Blasch Precision Ceramics

The Blasch VectorWall^{TM}
Reaction Furnace Volume Management System – Combustion Efficiency Reimagined

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The Question

- People have been asking the tough questions for millennia…
  - Like, “How do we design this thing so the stone beams won’t crack and fall on our heads, thus killing us?”

The Answer

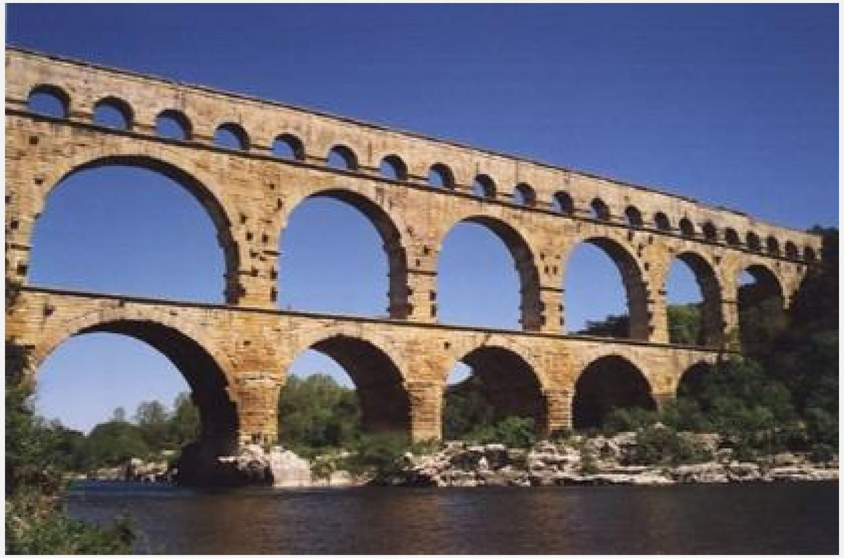
- People have been answering those questions for millennia…
  - This is sometimes referred to as the Brute Force approach, and while it is effective, it does have significant limitations…
    - You reach a point of diminishing returns.
    - You remain limited by the parameters of the original design

The Right Question

- The right question should not be how to make the existing design work better, but how to best achieve the aims that the existing system was designed to address…
  - Like, “How can we span greater lengths and support more weight?”

The Right Answer

- The right answer almost always starts with a fresh look at the problem and a blank sheet of paper...
  - And it can sometimes yield solutions that are great leaps forward...



The Right Answer

– And, sometimes, asking the right question makes all the difference in the world…

Mechanical Reliability

Mechanical Reliability

Designs that rely upon mortar for their mechanical integrity, or contain flat spans that can sag, or those that are not interlocking, can fail over as the number of thermal cycles increases.

Mechanical Reliability

Construction begins at the bottom center of the furnace. Blocks may be laid directly on hot face, or embedded in a groove left by removing row of hot face brick.

First Generation

The VectorWall can be built into a groove left behind by omitting selected hotface bricks.

Alternatively, the VectorWall can be built directly against the hotface brick and secured by upstream and downstream soldier courses of hotface grade arch brick.

Mechanical Reliability

Blocks contain a series of tongue and groove features to ensure there is no lateral movement.

Mechanical Reliability

No mortar is used between the blocks. Repeated thermal cycling leads to cracking of mortar joints.

Mechanical Reliability

Openings are round. Arches have greater strength than flat spans. Arches are in compression under load, not tension. Refractory is much stronger in compression.

Mechanical Reliability

As a last step, the Vector Tiles must be cemented into place. This is the only use of refractory cement for bonding purposes

Process Improvement

Combustion Efficiency

Q: What is the purpose of a Thermal Reactor/Reaction Furnace/Thermal Oxidizer/ Incinerator?

A: To convert a series of inputs into other, less hazardous, or more saleable, products.

How does it do that? By Combustion. The above described process units are all really combustion chambers. What is combustion? ***"Combustion is a (usually rapid) chemical process (such as oxidation) that produces heat and usually light ."***

Combustion Efficiency

Q: What fundamental properties influence the efficiency of the chemical process/ reaction in the Combustion Chamber?

A: Time, temperature, and turbulence.

- In order to have a chemical reaction…
  - You need to get all the reactants together in close contact with one another so that the reaction can occur.
  - You need to have the reactants together long enough for the reaction to occur
  - You need to have the reactants at the proper temperature for the desired reaction to occur.

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Combustion Efficiency

Q: How do various process licensors attempt to ensure that their Combustion Chambers provide the environment necessary to meet minimum efficiency requirements for a specific process?

A: Through the use of specific combinations of burner/internal structures to impact time, temperature, and turbulence in positive way.

- Burners can include high intensity mixing burners, conventional burners, or tangential burners
- Structures can include checker walls, choke rings, or baffles

Burners

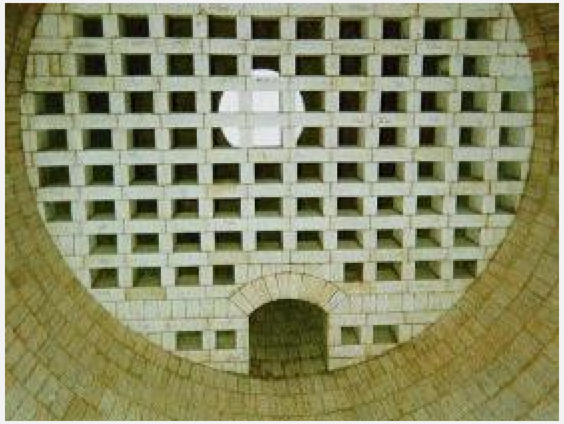
Burner Types

- Hi Intensity Mixing Burners – Duiker, HEC
  - Very expensive. Create strong mixing/rotation. Short flame length
- Conventional Burners – John Zink Hamworthy, Zeeco, Combustion Solutions
  - More economical. Less mixing. Longer flame length
- Tangential Burners – Fives Pillard.
  - Burner is perpendicular to axis of combustion chamber. Goal is to create rotation.

Structures

Structure Types

- Checker walls
- Choke Rings
- Baffles



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Structures

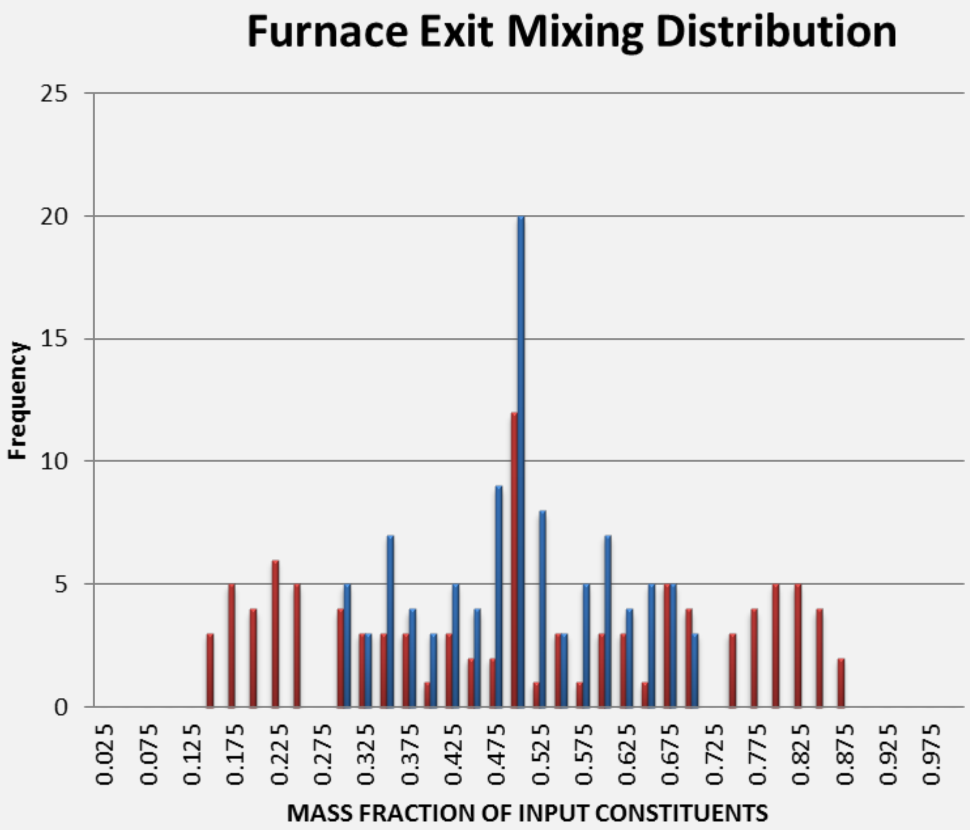
Q: What do all these structures have in common?

A: They all constrict the flow in some manner

- When the flow is constricted, the velocity through the remaining open area increases, the "venturi effect". In fluid dynamics, an incompressible fluid's velocity must increase as it passes through a constriction
- When you take into account the % of gas being turned back, plus the % of gas being accelerated, you can see that the **Residence Time** is being spread way out. If a residence time of 1.5 seconds is desired, you may have created a residence time from 1.0 seconds to 2.0 seconds.

Structures

- Gases that exit too quickly does not get properly reacted.
- Gases that remain in the furnace longer than necessary reduce overall available furnace volume and therefore, efficiency



Structure

How does the VectorWall get around this?

- In a word, rotation.
  - Rotation creates something called Plug Flow.

Structures

Simple vs. Complex Systems

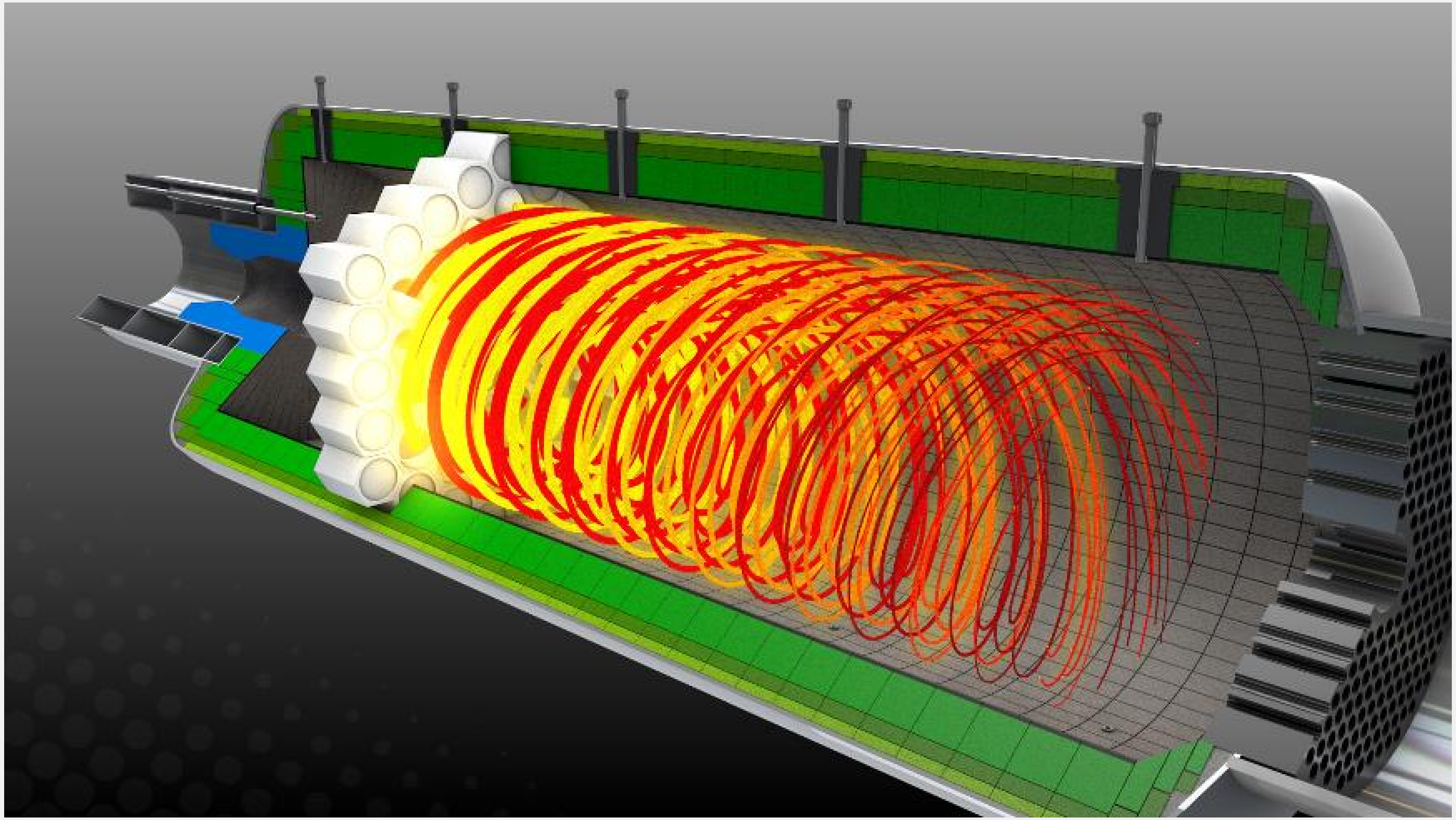
Single Zone/Straight Through Configuration

CHARACTERISTICS

- All inputs enter the furnace from one location, typically through the burner
- Typically used:
  - With homogeneous feeds, or feeds with similar reaction kinetics.
  - In Claus when acid gas H_2S concentration is 50% or higher
  - In sulfur burning furnaces

GOALS

- Maximize use of furnace volume; minimize dead zones
- Establish the tightest possible residence time distribution centered on the optimal residence time for the application



2-Zone/Split Flow Configuration

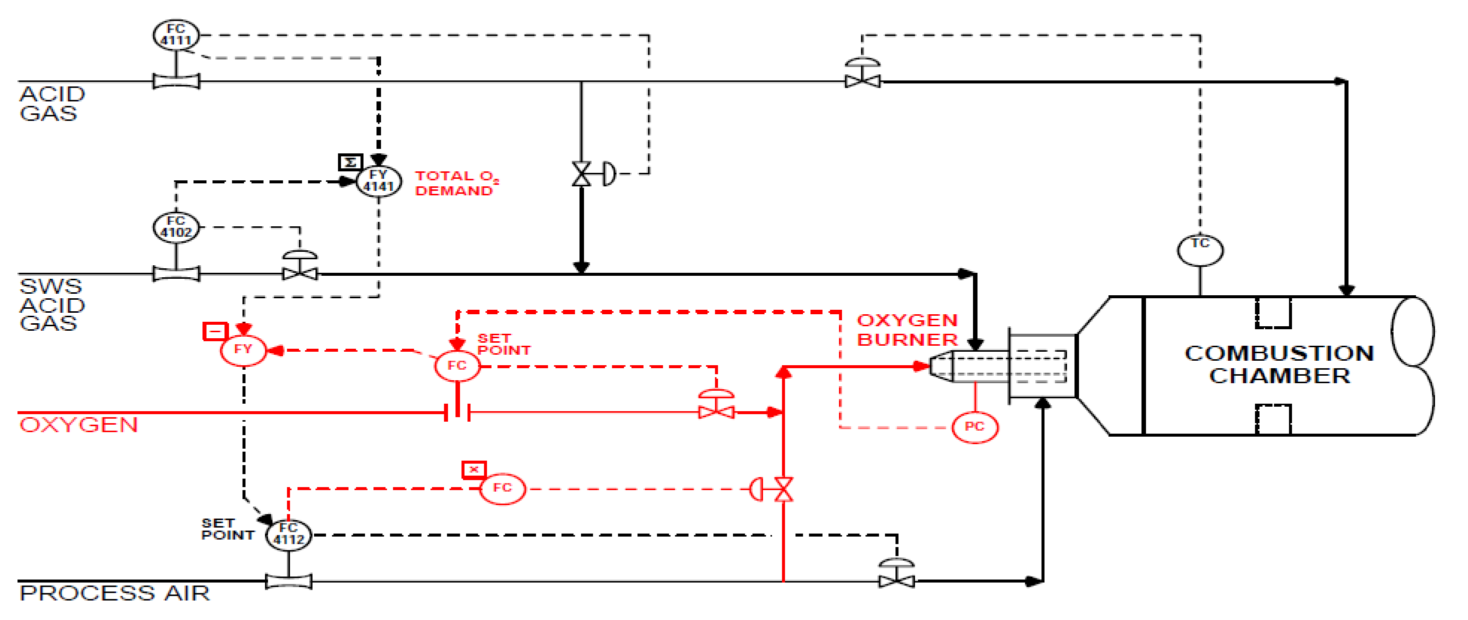
CHARACTERISTICS

- Secondary injection point(s) exist within the furnace, typically behind a choke ring.
- Typically used:
  - With non-homogeneous feeds, or feeds with dissimilar reaction kinetics.
  - In Claus when acid gas H2S concentration is 50% or lower or when processing SWS offgas
  - In spent acid furnaces

GOALS

- Create two distinctly different zones within the furnace.
- In Claus with SWS offgas, temperatures in zone 1 should be higher to encourage complete ammonia destruction

2-Zone/Split Flow Configuration



The 2-Zone reaction furnace was developed by WorleyParsons in the 1970's to accommodate ammonia destruction in a single furnace. They held that:

- It is critical to maintain adequate combustion temperature in Zone 1 (1,200-1,250°C)
- Choke Ring was intended to create "turbulent velocity" and enhanced mixing
- Split approximately 2/3 of acid gas to Zone 2, keeping Zone 1 hotter and Zone 2 cooler

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Modeling Performed by Zhejiang University, Hangzhou, China, Showing Choke Ring vs. VectorWall in a Split Flow Configuration

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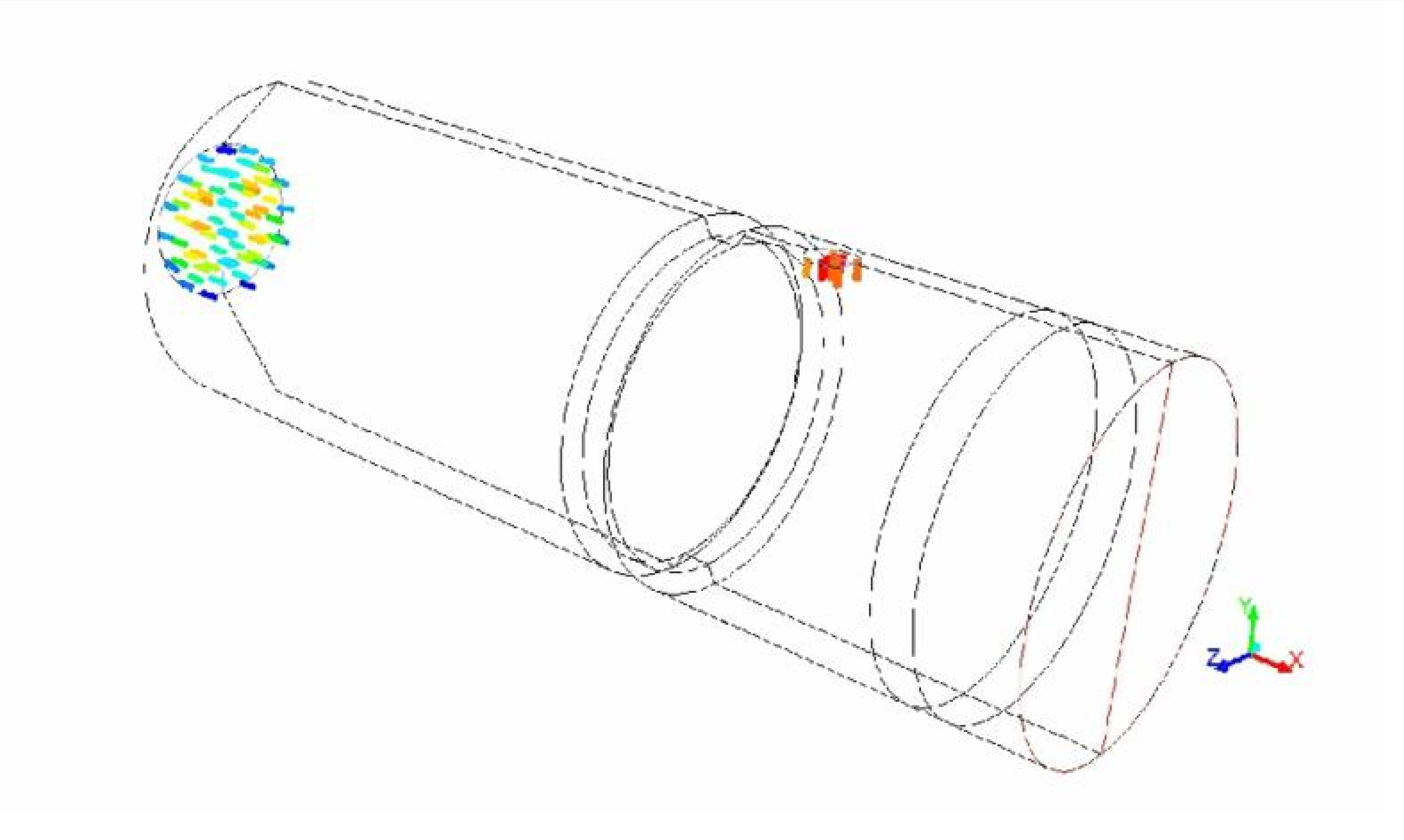
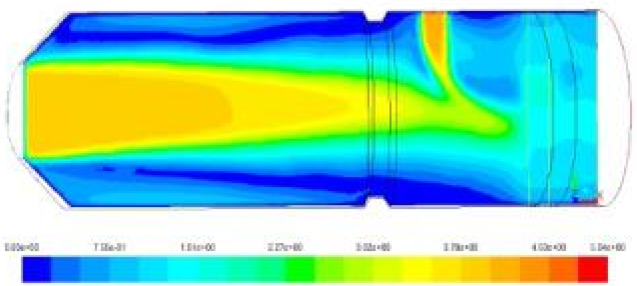
2-Zone/Split Flow Configuration

Rendering of a similar furnace with a typical choke ring and secondary injection point

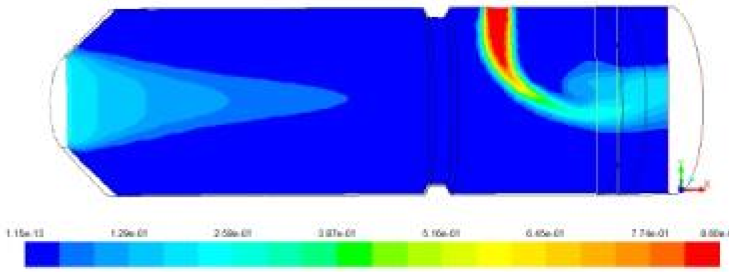


2-Zone/Split Flow Configuration

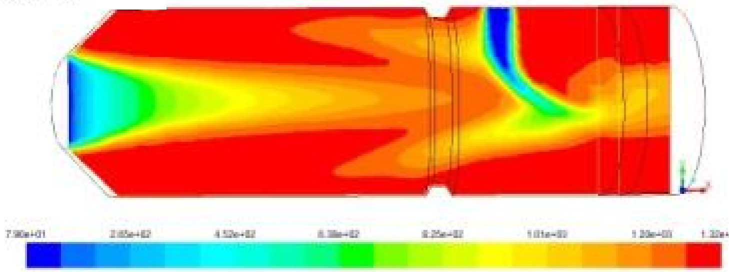


Gas Velocity is at about 3m/s

CHOKE RING WITH SECONDARY INJECTION

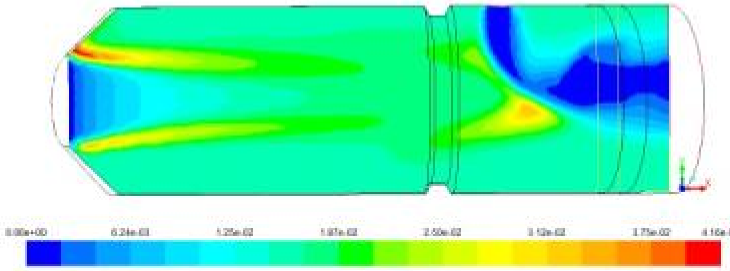


Molar concentration of H_2S

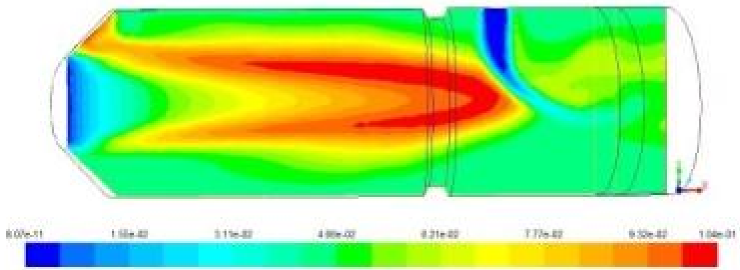


Temperature

Courtesy of Zhejiang University, Hangzhou, China



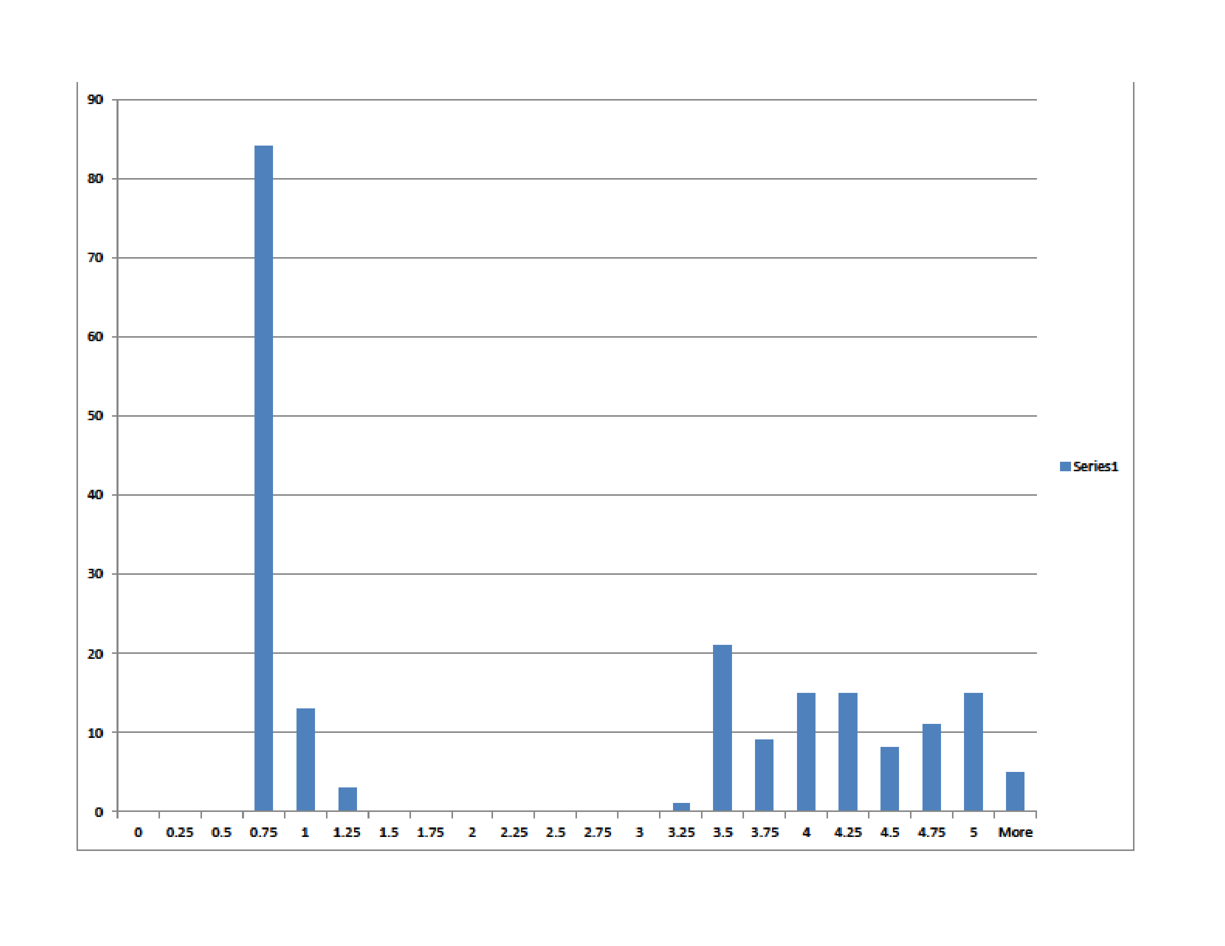
Molar concentration of SO_2



Molar concentration of S (g)

2-Zone/Split Flow Configuration

Residence time distribution histogram for a choke ring equipped furnace



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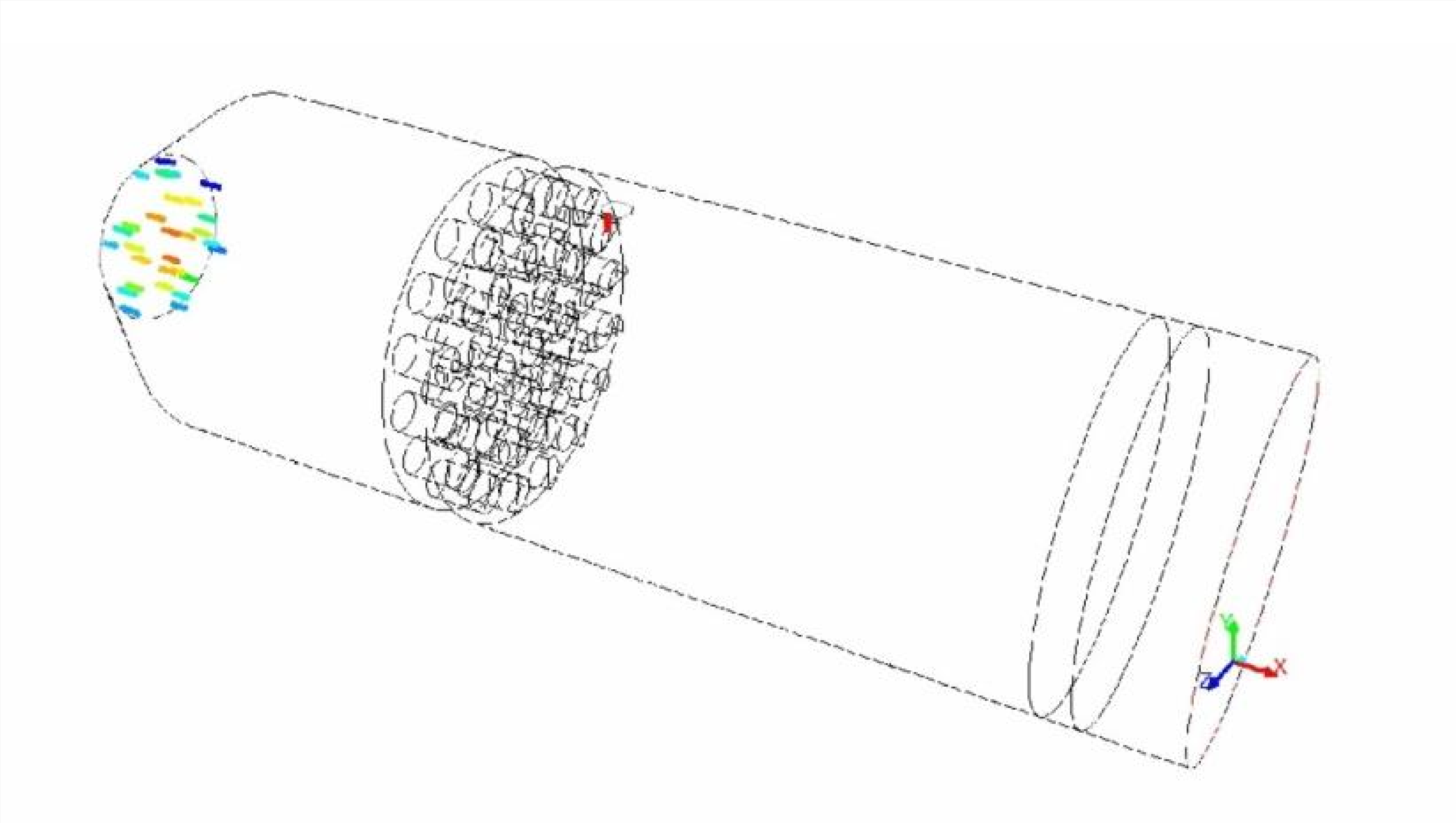
2-Zone/Split Flow Configuration

Rendering of a similar furnace with a typical VectorWall and secondary injection point



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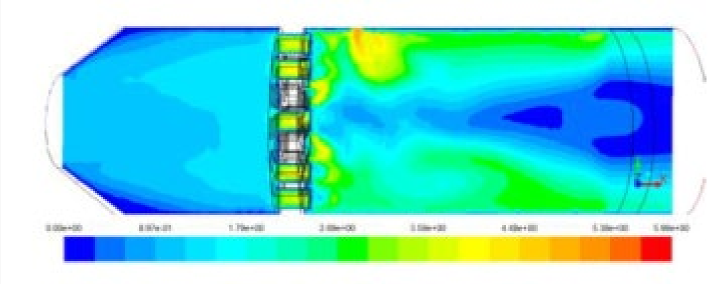
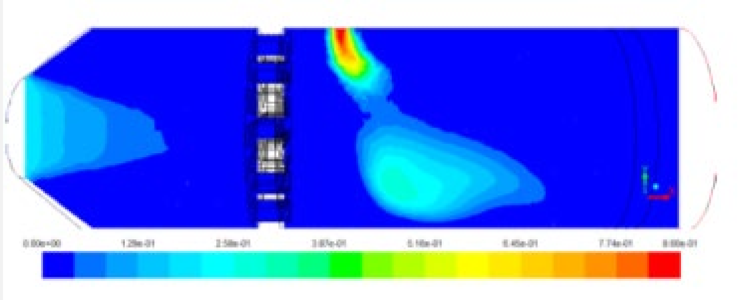
2-Zone/Split Flow Configuration

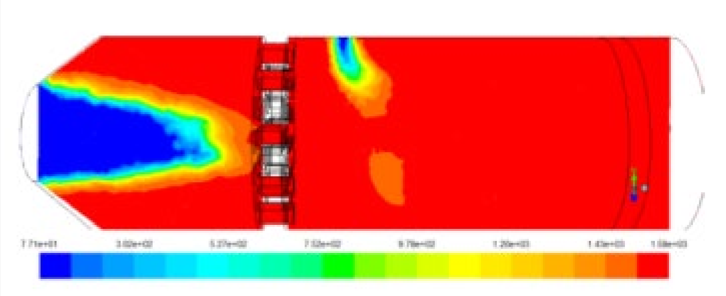
VECTORWALL WITH SECONDARY INJECTION



Gas Velocity

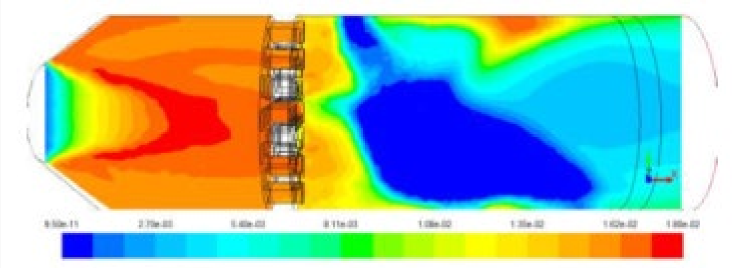


Molar concentration of H_2S

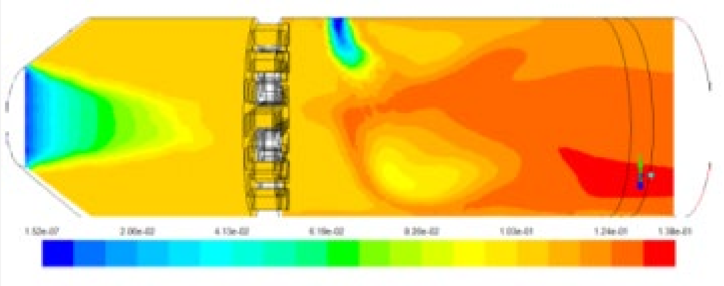


Temperature

Courtesy of Zhejiang University, Hangzhou, China



Molar concentration of SO_2



Molar concentration of S_2

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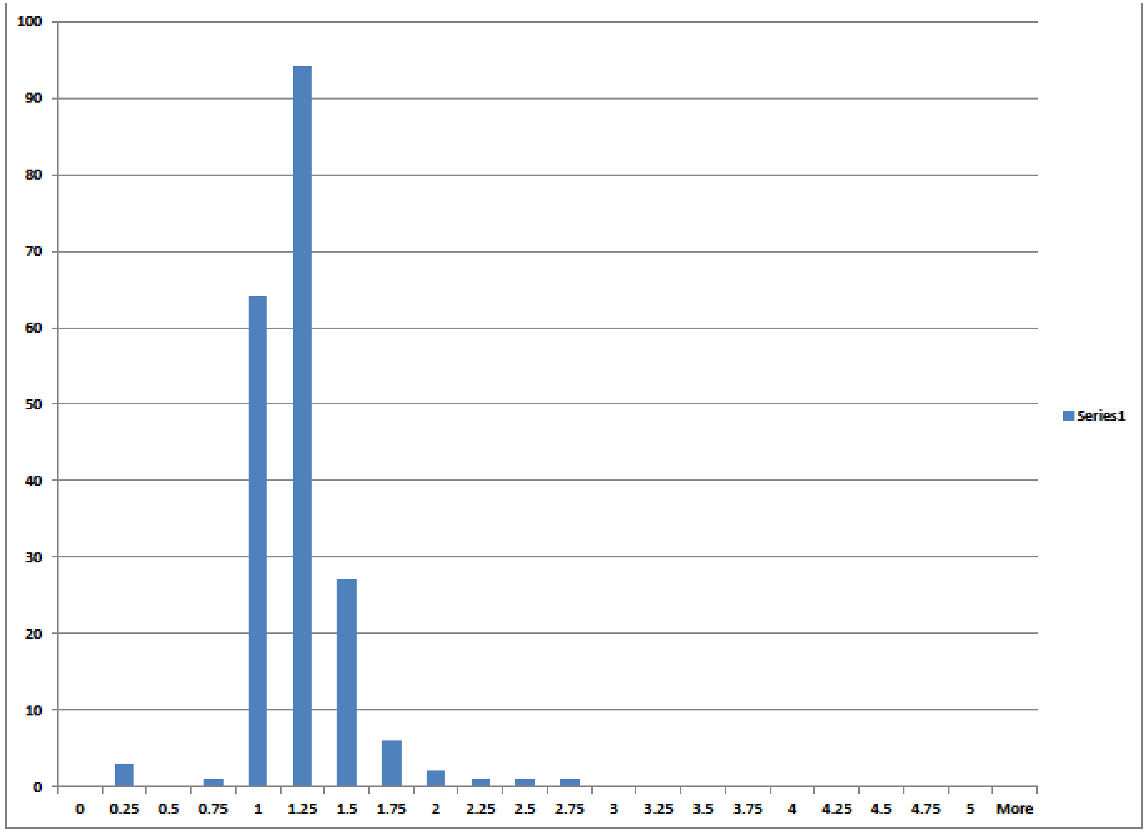
2-Zone/Split Flow Configuration

Residence time distribution histogram for a VectorWall™ equipped furnace



Modeling Performed by Porter McGuffie, Inc., Overland Park, KS, USA, Showing Choke Ring vs. VectorWall in a Split Flow Configuration

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Porter McGuffie, Inc.

Engineering Measurement & Analysis Services

1.0 Executive Summary

Porter McGuffie, Inc. (PMI) was retained by DuPont to perform computational fluid dynamics (CFD) analyses to characterize and compare the performance of the CPC Taoyuan thermal reactor before and after the 2012 replacement of the choke ring with a VectorWall [1]. Prior to the 2012 revamp, when the reactor was equipped with a choke ring, the sulfur recovery unit (SRU) was limited in capacity by vibrations and insufficient ammonia (NH_3) destruction. After replacing the choke ring with a VectorWall, the SRU could process acid gas (AG) at higher capacity because NH_3 destruction was improved and vibrations were eliminated. The present study characterizes performance of the two reactor configurations at average operating conditions, with comparative analysis performed using quasi-steady state techniques. The reactors are compared in terms of velocity distributions, flame shapes, and residence time for ammonia destruction.

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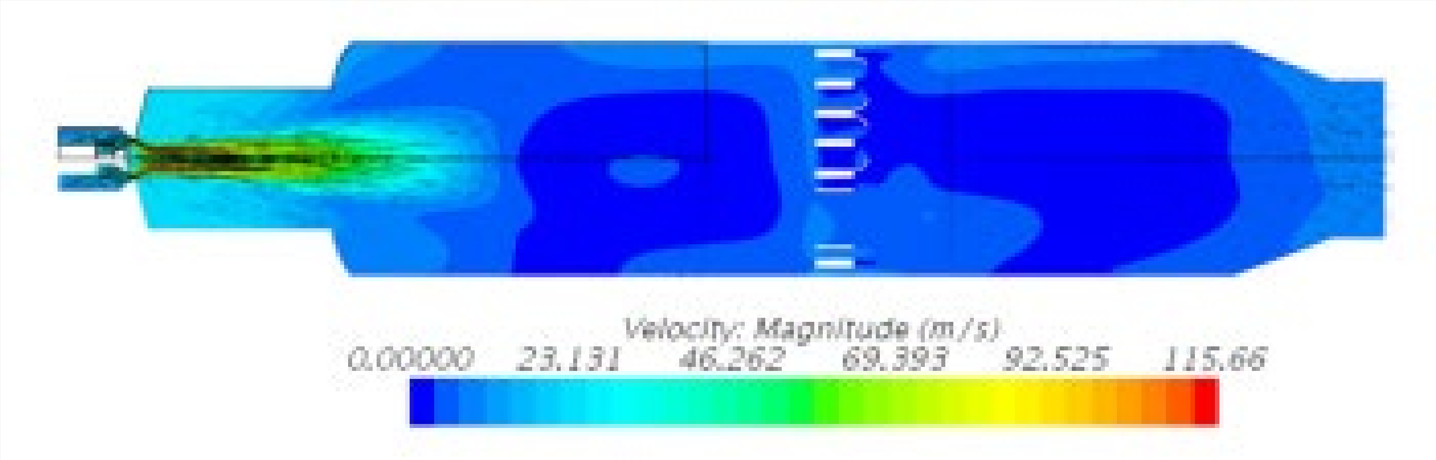

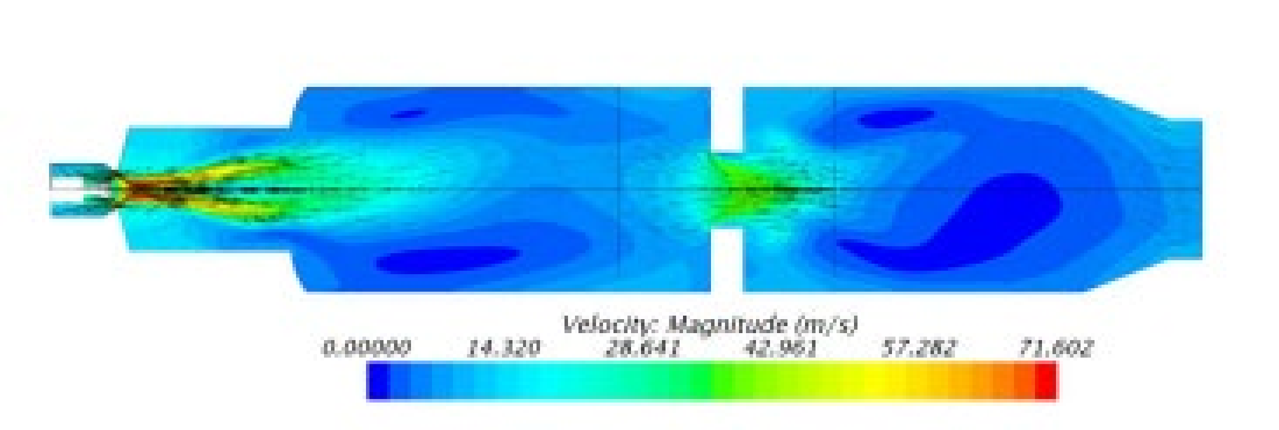

Figure 16: Velocity Magnitudes and Vectors, Choke Ring Configuration

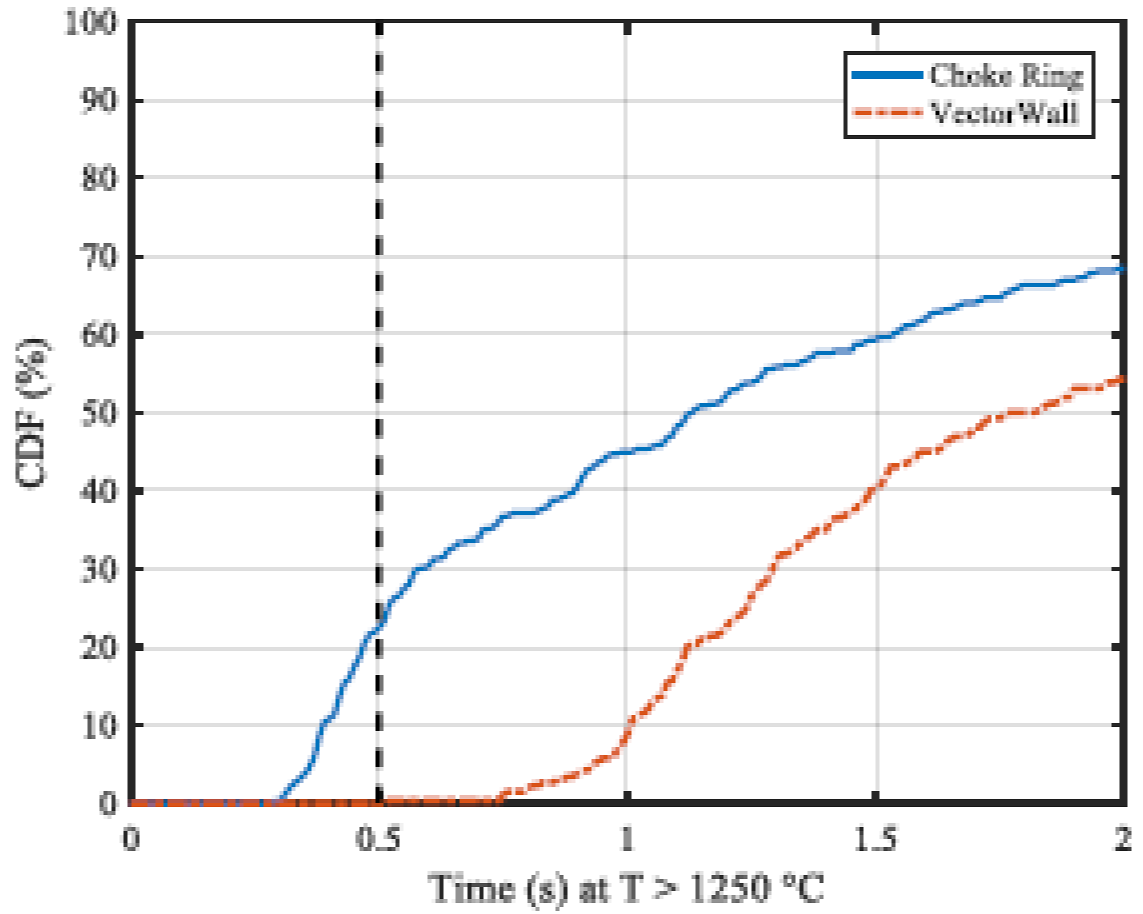

Figure 26: Cumulative Distribution Functions of Residence Time at T > 1250 °C Vertical dashed line indicates cutoff residence time for contaminant destruction.

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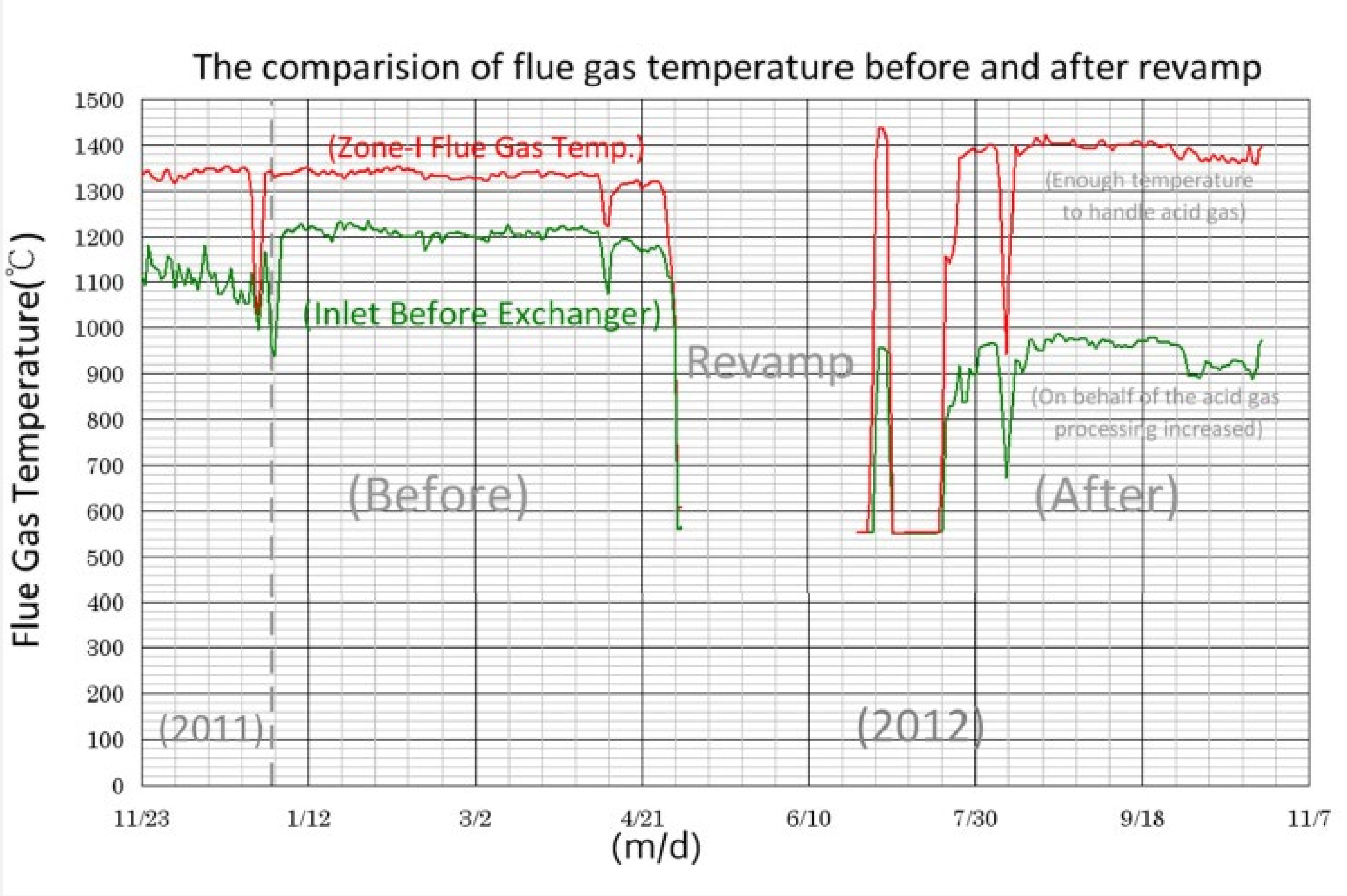
Actual Results From Field

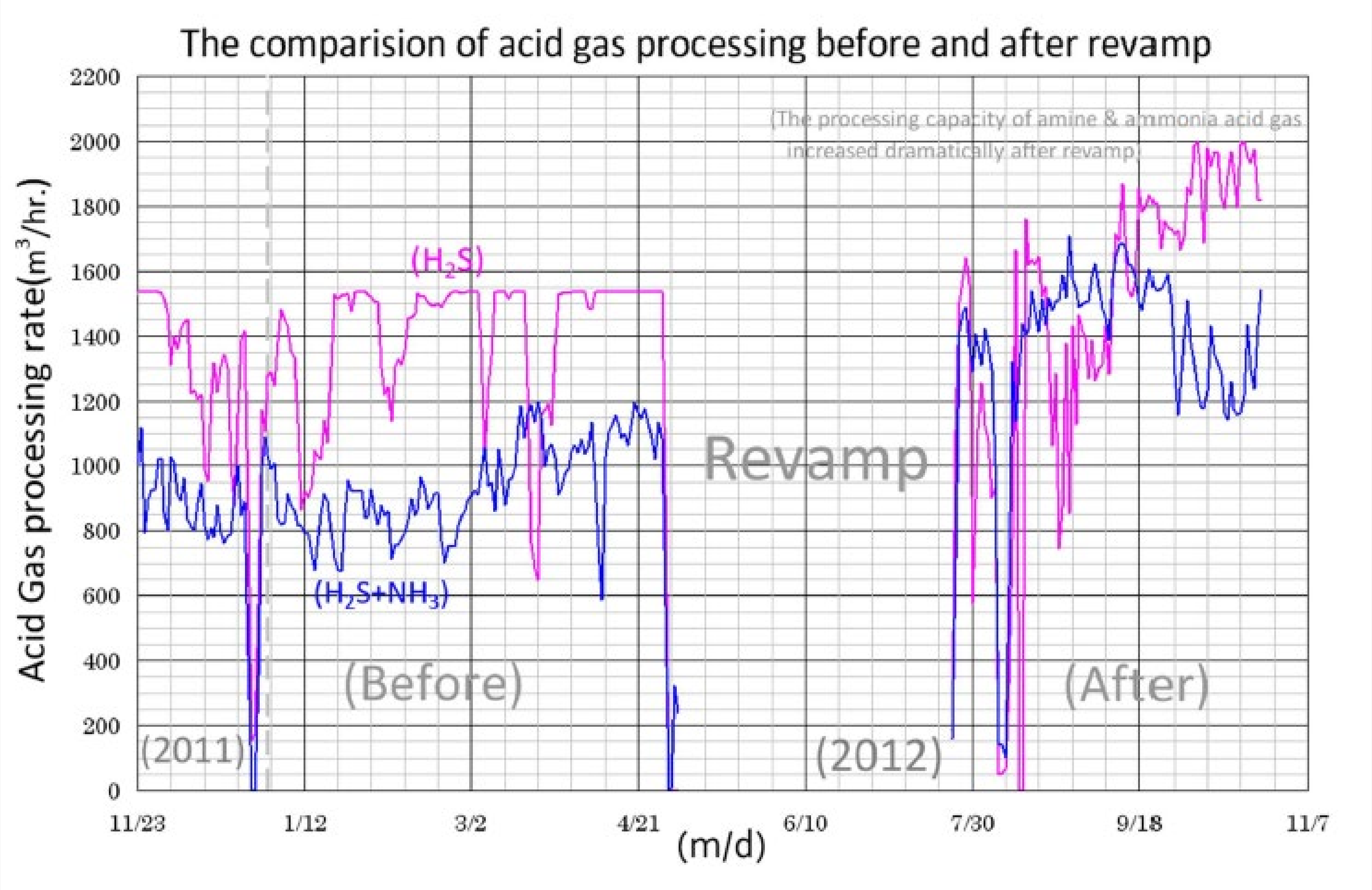
Update to CPC Taoyuan SRU VectorWall™ installation in early

Temperature difference between Zone 1 and 2 increased from 125°C to 450°C and remained consistent. Zone 1 temperature remaining between 1,350-1,375°C.



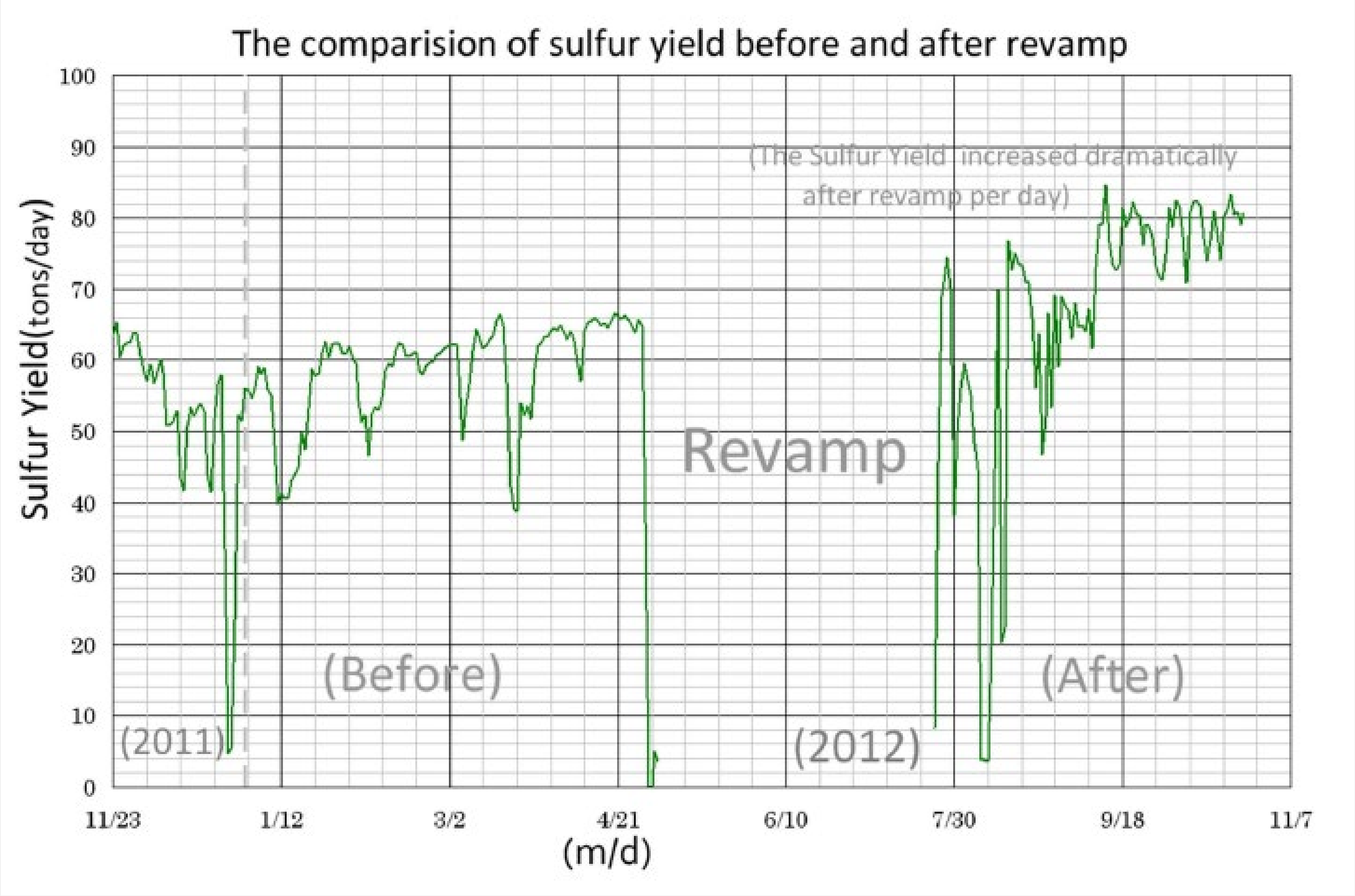
Update to CPC Taoyuan SRU VectorWall™ installation in early 2012

SWS offgas capacity remained nearly 50% higher through late 2014, on average than before retrofit.



Update to CPC Taoyuan SRU VectorWall™ installation in early 2012

Sulfur production increased from 105 tpd to 120 tpd, a 30% increase.



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Excellent results from operation in the tail gas incinerator at a Tessenderlo Kerley facility in USA

Attached: TKI-Case-Study-HydrocarbonEngineering-05-14

Excerpt below:

Results

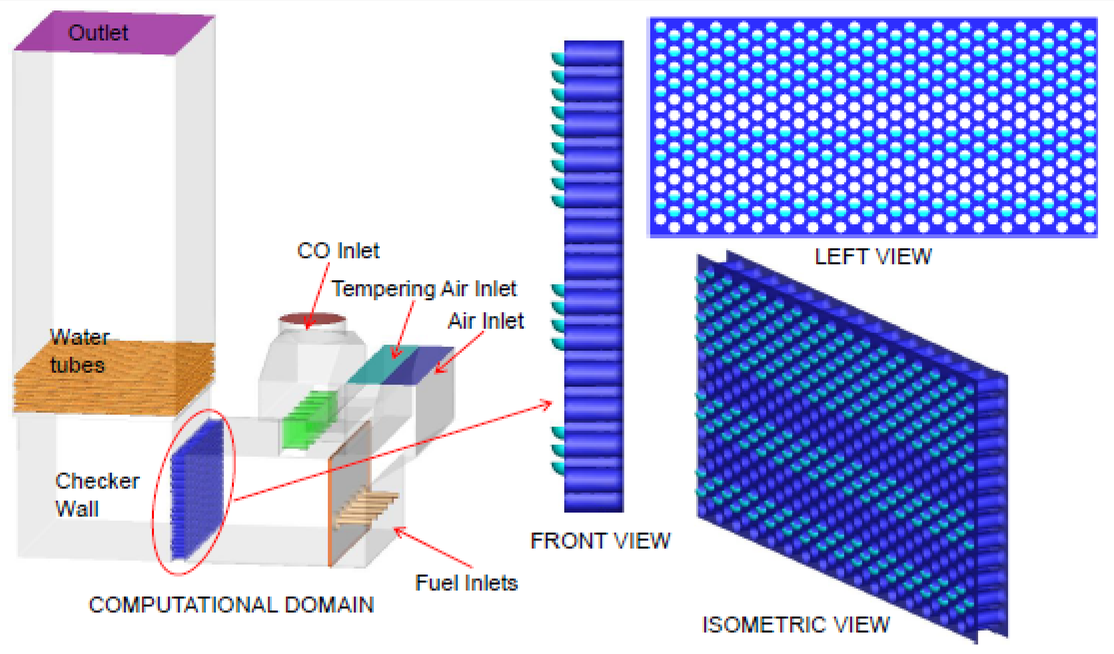
Results of the conversion have been very positive for plant operation and maintenance. Since the conversion, the incinerator operating history has shown:

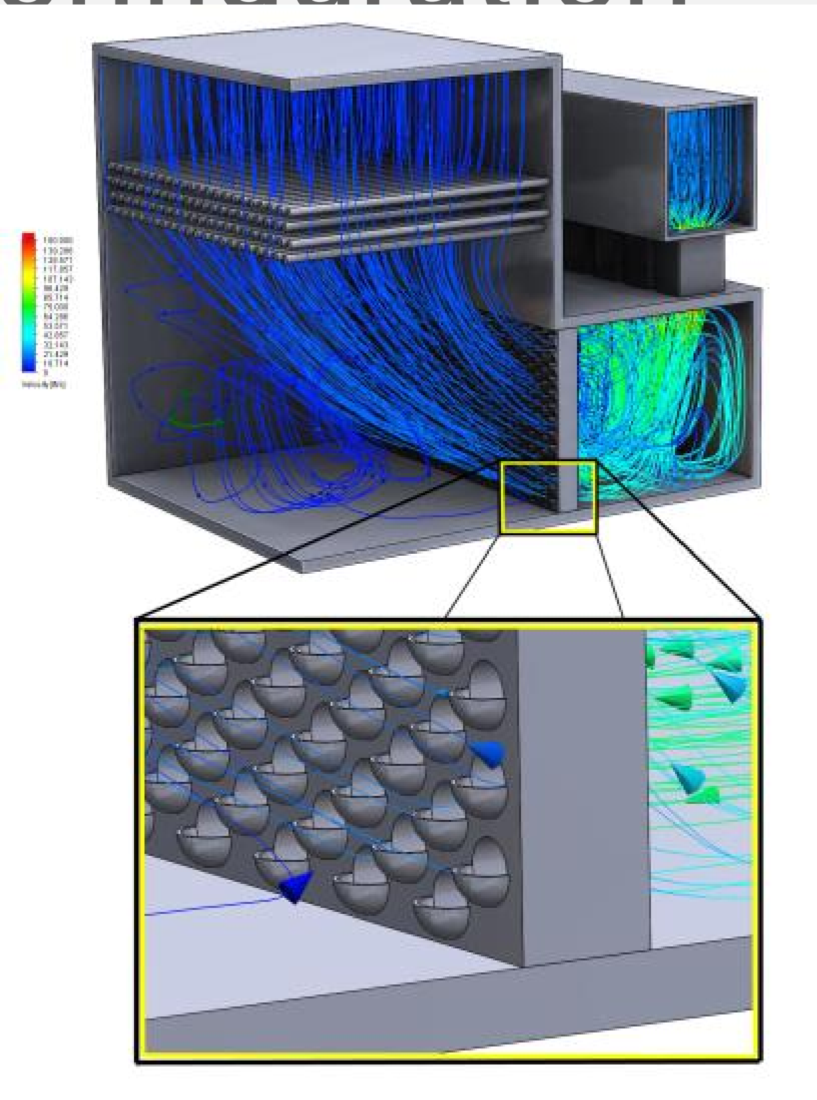
- Reduced fuel gas requirements; fuel gas usage has been cut by almost 50%.
- Elimination of almost all sulfur carryover; downstream equipment no longer has residual sulfur buildup.
- Lower excess oxygen required to maintain complete combustion; excess oxygen cut by 2%.
- Increased incinerator skin temperature to optimal temperatures of above 500°F; this eliminates sulfuric acid condensation.
- Visual inspections have shown the Vector Wall has not cracked or deteriorated even after five years of service.

Additional uses for VectorWall

2-Zone/Split Flow Configuration

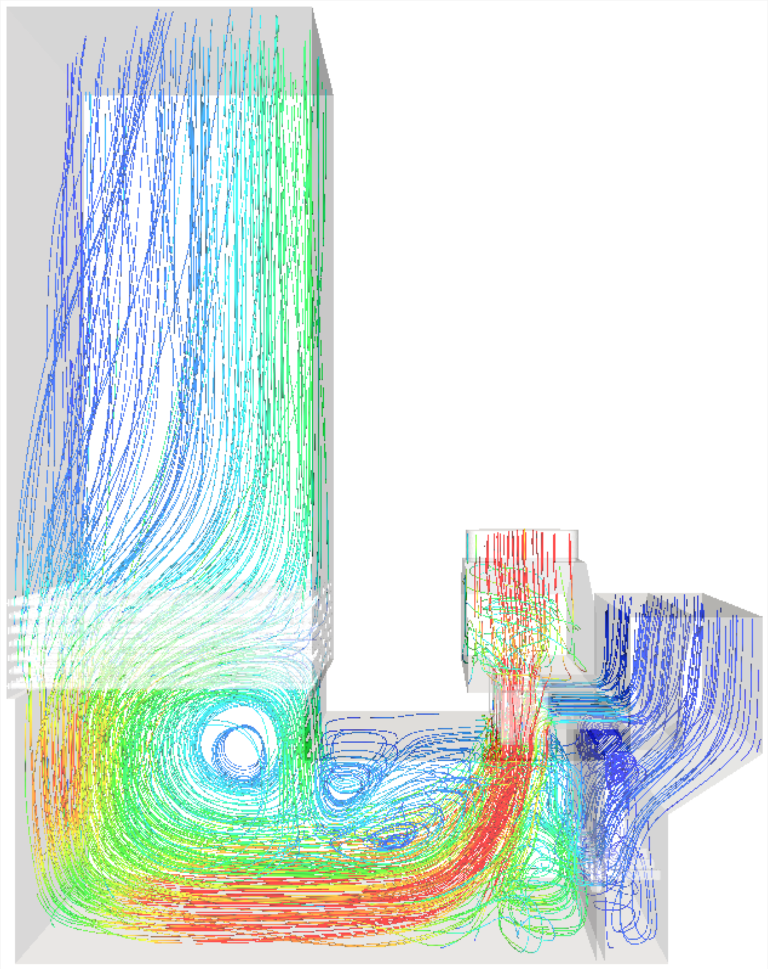
- Concept Drawing
  - VectorWall placed at back edge of combustion zone; right at corner. Vector Tiles all turned in upward direction.

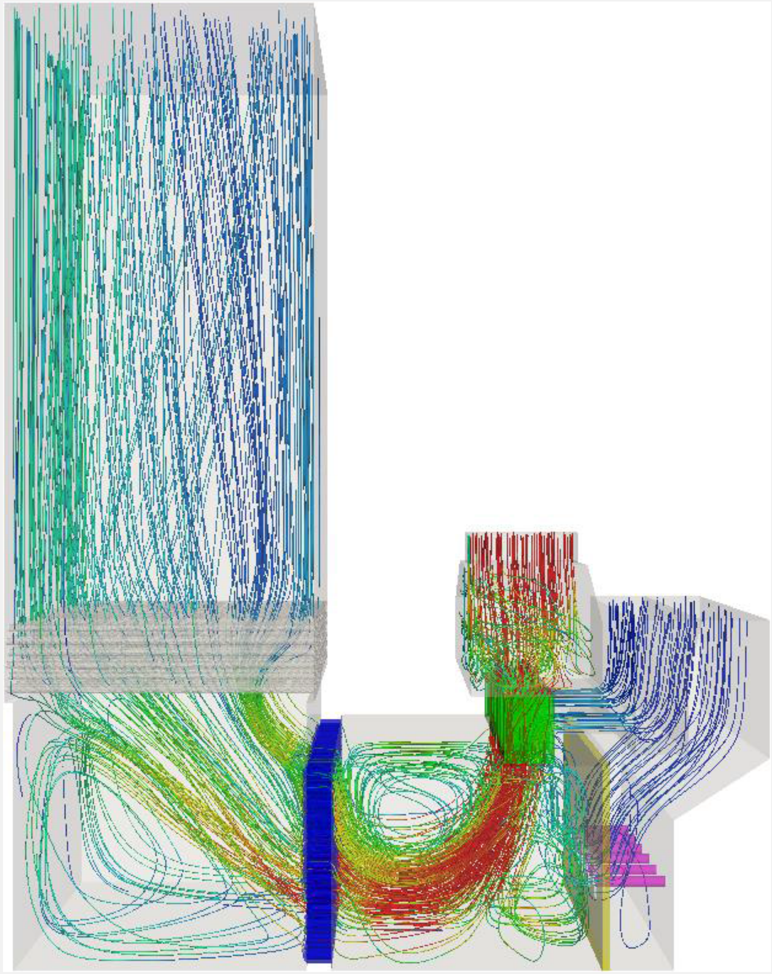




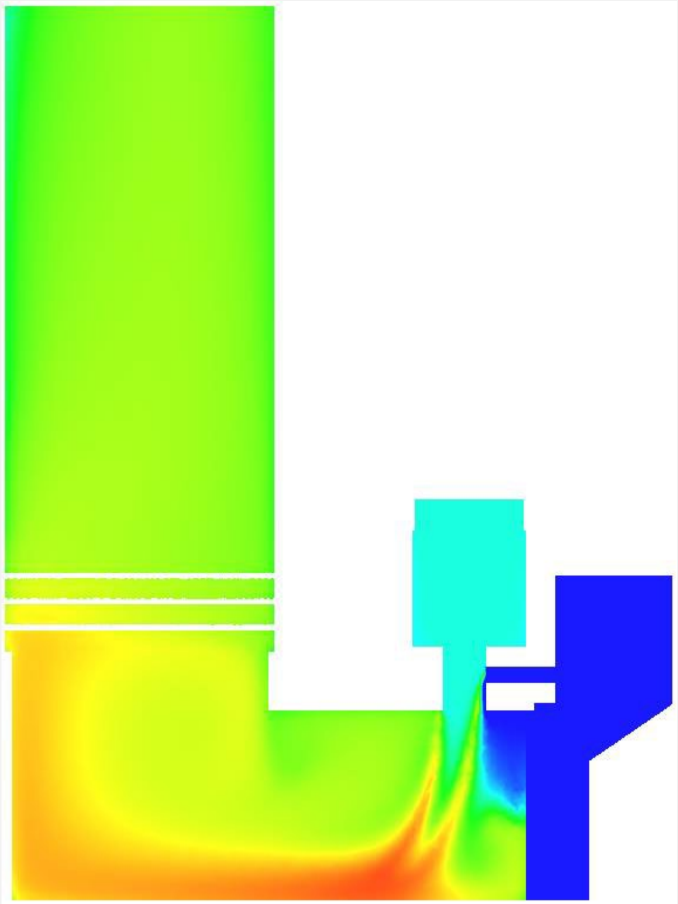
2-Zone/Split Flow Configuration

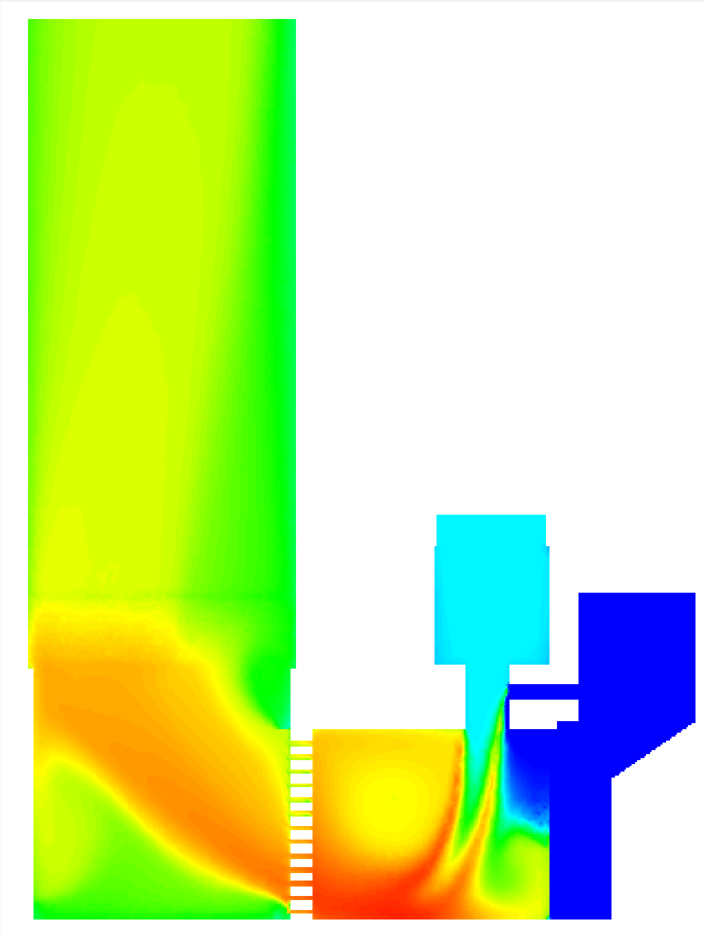
- Velocity Profile
  - Catalyst fines carried by high velocity stream to outside wall caused abrasion of the refractory lining.





2-Zone/Split Flow Configuration





- Temperature Profile
  - Most of heat flowed toward the back wall, underutilizing the entire convective heat transfer surface.

Reflection of Radiant Heat

- The hoods/ tiles on the VectorWalls reduce the heat loss from the flame to the back of the furnace, by blocking/reflecting the majority of radiant heat.
- Alternate Vector Tile designs that block greater amounts of radiant heat are available.

Thank You

Visit www.blaschceramics.com
for more product & industry information.