Increasing production rates with through the use of innovative furnace internals.

BASF SULFURIC ACID SYMPOSIUM

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Director of New Business Development

BLASCH PRECISION CERAMICS
Where your ideas take SHAPE in CERAMIC

Presentation Outline - Vectorwall

- Introduction to Blasch
- How the VW can increase capacity

1. Lower Pressure Drop
2. Improved Gas Distribution
3. Longer/Better Flow Path
4. Uniform Temperatures
5. Ease of Maintenance and Repairs
6. Other Intangibles

- Summary

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Blasch Precision Ceramics

Founded in 1979, Blasch is an employee-owned manufacturer of engineered industrial ceramic shapes and systems

- Headquarters and engineering and manufacturing facility located in Albany, New York
- Highly experienced team with extensive product and system design capabilities in most industries
- Sales / agency offices worldwide
- Custom engineered and often patented shapes that replace monolithic or brick-n-mortar structures



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Takeaway

- Blasch's **VectorWall™** can help a sulfuric acid plant increase production rate primarily by **improving gas-flow distribution and reducing the limitations imposed by conventional refractory construction.**
- The value is not simply that the VectorWall can withstand higher temperature—it is that the system can allow the plant to **push more gas through existing equipment while maintaining the required process conditions.**

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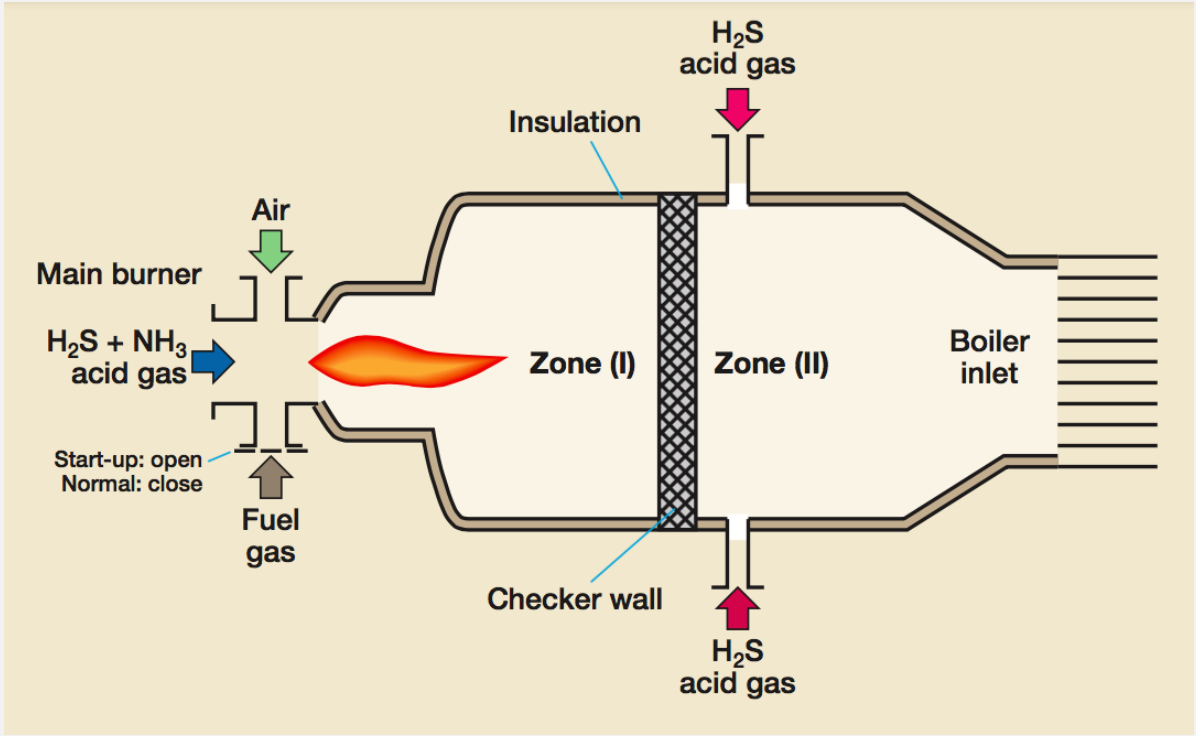
Performance of the SRU Reaction Furnace, Thermal Oxidizer, Sulfur Burner, SAR, Incinerator is Critical to Trouble-free pperation

- **Key Reaction** $2H_2SO_4 \rightarrow 2SO_2 + O_2 + 2H_2O$

$H_2S + 3/2\ O_2$	$\rightarrow$	$SO_2 + H_2O$	(Combustion reaction)
$2H_2S + SO_2$	$\leftrightarrow$	$3S + 2H_2O$	(Claus reaction)
$3H_2S + 3/2\ O_2$	$\leftrightarrow$	$3S + 3H_2O$	(Overall reaction)

- **Destruction of contaminants**
  - Ammonia
  - Hydrocarbons (CO)
  - BTEX
- **Thermal and structural stability**



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1. Lower Pressure Drop

Increase gas throughput through the same equipment
Sulfuric acid plants are often constrained by the capacity of the converter, furnace, heat exchangers, towers, or ductwork to handle additional gas volume. A VectorWall can be engineered to provide a more open, hydraulically efficient flow path than conventional brick-and-mortar construction.
That can translate into:

- Lower pressure drop
- Higher allowable gas velocity
- More available capacity within existing equipment
- Less of a bottleneck as SO_2 throughput is increased

This is particularly valuable for **debottlenecking an existing plant without a major equipment expansion**.



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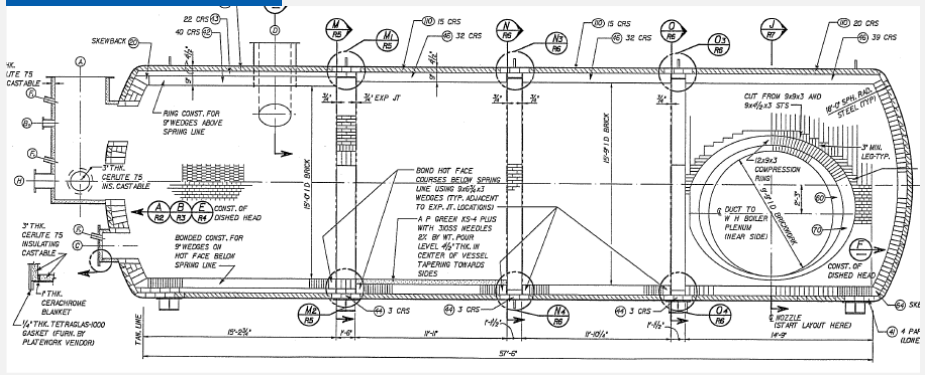
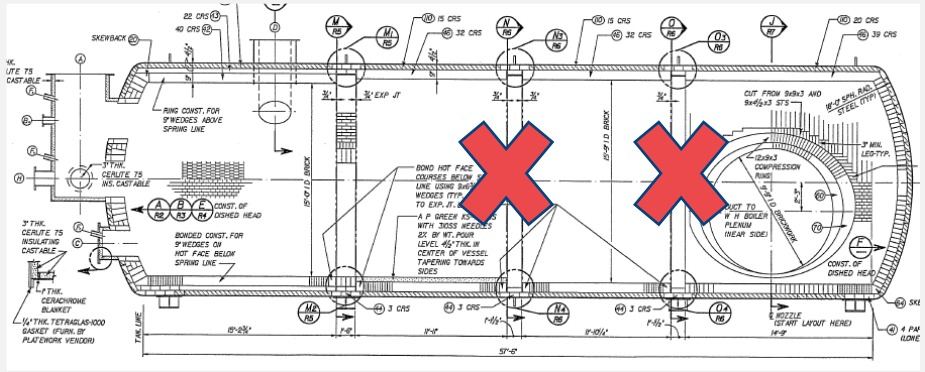
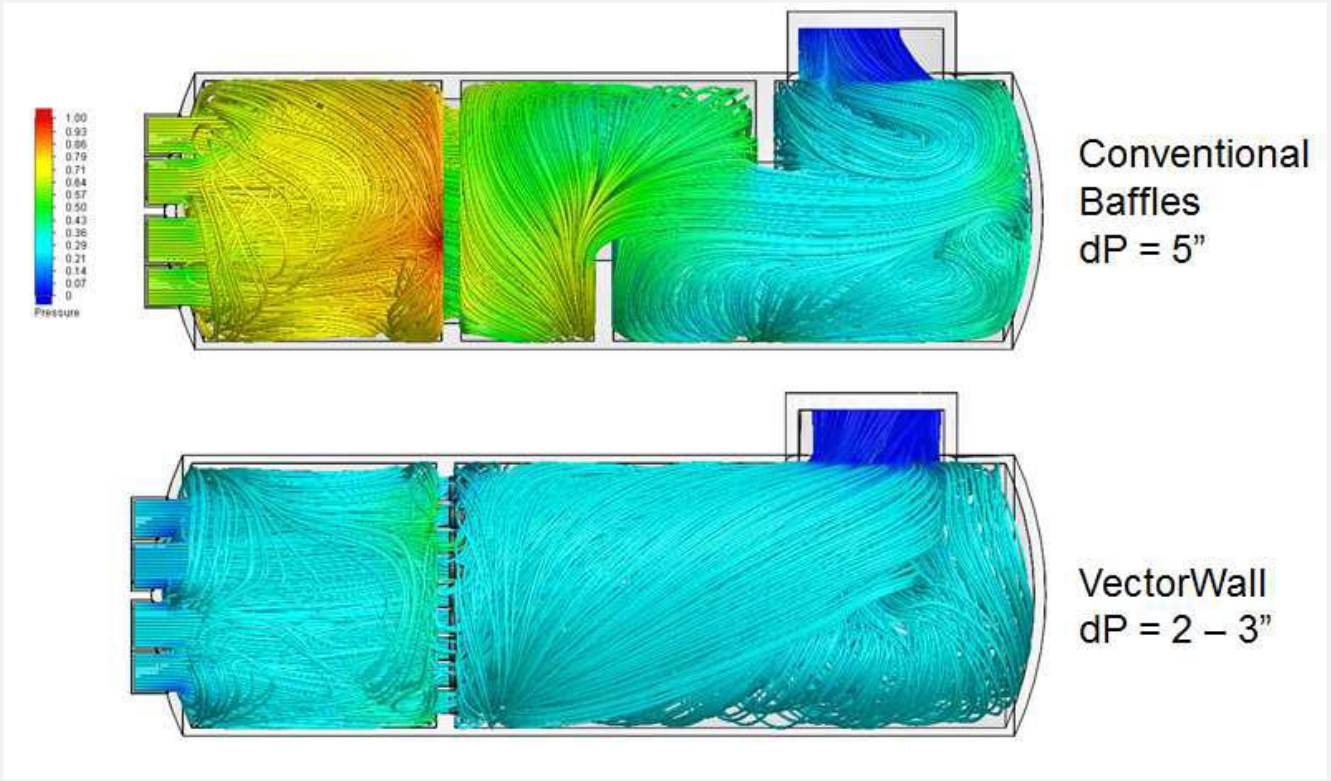
Reduced Pressure Drop







Pressure Drop for 3 Baffle Walls vs. 1 VectorWall™

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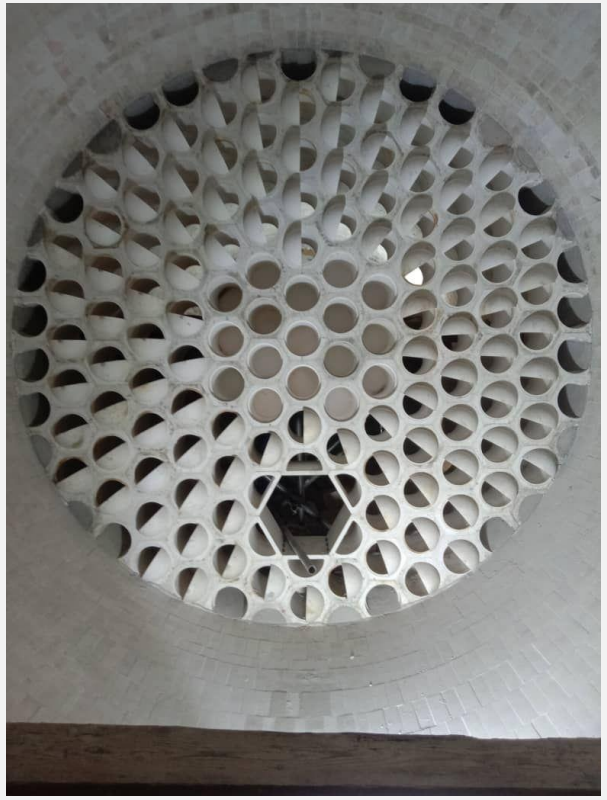
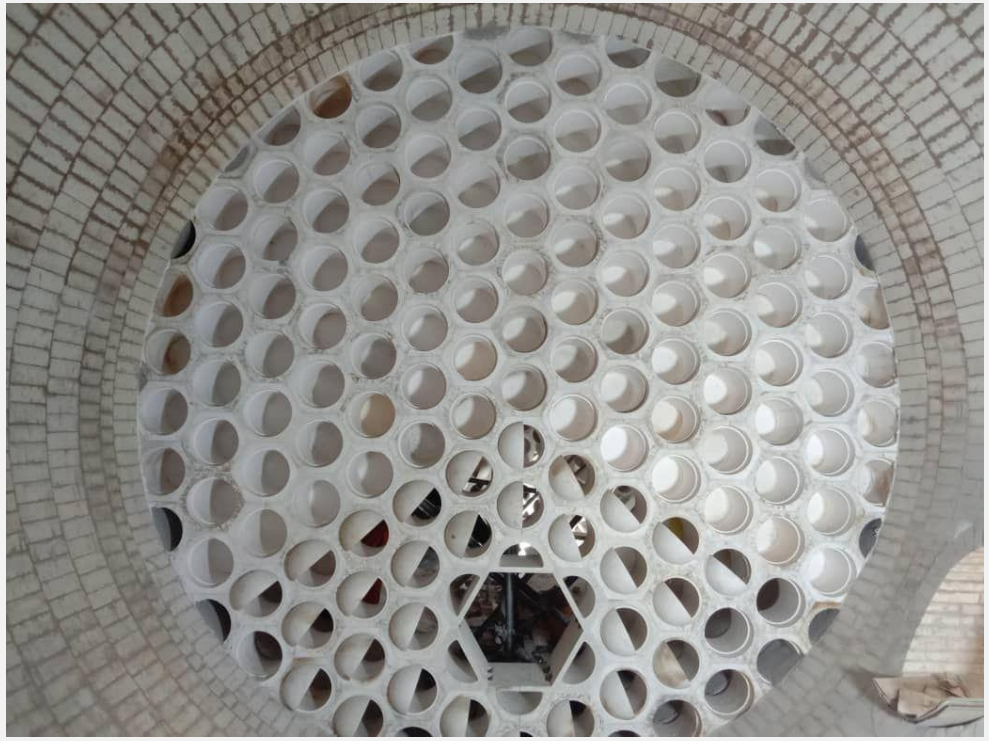
Blasch VectorWall™ Decomp Furnace







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2. Improved Gas Distribution

Improve gas distribution

At higher production rates, poor gas distribution becomes increasingly problematic. Gas that bypasses portions of the catalyst bed doesn't contribute proportionally to conversion, while areas receiving excessive flow can experience higher pressure drop, temperature gradients, and catalyst loading.

A precision-engineered VectorWall can be designed around the actual vessel geometry to help create a **more uniform velocity profile**.

The objective is essentially:

More uniform gas flow → better catalyst utilization → greater SO_2 conversion at the same catalyst volume.

That can give an operator additional production capacity before reaching a conversion, temperature, or pressure-drop constraint.



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Combustion Efficiency – Three T's

Parameter and Operation/Design Levers

- **Time**
  - Reaction furnace (RF) size
  - Flow rate (OE, etc.)
  - RF internals
- **Temperature**
  - Burner
  - Preheating feed/air
  - Co-firing
  - Oxygen enrichment
  - Front-side split operation
  - RF internals
- **Turbulence**
  - Burner
  - RF internals



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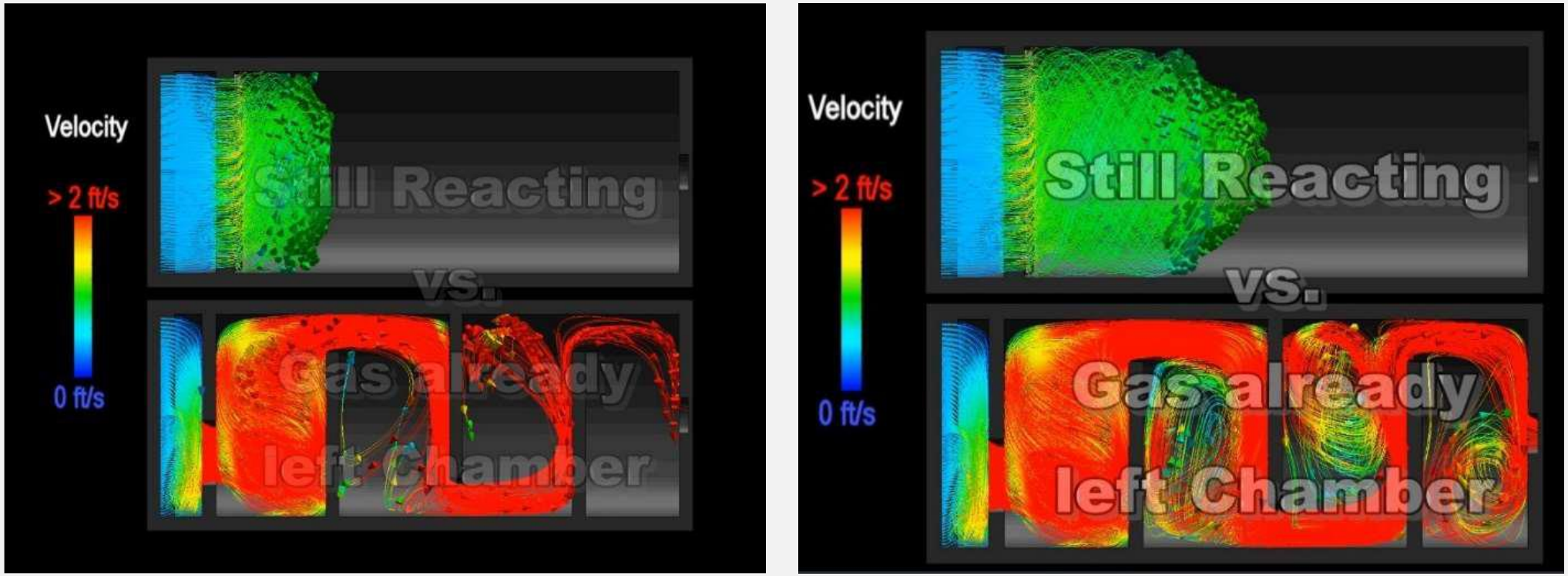
Improved Mixing and Residence Time with Blasch VectorWall



Residence Time Distribution for 3 Baffle Walls vs. 1 VectorWall™

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Create Turbulence and Improve Mixing

- Inserts in the blocks increased pressure drop & didn't create the desired macro-furnace mixing
- Thoughts then turned toward impacting the flow direction at the exit of the block; utilizing all of the blocks together to create a specific flow field
- The result was a series of highly engineered add-on vectoring tiles installed in the blocks





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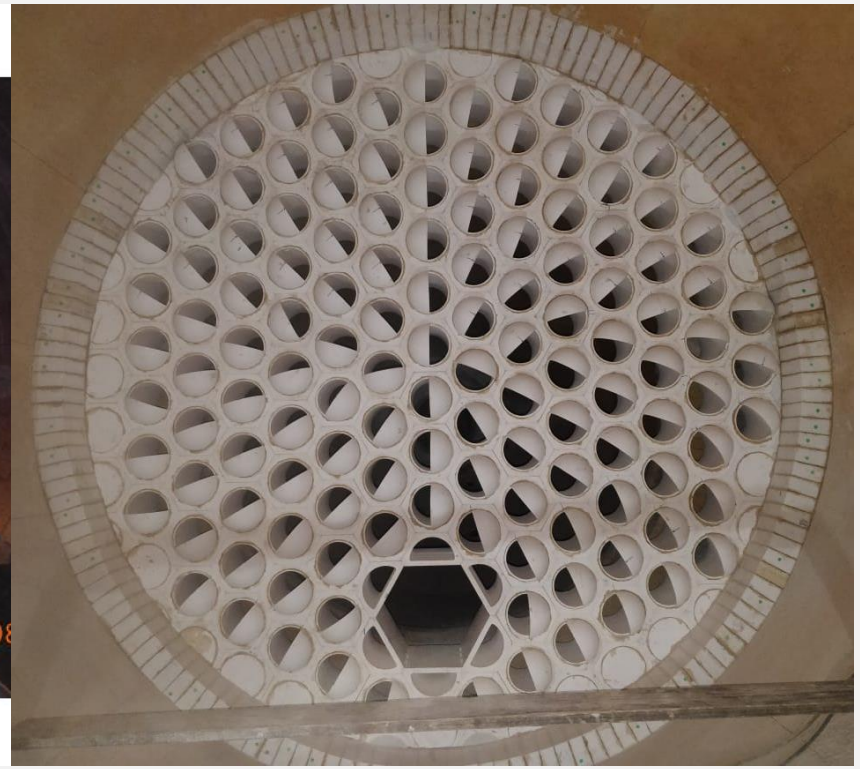
Blasch VectorWall™







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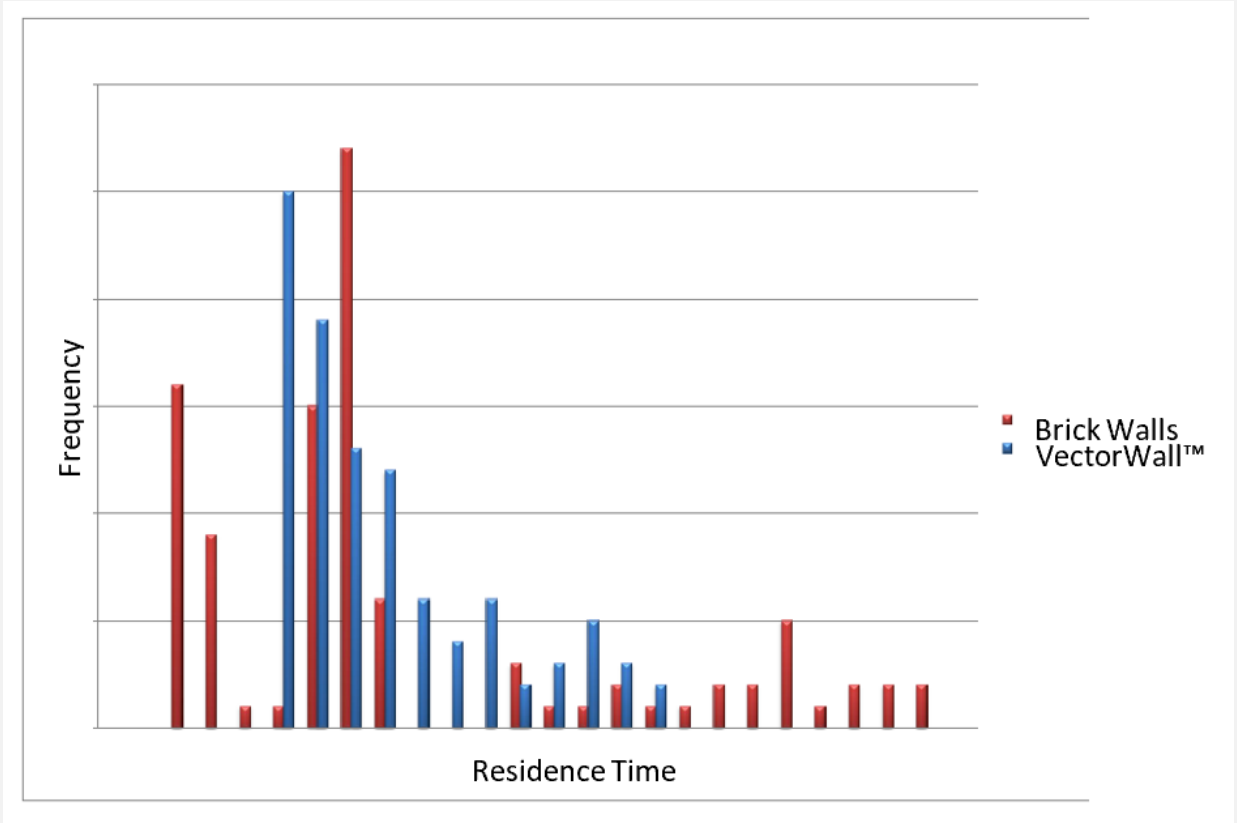
VectorWall Installation Results In tighter Residence Time

Improved Flame Characteristics & Reduced Vibrations

- Narrower residence time distribution
- Longer residence time, which allows all particles to mix and react accordingly
- For a debottlenecking situation whereas space is limited, an increase of 7-10% capacity can be realized.
- Baffle walls have a broad residence time dist where there are areas of no reactions taking place



CFD Analyses Porter McGuffie, Inc.

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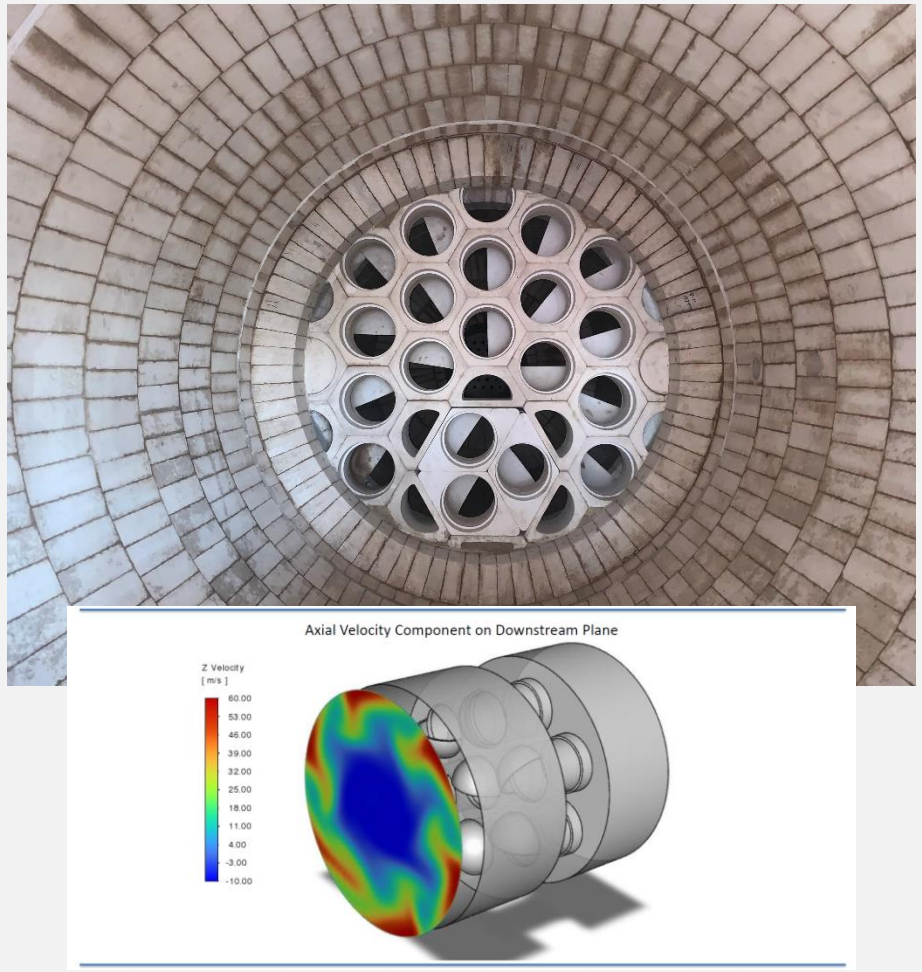
3. Longer/Better Flow Path

Reduce refractory intrusion into the process gas path
Traditional brick-and-mortar refractory can require substantial structural thickness, ledges, joints, and other construction features. As refractory deteriorates, pieces can also intrude into the gas path.

A shaped ceramic system allows Blasch to engineer the refractory geometry specifically for the application rather than building the required shape from standard refractory units.
That can provide a **more aerodynamic internal geometry**, particularly in transitions, walls, inlets, outlets, and other areas where flow separation or turbulence can occur.



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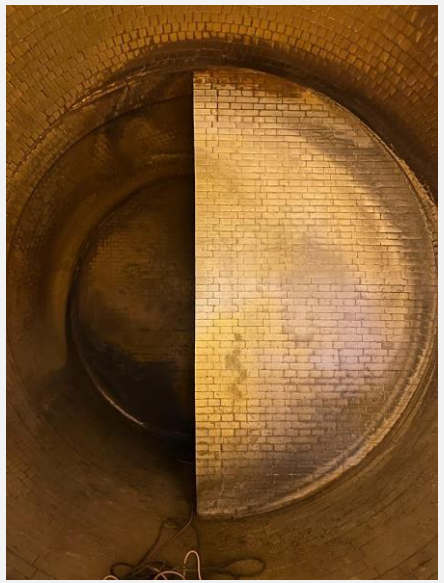
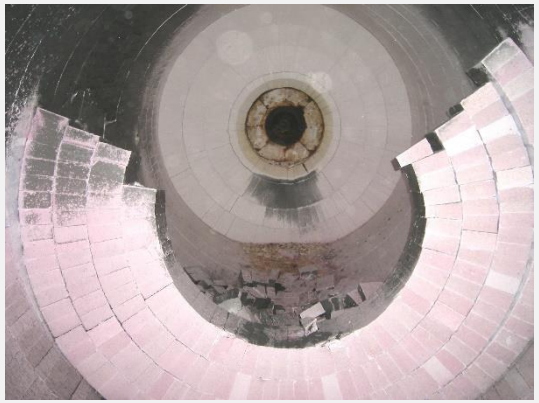
Poor Integrity of Conventional Sulfur Furnaces



BRICK CHECKERWALL
Most common



BAFFLE WALLS
Cheap alternative



CHOKE RING
Common

Brick Checkerwall

- Constructed from standard 9” refractory brick, two layers thick
- Bricks are mortared together in an open configuration
- Thermal cycling causes mortar to crack & fail over time
- Design inherently unstable - bricks are flat spans therefore in tension
- Generally erected with a manway, further complicating & destabilizing wall

These designs were not lasting the length of a campaign leading to expensive S/Ds and repairs

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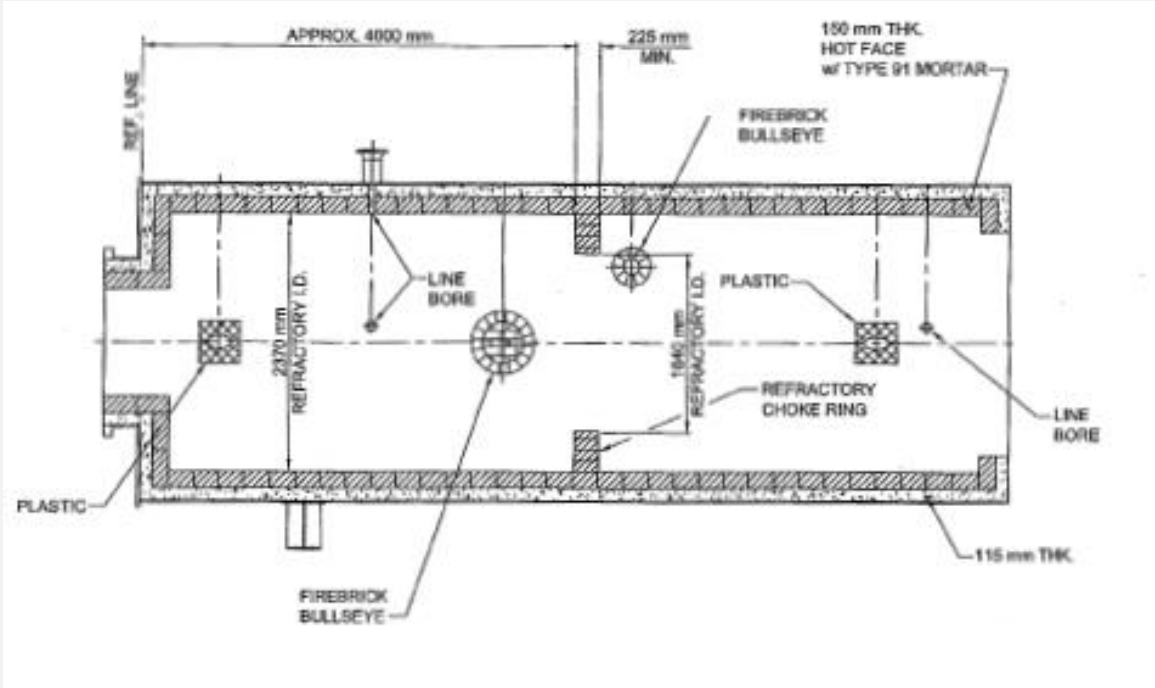
Problems with Choke Rings

Purpose: Reflect back some of the flow and create a degree of back mixing in the front zone of the furnace



The Choke Ring also results in:

- a large portion of the flow jetting through the center of the ring
- jeopardizing minimum residence time requirements for key reactions
- impingement of this strong jet on the tube sheet
- occasional vibration and flame stability issues

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Problems with Baffle Walls

Purpose: Create a tortuous path for gas to flow and increase the residence time within a given furnace distance.

The Baffle Walls results in:

- Areas of dead zones where gas is not mixed jeopardizing minimum residence time requirements for key reactions
- Increased pressure drop
- Poor structural integrity and constant repairing of brick work



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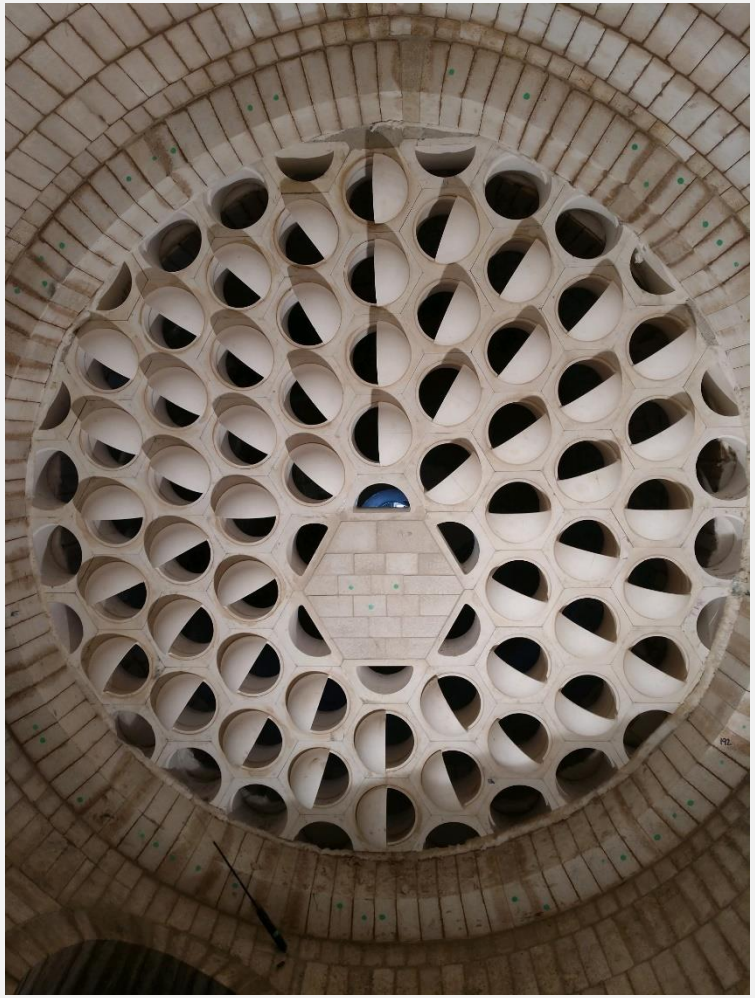
4. Uniform temperatures

Maintain performance at higher operating temperatures
Production rate is strongly tied to the thermal balance of the sulfuric acid process. If a plant can operate at a higher or more controlled process temperature without accelerating refractory degradation, it can potentially increase throughput.
Blasch's engineered ceramic components can be designed for:

- High-temperature operation
- Thermal cycling
- Corrosion from sulfur-containing process gases
- Abrasion/erosion where applicable
- Controlled thermal expansion
- Long-term dimensional stability

The important point is that **temperature capability alone doesn't increase acid production**. It gives the operator more operating margin when temperature is one of the constraints limiting throughput.



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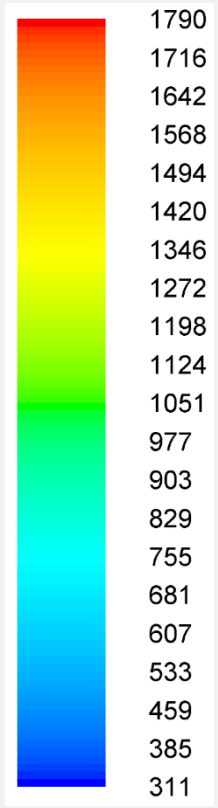
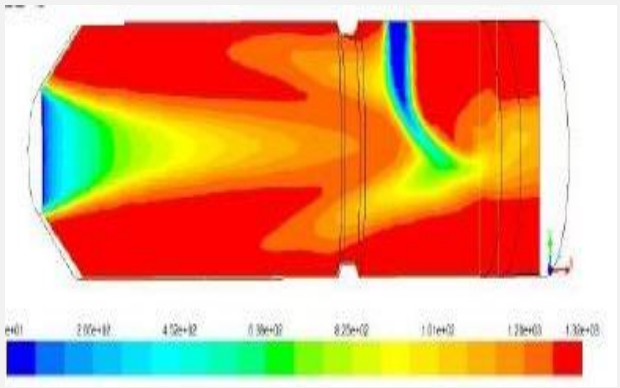
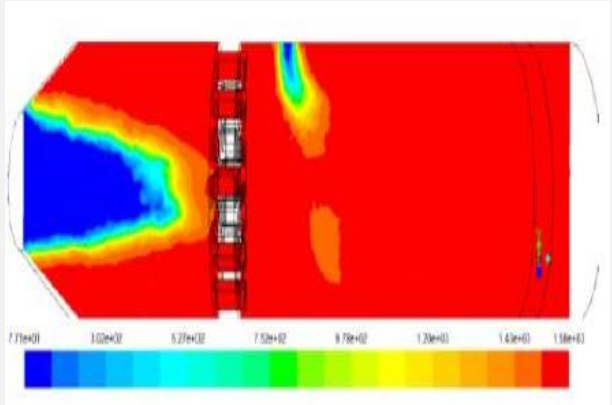
Improved Temperature Profile

Temperature [K]

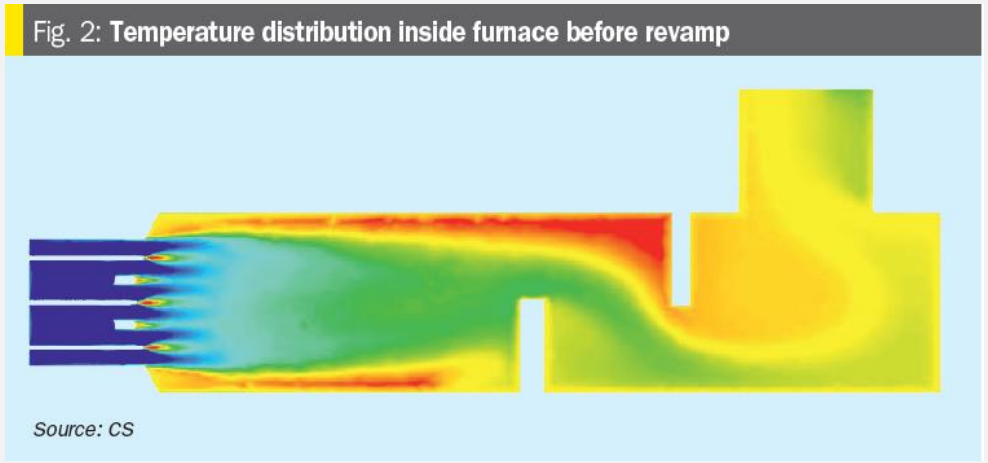


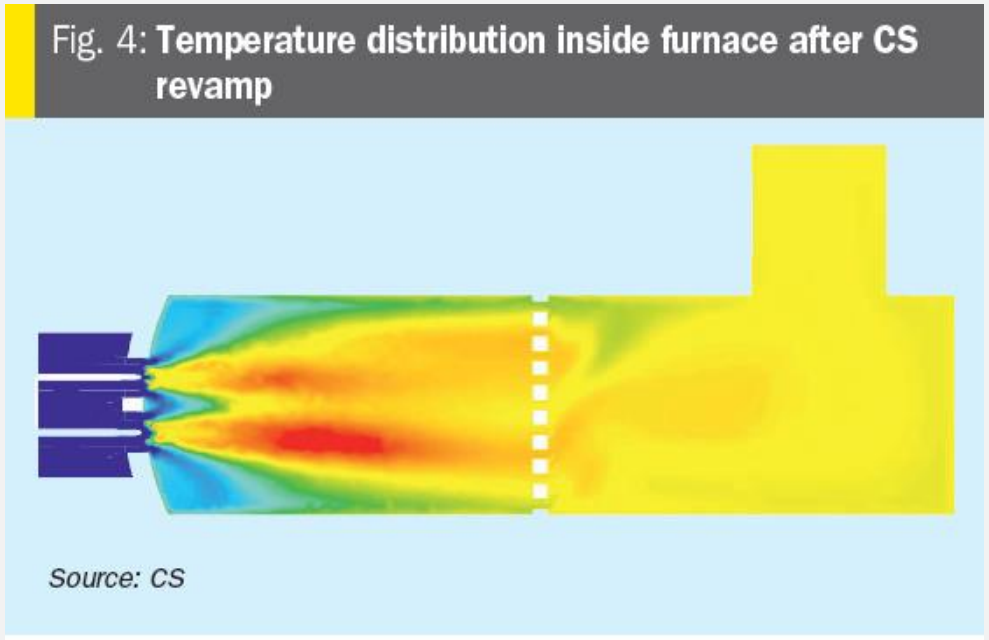


Temperature profile with choke ring and AAG into 2nd Zone



Temperature profile with Vector Wall and AAG into 2nd Zone





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5.Ease of Maintenance and Repairs

Eliminate some of the weaknesses of brick-and-mortar construction

This is probably one of the stronger arguments for VectorWall in a rate-increase discussion.

Conventional refractory walls depend on **many individual bricks and mortar joints**. Thermal cycling can progressively degrade those joints, creating movement, gaps, cracking, and eventually refractory failure.

A Blasch engineered ceramic wall can use **mechanical engagement and precision-shaped components** rather than relying on mortar as the primary structural connection.

That can provide:

Fewer joints → less maintenance → less refractory debris → more stable flow geometry → longer campaigns.

And importantly for a production manager, avoiding an outage can be worth considerably more than the refractory itself.



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Improved Structural Integrity with VectorWall™

- Large hexagonal blocks are inherently stable
- Patented design ensures that all blocks are fully supported – created by the natural arch.
- Tongue & Groove interlocking joints
  - Precision cast parts fit reliably together
  - Blocks lock firmly together; can be rocked to and fro, unsupported
  - Can withstand substantial lateral forces from upset or delayed ignition
- Quick, Clean Installation – No mortar



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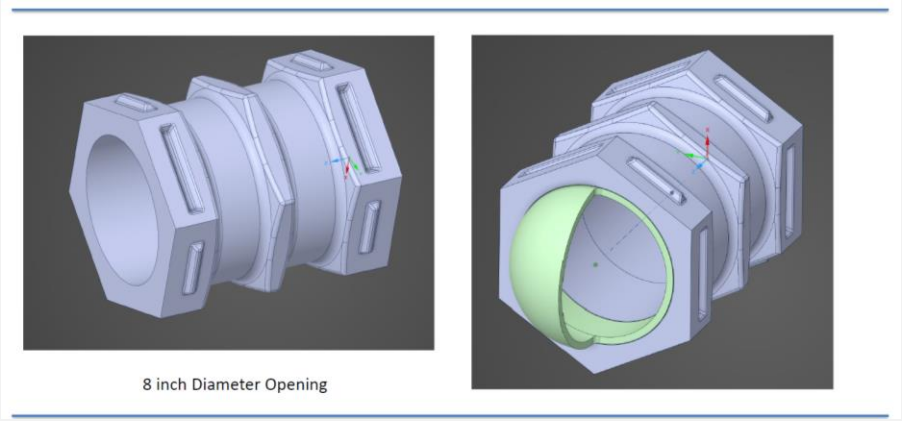
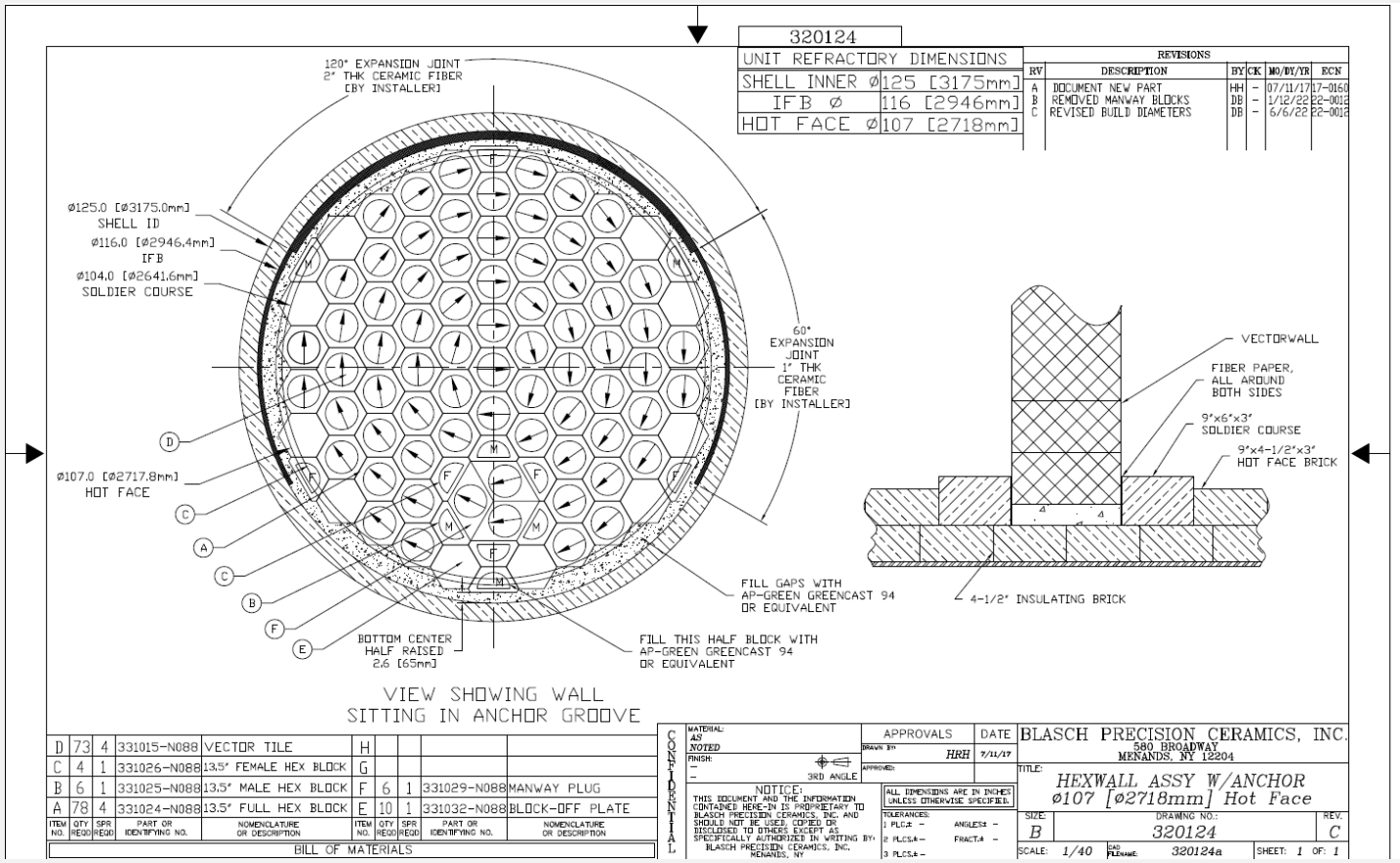
Improved Structural Integrity with VectorWall™



8 inch Diameter Opening



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6. Other intangibles (SRU/TOX related)

Other intangibles

- Lower cost option
- Lower Nox
- Shorter furnace?
- Hotter Zone 1
- Improved Ammonia Destruction
- Elimination of fireflies – visual clue
- CO Destruction



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Qualitative Impact of the Various Temperature Enhancement Methodologies

	Capital Costs	Operating Costs	Capacity	CO_2 Emissions
Fuel gas co-firing	↑↑	↑↑	↓↓	↑↑
Air/Process Gas preheating	↑↑	↑		
Oxygen Enrichment	↓↓↓	↑↑↑	↑↑↑	↓↓
High Intensity Burners	↑↑			
RF/TOX Internals VectorWall™	↑	↓	↑	↓

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VectorWall Installation Results in Lower NOx

- **Goal =** Release more capacity while reducing stack NO_x emissions.
- **Problem =** Required staged combustion with 2 chambers/zones and client was limited in footprint.
- **Solution =** Utilize Vectorwall to create 3 distinct chambers/zones.

Secondary air is forced down into the bulk gas flow stream

Gas is mixed in the second chamber by the Vector tiles

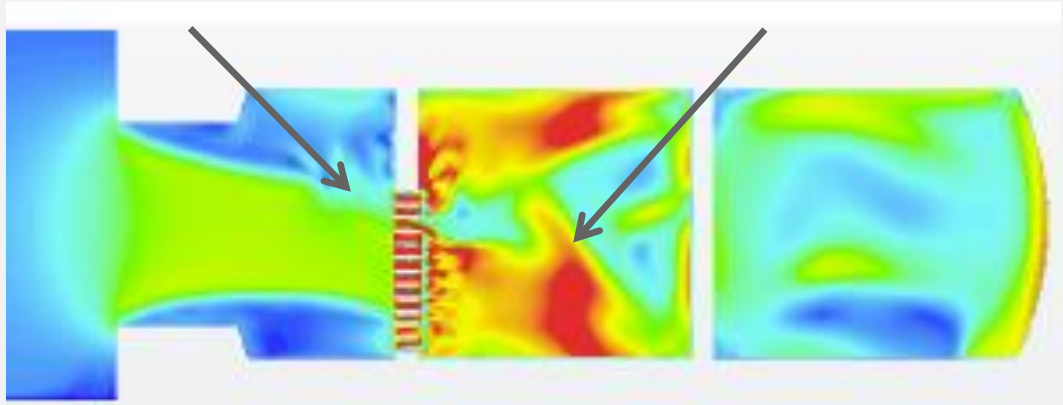

Table 1
Emissions and Production Results

Daily Averages	Production Rate mtpd	Tail Gas NOx mg/Nm^3
BEFORE Revamp	900	150
AFTER Revamp	1082	49

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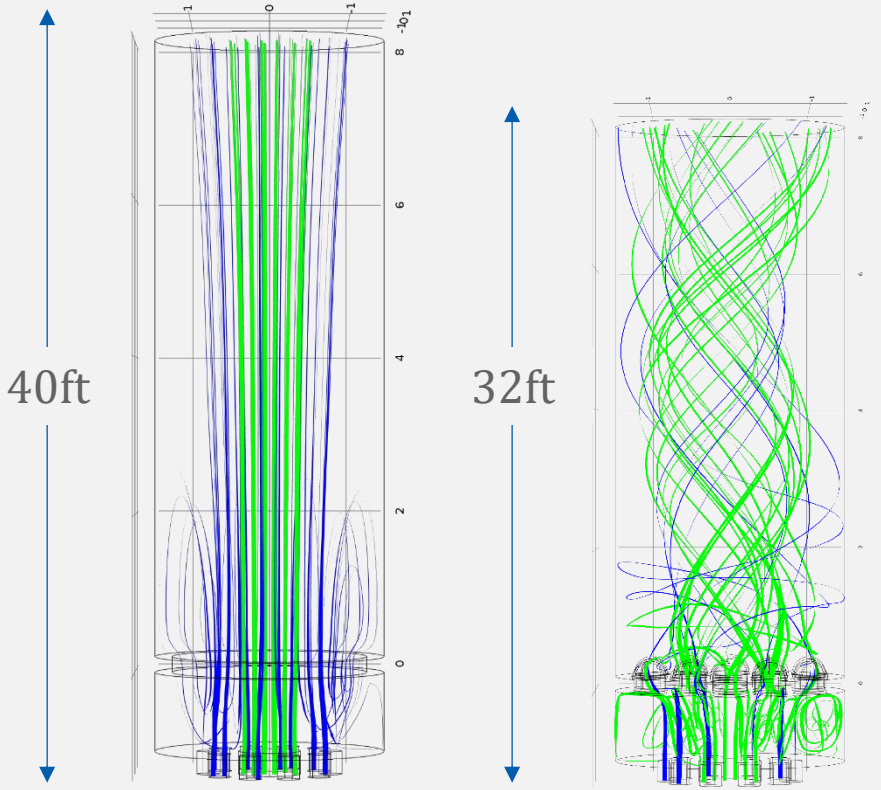
Shorter Furnaces?

- **Shorter furnaces**
  - So as an engineer if you are designing a reaction furnace or incinerator you are trying to calculate how long of combustion zone do you need to achieve what you are after. If you can achieve everything in a shorter amount of space, wouldn't this decrease overall costs = less brick, less steel, less fuel, less installation time, etc.



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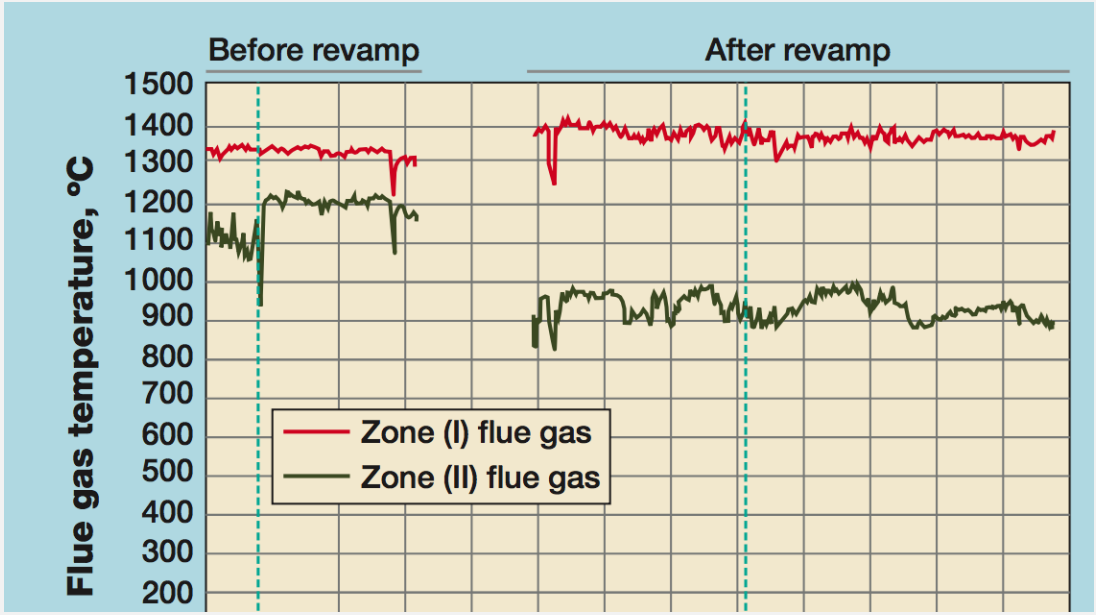
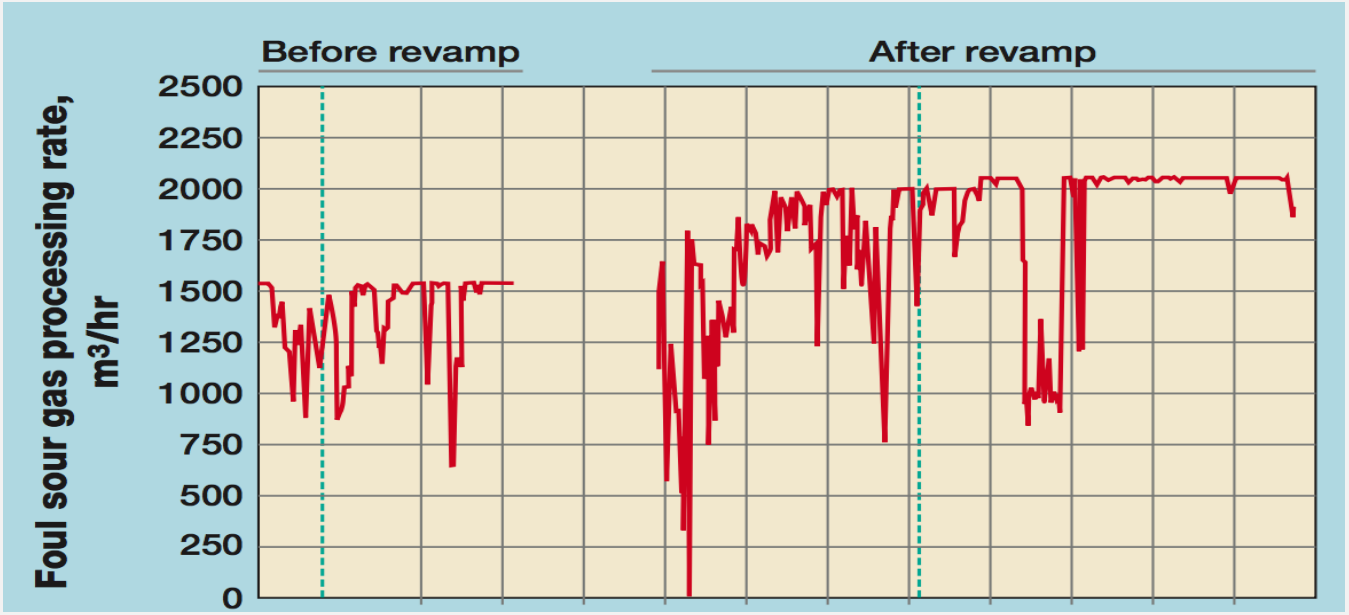
VectorWall Installation Results Higher Temperature & Capacity



High Front Zone Temperatures



SRU Capacity

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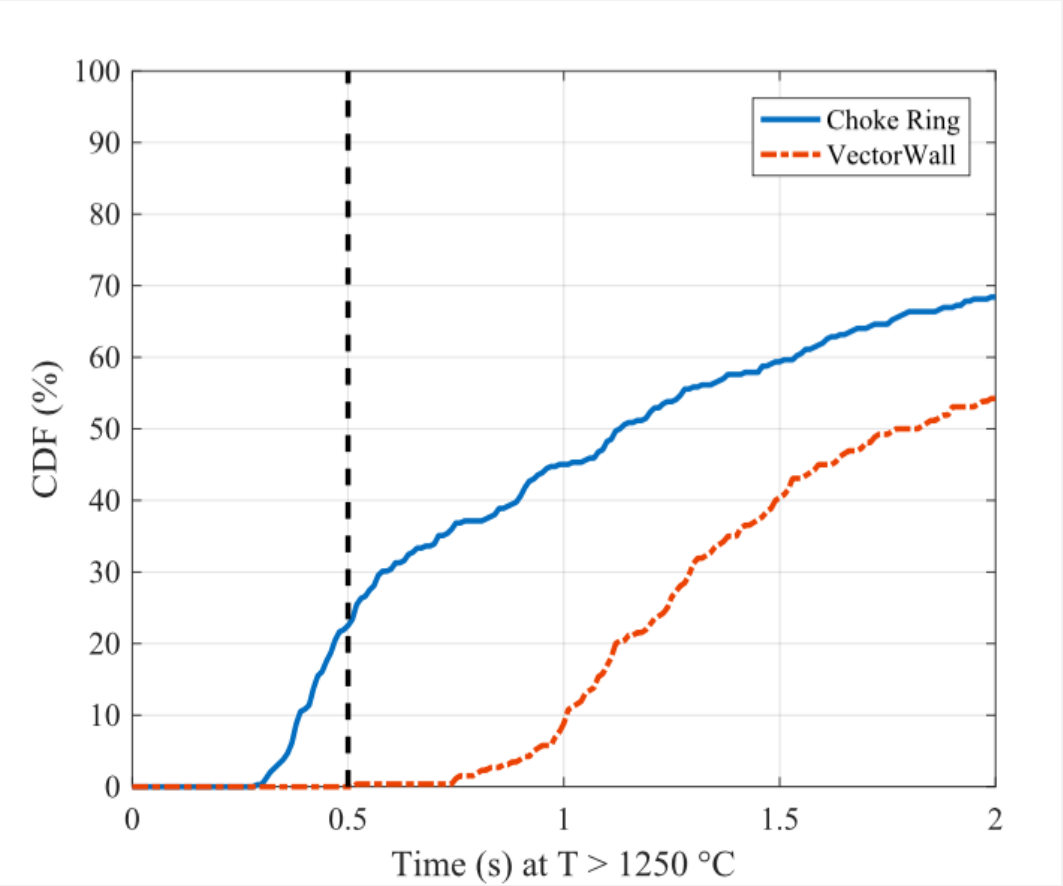
VectorWall Installation Results Improved Ammonia Destruction

- **Before**
  - With choke ring, about 22.5% of the flow estimated to not meet minimum residence time requirements for NH3 destruction. Consistent with field performance and evidence of ammonia salt deposits.

- **After**
  - With VectorWall installation, all of the Zone 1 gas flow meets the retention time requirements for NH3 destruction.



Cumulative Distribution Functions of Residence Time

Vertical dashed line indicates cutoff residence time for contaminant destruction

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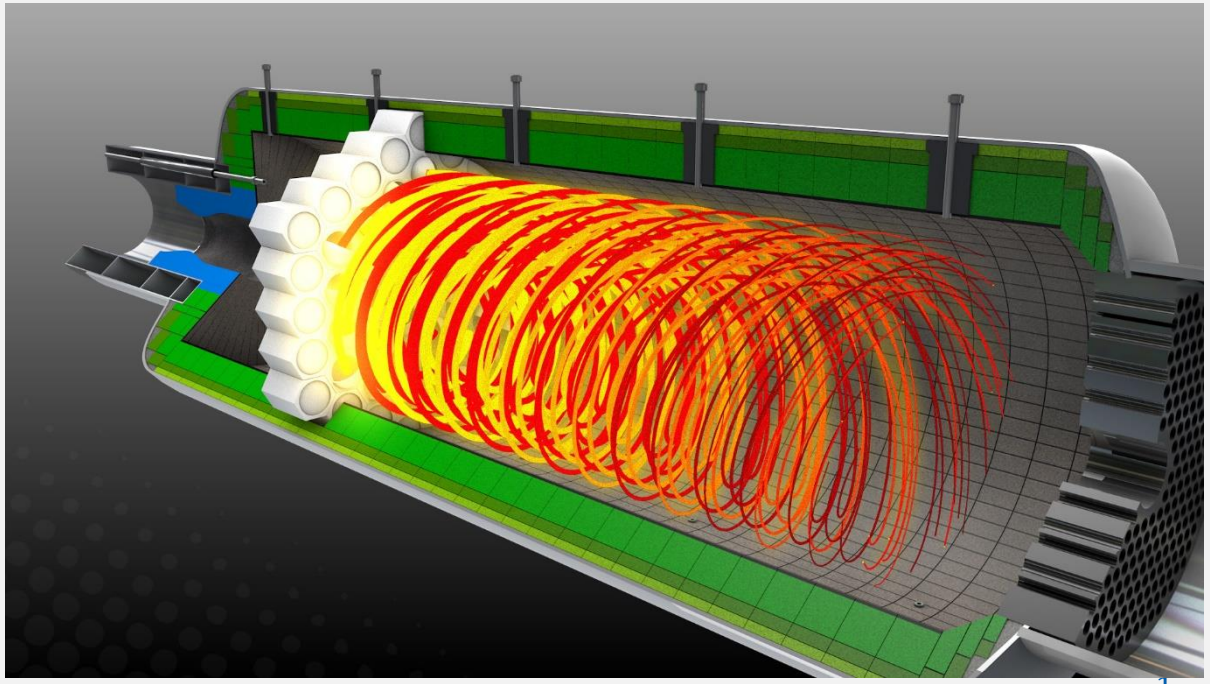
Fireflies

- **Fireflies** - Elimination of “fireflies”; VectorWall can help protect the WHB by eliminating uncombusted sulfur that may exit the furnace (fireflies). Since so much of the gas volume collides with the VectorWall and is redirected, the turbulence induced improves furnace combustion efficiency, while baffles allow a large portion of the gas to sneak by unaffected, significantly reducing the residence time of those particles increasing the probability of uncombusted sulfur making it to the WHB tubesheet and causing damage.



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Ways to destroy CO

Time vs. Temperature vs. Contact

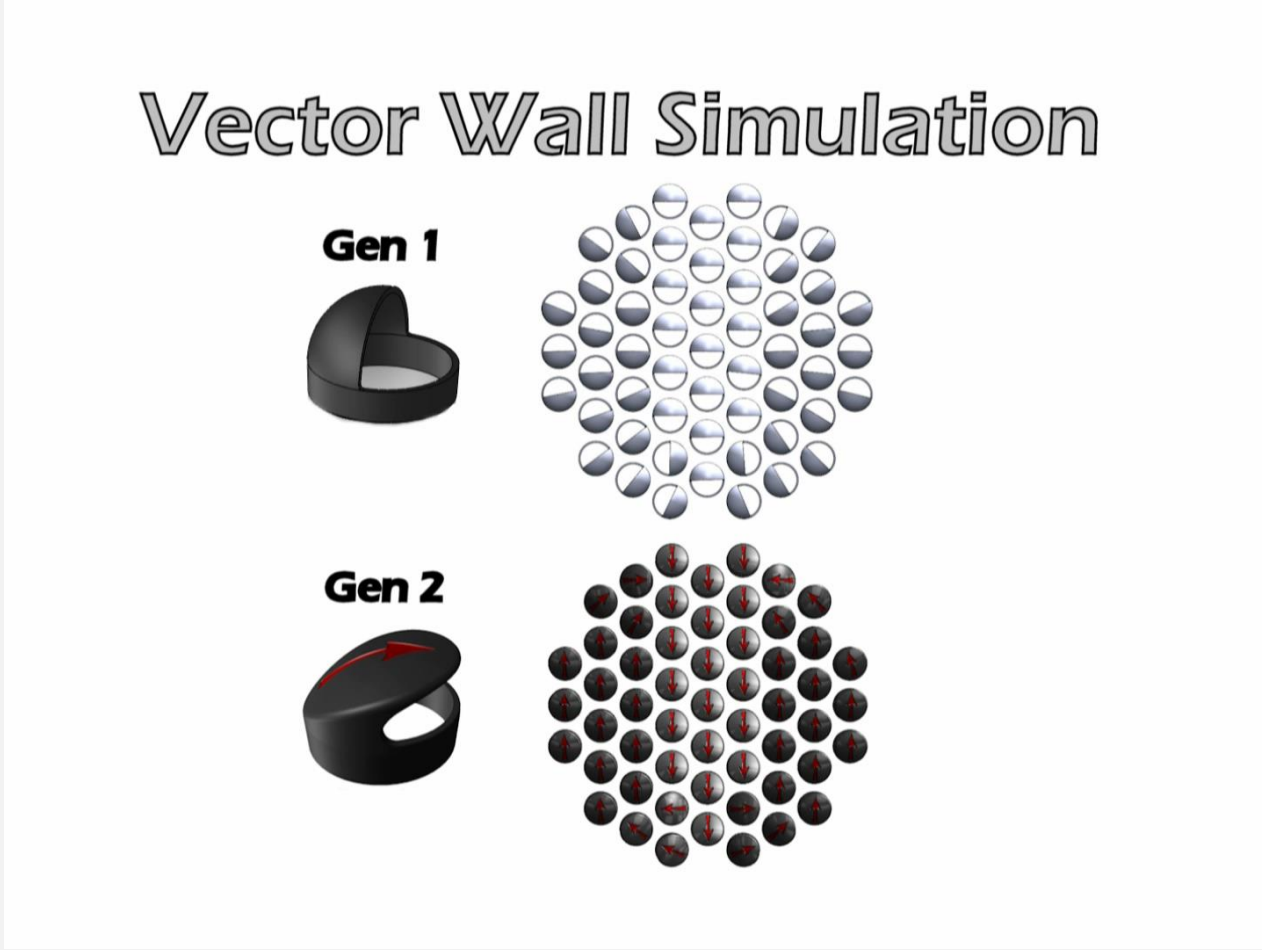
- **Increase temperature**

CO destruction, like ammonia, is a time/temperature phenomenon, and traditionally operators add fuel to make the temps higher. Now take time or more accurately, the length of the path that they are on while they are in the furnace - take that long, winding path, rather than the shortest distance between two points, and its the same thing as more time - what it really is, is more distance. This longer distance increases CO destruction at the same temperature/fuel usage, or leaves it the same and lets you back down the fuel/temp.

- **Increase contact time**

If you can increase the length of the path that adjacent particles are on, they are more likely to interact. Even if the residence time is the same in either case.

*Contact tracing just like with Covid!



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Blasch Experience

- Blasch HexWalls and VectorWalls have been successfully deployed at over 150 reaction furnaces worldwide
  - Gas Plants, Acid Plants, Refineries and Thermal Oxidizers
  - Sizes ranging from under 100 TPD to over 1,000 TPD
  - Very recently installed at two TOX in the Middle East to demonstrate fuel savings (5 – 10% as measured)
  - Several offering reliable service in SRUs with oxygen enrichment
- Also deployed in several dozen sulphuric acid plants to obtain a more compact furnace design and reduce NOx

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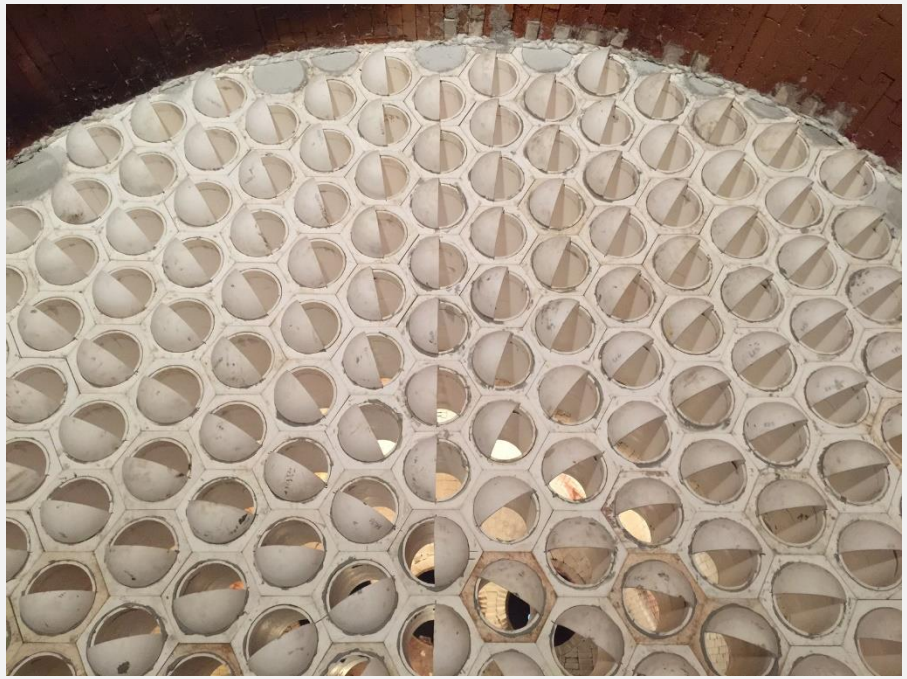
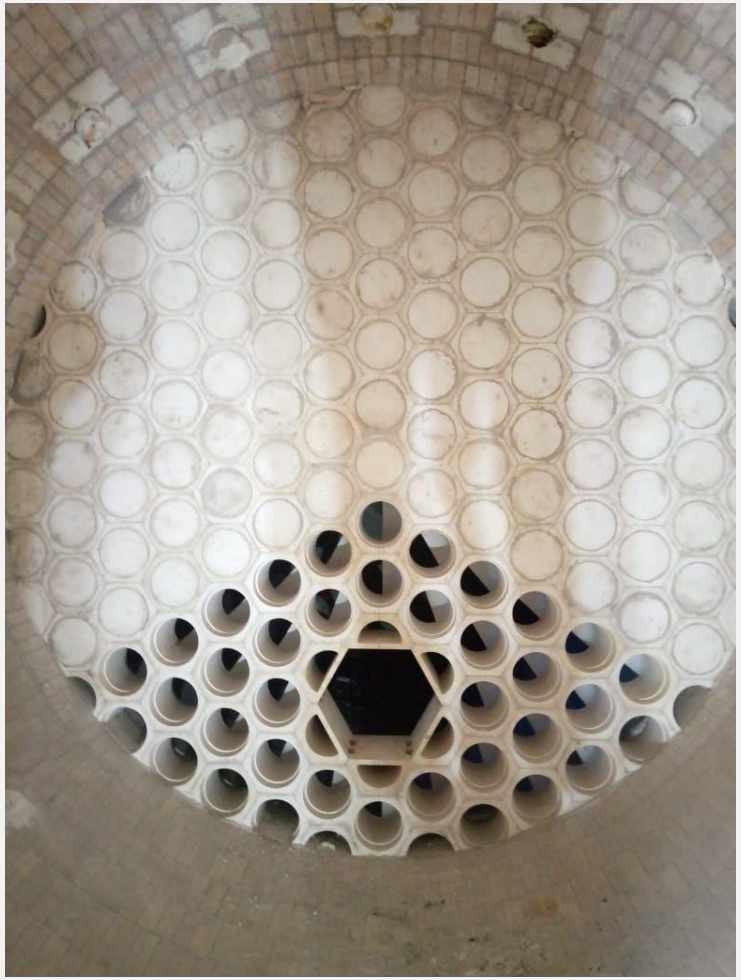
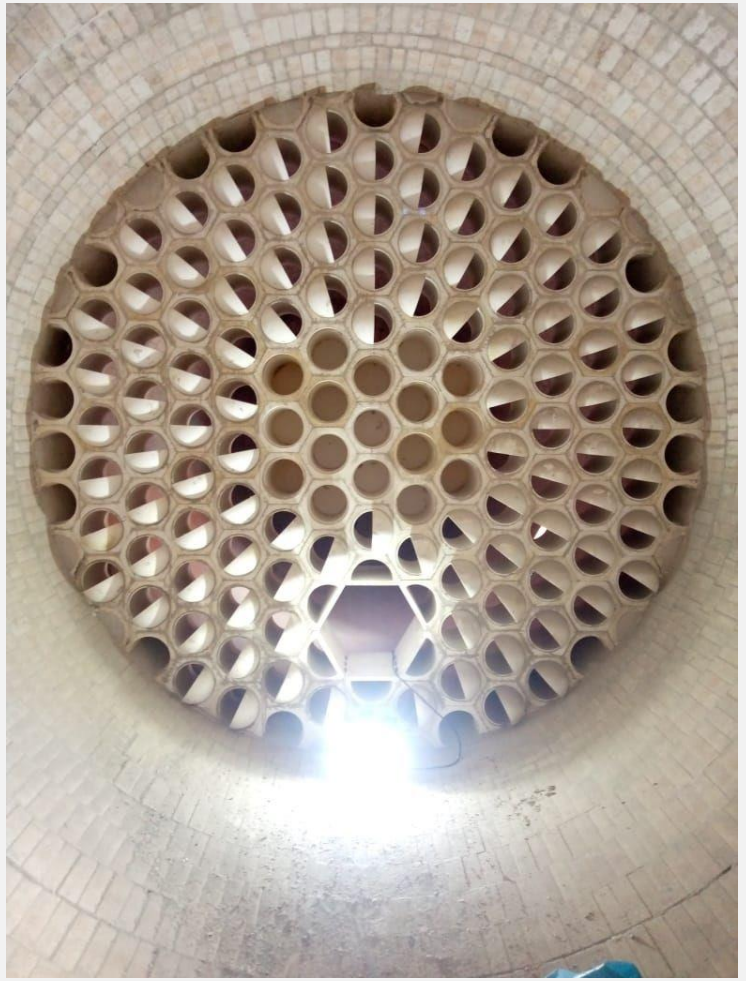
Blasch Experience







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Summary
VectorWall Benefits

Conclusions

- **Reduced pressure drop**
- **Vectorwall significantly promotes mixing and swirl – In both front and read chamber**
- **Can eliminate sulfur carryover; downstream equipment no longer has residual sulfur buildup/fouling**
- **Temperature non-uniformity at the WHB is reduced by ~50-90%**
  - **Reduced potential for hot and cold areas on vessel shell**
  - **Reduced potential for non-uniform flow in WHB tubes – less fouling**
  - **Reduction in fireflies – unburnt sulfur**
- **Flame length is shortened by up to 2ft with minimal pressure drop from the Vectorwall**
- **Can eliminate or reduce harmonics that cause vibration – Quote "***VectorWall retrofit of the original matrix wall in 2 of the trains (AKG2 and RG6) and will be doing RG7 in the near future. The VWs seem to eliminate the vibration tendency associated with increased operating loads. Thus, they have been able to increase the production capacity for the trains with the VWs."*

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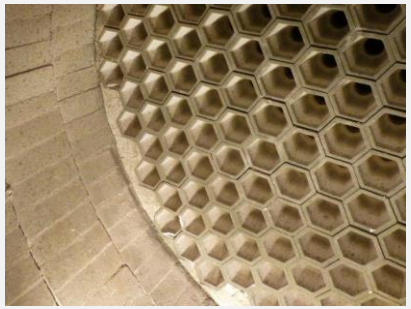
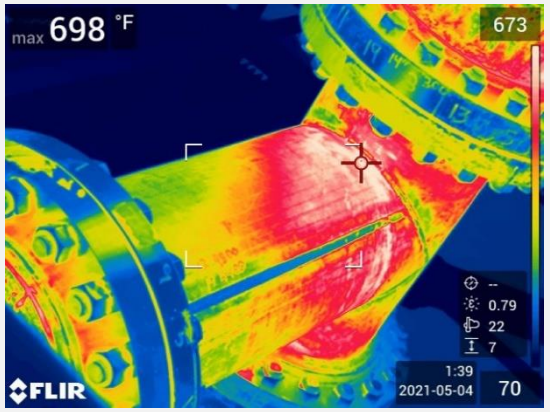
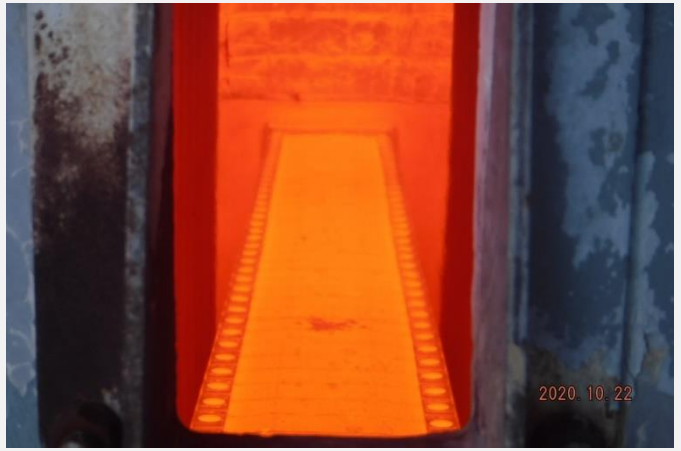
Blasch Design Experience















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