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CFD DEMONSTRATION OF EXTREME LOW EMISSIONS COMBUSTION SYSTEM INCLUDING OXYGEN AND HYDROGEN COMBUSTION

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Great Southern Flameless (GSF) has now demonstrated with CFD modeling GSF's flameless combustion using 100% oxygen with refinery fuel gas and also 100% oxygen with 100% hydrogen. Also, the CFD modeling will demonstrate the simplicity to scale up the size while maintaining symmetry. This is a fundamental design concept made part of all GSF's cool combustion applications.

Cool combustion is GSF's patented combustion system based on purpose built fired heaters for refinery and petrochemical plant service.

Features included in the GSF design are as follows:

1) Double fired radiant coil

2) GSF Cool Combustion burners

3) Tangential firing along the walls of the heater

4) Dimpled radiant refractory to pin the flue gas in circulation against the walls of the heater

5) Air nozzles

6) Fuel nozzles

7) Elimination of burner tiles and burner diffusers

These features have been described and illustrated in past GSF papers presented to the AFRC (please go to the Great Southern website to read previous papers presented by GSF)

The purpose of this paper is to document CFD modeling showing the following:

A) 10.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant

B) 10.0 MM Btu/Hr – Oxygen oxidant with refinery fuel gas reactant

C) 10.0 MM Btu/Hr – Oxygen oxidant with Hydrogen reactant

SCALE UP:

D) 30.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant

For each case we will compare the following:

The Temperature Profile

The Velocity Profile

The CO Smear Profile

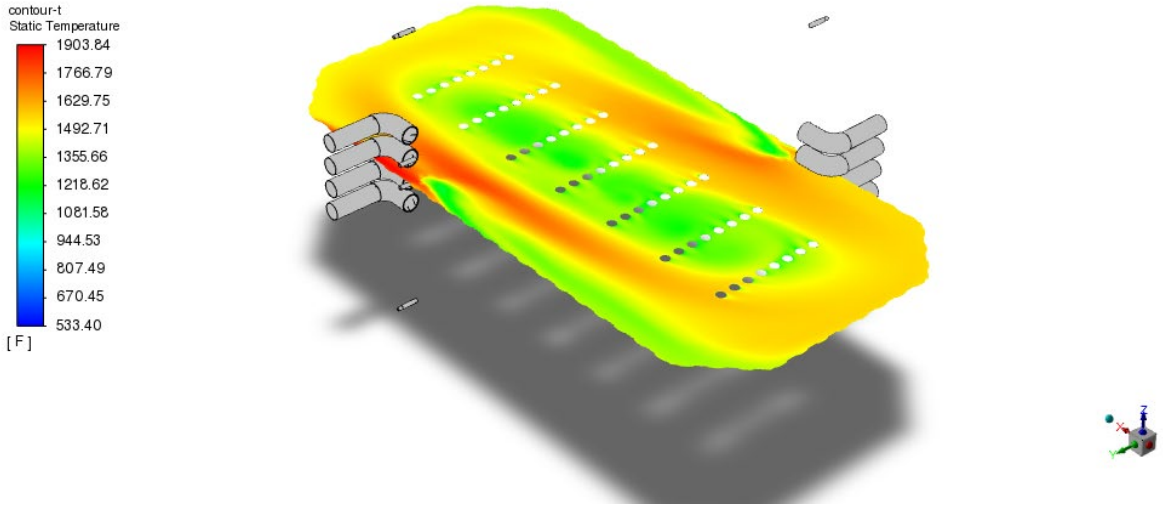
A) 10.0 MM Btu/Hr – Air and Refinery Fuel Gas

1. 10.0 MM Btu/Hr heater with air/refinery fuel gas has been in operation for 10+ years.
2. Very even flux rate to the double fired radiant coil.
3. The inside of the heater process coil has never been cleaned in 10+ years. The heater is in crude heater service.
4. Low average and maximum tube metal temperatures.
5. NOx between 3-5 ppmvd as documented by CEMS during the operational life of the heater.

(3 pages CFD Modeling)

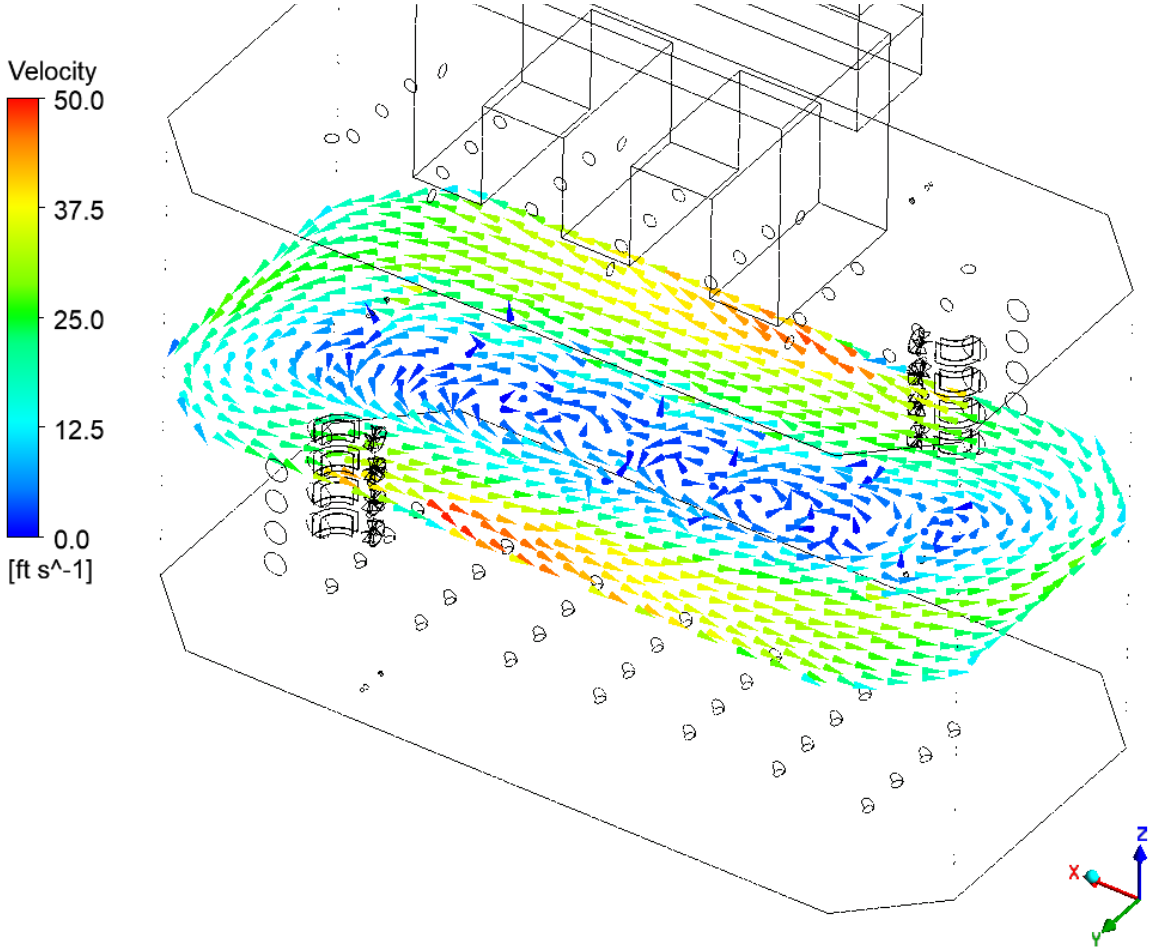
GREAT SOUTHERN FLAMELESS

CFD Temperature Profile



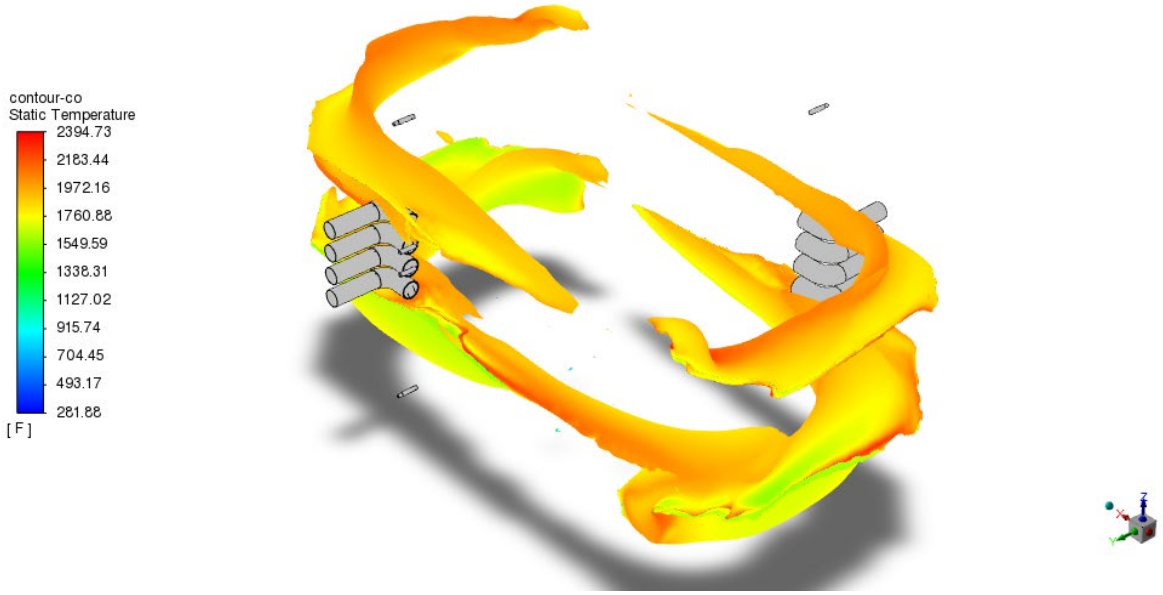
10.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Temperature contours on a horizontal plane through the center of the heater.

CFD Velocity Profile



10.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Velocity vectors colored by velocity magnitude on a horizontal plane through the center of the heater. The color scale is clipped between 0 fps and 50 fps.

CFD CO Smear Profile

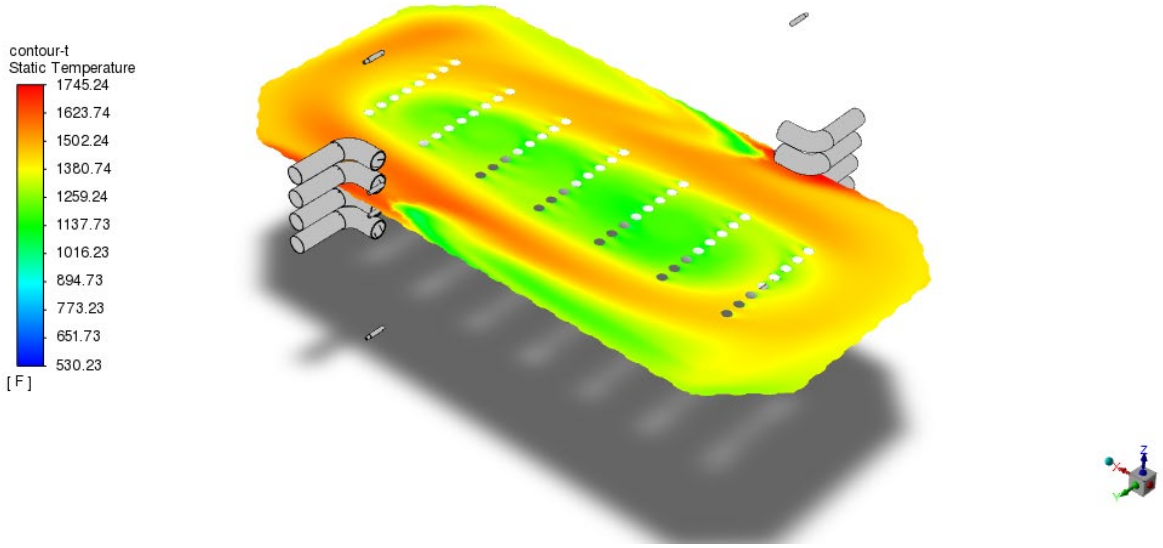


10.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Isosurface of 1500 ppm CO (wet basis) colored by temperature.

B) 10.0 MM Btu/Hr – Oxygen and Refinery Fuel Gas

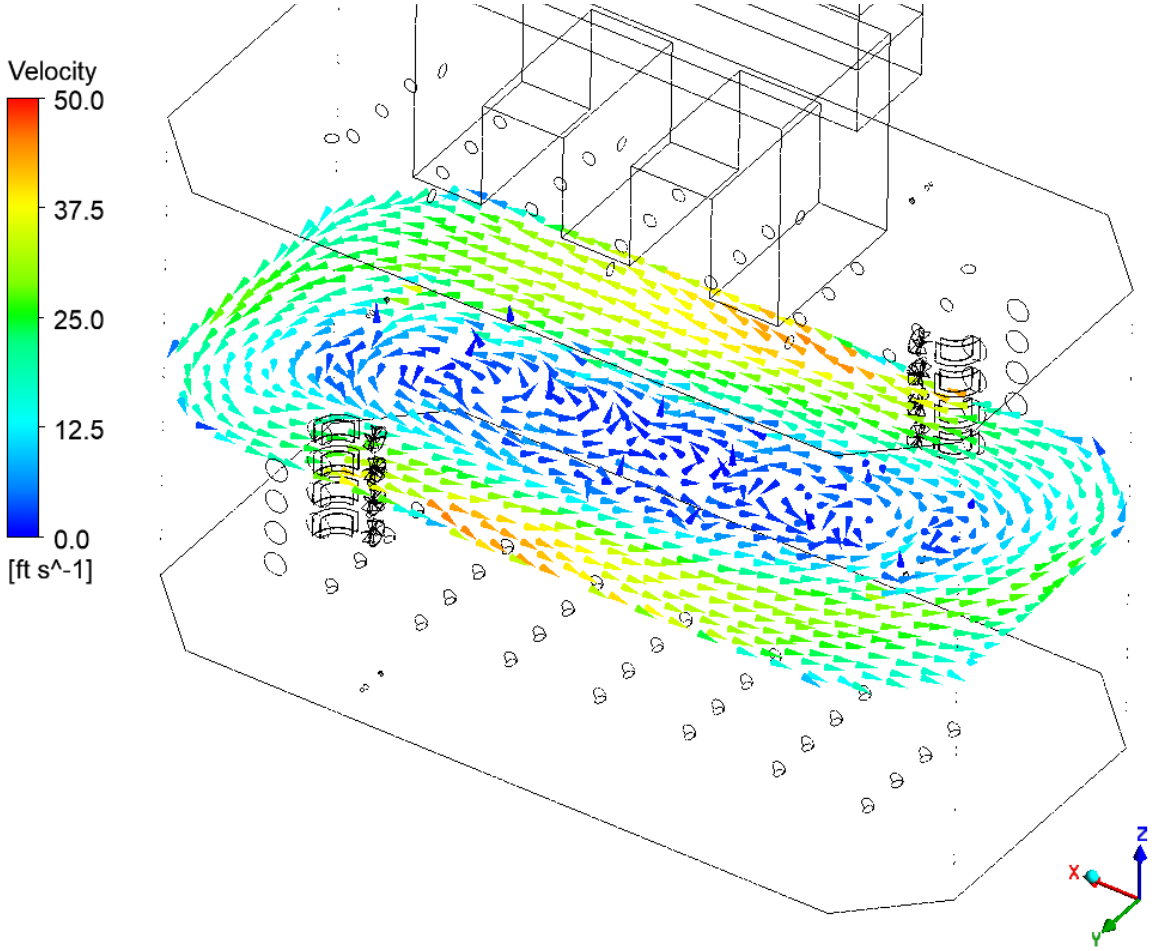
(3 pages CFD Modeling)

CFD Temperature Profile



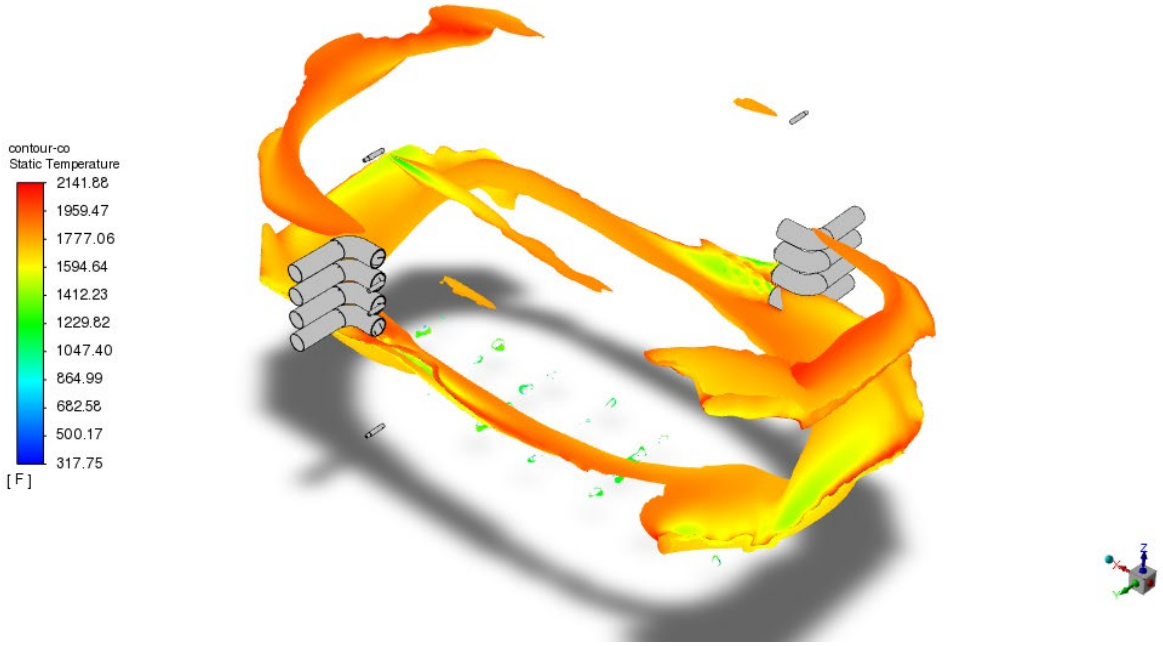
10.0 MM Btu/Hr – Oxygen oxidant with refinery fuel gas reactant. Temperature contours on a horizontal plane through the center of the heater.

CFD Velocity Profile



10.0 MM Btu/Hr – Oxygen oxidant with refinery fuel gas reactant. Velocity vectors colored by velocity magnitude on a horizontal plane through the center of the heater. The color scale is clipped between 0 fps and 50 fps.

CFD CO Smear Profile



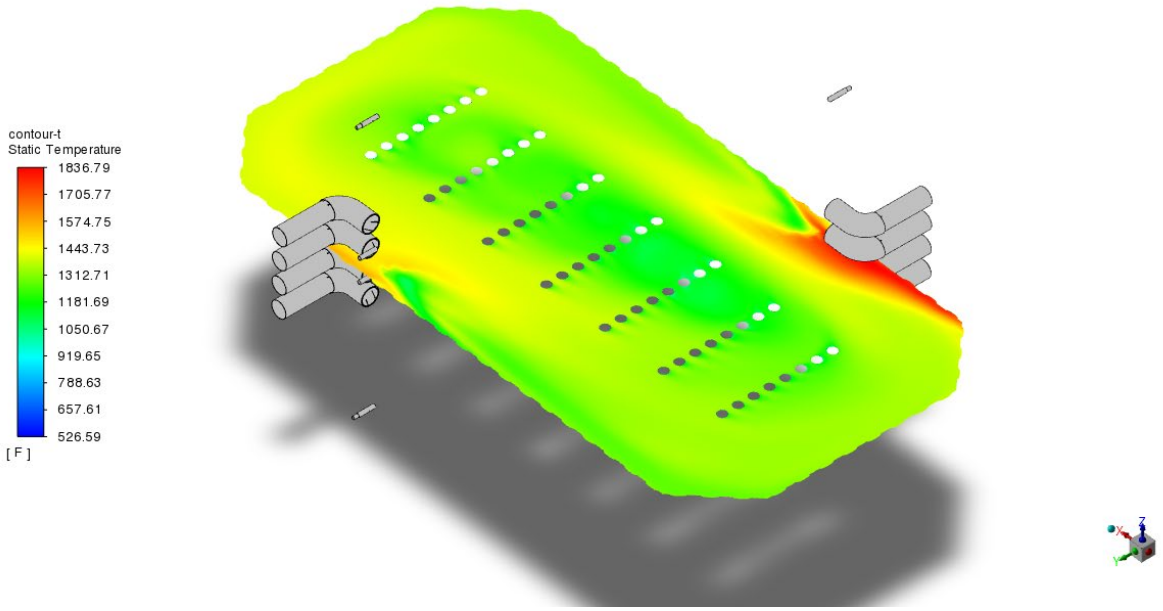
10.0 MM Btu/Hr – Oxygen oxidant with refinery fuel gas reactant. Isosurface of 1500 ppm CO (wet basis) colored by temperature.

C) 10.0 MM Btu/Hr – Oxygen and Hydrogen

(2 pages CFD Modeling)

GREAT SOUTHERN FLAMELESS

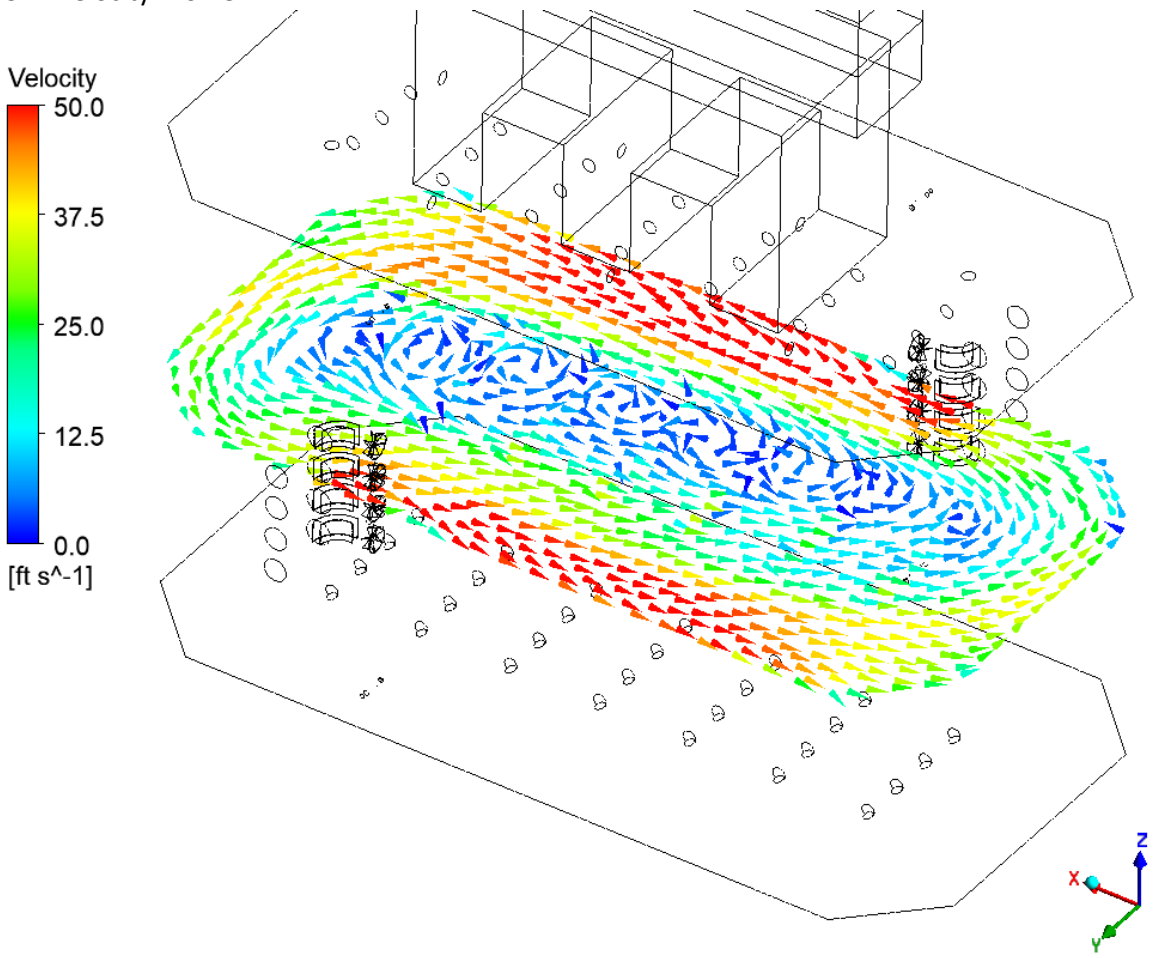
CFD Temperature Profile



10.0 MM Btu/Hr – Oxygen oxidant with Hydrogen reactant. Temperature contours on a horizontal plane through the center of the heater.

GREAT SOUTHERN FLAMELESS

CFD Velocity Profile

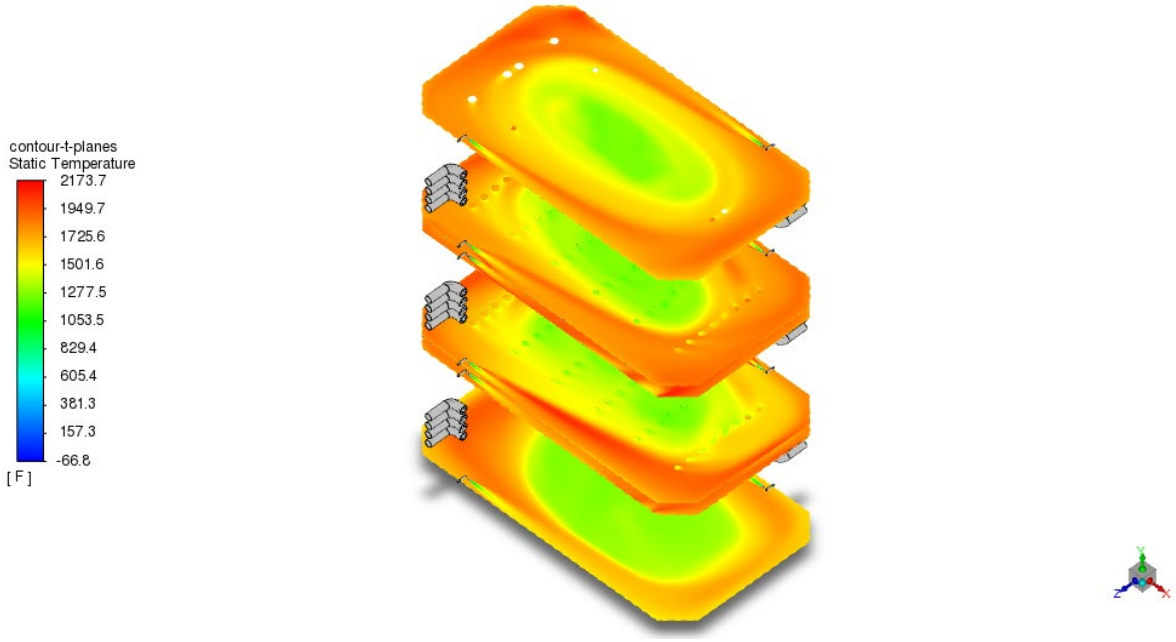


10.0 MM Btu/Hr – Oxygen oxidant with Hydrogen reactant. Velocity vectors colored by velocity magnitude on a horizontal plane through the center of the heater. The color scale is clipped between 0 fps and 50 fps.

D) 30.0 MM Btu/Hr – Air and refinery fuel gas reactant

(3 pages CFD Modeling)

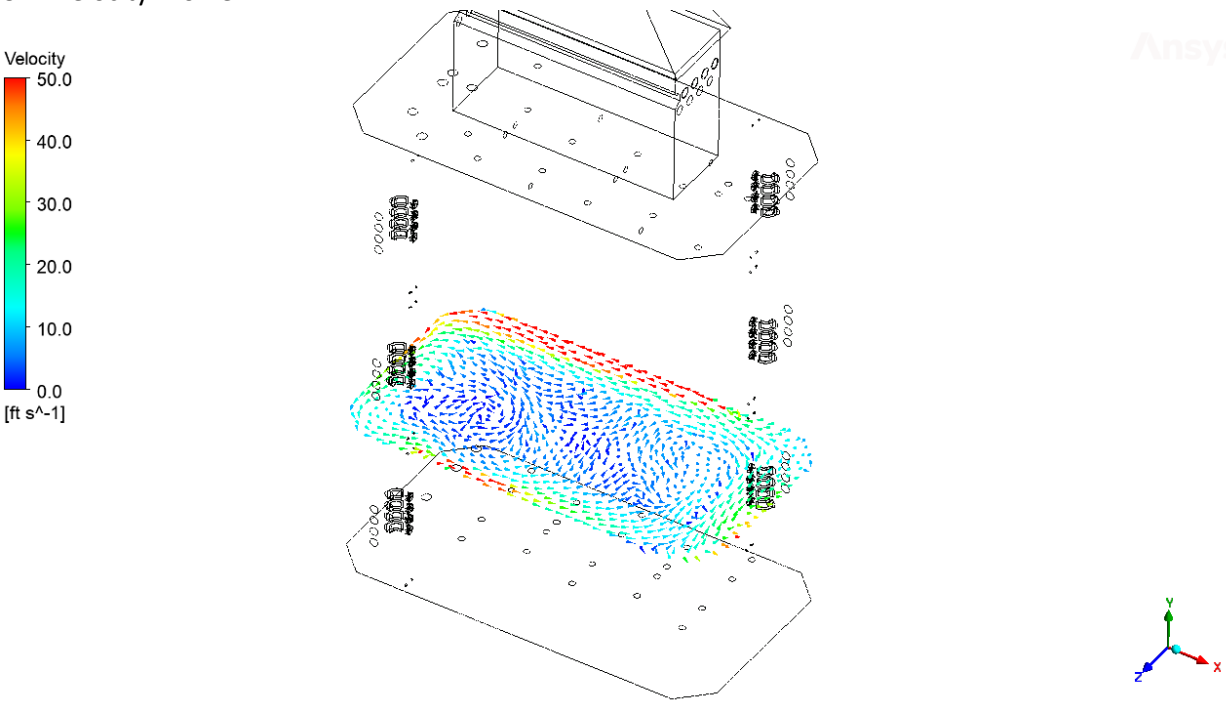
CFD Temperature Profile



30.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Temperature contours on horizontal planes through various fuel injectors.

GREAT SOUTHERN FLAMELESS

CFD Velocity Profile



30.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Velocity vectors colored by velocity magnitude on a horizontal plane through a fuel injector. The color scale is clipped between 0 fps and 50 fps.

CFD CO Smear Profile

30.0 MM Btu/Hr – Air oxidant with refinery fuel gas reactant. Isosurface of 1500 ppm CO (wet basis) colored by temperature.

IMPORTANT COMPARISONS TO REVIEW BETWEEN THE FOUR MODELS NOTED ABOVE

1) Consistency of temperature symmetry between different sizes and different oxidants and reactants

2) Consistency of velocity symmetry between different sizes and different oxidants and reactants

3) The smear for CO in every case shows cool combustion along the wall of the heater. It also shows complete combustion before the flue gas leaves the radiant section to enter the convection section.

SUMMARY:

The goals have been achieved. GSF Patented Cool Combustion based on purpose built heaters will meet existing and future emissions and performance requirements.