REINHOLD ENVIRONMENTAL Ltd.

2019 NOx-Combustion-CCR Round Table Presentation

February 11 & 12, 2019, in Salt Lake City, Utah / Hosted by PacifiCorp

LNB TUNING 301.

Bruce Salisbury

February 10th, 2019

Particulars

- There are several types of low NOx burners out there.
- Since my experience is primarily the Foster-Wheeler series, I will speak to those in terms of definitions of burner parts.
- Even with post combustion NOx control, it is important to achieve as low as practical NOx emissions from the boiler for cost control of chemicals.

Particulars

- There are different nomenclatures for these parts, but Low NOx burners usually consist of;
  - A secondary air control or sleeve damper.
  - A way to control the swirl characteristics on the outside of the combustion envelope.
  - A way to control the swirl characteristics on the inside of the combustion envelope.

Particulars

- The specific, tunable portions of the burner are;
  - Coal throughput, and particle size
  - Secondary air
  - Rotational speed of the outer envelope
  - Rotational speed of the inner envelope
  - There are also some fixed positions you need to be cognizant of.

Windbox to Furnace differential

- Windbox to Furnace Differential is a measure of the differential pressure between the windbox and the furnace.

- While some is good, a lot is not necessarily better.

Windbox to Furnace differential

- Too small a differential pressure will allow no control. Large movements of dampers, will provide little to no change in throughput..
  - This is what we refer to as the “Fischer-Price busy box effect.
- Too much differential, allows very good control, but chews up fan power, and may limit load, when you become fan limited.

Windbox to Furnace differential

- Unfortunately , the sweet spot is pretty small, somewhere between 1-1/2” to 3” of differential pressure .
- Run toward the top of this range, if you have enough fan to do it.
- Tuning will impact this, raising and lowering it as you tune, so you have to be cognizant of this throughout the entire tuning process.
- Most burners have overly large sleeve dampers. This is actually good, because you always have enough sleeve damper, but you have to be aware that your starting position is going to be 70% of the open position, or you are going to suffer from the Fisher-Price busy box effect.

Individual Burner flow measurement devices.

- There have been several iteration of these types of devices over the years. They consist of a pitot tube inside a burner whose intent is to measure the air flow through the individual burner.
  - Due to the fact that as you increase the swirl, you change the aspect ratio of the pitot tube in the burner, these devices are frustrating, unreliable, and should not be trusted for burner data.

Knowing where everything is at.

- Throat settings.
- The tip of the burner should have a very specific position with the throat quarl tile. This is usually laid out very clearly by the burner manufacturer.
- While these are rarely moved, it is important to measure the position of these devices, and as importantly, translate the measurements to something outside, so these measurements can be checked, and if necessary, changed when the unit is operating, if needed.

So are we tuning yet?

Coal Loading

- While it is not critical per se to have perfect coal loadings prior to tuning burners, it is a great advantage to have them close, to prevent large disparities of flue gas from one side of the furnace to the other. Particularly if the system feeds into a flow dependent device like an SCR.

- There are several ways to measure coal flow, all of which have flaws.
  - ASME probes, are good at coal particle sizing, but are not good at coal loading.
  - Rotoprobes are good at coal loading, but can’t really provide particle sizing data.
  - Both methods are time and labor intensive. And cannot provide quick data. Recovery time for data is measured at best, in hours.

So are we tuning yet?

- The third option is unconventional, and involves the use of a spike energy meter. Like the previous methods, this has value, but is not perfect.
- G's Spike Energy is a measurement of the vibration of an object. This is a common function that is measured in rotating equipment with a hand held meter, so the equipment is probably already in your facility in the hands of the vibration and balancing people.

Spike Energy data for coal flow

- It has been found that measuring the spike energy on the outside radius of coal pipe coming off a mill can provide a good and quick, relative value for coal flow on a mill, in a few minutes.
- It also provides real-time data when classifier changes needed to be made with a pulverizer online.
- So you don’t get perfect data, but you get pretty good data, very quickly.

Almost there…

- Like coal tips in throats, you need to go into the windbox at some point in time, and actually verify the position of sleeve dampers, and the inner and outer registers, or equivalent. After setting the initial position, take the measurements to the outside of the burner so that you have data outside, that translates to the position inside.
  - All of these devices are clunky enough that this translation of measurement is necessary to have a high degree of confidence that your measurements outside, translate to measurements inside.
- We'll get to tune in a moment. I promise.

So let's start.

- Your initial setting should have gotten you into the ball park.
- After the unit comes up and online, you need to employ, and then come back to a couple things that you will use in a feedback loop to get the burners closer and closer to the perfect place to be.
- These three techniques involve measuring turbulence, having an eye for color, and a method know as Blinking.

All about turbulence

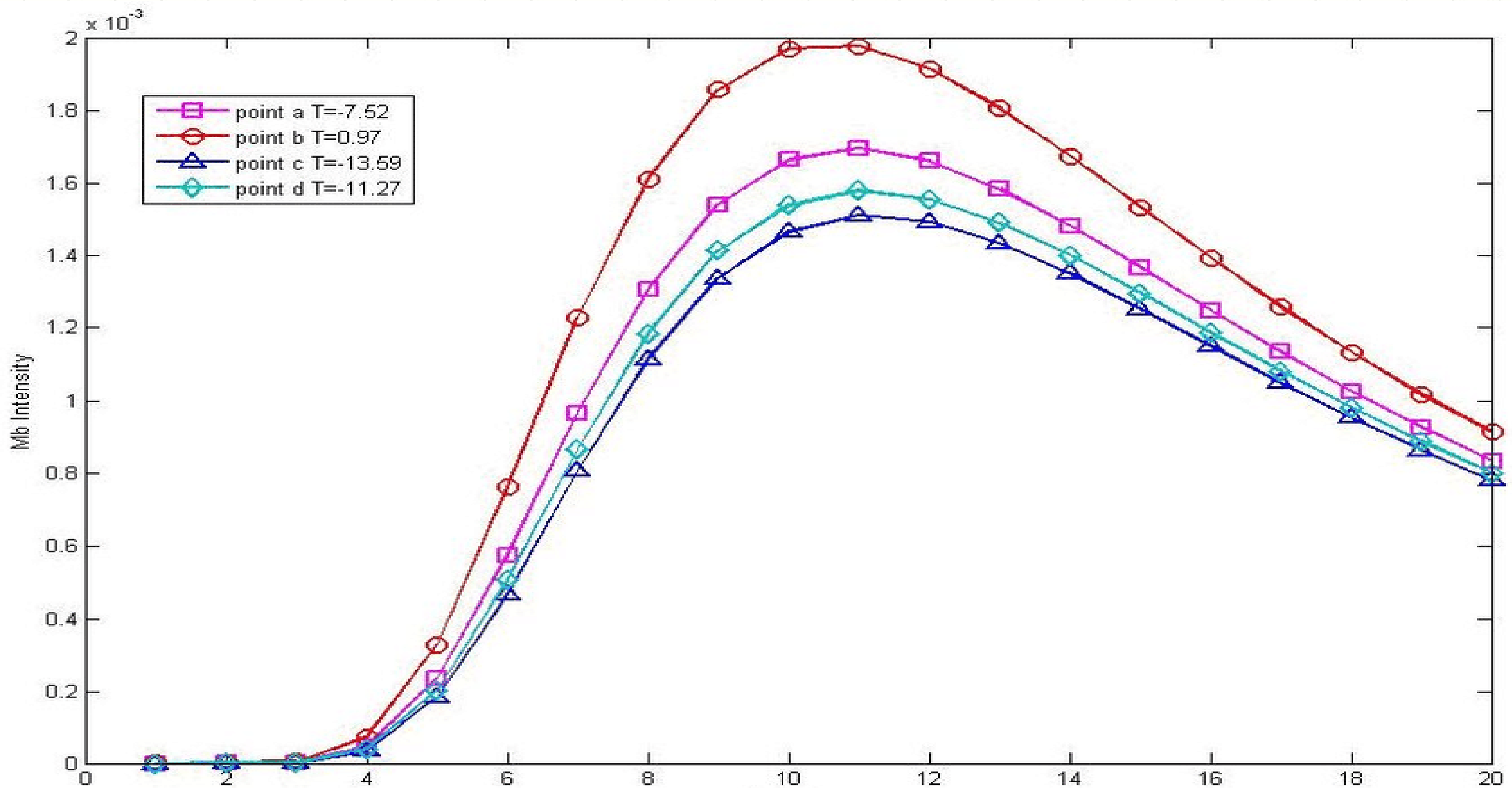
- For a very short relaxation period after it forms, the NO molecule is profoundly opaque. As it forms and relaxes, the molecules extinct light and then allow light through, giving the illusion that the flame is “flickering”.
- Main flame scanners can see this as flicker, and in some cases, can actually construct flicker frequency blackbody curves.
- If these are not available, the fallback for this tuning, is the Mark I eyeball.

All about turbulence

- The turbulence of a burner will configure itself as a flicker frequency black body curve.
  - The primary frequency, or peak of the curve is the rotational speed of the flame front.
  - The typical peak frequency of burners is approximately 5 hz.
- As you match the inner and outer speeds of the burner, the blackbody curve will become smoother.
- The smoother the curve, the lower the NOx emission.

All about turbulence

Which is all about Flicker. This is a two dimensional slice, of a three dimensional object



All about turbulence

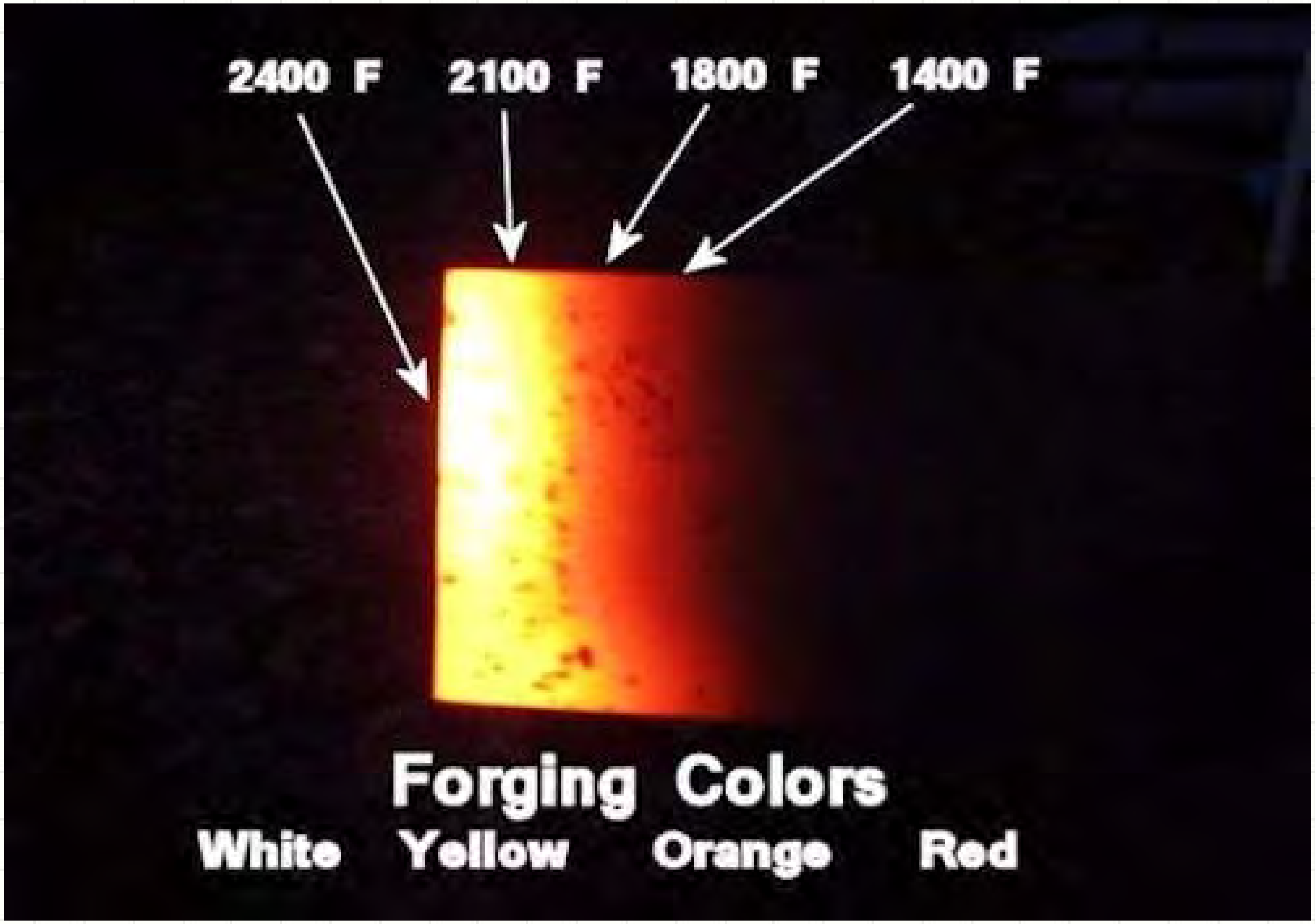
- The less smooth the curve, the more turbulent the burner
- Although the burner curve can become very smooth, the limitation is when the core of the burner becomes dark.
- A dark inner core to the burner can produce even lower NOx, but does so at the expense of creating slagging issues, and causing fireside corrosion in the lower furnace.
- The center of the burner can typically be viewed through the siting port for the ignitor scanner.

And having an eye for color

- If you know the color, you know the temperature.
  - This Blacksmithing 101.
- Regardless of the coal flow, this color corresponds to stoichiometry, so varying the air throughput will vary the temperature, will vary the color.
- Since you are ultimately running a finished stoichiometry of 2-1/2% excess O2, what really matters is that at least initially, when you are done, the colors are the same.
- Tiny movements with subsequent observations are the order of the day. This method is tedious and time consuming, but ultimately leads to good results.
- Obviously, the better eye you have for color, the better this method will work.

Color IS Temperature

- This range of colors is wider than you tune.



Blinking the burner

- Blinking consists of nothing more than taking a burner, specifically opening or closing it and stopping to measure it. From the previous slides, we have already attempted to get the burners to the same color.
- At some point, these changes are small enough that we need to change approaches, in this case to blinking.
- Separate the burners into two groups:
  - Burners that have too little air.
  - Burners with too much.
  - At this point in time, the majority of the burners are going to be very close, if not perfect. So the middle 80% of the burners don’t need blinking, until you have squashed the top and bottom of the bell curve, making those middle of the pack, burners outliers.
  - We want burners to blink open, and burners that we are blinking closed, so that we can end up with no net increase in Windbox to Furnace Differential Pressure.

Blinking the burner

- So now we merely open (or close) the burners sleeve damper by a few percent. Take a snapshot of the NOx after a few minutes to allow the systems to levelize.
- We then put the burner back in it's previous position, and after a few minutes, take more data.
- This process is repeated several times until the data indicates if the NOx went down when we slightly closed the sleeve damper. If it did not, we place it in the previous position, and merely move on to the next burner on our list.
- This method may require three or four rounds of tuning, with each subsequent round involving smaller blinks.
- While this is an extremely tedious method to tune, it is very low risk, and ultimately, could be automated, depending on your control system.
- Like all tuning, remember to check the core, to assure you are not creating a slagging or fireside corrosion issue.

Stoichiometry schools of thought

- There are two schools of thought concerning this type of tuning:
  - Keeping all of the finished colors the same provides the least corrosive atmosphere in the bottom of the furnace, but at the cost of some NOx performance.
  - Going from a straw color on top to an Orange Sherbet color on the bottom of a furnace gives the best NOx performance, but can cause corrosion issues on waterwalls in the furnace.
  - This range of color also seems to be the best choice for units with overfired air systems.

And finally, really small pixels.

- With practice, the tuner will realize that as they get practice tuning, the smaller the pixels, the smaller the turbule.
- The smaller the turbule, the smoother the blackbody curve, and the lower the NOx component.
- Don't forget to check the core, to prevent slagging issues with a dark core.

bruce.Salisbury@aps.com

QUESTIONS?