



Computational modeling in FCC design and troubleshooting

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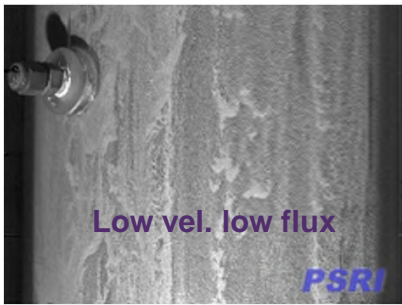
- FCC technology development
 - Cold flow testing
 - Computational modeling
- Screening new concepts and design changes
 - Stripper packing
 - Mushroom distributor
 - Regenerator air distributor location
 - Riser termination device
- Case study
 - Troubleshooting riser / reactor operation
- Summary

FCC technology development

Cold flow testing vs Computational modeling

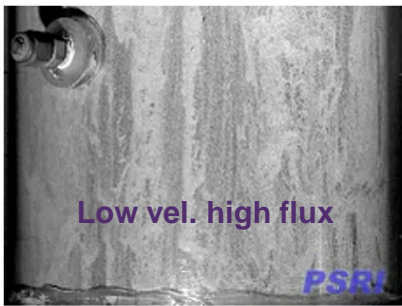
FCC technology development: Cold flow testing

Precise / good Insight of basic phenomena / limited scale / time consuming



Low vel. low flux

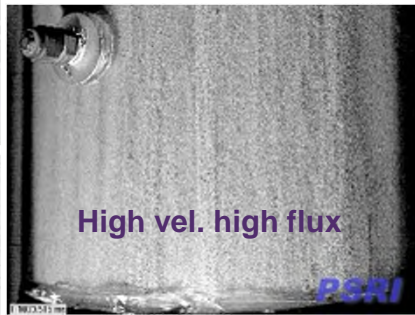
PSRI



Low vel. high flux

PSRI

Catalyst flow in Riser

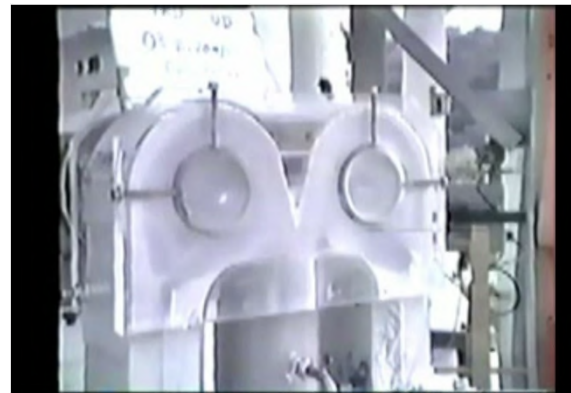


High vel. high flux

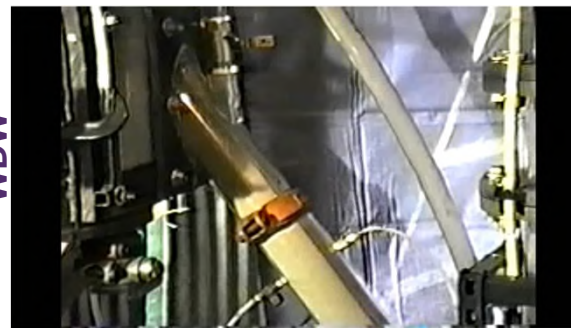
PSRI

PSRI
Particulate Solid Research, Inc.

Flow in RTD



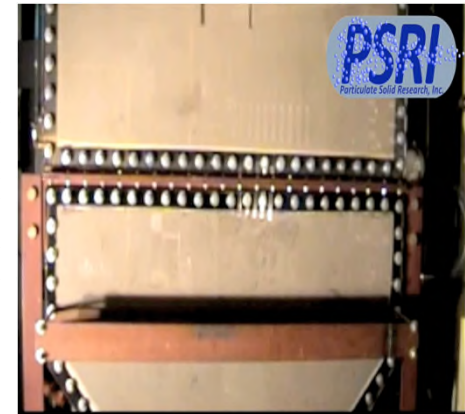
Flow in FCC
WDW



Flow in FCC
Cyclones



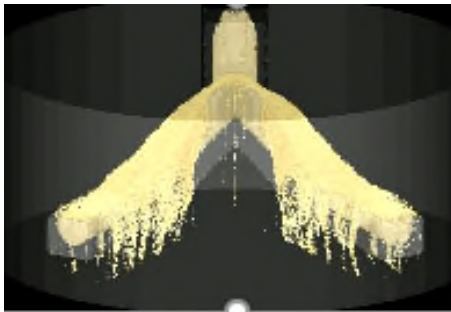
Flow in
Fluidized Bed



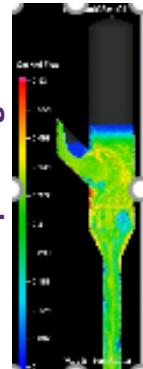
FCC technology development: Computational modeling

Full 3D / qualitative + quantitative comparison / valuable initial screening

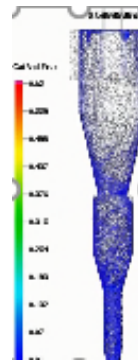
Spent catalyst distributor



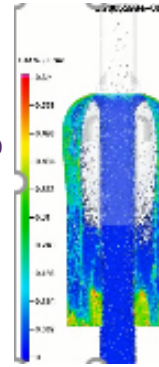
Flow through WDW packing



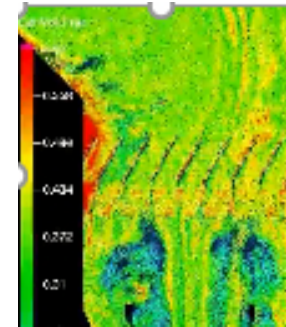
Flow through Cyclone



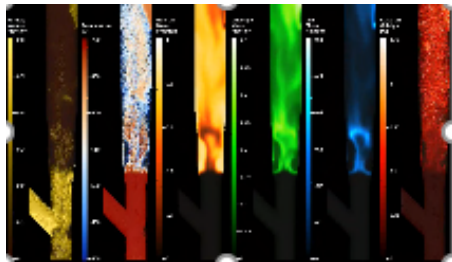
Flow through RS2



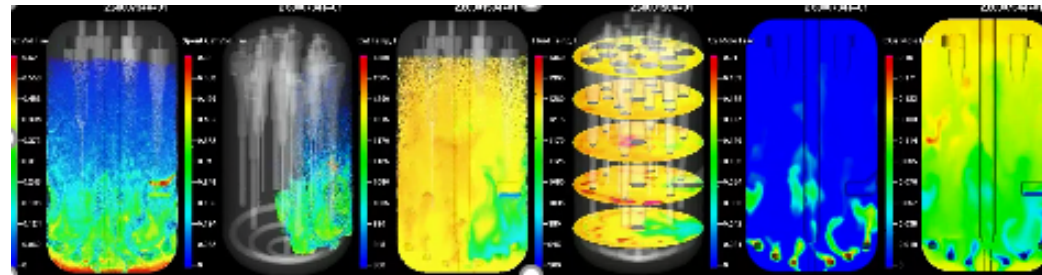
Flow through packing



FCC Riser



FCC Regenerator



Computational modeling

Key to FCC technology development

- Troubleshooting tool
 - Look at many different facets of problem
 - Guide for cold flow test set up
- Compliments cold flow tests
 - Screens ideas quickly = Reduce experiment count
 - Expands / Extend innovation
- Saves time
 - Bring new technologies to market faster
 - Improve new and existing technology without expensive cold flow testing
- Know the limitations
 - Empirical models, numerics, assumptions, boundary conditions

CFD Modeling Performed Using



Screening new concepts and design changes

Stripper packing

Mushroom distributor

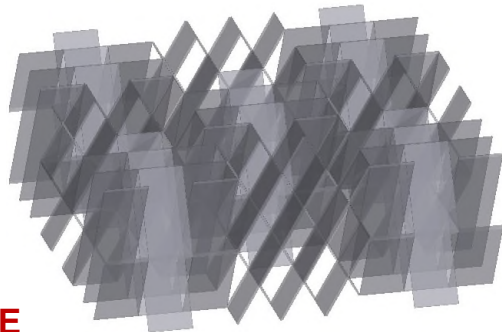
Regenerator air distributor location

Riser termination device – RS2

Screening new stripper packing concepts

Effectively screen new ideas using CFD

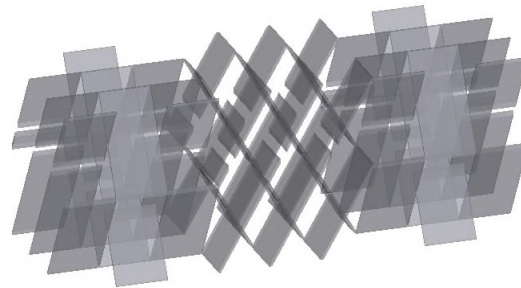
**Four directional
Packing block**



**Standard KFBE
Packing**



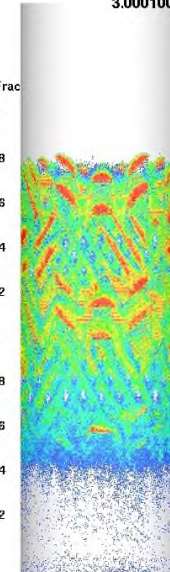
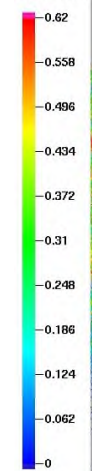
**Four directional
Mandoline**



**Standard KFBE
Packing**

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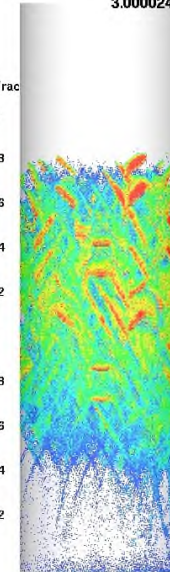
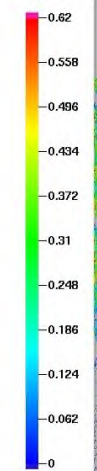
Cat Vol Frac



**Four directional
Packing block**

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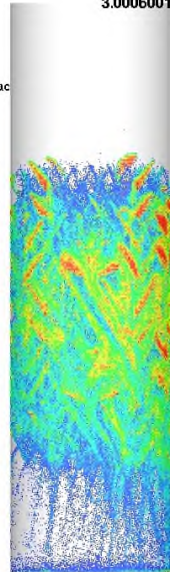
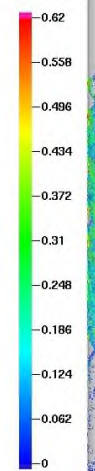
Cat Vol Frac



**Four
directional
Mandoline**

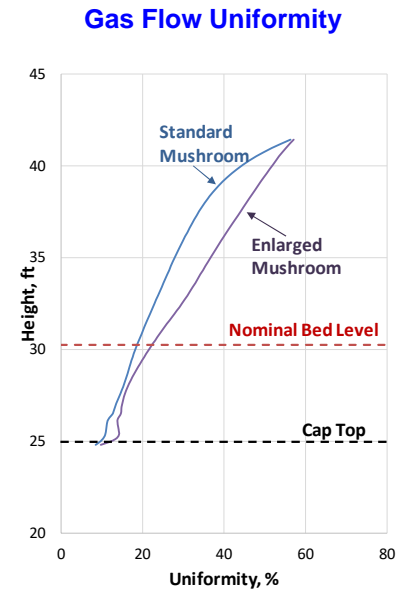
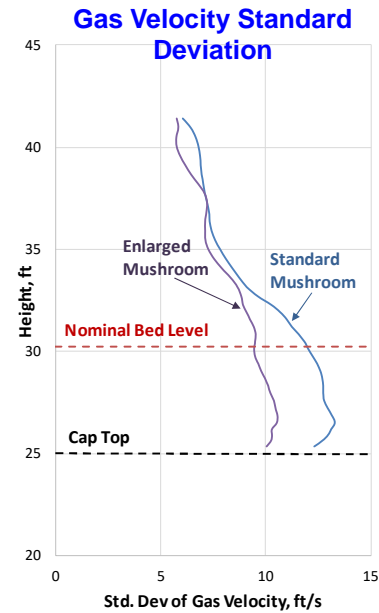
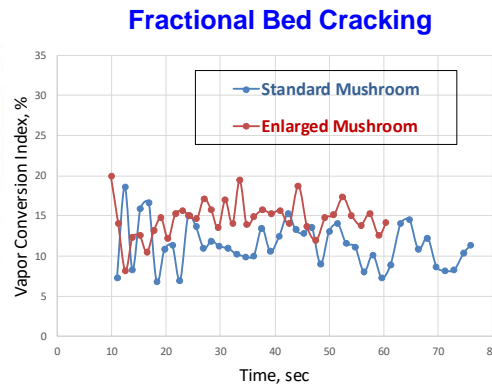
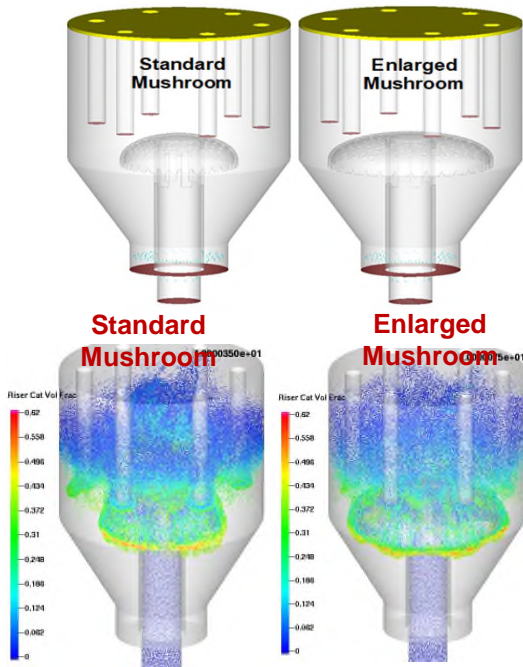
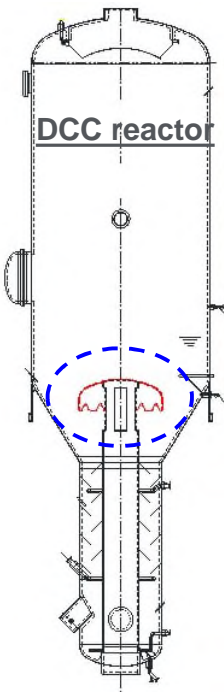
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Cat Vol Frac



Mushroom distributor design optimization

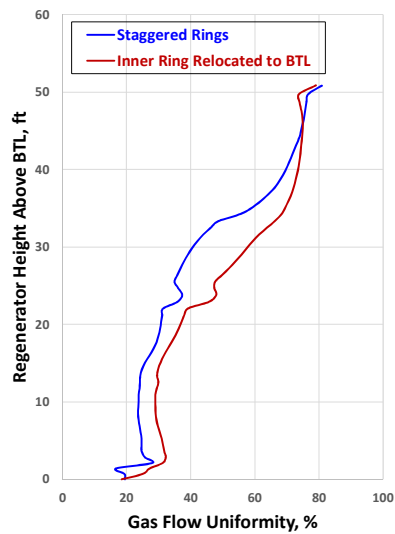
Effectively evaluate design changes using CFD



Regenerator fluidization optimization

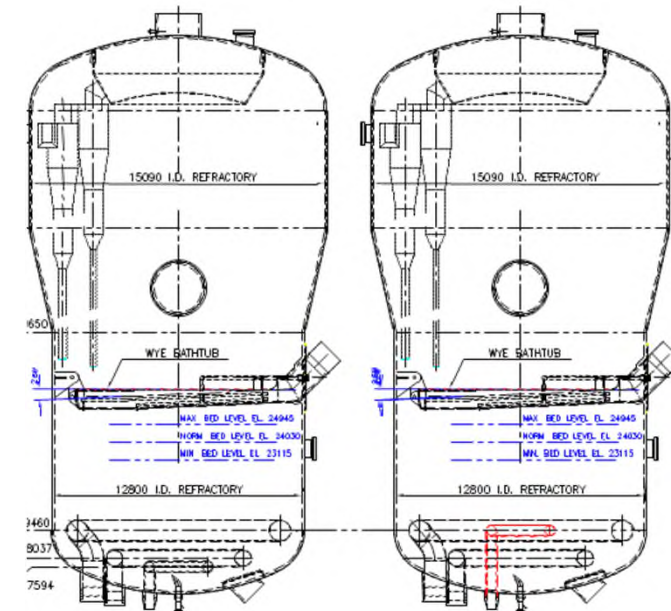
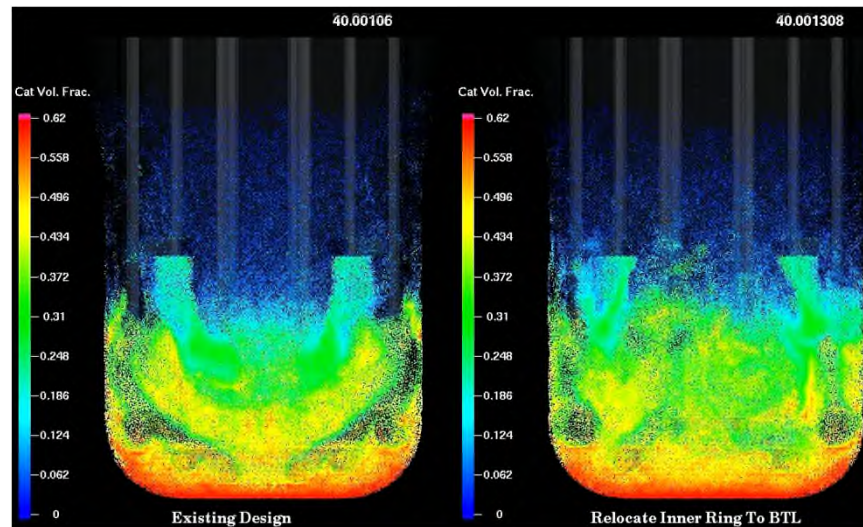
Effect of distributor location on bed hydrodynamics

- Relocating the ring improves
 - Gas flow distribution, uniformity, cyclone loading and bed density distribution



Staggered Ring

Relocate Inner Ring To BTL

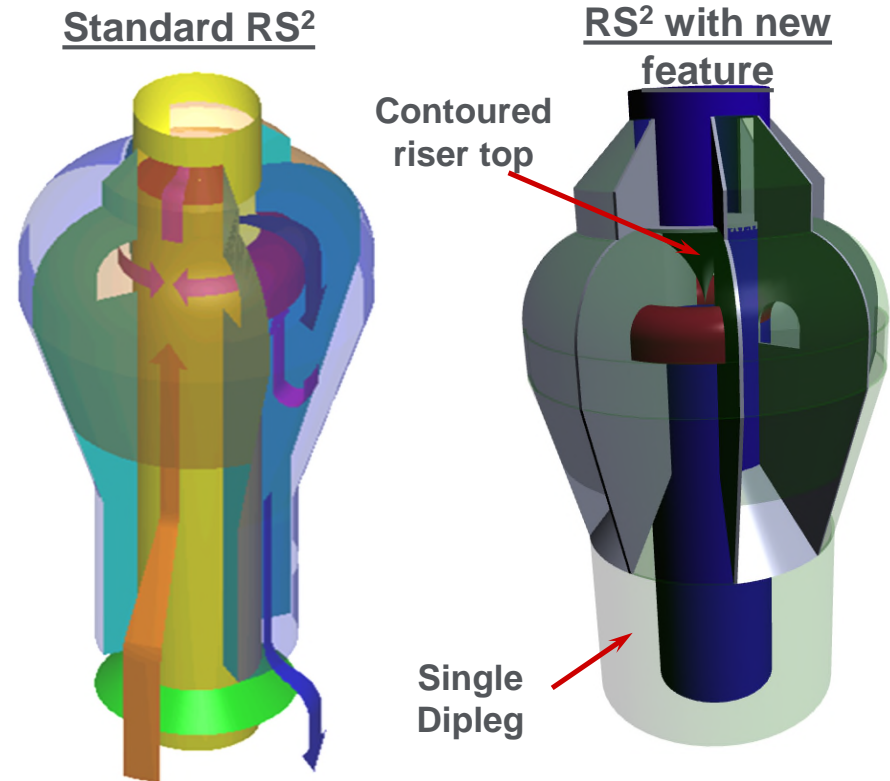


Staggered Rings

Inner ring relocated To BTL

Next generation RS2 development

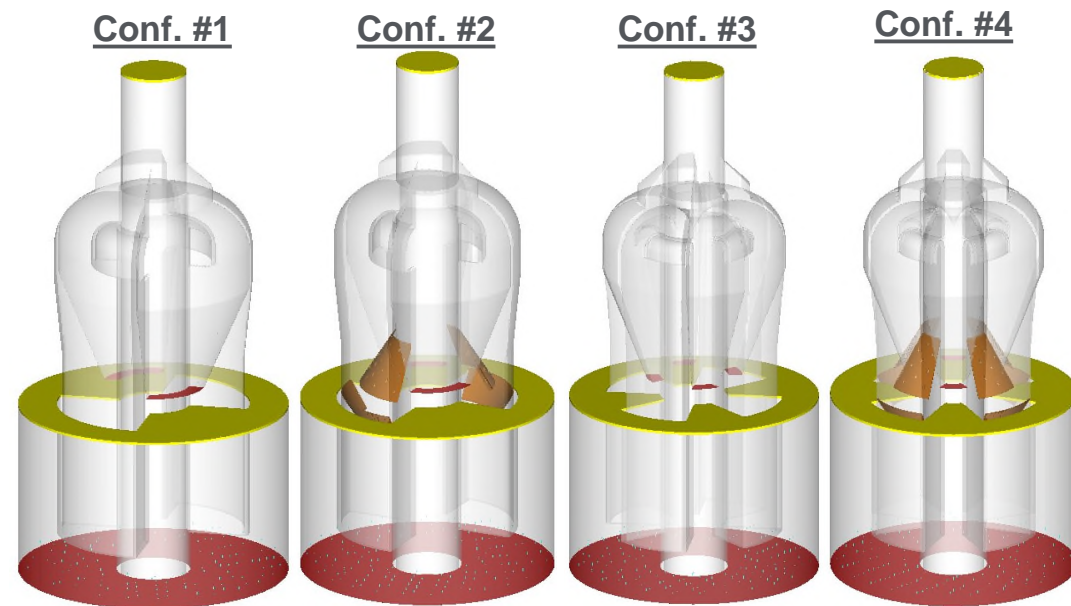
- Standard RS2
 - Multiple separation chambers
 - Multiple stripping chambers
 - 90° turn for initial gas catalyst separation
- Potential new features
 - Contoured riser top
 - Provide smooth 180° turn to gas catalyst flow
 - Promotes gas catalyst separation
 - Single dipleg = compact design
 - Balanced flow distribution to each separation window
 - D&D baffles above catalyst bed in RS2 dipleg
 - Reduces re-entrainment of separated catalyst



Next features: CFD evaluation

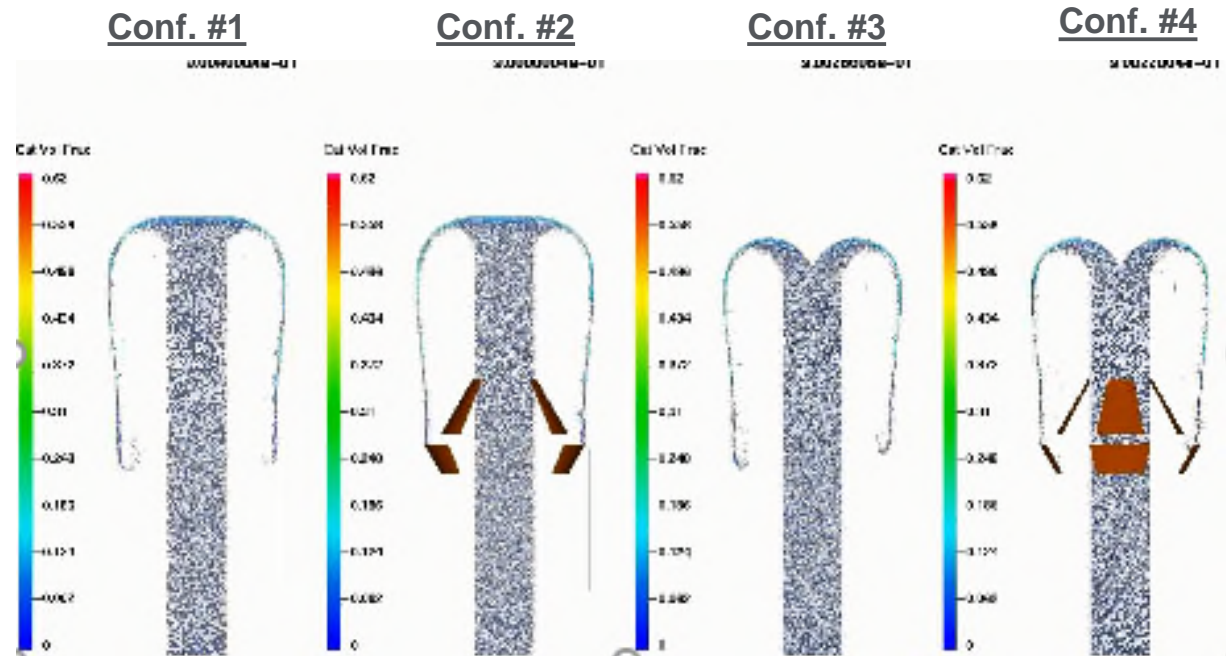
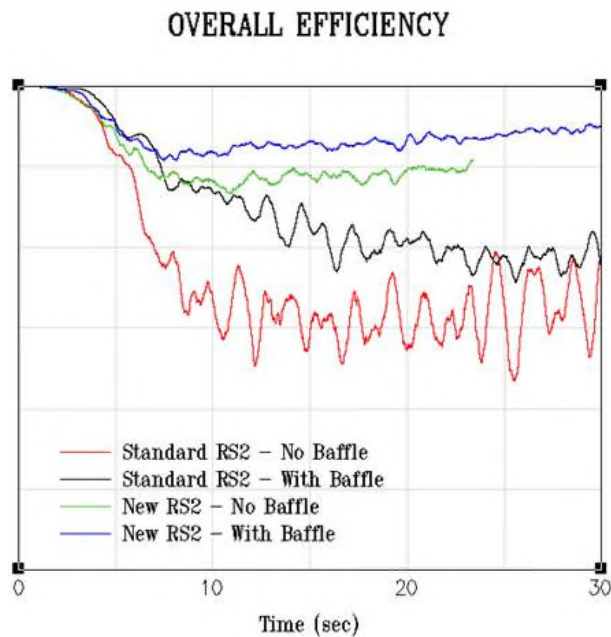
Evaluate new concepts using CFD

- **Standard RS2**
 - Two separation and two stripping chambers
- Standard RS2 with D&D baffle in RS2 Dipleg
- **New RS2**
 - Multiple chambers and contoured top
 - Four separation and four stripping chambers
- New RS2 with D&D baffles in RS2 dipleg



Screening new RS2 features

- CFD predicts improved separation efficiency on adding contoured riser top and D&D
- Awaiting cold flow testing

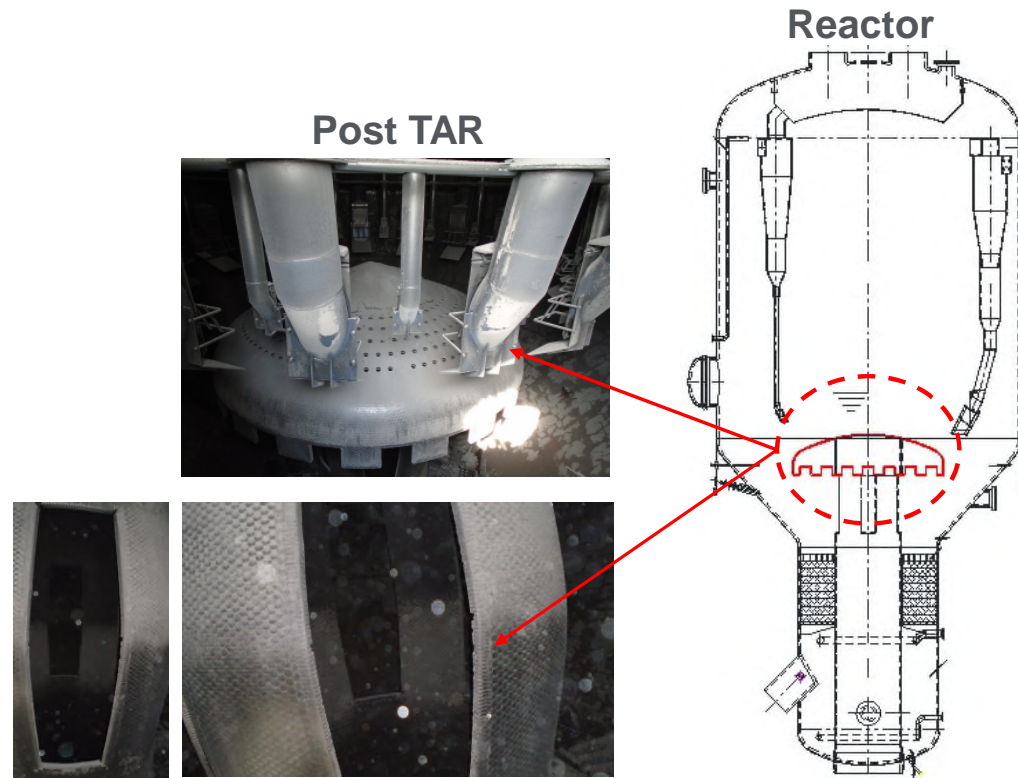


Case study

Troubleshooting FCC riser / reactor operation

Reactor model

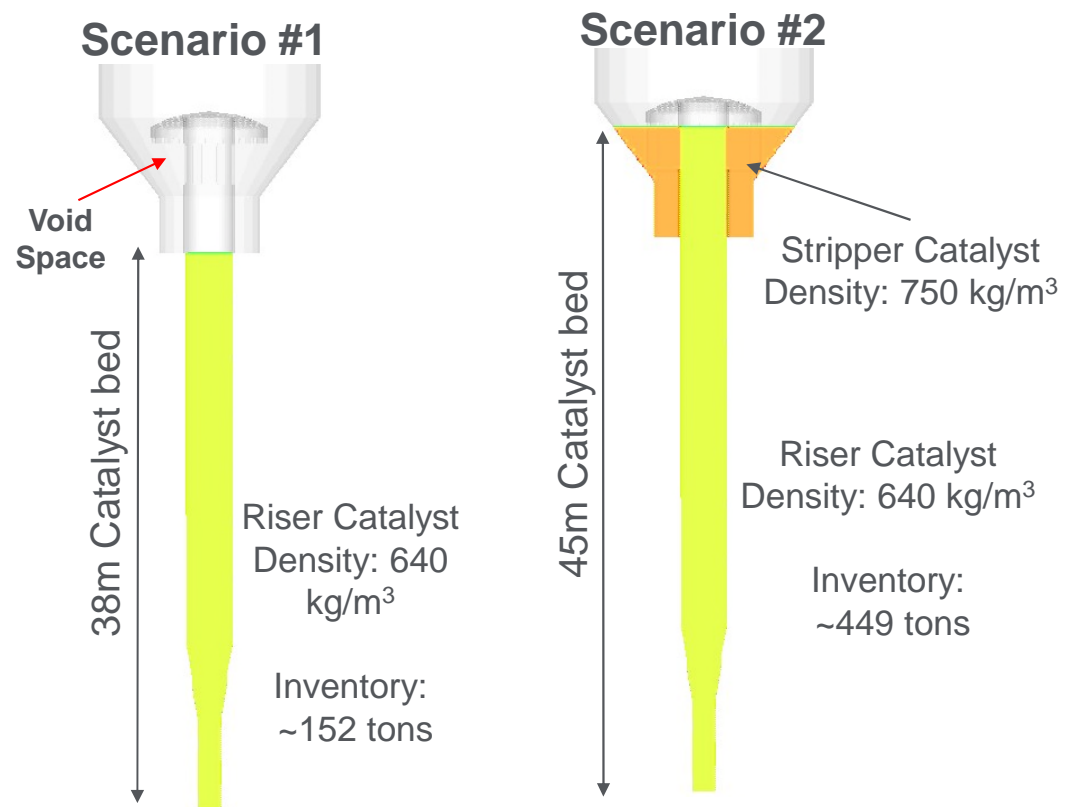
- Commercial scale FCCU
 - RTD submerged in catalyst bed
 - Mushroom type riser termination device
- Turnaround finding
 - Deformed bird cage tendons (bulging)
 - DP required: 2 kg/cm²
- CFD modeling
 - Investigate if riser “de-clogging” could generate adequate dP to bow tendons



Possible scenarios

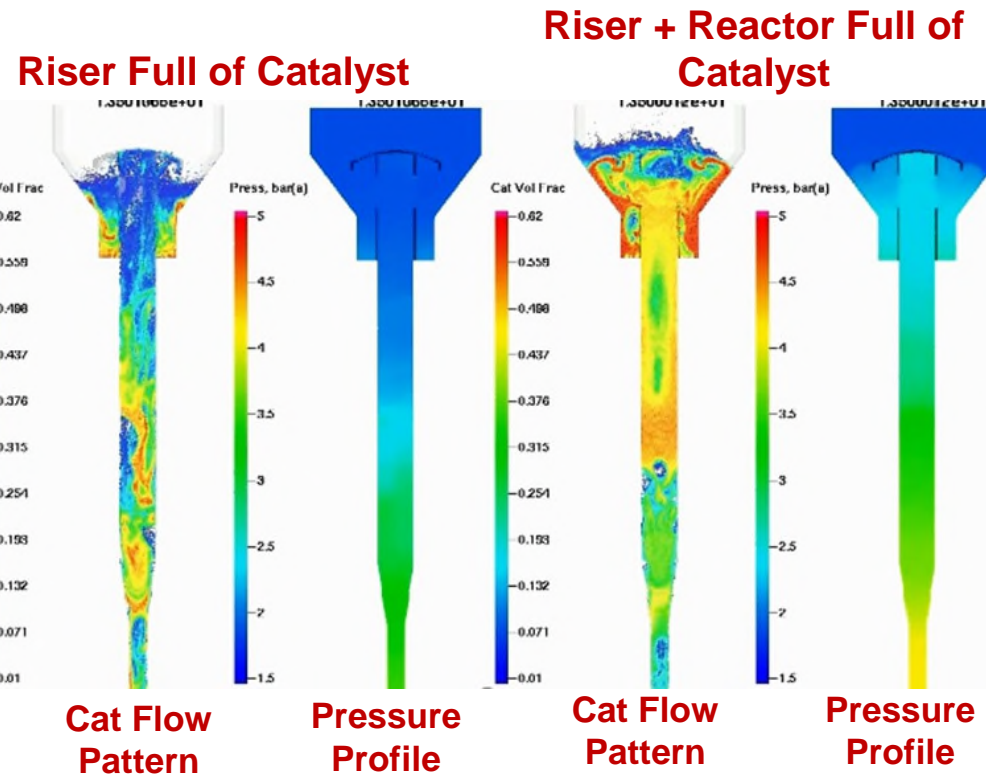
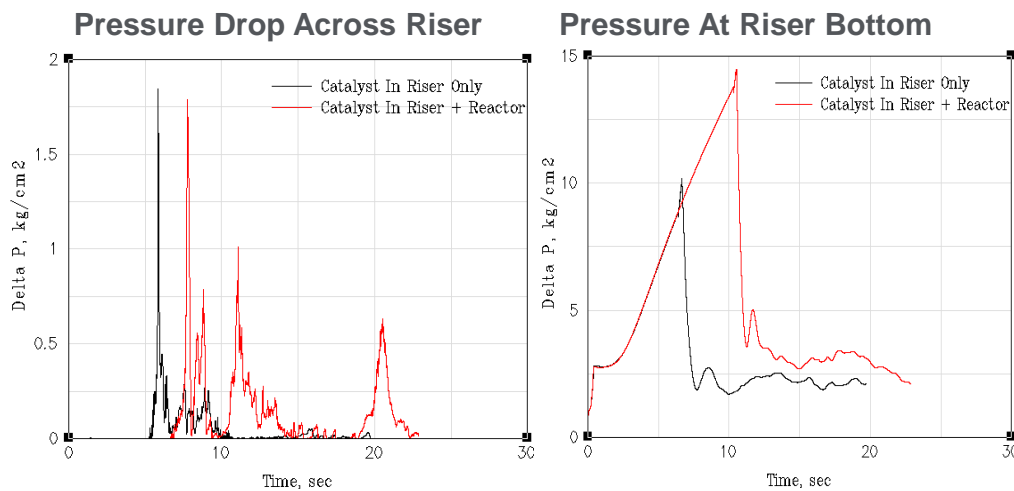
Scenarios after initial screening

1. Riser back filled with catalyst
2. Riser + reactor back filled with catalyst



Modeling results

- CFD predicts pressure surge created during “de-clogging” operation is enough to deform tendons
- Unit start-up guideline revised



Summary

- CFD is an effective tool for FCC R&D, design and troubleshooting
- TechnipFMC actively utilizing CFD
 - Develop and design new FCC technology
 - Bring new technologies to market faster
 - Improve FCC technology without expensive cold flow testing
 - Troubleshooting FCC units
 - Provide confidence in implemented changes

