Blasch Precision Ceramics

From Hydrogen Production to Sulphur Recovery - Let Ceramics Pave the Way

BLASCH PRECISION CERAMICS

Where your ideas take SHAPE in CERAMIC

Agenda

- Introduction to Blasch
- Hydrogen Production and Sulphur Recovery
  - Industry Drivers
  - Process Description
  - Reliability Issues/Pain Points
  - Innovative Ceramic Based Solutions
  - Benefits
  - Case Studies
  - Key Underlying Design Features
  - Summary
- Q&A

Our Company

Founded in 1979, Blasch Precision Ceramics is an employee-owned manufacturer of engineered industrial ceramic shapes and systems. Our highly experienced team has extensive product and system design capability in most industries, and can develop a solution for virtually any situation.

- Headquarters and engineering and manufacturing facility located in Albany, New York
- GSP division located in South Carolina
- Sales / agency offices worldwide

Our Unique Capabilities

- Unique, precision-shape forming process that deploys a large variety of available engineered ceramic materials to meet customer-specific needs
- Complex, large and small, near net shapes without machining that have excellent thermal shock performance
- Typical fired dimensional tolerances are +/- 0.5% or better
- Extremely high green strength allows for handling
- No binder burnout
- High and low volumes

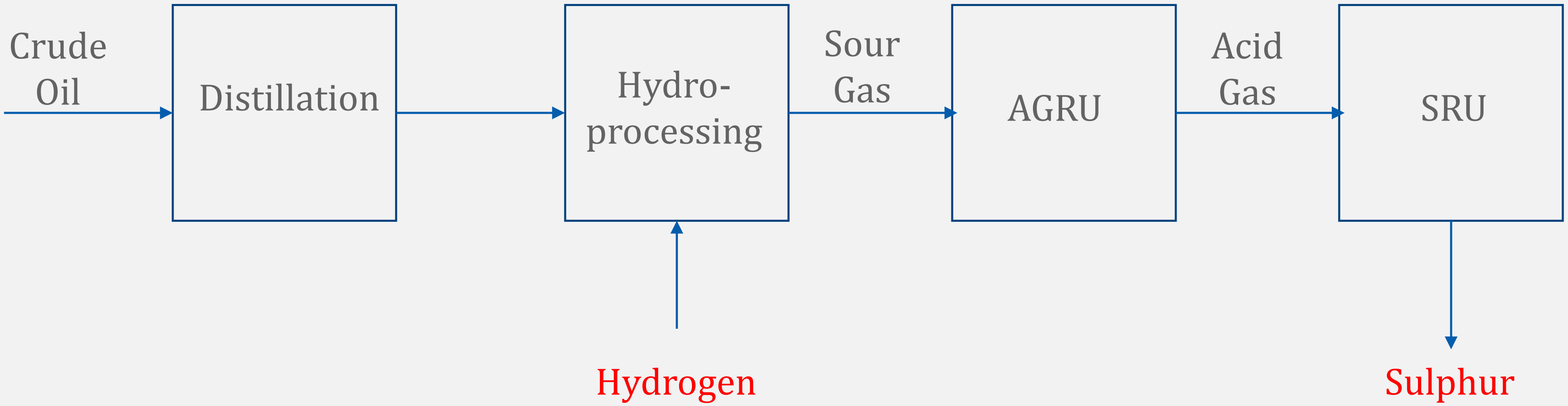
Industry Drivers

Hydrogen Production and Sulphur Recovery can be viewed as the bookends of a conventional refinery. Both processes have increased very significantly in importance due to more hydroprocessing.

Trends

- Feedstocks – heavier and more sour
- Refined Product – more stringent specifications
- Increased demand for lighter fuels

Refinery Overview
(Relevant Process Blocks)



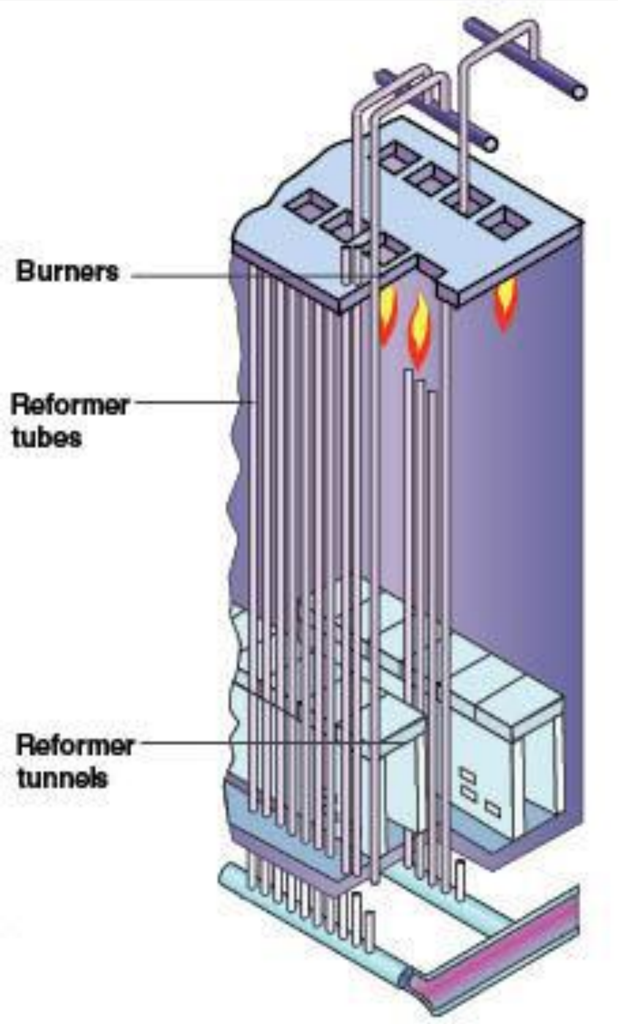
Hydrogen Production

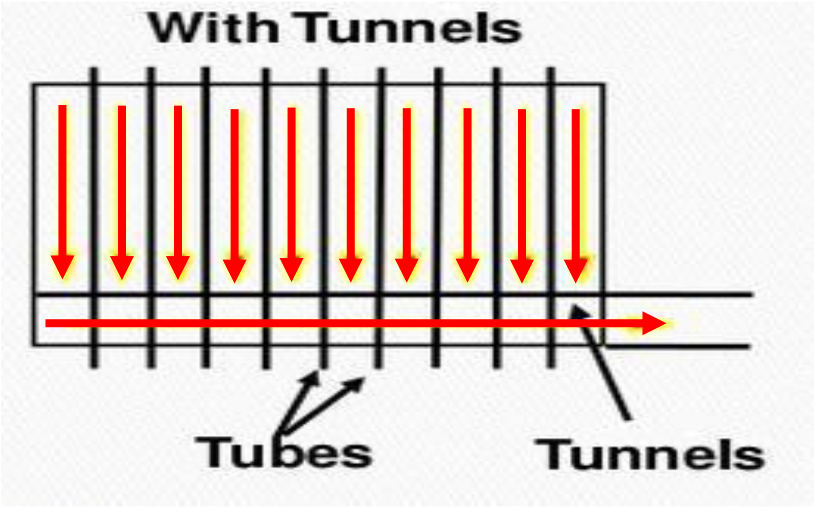
Blasch StaBlox^{TM} Reformer Tunnel System

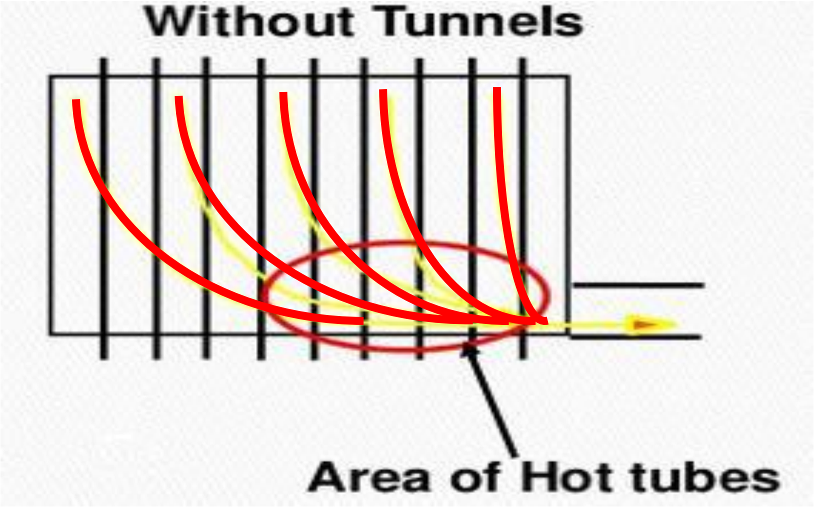
Introduction

SMR Radiant Section Components

- **Catalyst Tubes**
  - Reforming: $H_2O(g) + CH_4 \rightarrow CO + 3H_2$
  - Arranged in rows
- **Burners (top mounted)**
  - Produce flue gas (exhaust)
  - Radiation
  - Convection
  - Arranged in rows
- **Tunnels (coffins)**
  - Collect flue gas through engineered openings
  - Transport flue gas to convection section







Conventional Structure

Tunnels

- Transport flue gas out of radiant section
- Essential for uniform flow

Conventional Structure

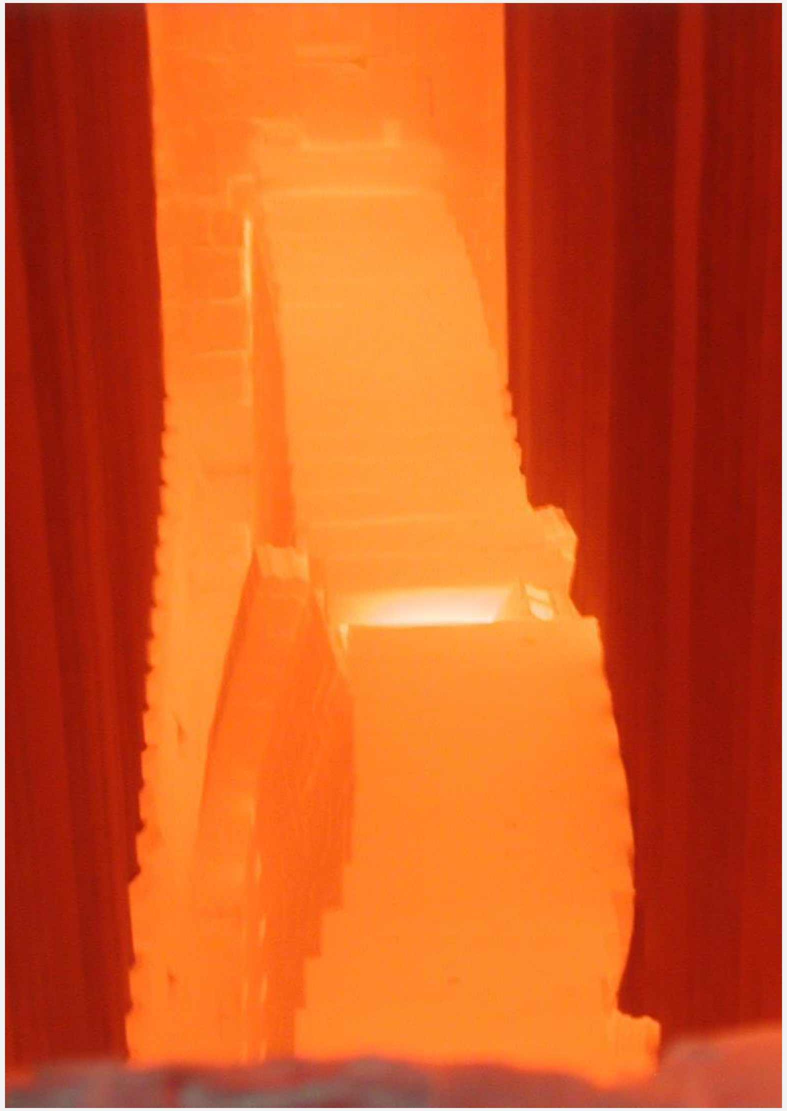
Side Walls

- Tongue & groove (or flat)
- Built up from floor
- Mortared joints
- Discrete expansion joints
- Support buttresses
- 1/2 brick openings

Conventional Structure

Mortared System

- Creates large monolithic structures
- Expansion Joints remove mechanical connection between wall "sections."
- Snaking results



Conventional Structure

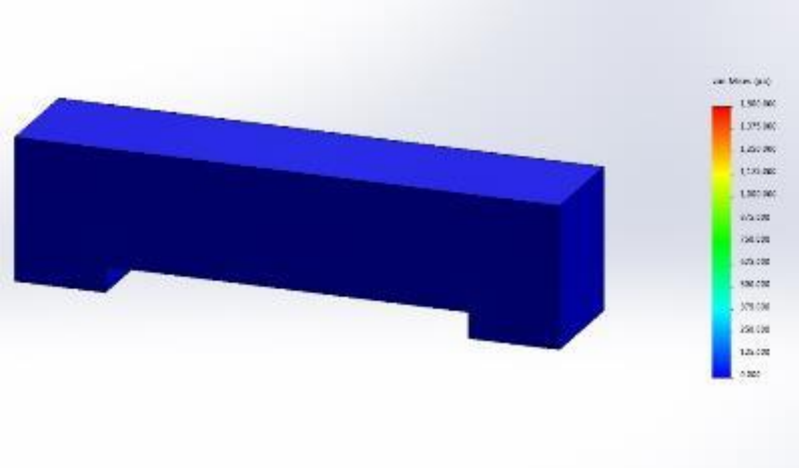
Isolated slab failure

- Falling burner tiles
- Walking on slabs

Complete slab failure

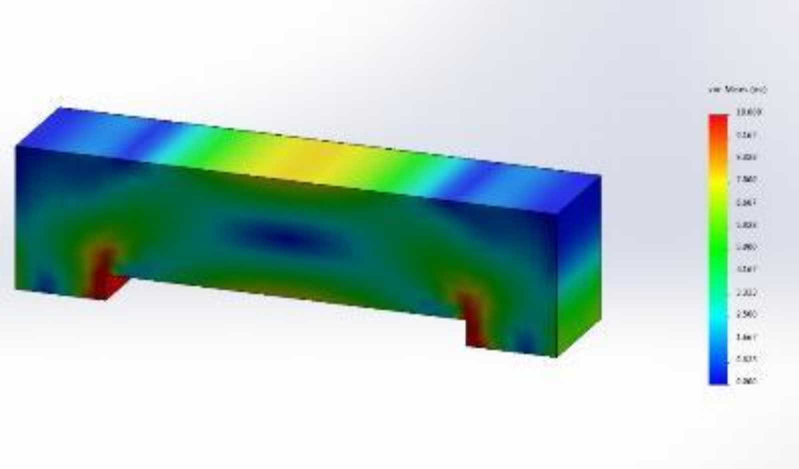
- Static stress
- Thermal stress
- Material selection

Conventional Structure



STATIC STRESS

- FEA of 9”x9”x42” Slab
- Constant 1900ºF Temp
- 10 psi max stress



THERMAL STRESS

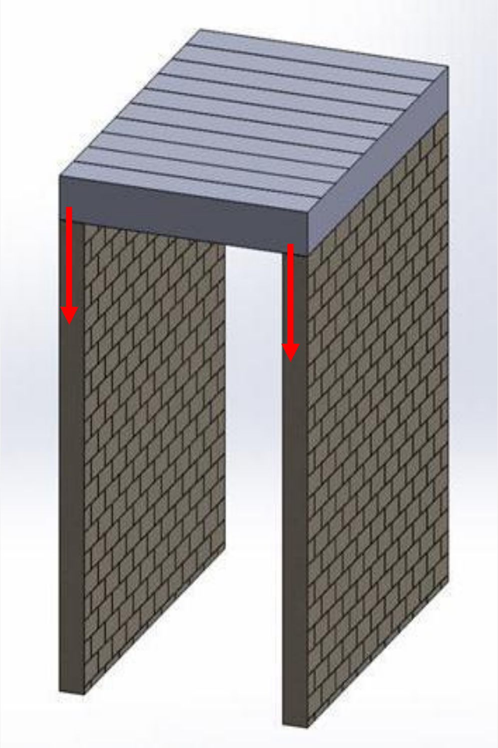
- FEA of 9”x9”x42” Slab
- 10ºF temperature variation
- 1500 psi stress

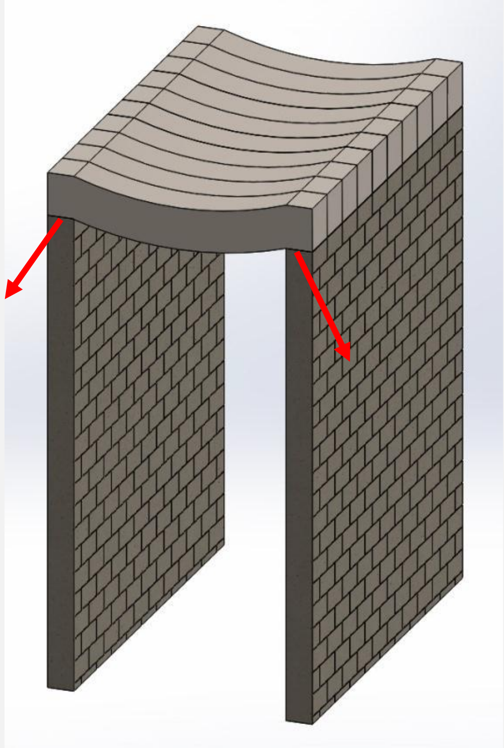
Conventional Structure

- Material Selection
- Hot MOR @ 2500°F
  - Super Duty Brick - 600 psi
  - Low grade alumina mortar - 150 psi
  - Mullite bonded high alumina refractory - 1700 psi

Conventional Structure

Sagging Effect

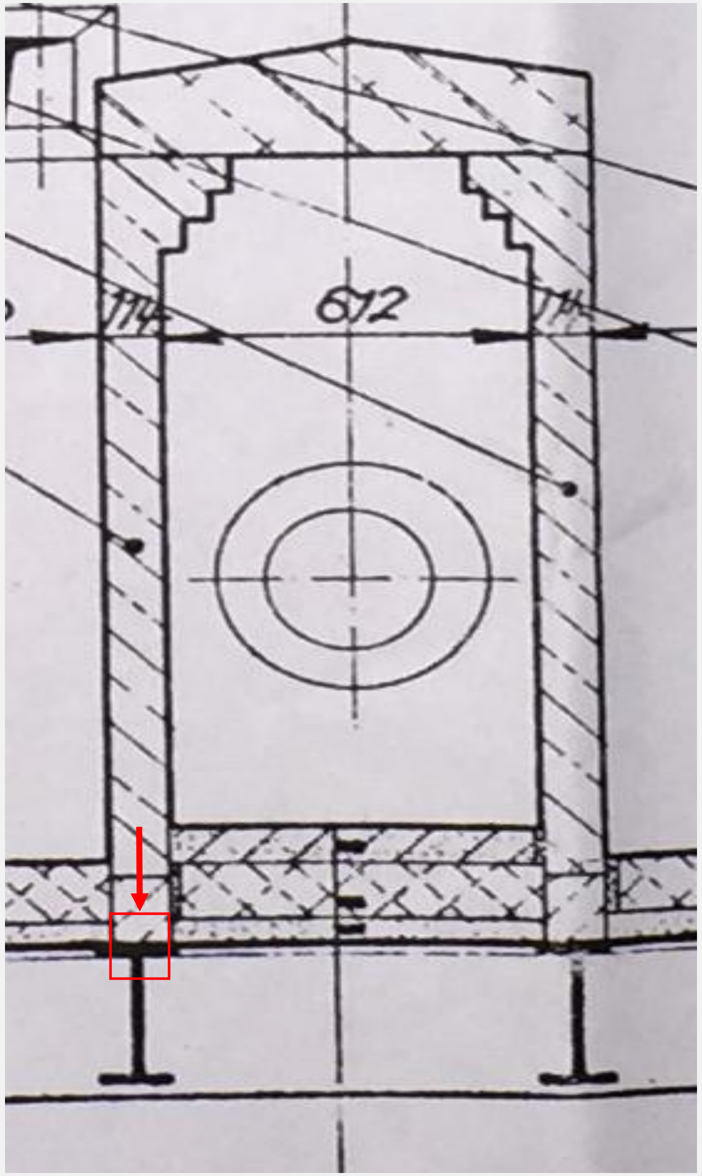




Conventional Structure

System Mass

- Enormous load at base layer
- 1% base layer deformation within 100 hours of service
- Decreased insulating value
- Shell warping and mortar cracking



StaBlox – Hydrogen Production

- Modular stackable components
- Expansion joints built-in
- No mortar necessary
- Consistent hole layout
- Infinitely adaptable (orifices)
- Variety of materials available
- Skilled bricklayers not required

Modular Base Components

- Installed above insulating castable or brick layer
- Sets the spacing for the side blocks
- Distributes tunnel load over roughly 5x the area
- Ties walls together/sets width
- Hollow design reduces mass

Modular Side Wall Block

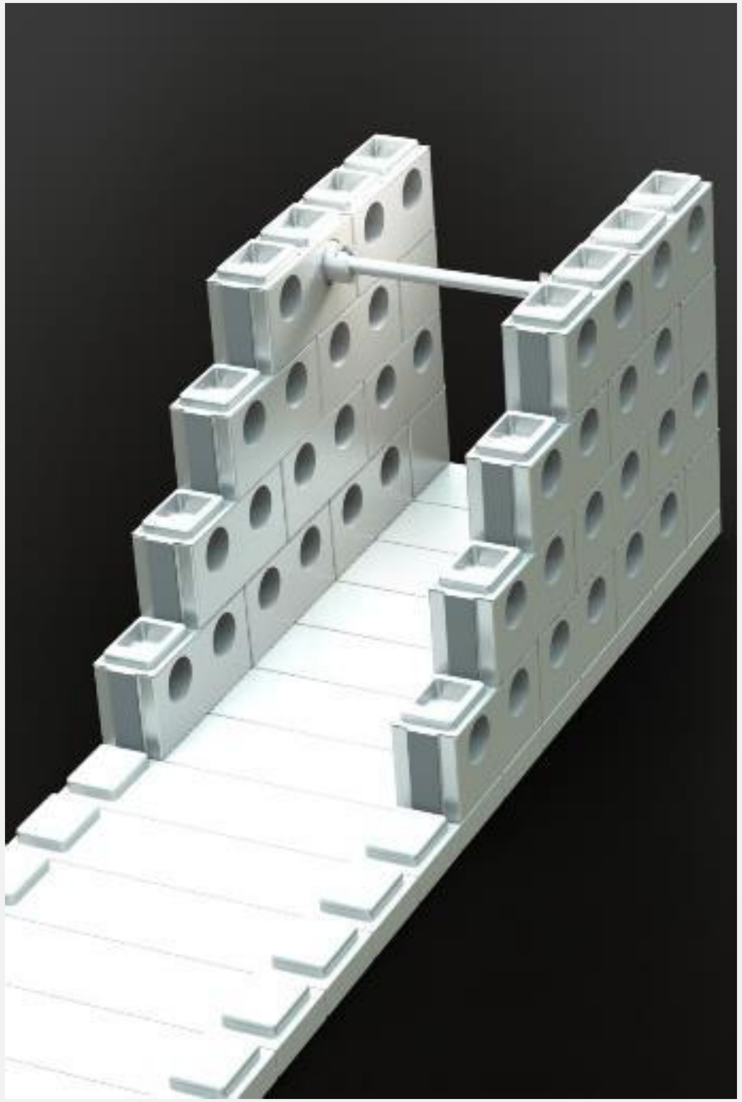
- Strong/lightweight
- No mortar necessary
- Engineered expansion
  - Fiber gaskets in joints
  - Leak tight at design temperature
- Uniformly distributed expansion gaps prevent snaking
- Hollow design reduces mass & thermal stress

Tie Rods

- Replace buttresses and intermediate support walls
- Reduces unsupported wall length

$$F = \frac{\pi^2 EI}{(KL)^2}$$

- Mated to tunnel wall block openings



Modular Hollow Covers

- Strong/lightweight
- No mortar necessary
- Ties together wall blocks
- Shiplap joints prevent leakage
- Built-in walkway support feature
- Hollow design reduces mass and thermal stress

Structural Comparison

Mortar-free assembly

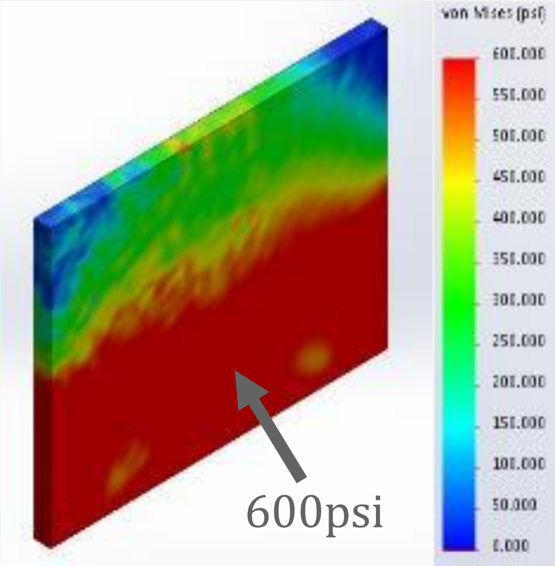
- Eliminates system weak point
- Reduces stress

Engineered expansion

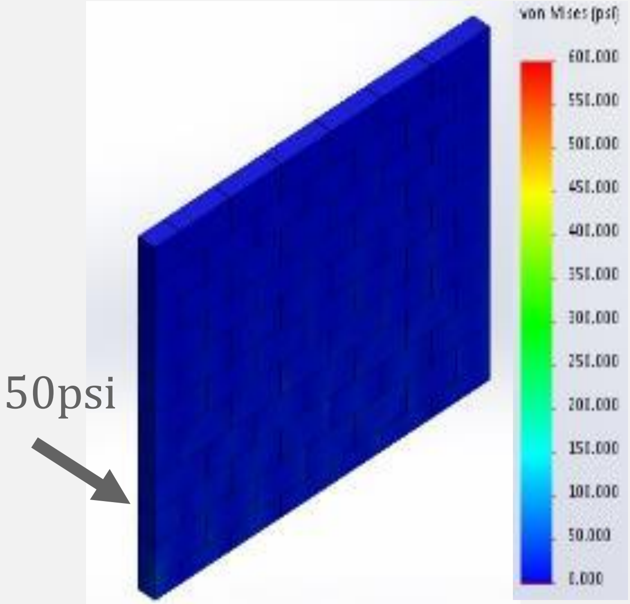
- Leak tight at design temperature

60% less mass

- Reduced thermal stress



Conventional Wall Segment



StaBlox Wall Segment

Reduced Install Time

- No mortar
- Fewer parts
- Lighter system
- Less complex installation
- No dry out required
- Reduced critical-path turnaround time

Summary

- Installs 10-15+x faster than brick and mortar
- 60% less overall mass than standard density firebrick
- Larger blocks/fewer individual pieces
- Expansion joints built into each block
- No buttresses or dead space
- Does not required skilled bricklayers
- Consistent design ensures every tunnel is exactly the same length and height
- Much greater number of pigeon holes – all adjustable in size for better flow balancing
- Usable with existing tunnel structures
- Amenable to just replacing lids (most failure prone)

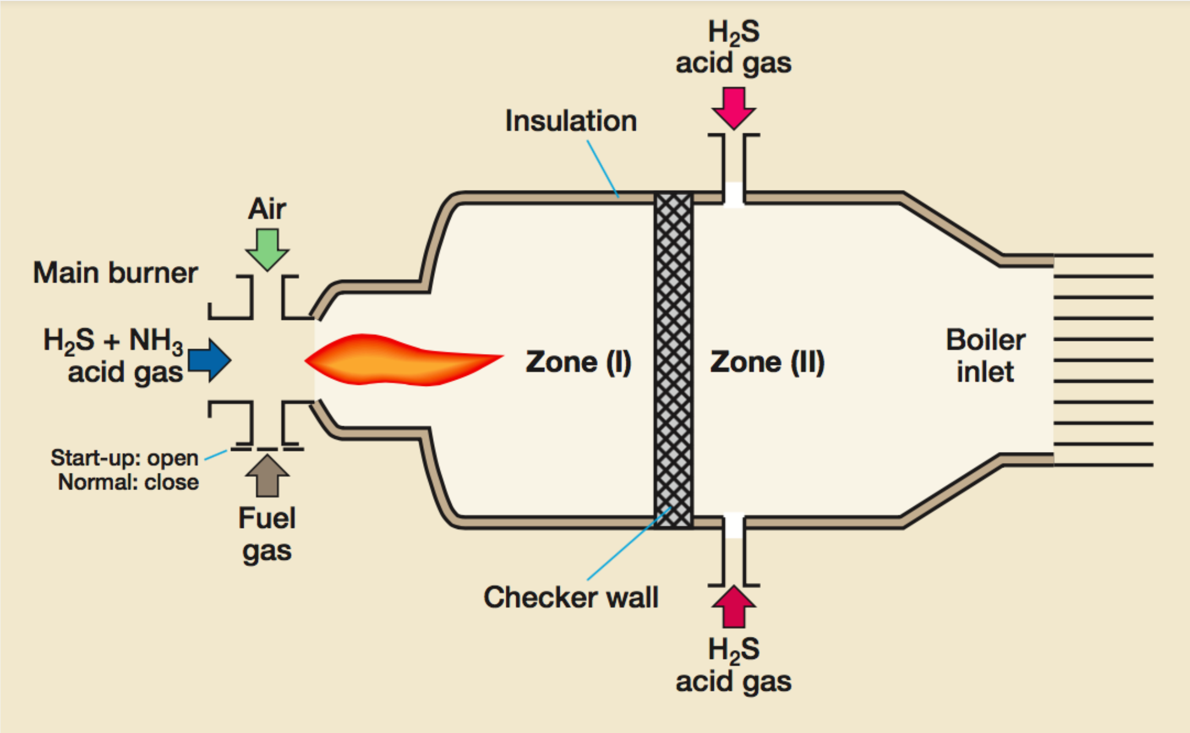
Sulphur Recovery
Blasch VectorWall^{TM}

Performance of the SRU Reaction Furnace is Critical to Trouble-free Operation

- **Key Reactions**

$H_2S + 3/2\ O_2$	$\rightarrow$	$SO_2 + H_2O$	(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
  - BTEX
- **Thermal and structural stability**



Combustion Efficiency – Three Ts

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

Poor Integrity of Conventional Reaction Furnaces

BRICK CHECKERWALL

Most common

MATRIX WALL

Variation on brick wall

CYLINDRICAL CHECKERWALL

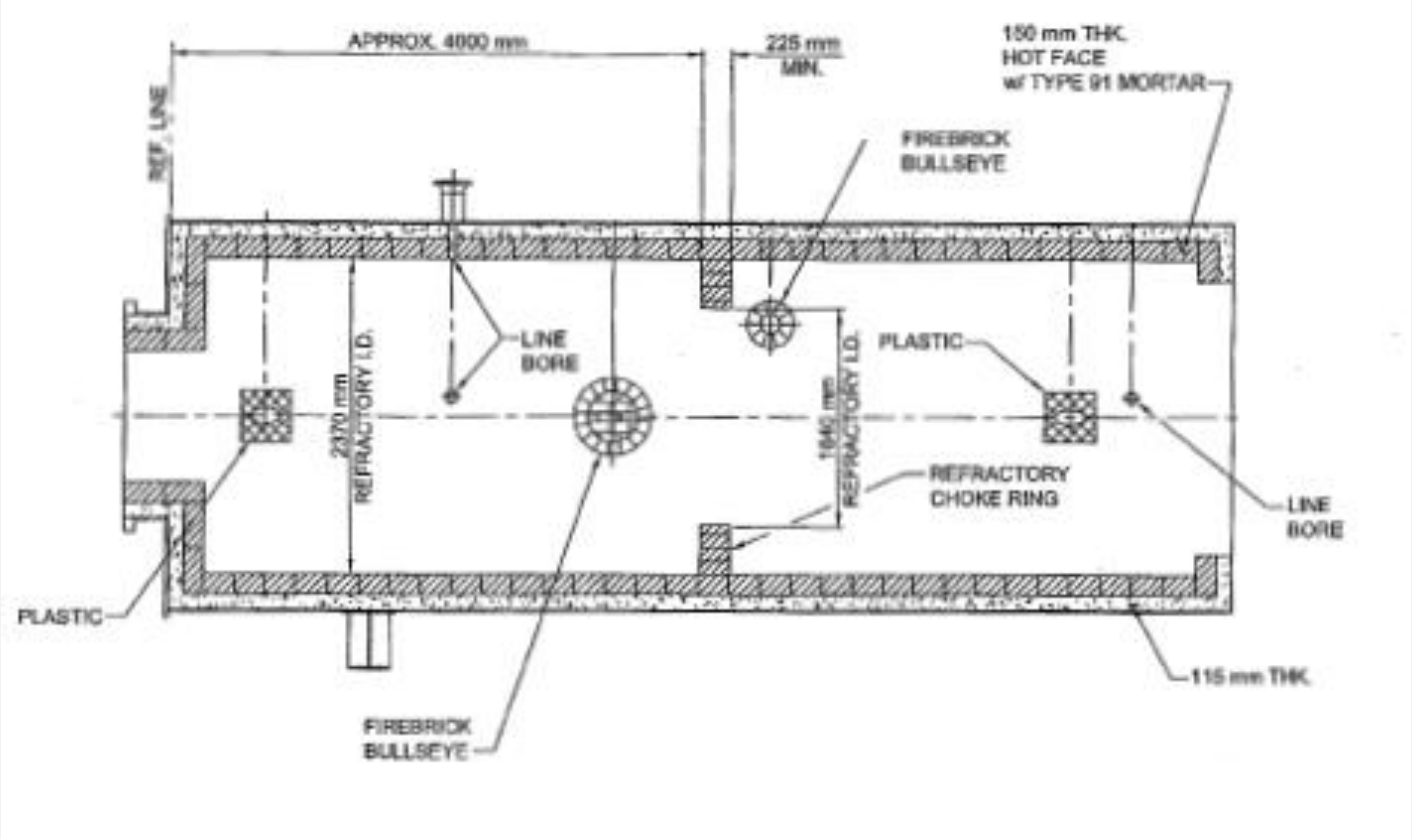
Less common

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 SRU campaign leading to expensive S/Ds and repairs

Choke Ring in SRU Reaction Furnace



Problems with SRU RF Choke Rings

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

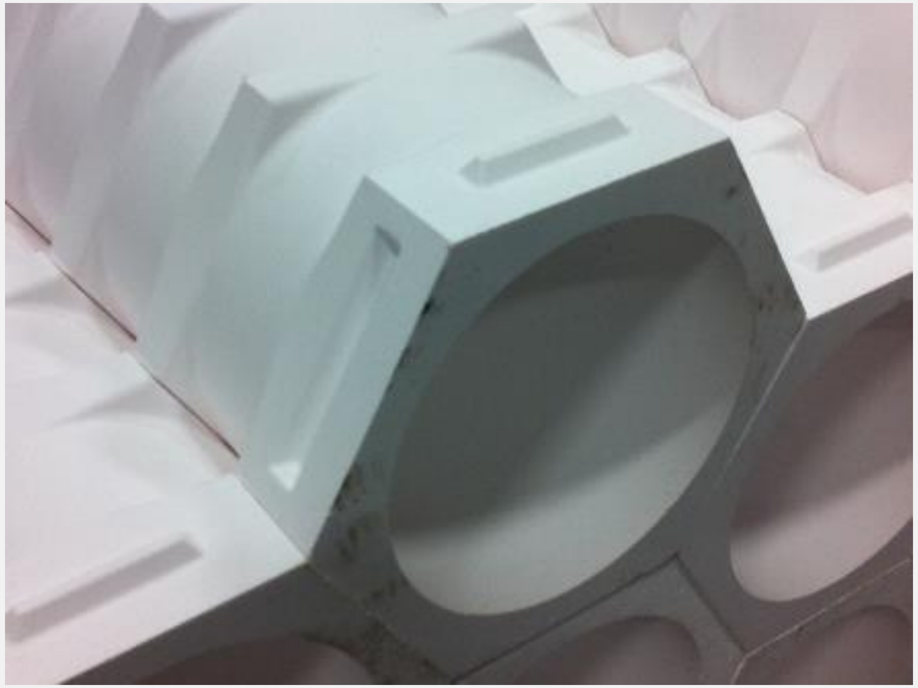
The Choke Ring also results in:

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

Improved Structural Integrity with HexWall™

- Large hexagonal blocks are inherently stable
- Patented design ensures that all blocks are fully supported
- 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



Fewer components, no mortar required

Blocks may be disassembled for maintenance and reused

Blasch HexWall Installation Options

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

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

Second Generation

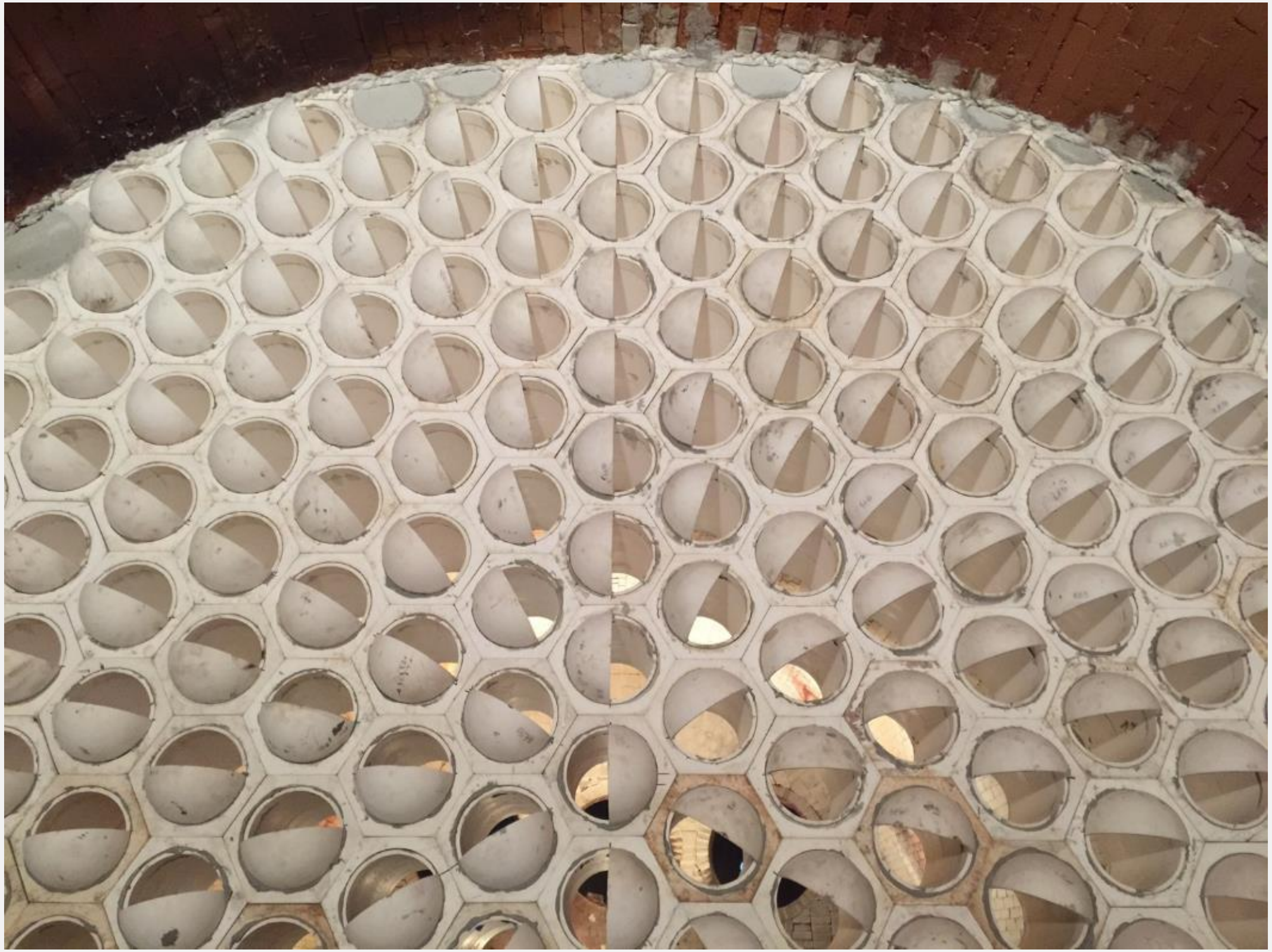
Vector Wall Development & Process Improvements

Key Enhancement Objectives

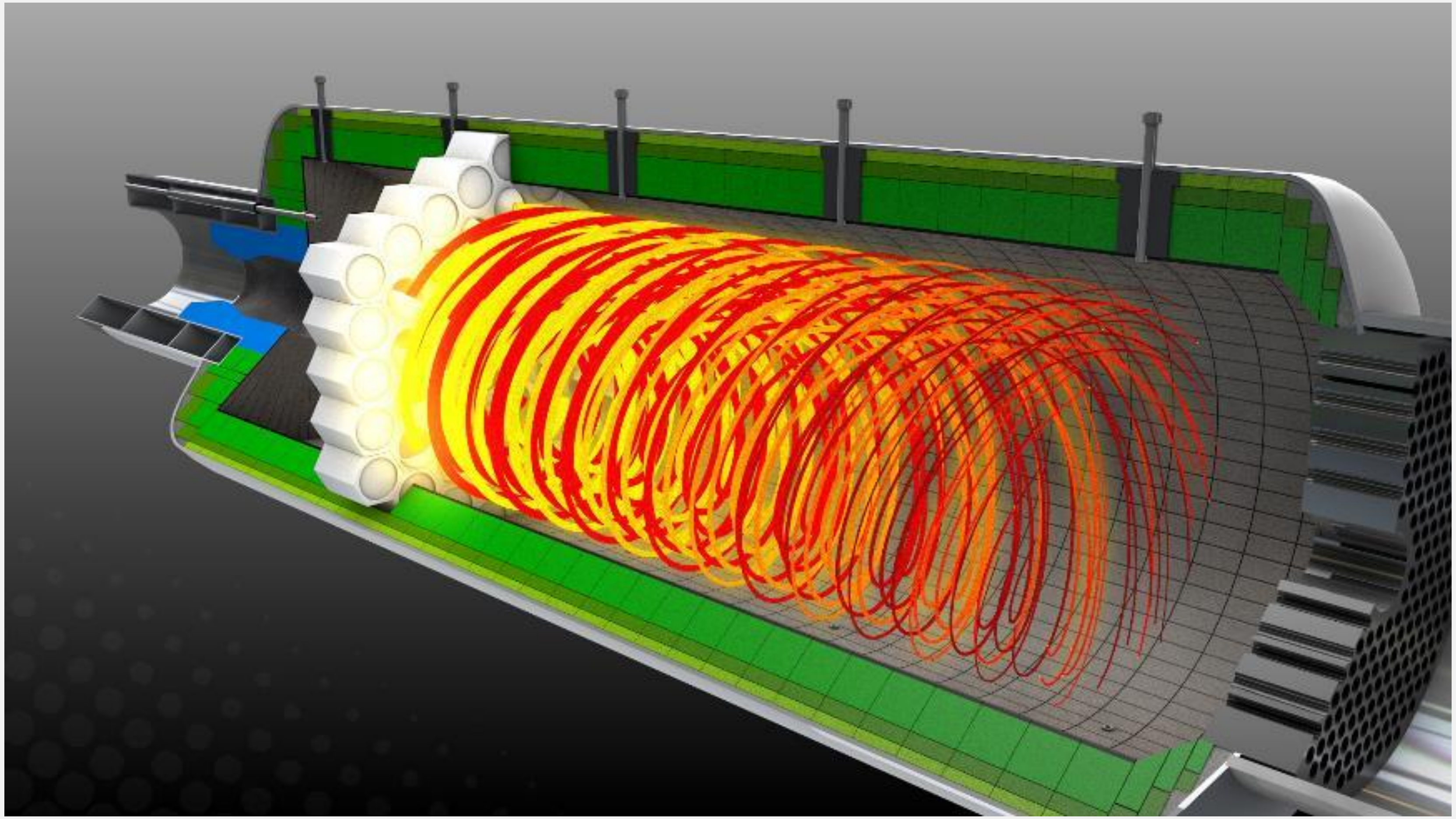
- Further improve mixing/RF residence times
- Higher front zone temperatures
- Further shield tube sheet from radiant heat
- Better contaminant destruction

Create Turbulence and Improve Mixing

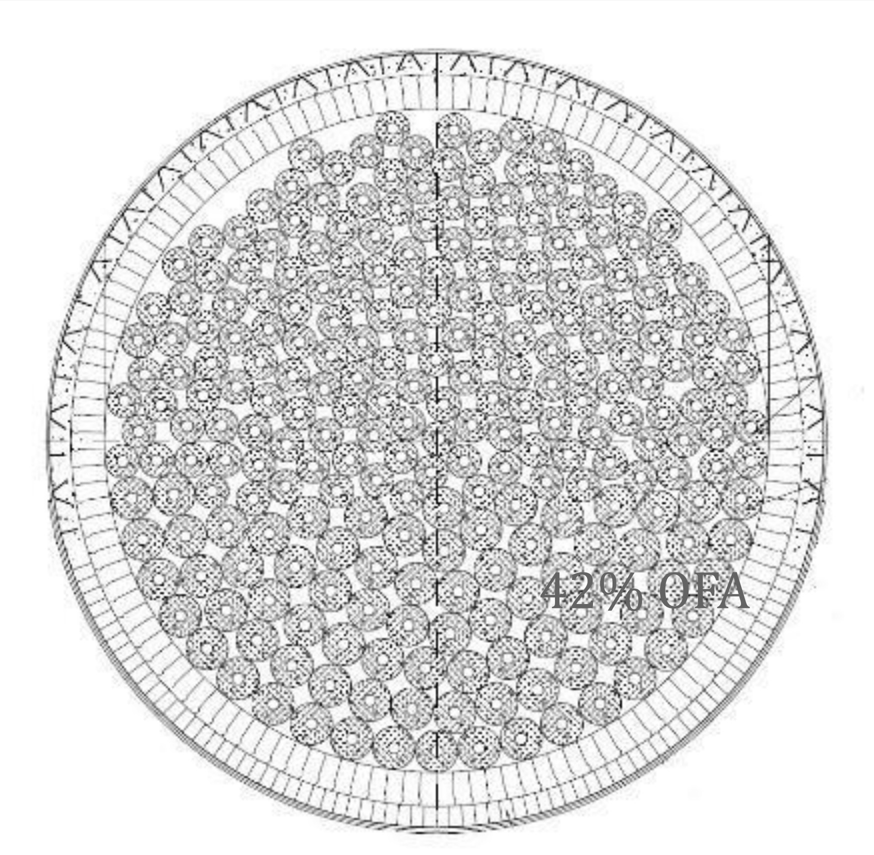
- Inserts in the blocks increased pressure drop & didn't create the desired macro-furnace mixing
- Thoughts then turned toward impacting the flow direction at the exit of the block; utilizing all of the blocks together to create a specific flow field
- The result was a series of highly engineered add-on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



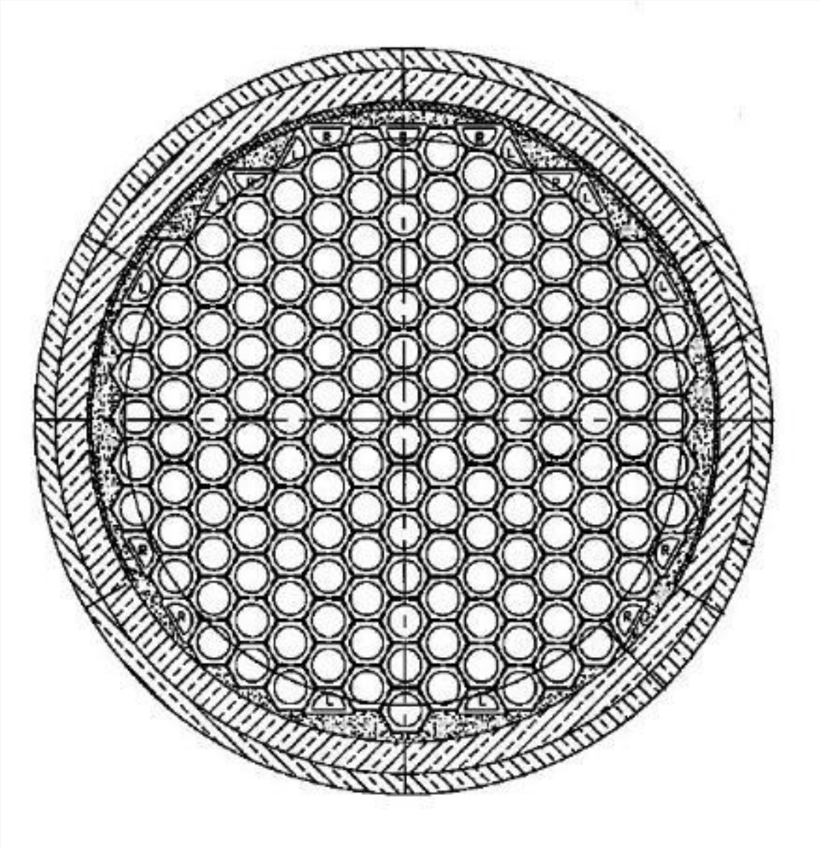
Improved Mixing and Residence Time with Blasch VectorWall



Matrix Wall vs. VectorWall Relative Open Area Comparison

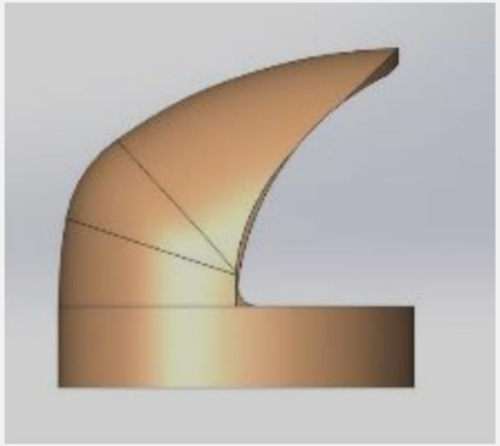


42% OFA

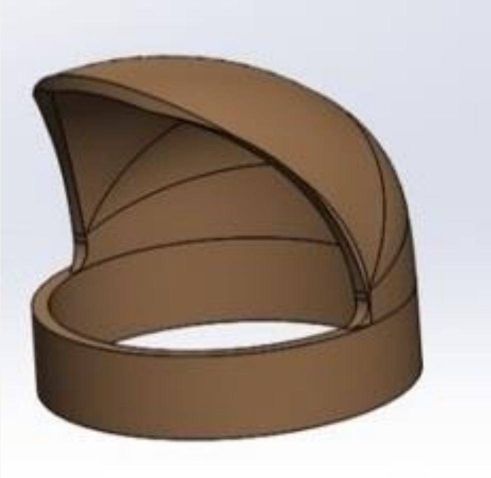


50% OFA

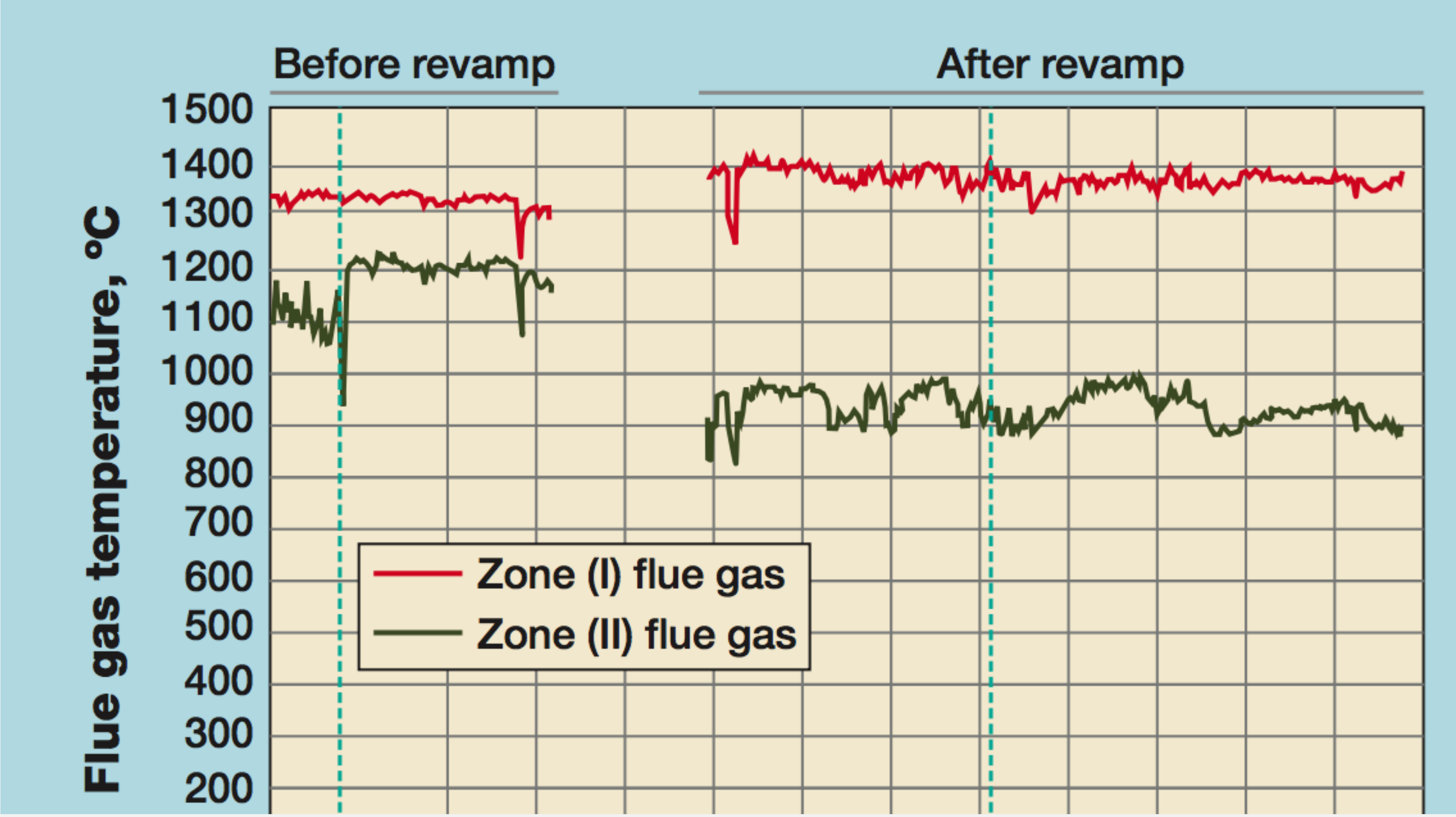
Vector Tile Configurations



Existing | **Enhanced**



VectorWall Installation Results
Higher Temperature



High Front Zone Temperatures

VectorWall Installation Results
Energy Savings

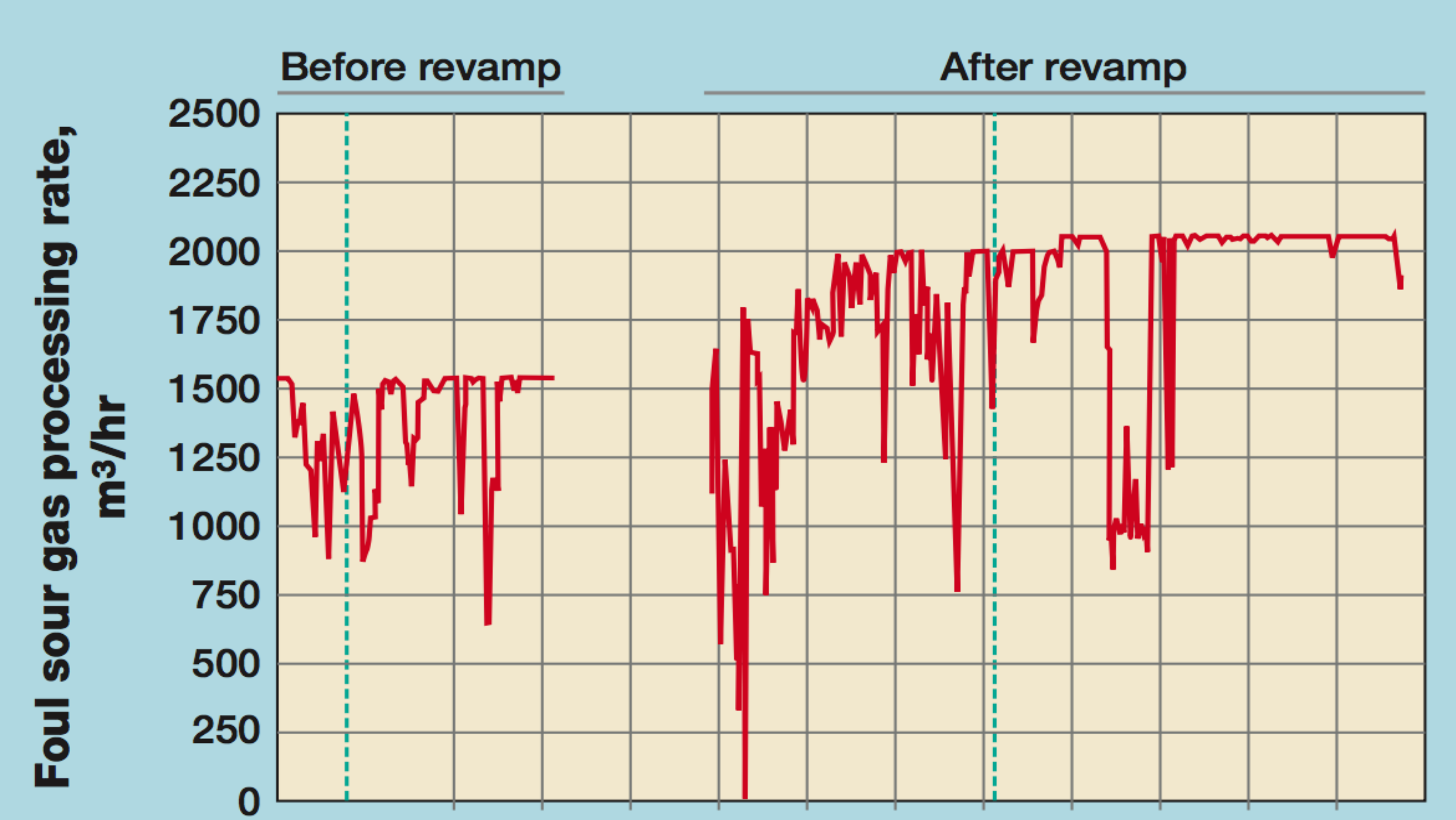
Energy Savings from Higher RF Front Zone Temperature

Significantly higher temperatures in the SRU RF front zone and incinerator result in reduced fuel gas co-firing to achieve adequate temperatures for contaminant destruction

- **Basis**
  - 500 TPD SRU
  - Temperature Increase in Front Zone: 100 C
  - Fuel Value: USD$3/MMBTU

- **Benefits**
  - Estimated Energy Savings of over USD $250,000/year
  - Increased Throughput
  - Lower CO2 emissions

VectorWall Installation Results
Higher Capacity

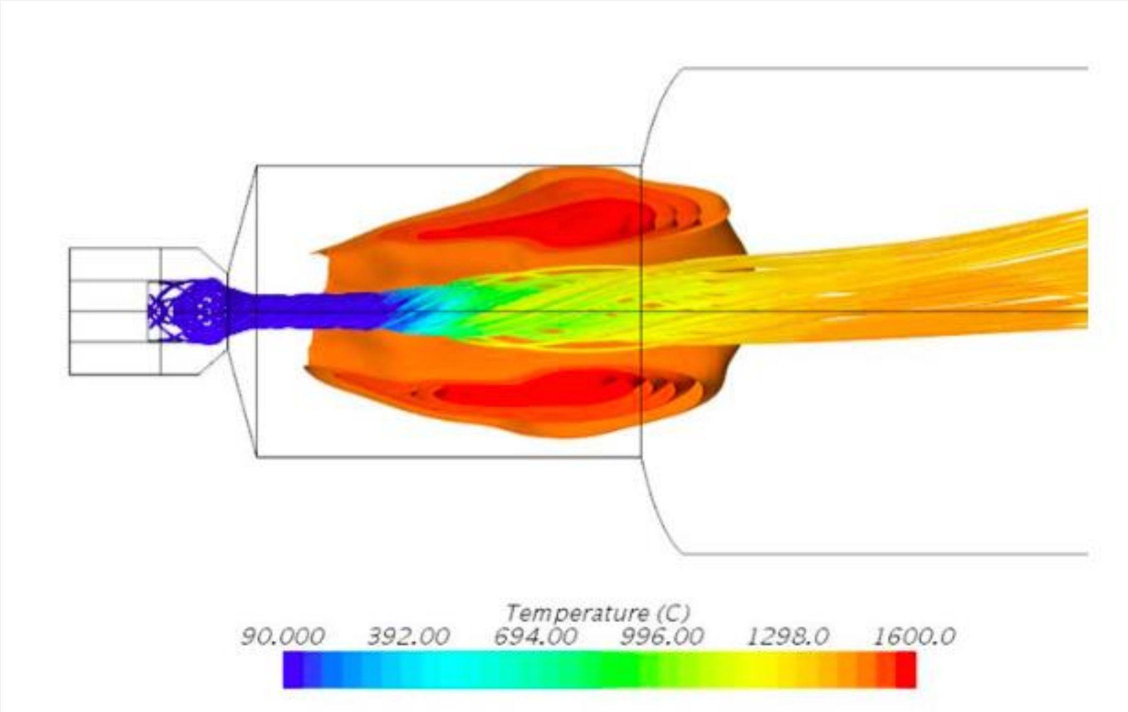


VectorWall Installation Results

Improved Flame Characteristics & Reduced Vibrations

- Pressure waves reflecting off the choke ring result in flame spreading to the ID of the burner, causing vibrations.

- Vibrations eliminated upon installation of the VectorWall - leading to much more stable SRU RF operations.



Mean Flame Shape with Choke Ring Configuration

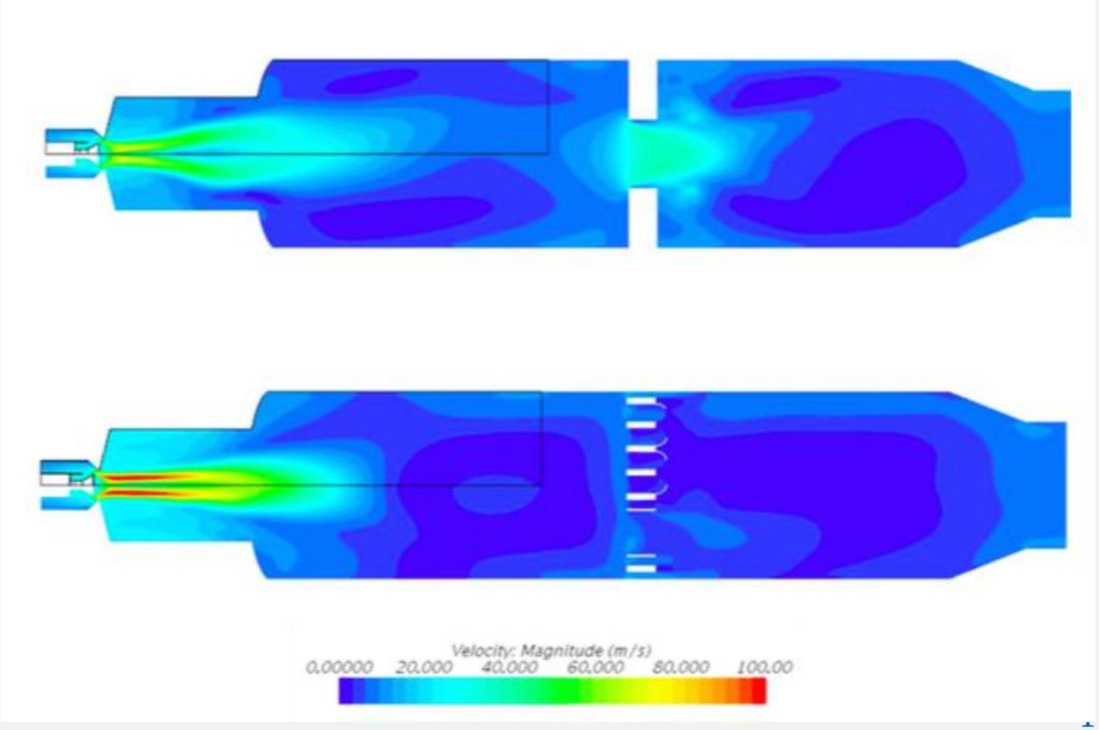
CFD Analyses Porter McGuffie, Inc.

VectorWall Installation Results

Improved Ammonia Destruction

- **Before**
  - Significant center line jet formed through the choke ring as seen by the "bullet" shaped protrusion in the choke ring configuration – resulting in substantial flow not meeting minimum residence time requirement for NH3 destruction.
  - Refinery experiencing significant problems with downstream ammonia salt deposits.

- **After**
  - VectorWall eliminated the centerline jet and NH3 destruction problem was solved.



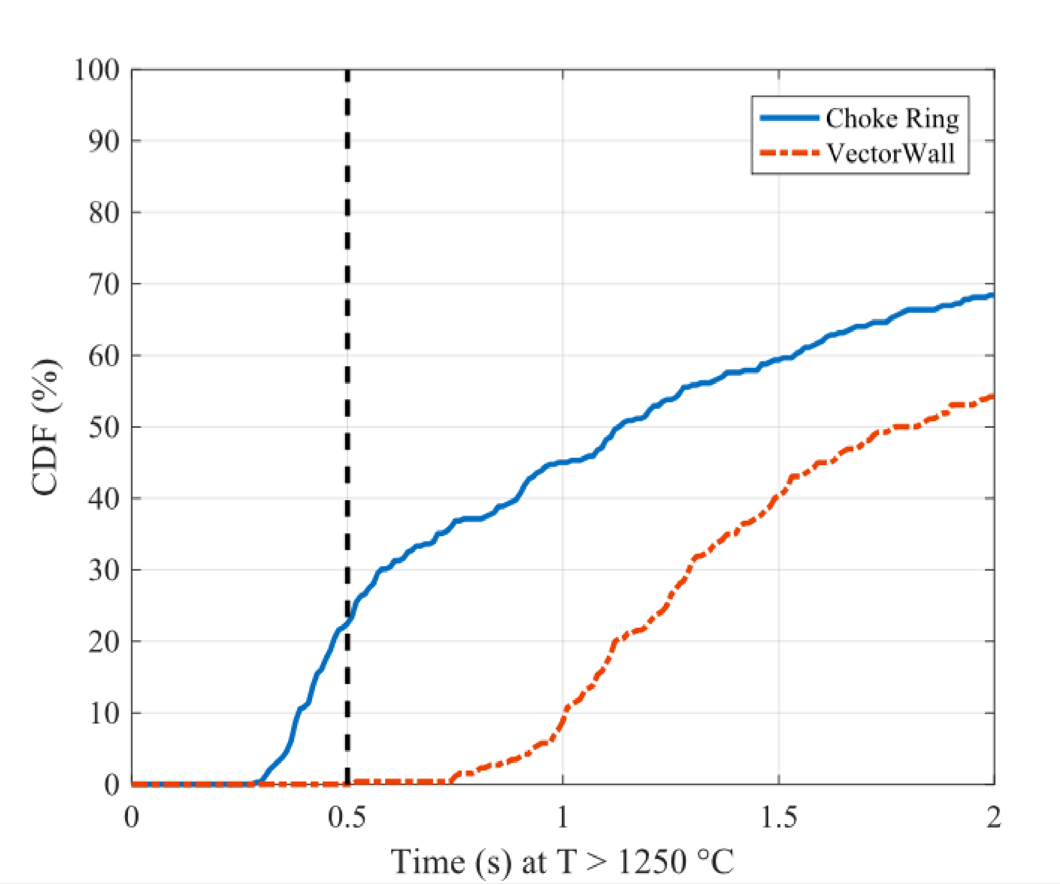
Velocity Magnitude Comparison Between Choke Ring (Top) & VectorWall (Bottom)

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.

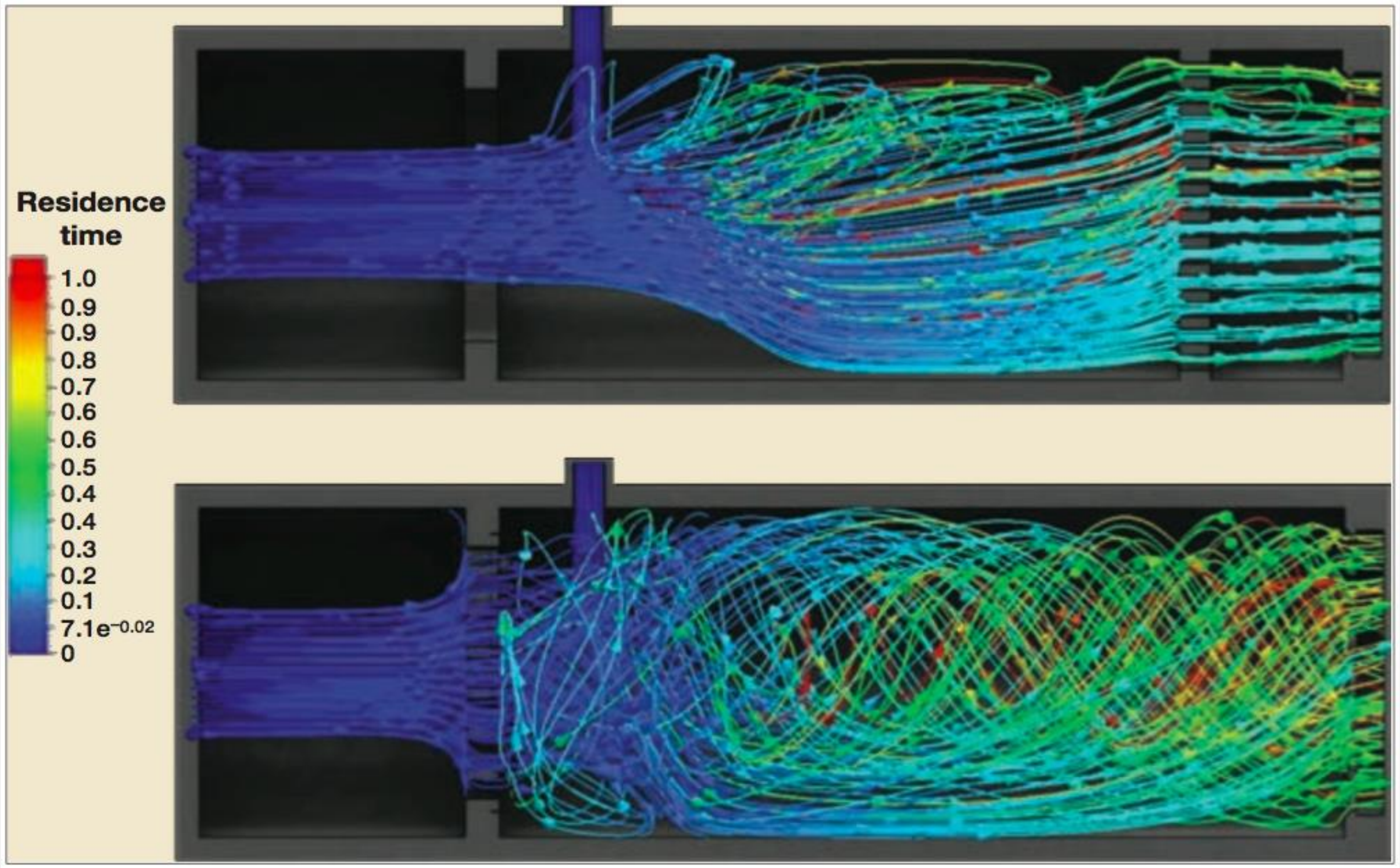
- **After**
  - With VectorWall installation, all of the Zone 1 gas flow meets the retention time requirements for NH3 destruction.



Cumulative Distribution Functions of Residence Time

Vertical dashed line indicates cutoff residence time for contaminant destruction

VectorWall Installation Results



Much Better Mixing of the AAG Introduced in Zone 2

Blasch Experience

- Blasch HexWalls and VectorWalls have been successfully deployed at over 100 SRUs worldwide
  - Gas Plants and Refineries
  - Sizes ranging from under 100 TPD to over 1,000 TPD
  - Eight SRU RFs at one of the largest plants in the world
  - Several offering reliable service in SRUs with oxygen enrichment

- Also deployed in sulphuric acid plants to effect a more compact furnace design and reduce NOx

Product and Process Adjacencies

- Ferrules for Waste Heat Boiler protection
- VectorWalls for Incinerators/Thermal Oxidizers
- VectorWalls in sulphuric acid plants
- FCC Air Distributor Nozzles

Summary
VectorWall Benefits

- Reliability/Operational
  - Much better structural integrity and uptimes
  - Ease of installation and reduced downtimes
  - Ease of operation – reduce/eliminate preheating, co-firing, front-side split configuration
  - Better flame stability; reduced vibrations
  - Reflect radiant heat and protect tubesheet

- Process Performance
  - Energy Savings
  - Higher throughputs via increased residence time and temperature
  - Environmental benefits – better ammonia, hydrocarbon and BTEX destruction
  - Lower CO2 emissions

- Over 100 installations at gas and refinery SRUs worldwide

Thank You!

Questions?

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