Belonio for his highly informative comments (below) on blue flames and rice hulls. He also sends an update on his work situation.

I do ask Alexis for a further comment that relates to the silica Si or SiO or SiO2 as a factor, relating to thermite. It might have no importance. But the question about silica or silica oxide should be resolved. Is there no other chemical (metal?) present with which the silicon oxide might be reacting is some small but important way?

Paul

Doc / Dr TLUD / Paul S. Anderson, PhD
Exec. Dir. of Juntos Energy Solutions NFP
Email: psanders@ilstu.edu Skype: paultlud
Phone: Office: 309-452-7072 Mobile: 309-531-4434
Website: www.drtlud.com

From: alexis belonio <atbelonio@yahoo.com>
Sent: Monday, January 14, 2019 2:08 AM
To: Anderson, Paul <psanders@ilstu.edu>
Subject: Inquiry re blue flame from rice husk gasifeir

Hi Paul,

Good afternoon and thanks to your email!!

After leaving Carbon Neutral Commons early last year, I work back again full time at Philippine Rice Research Institute developing hydrous bioethanol as fuel as well as paddy dryer using rice husk gasifier as heat source.

Over the last few days, I have been drawing up a dryer silo that would hold over 100 m3 of grain.
I offer two designs: one that involves retrofitting an existing silo, and one that offers a new design.
The one dryer silo takes advantage of both sunshine and gasifier heat.
Gasifier heat is supplied to the dryer silo when the sun does not shine.
I would like to share my drawings with Alexis Belonio and get feedback from him.
One design of a combined solar/gasifier silo:
https://www.dropbox.com/sh/36kfpzaehhtufmi/AAD7Yog2BIJLOj00h32AJWbSa?dl=0
Another design:
https://www.dropbox.com/sh/5vbpj98xa3w0nad/AACSH5g-aR9PUTXNNxUzws5Ba?dl=0

The gasifier warms water in a pot and routes this warm water between reactor and reactor housing.
The warm water is routed to a rebuilt automotive radiator.
The grain silo is downdraft.
Warm air is pulled up on the outside of the silo and enters the top of the silo where is is sucked down by the one centrifugal fan.

This year, I was given an assignment to develop a biomass gasifier with dry scrubber that will run non-retrofitted diesel engine as power unit.

It is almost 5 years now that I don't have any contact with Dr. Olivier. Maybe, you need to email him about his current activities. Glad to hear it also!

With regard your questions about rice husk gasification to obtain blue flame, what I can share to you is all based on my studies and experiences in the past. Here they are below.

1. Rice husk contains high amount of ash (20%) which is crystalline white in color. 90% of the ash is silica and difficult to handle in any combustion devices. The volatile matter content is quite low of around 76% as compared with other biomass.

Because of the high content of amorphous silica in rice hulls, great care must be taken in emptying a gasifier not to let biochar combust.
If combustion takes place, cristobalite might be formed.
Cristobalite is highly carcinogenic.
After a gasifier run, ideally the gasifier should be sealed off with an air pipe cap and a reactor plate.
In this way, oxygen does not enter the reactor.
Then the reactor full of biochar is allowed to cool off over a period of two hours.
When it is emptied, the biochar does not combust.

2. Gasifying rice husk is quite difficult to operate is a moving-bed gasifiers. The gasifier must be properly designed not to interfere the gasification zone during operation. When rice husk is use in fixed bed reactor, operation is very much stable.

I fully agree.
A uniform biomass left in a completely static state gives a higher quality syngas and a higher quality biochar.
I designed a 150 gasifier where the burner is quite low (< 40 cm above ground level) and yet the burn time on pellets can be more than 8 hours:
https://www.dropbox.com/sh/jiw327b9zjm5ioq/AACcA457ELIcG7xNAIJUaAOja?dl=0

The only problem is if operation of more than 2 hours is required. Restarting between operation is inconvenience in this gasifier.
3. When gasifying rice husk, you can possibly obtain bluish colored flame as compared with other biomass. This is because rice husk exhibited low volatile mater as mentioned as compared with wood. However, not all the time when you gasify rice husk, bluish flame is present. I have rice husk gasifiers which produces pink to yellow flame and hardly can get the desired blue flame when operated.
4. The moisture content of rice husk when gasified also affects the color of the flame. When I use low moisture rice husk of around 10% and below, I can achieve a blue flame color. However, when rice husk is a little bit with high moisture say 14% and above. A pink colored flame usually appears.

To overcome the problems associated with biomass of a moisture content greater than 10%, I put a housing around the reactor.
The fan is situated at the top of the housing, and it blows air tangentially between housing and reactor.
When this happens, the primary air gets very hot.
Hot primary air swirls around and down the reactor and comes up through the grate at the bottom of the reactor.
When it travels up through the reactor, it dries the biomass within the reactor.
In the first few minutes of a burn, the flame might be orange, but after a short while, it turns blue.
Here is my latest design:

https://www.dropbox.com/sh/1kaurczwj5jtxlj/AACEF3VUnL_8eGBG9s0-252Oa?dl=0
Note that the housing does not have bottom.
The gasifier is simply placed of a flat, smooth surface such as a floor tile.
Note also that the fan is situated at a more accessible, ergonomic height.

5. Air fuel ratio, superficial gas velocity, and specific gasification rate all affects the quality of gas from the gasifier. These all depends on the quality of rice husk used such as maturity, impurities, whether deteriorated or not, moisture content, etc.
6. The design of gasifier reactor and the burner also contributed in attaining blue flame color with rice husk as fuel. Properly design reactor having long but short diameter produces bluish flame.

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When the diameter is greater, this creates problems as tertiary air rushes in toward the middle.
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https://www.dropbox.com/s/mvje31ajn06uych/005.pdf?dl=0
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Also, when the reactor is insulated capable of increasing the bed temperature and injecting hot air to the fuel, blue flame appears.
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One can boil in a pot above the gasifier and route saturated steam between the reactor and housing where it gets superheated.
One can also put a housing and heat changer around the boil pot to take advantage of heat rising up the sides of the boil pot.

See:
https://www.dropbox.com/sh/0nx4rwze4m605jz/AABi1sg5dK-OjoQMskHRAcoBa?dl=0
https://www.dropbox.com/s/c5fp15c3ppqypgy/001.pdf?dl=0
https://www.dropbox.com/s/feysn57b1x8vw6e/002.pdf?dl=0

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Also, there is a more detailed explanation of how gasification and biochar fit into a larger strategy of waste transformation:
https://www.dropbox.com/s/wbarsaz89mvtglw/Summary.pdf?dl=0

Note well the many studies done by Dr. T.R. Preston on the biochar from my gasifier.
I add to and modify this paper almost every day.
So always use the above link and open it afresh.

Many thanks to you and Alexis Belonio.

Paul Olivier

10. Therefore, if we really want to produce bluish flame from gasifier, what we need to do is to process first our fuel that has no moisture in it. Torrefied it if possible to remove part of the volatile matter that would not help in the combustion of gases. However, doing this will be costly unless the process can be integrated into the design of the reactor and the burner of the gasifier. For small systems like cookstove, this would be more quite difficult.

Again, thanks and God bless!!

Alexis

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