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EXTREME LOW EMISSIONS COMBUSTION

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ABSTRACT

Great Southern Flameless (GSF) has created and patented a combustion system that has the following advantages over conventional combustion using burners and any recent developments with Ultra Low NOx combustion:

1) Absolute uniform radiant flux rates eliminating any possibility of hot gas impingement or flame impingement.

2) Radiant efficiency that results in 1100-1200 Deg. F flue gas temperatures leaving the radiant section.

3) Longitudinal and circumferential ratios equal to 1.0.

4) Extremely Low Emissions Combustion (Cool Combustion) reduces the temperature variance in a radiant section of a fired heater from a 2800 Deg. F. flame burst temperature to a floor flue gas temperature of 1000 Deg. F. (1800 Deg. F. variance) to a hot gas temperature of 1800 Deg. F and a cold gas temperature of 1600 Deg. F. (200 Deg. F. variance).

5) Cool Combustion eliminates all the problems associated with conventional combustion.

How –

Every mechanism that creates the problems with conventional combustion are not present with cool combustion.

Cool Combustion is well mixed combustion but utilizing diffusion not turbulence.

6) Oxy combustion is possible while maintaining the temperatures noted above by diluting the oxygen with recirculated flue gas. By the time the mixture is diffused into the fuel gas, the oxygen content is not higher than 21 percent. The combustion process created is identical to air combustion.

SUMMARY:

Cool Combustion:

100% air combustion

100% oxygen combustion

Blend of any proportion of air/oxygen combustion

100% Hydrogen combustion

100% Methane combustion

100% off gas combustion

100% refinery fuel gas combustion

TECHNICAL PAPER

We will begin with a brief history of process heater combustion to reduce emissions:

1) Low NOx burners first appeared in the 1970's.
    a. Staged Air: Air was staged downstream of the primary combustion zone to reduce the intensity of a flame and therefore reduce thermal NOx. The combustion air was staged in up to three zones, Primary, Secondary and Tertiary . Staged air burners are still used to reduce NOx when firing oil.
2) Staged Fuel: Fuel staging or zones to reduce the intensity of a flame and therefore reduce thermal NOx. The zones are called the primary and secondary zones.

3) Ultralow NOx

    a. The AFRC March 18, 1991 technical paper by William C. Gibson was published to present that NOx could be reduced to meet the SCAQMD (LA Basin) 25ppm @ 3% O2 dry NOx requirements. The technology used was Ultra-Low NOx technology.
    b. The Ultra-Low NOx technology concept which uses internal flue gas recirculation to inert the fuel gas is the lowest emission level that burners will be able to achieve while still maintaining:
        i. Acceptable window of operation
        ii. Stability
        iii. Safety

iv. Reliability

Attempting to get lower emissions with burners will not achieve consistent performance due to choosing between the stability limit and further reduction in emissions.

Conclusions about burners:

- You can't put band-aids on burners and solve the emissions reduction problem.
- You can't burn 100% O2 with 100% H2 while still having the ability to operate with air and refinery fuel gas.

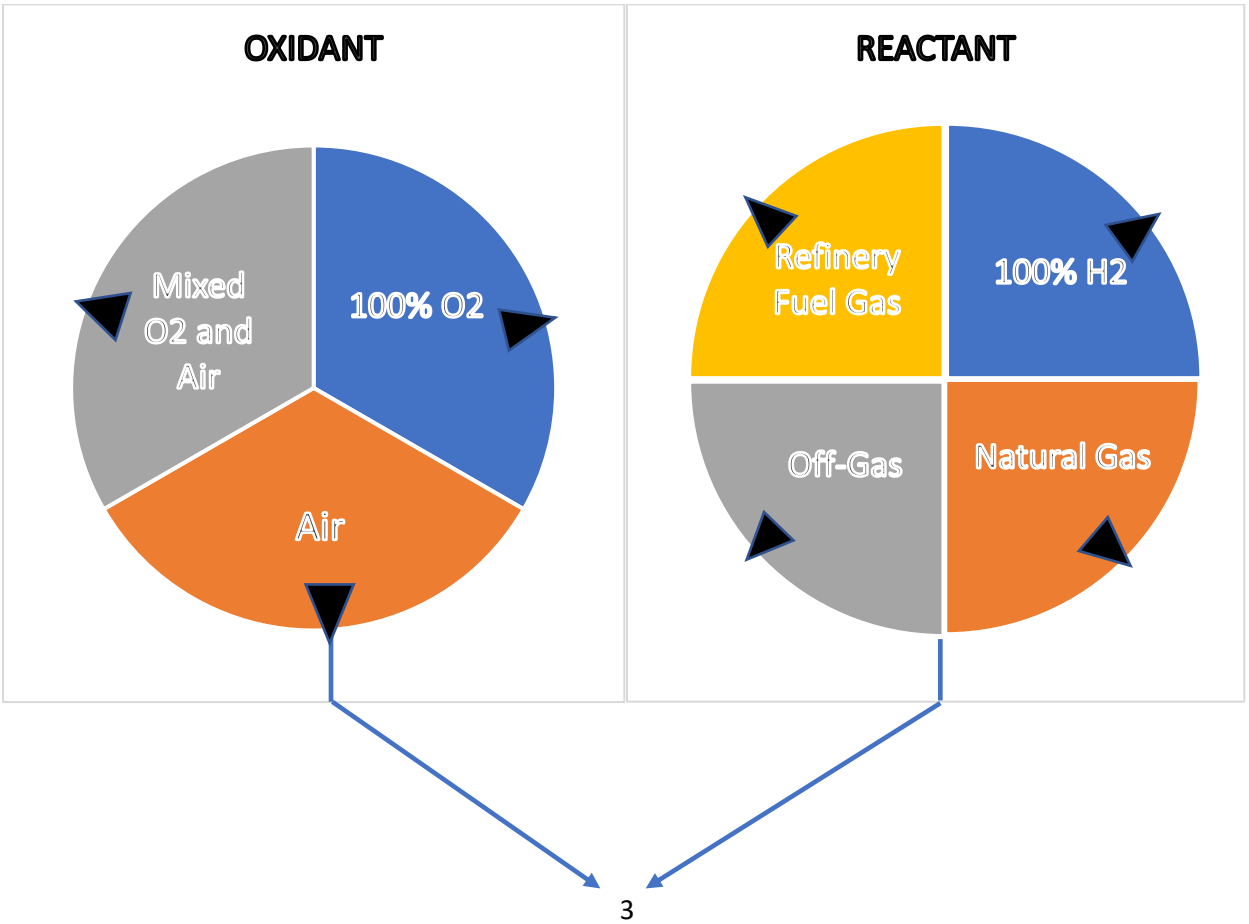
Today we are looking at a full range of emissions reduction:

1) NOx
2) CO2
3) Fuel Consumption (increase efficiency)
4) Particulate Reduction
5) Ammonia Reduction

What is needed is a purpose-built heater design that will address all the types of oxidants (air, 100% O2, mixture of air and pure O2) and reactants (100% H2, natural gas, refinery fuel gas and off-gas).

EXTREME LOW EMISSIONS COMBUSTION:

What we are specifying is as follows:



Simply dial in the type of combustion desired.

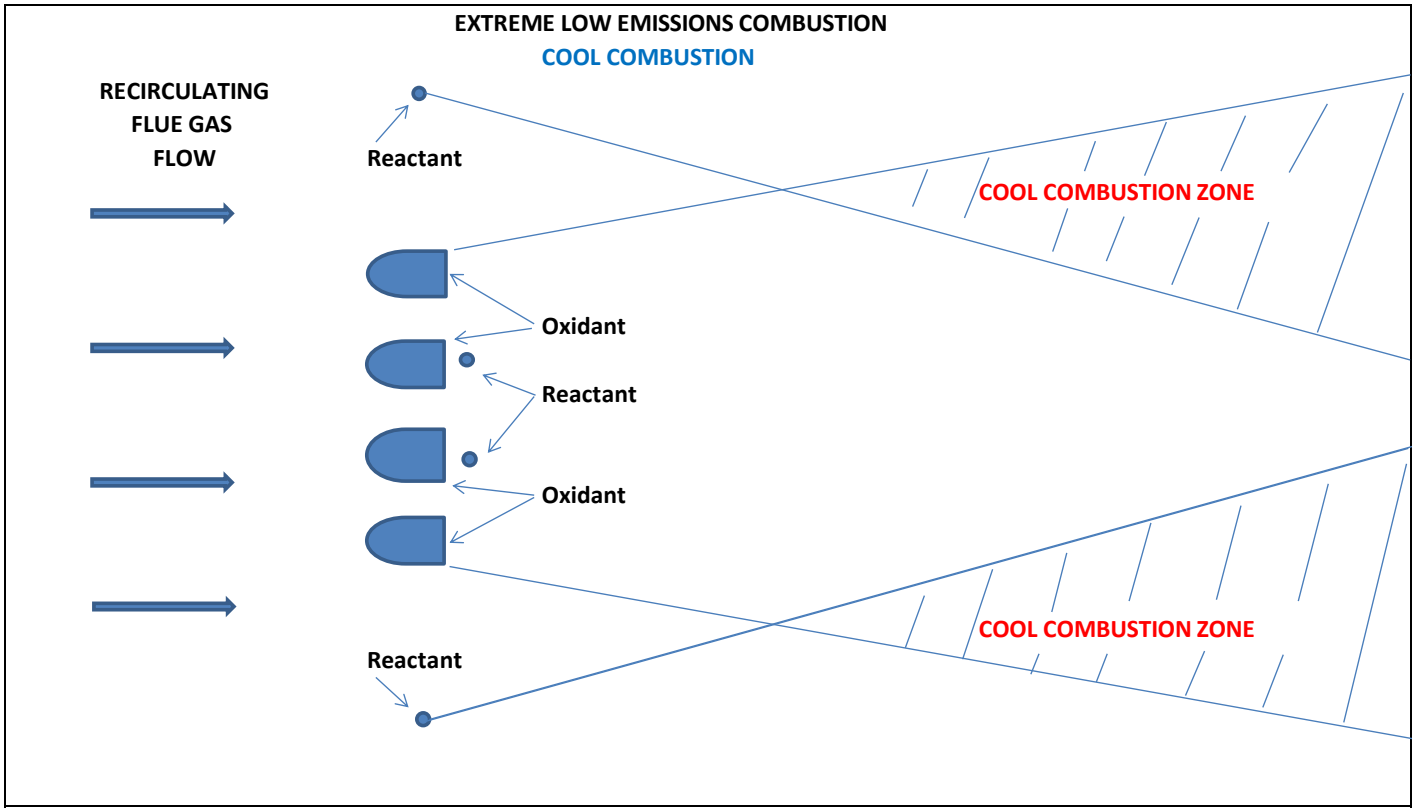
How can this be achieved? Not by tinkering with existing burner technology.

On the surface this looks impossible because of the wide variance in flame speed, flame temperatures, flue gas emissivity and acceptable radiant flux rates.

Here is how this is accomplished:

1) Process heating coil in the middle of the radiant section - double firing the radiant coil.
2) Tangential firing – Flue gas in rotation along the outside walls of the radiant section.
3) Maintaining the flue gas rotation mass flow at high levels during all modes of operation. The GSF Extreme Low Emissions Combustion design maintains five times the traditional fired heater mass of flue gas in rotation based on CFD modeling.
4) Inerting the oxidant and the reactant with the flue gas in recirculation.
5) Allowing the inerted oxidant and reactant to diffuse into each other above the auto ignition temperature.
6) Achieving stable combustion. In essence, we are creating an environment inside the heater that at the point of diffusion, the tempered oxidant and tempered reactant have the same combustion qualities no matter what oxidant or reactant is initially being fired.

Let's look at an elevation view of the heater side wall:



Advances with Cool Combustion Technology:

1) There is no need to stabilize a flame on a burner.
2) Flame speed and stability is not an issue. The heater self-adjusts to whatever flame speed by moving towards or away from the oxidant nozzles.
3) Combustion is maintained along the wall of the heater radiant section.
4) Combustion can be accurately monitored because it is always adjacent to the radiant wall of the heater.
5) We create essentially the same mixture of oxidant and reactant when they diffuse into each other above the auto ignition temperature.

Why is this flexibility of operation desirable?

- CO2 Capture – Moving toward an oxidant mixture of air and O2 or 100%O2 reduces the volume of CO2 emissions thus reducing cost of Carbon Capture and Storage units.
- Zero CO2 emissions – Achievable with 100% H2 combustion.
- Zero NOx emissions – Achievable with 100% oxygen combustion.
- Zero particulate emissions – Using pure reactants and pure oxidants.
- Zero ammonia slip – Eliminating requirement for an SCR.
- 100% O2 + 100% H2- Produce only water as the stack gas.

Conclusion:

- Extreme Low Emissions Combustion is achievable with a purpose-built new or retrofit fired heater or boiler.
- Extreme Low Emissions Combustion is not possible by putting a band-aid on a burner.

Select a heater and contact us. We will custom design Extreme Low Emissions Combustion for your next revamp or new heater project.