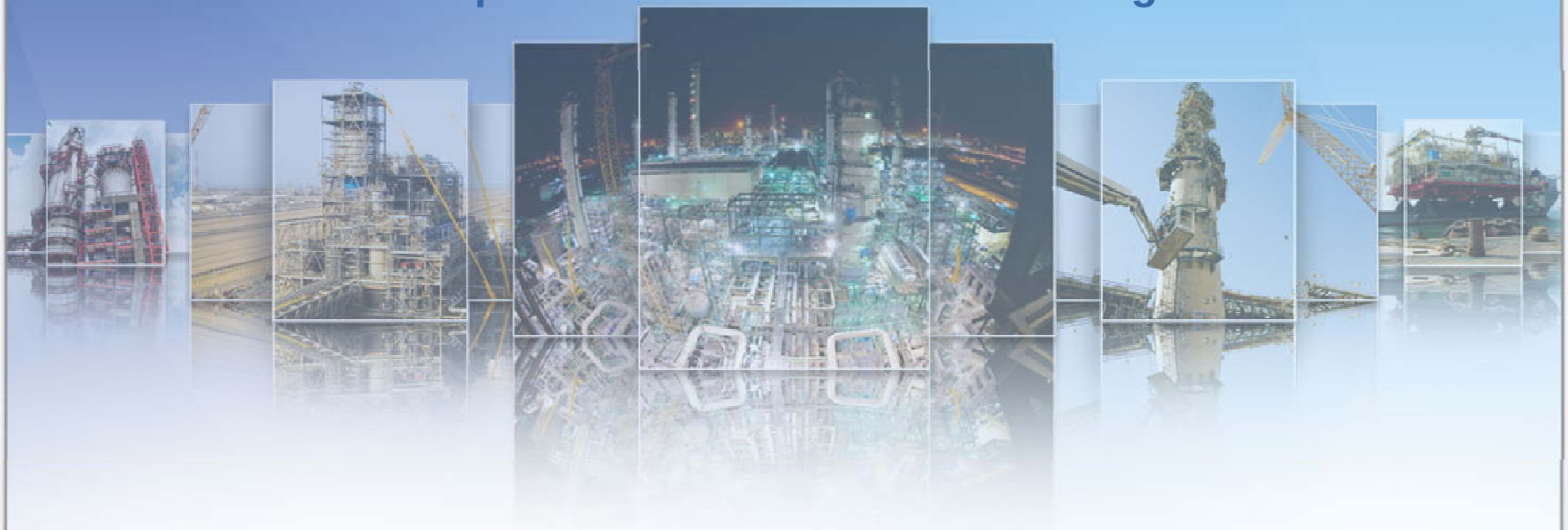
Computational Fluid Dynamics (CFD):
An Effective Tool for FCC Design, Improvement and Troubleshooting



David Chaplin, FCC Technology Manager
david.chaplin@shawgrp.com

CatCracking.com Safety Seminar – Düsseldorf, October 2011

CatCracking.com®
MORE PRODUCTION - LESS RISK!

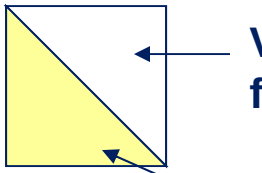
Axens
IFP Group Technologies

Shaw® a world of Solutions™

CFD Modeling Philosophy

- Two CFD modeling approaches for multiphase gas-solid systems
  - Continuous approach
    - Gas phase as fluid; solids phase as pseudo fluid
  - Discrete approach
    - Gas phase as fluid; solid phase as solid particles
- CFD software used within the Alliance
  - Fluent
  - Barracuda by CPFD Software LLC
  - Software selected depends on problem

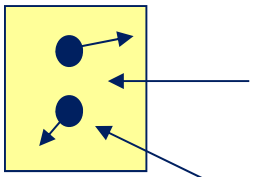
Continuous Approach
two-fluid model



Vapor Volume fraction

Solid Volume fraction

Discrete Approach
particle-dynamics model



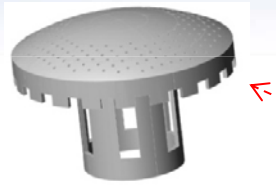
Vapor

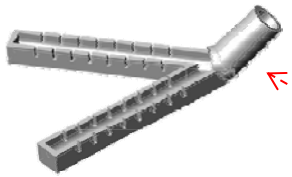
Solid Particles

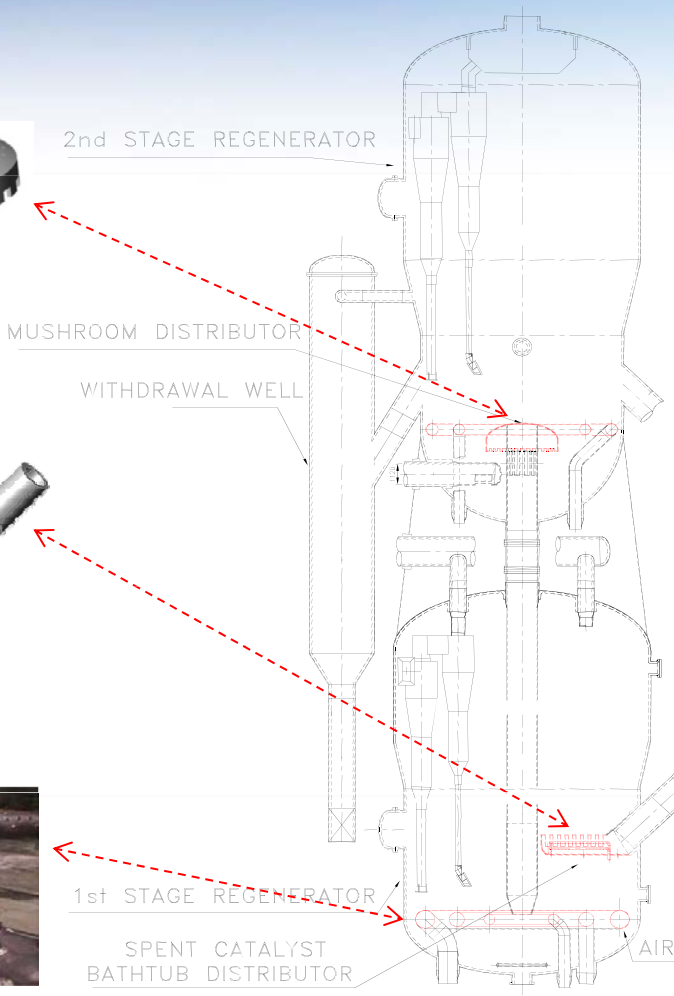
CFD Application in Alliance FCC Technology

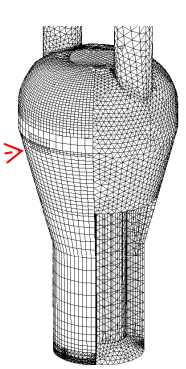
- Research and Development
  - Development and design of new technology
  - Cost-effectively screen new designs
  - Minimize cost of cold-flow testing
- Design
  - Developing design criteria
  - Fine tuning and optimization
- Unit Revamps and Troubleshooting
  - Design optimization
  - Diagnose root causes
  - Validating solutions

FCC Areas Modeled With CFD









Tracking No.: 00.00.2010

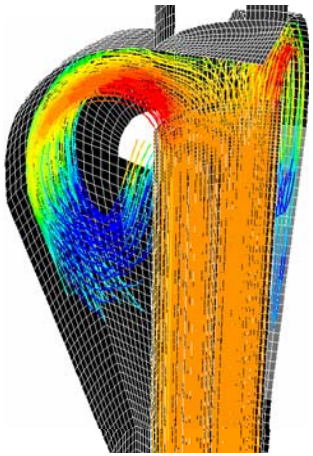
Axens

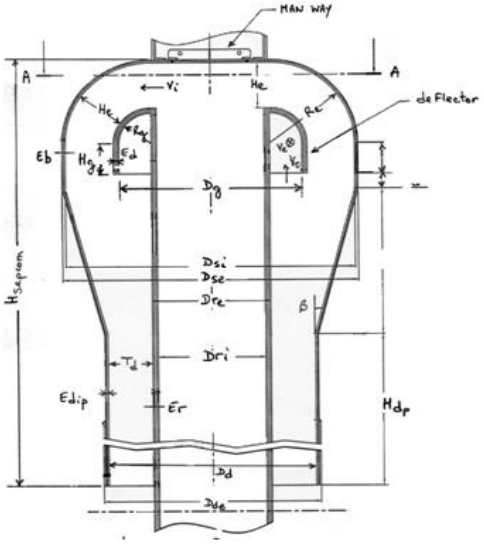
Shaw® a world of Solutions™

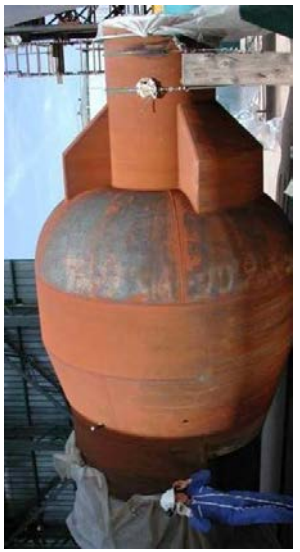
Reactor RSS Development

- Validate cold flow results with fluent CFD software
- Optimize design with CFD
- Develop design criteria

Concept → Validation Cold Flow Experiments & CFD → Design → Implementation



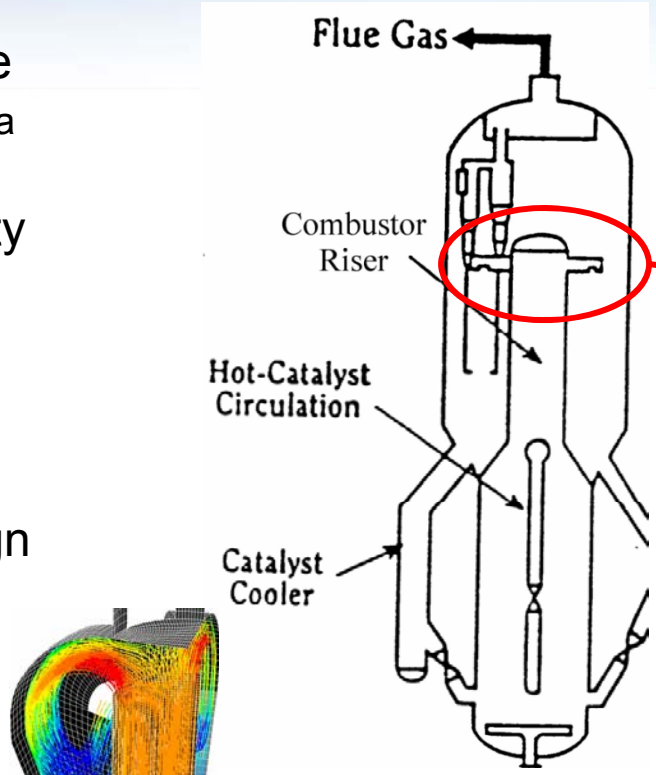


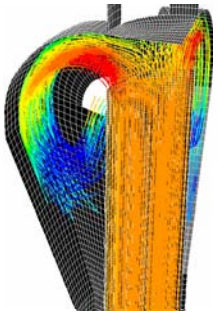


Regenerator RSS Development

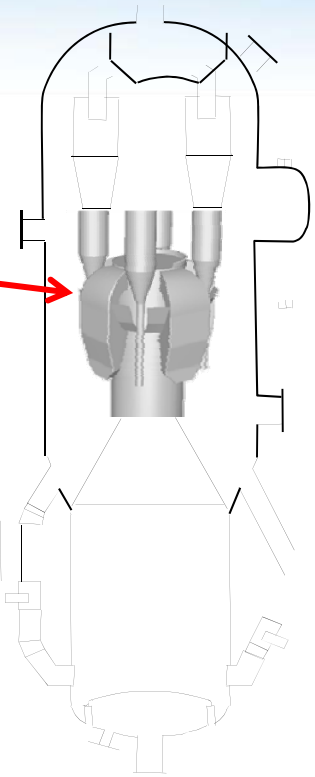
Objective

- Reduce catalyst loss rate
  - Replace tee separators in a high efficiency combustor
- Improve cyclone reliability
- Regenerator too small to increase number of cyclones to reduce inlet velocity
- Adapt reactor RSS design
  - No cold flow work
  - CFD modeling only





Before Revamp

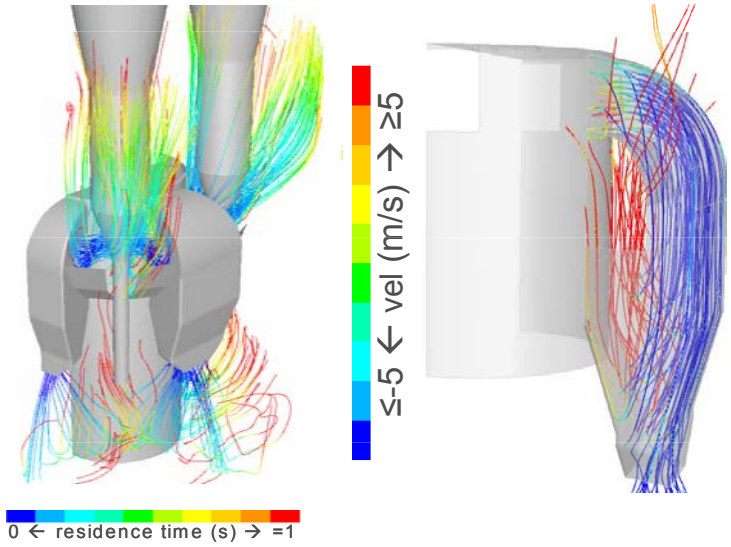


After Revamp

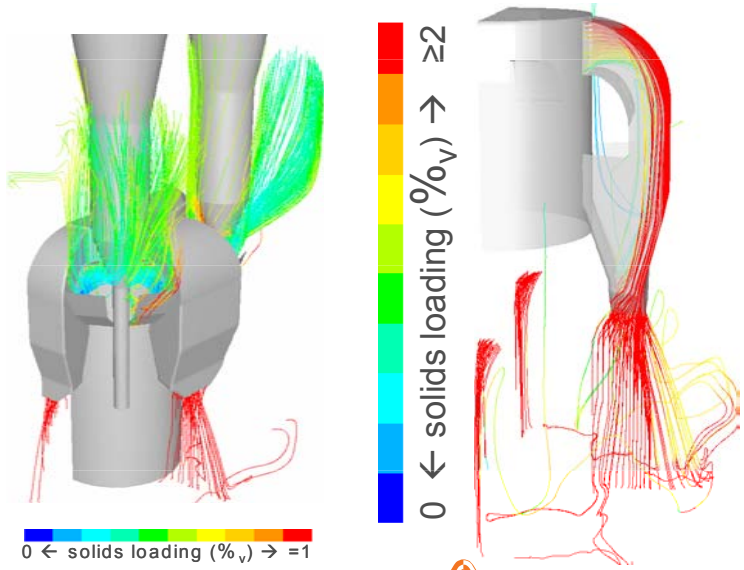
Regenenerator RS^2 Development

- Replace Combustor Tee Separator
- High separation efficiency of RS^2
- Improved cyclone reliability
- Increases regenerator capacity
- No interference with cyclones diplegs

Gas Flow Patterns



Solid Flow Patterns

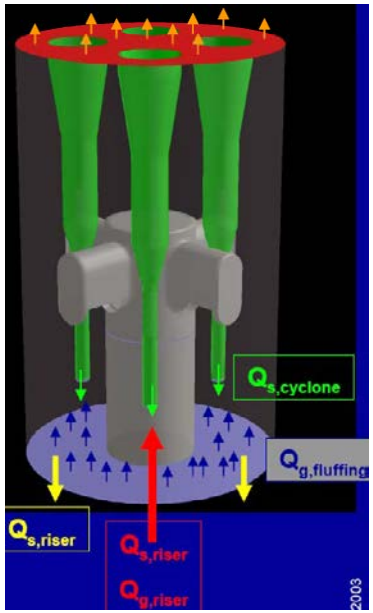


Axens

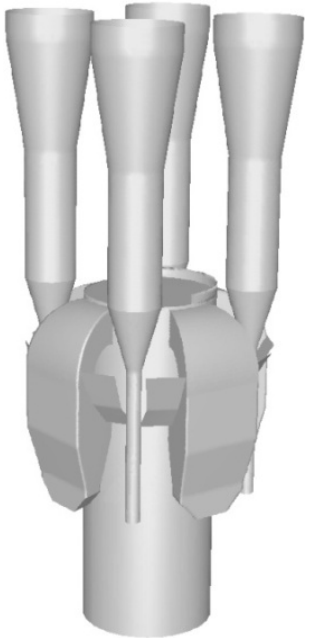
Shaw® a world of Solutions™

Regenenerator RS² Development

BEFORE



AFTER

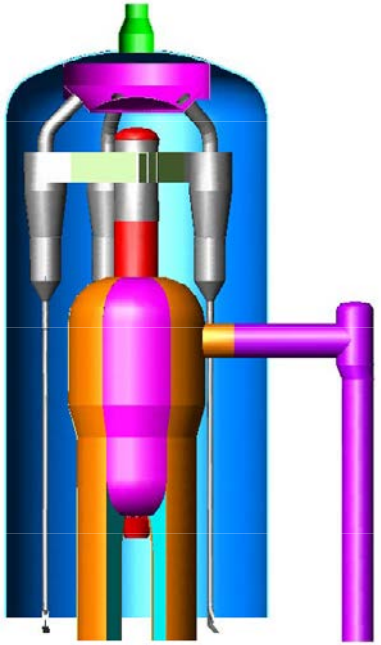


Axens

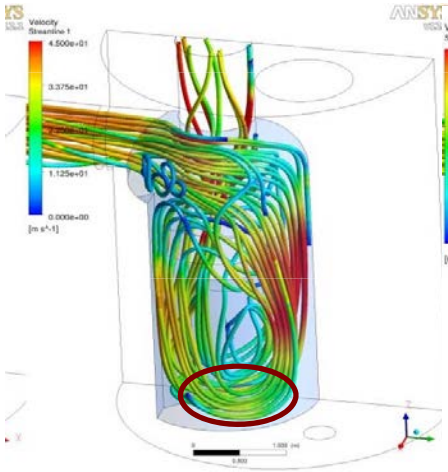
Shaw® a world of Solutions™

RS² Development for External Riser System

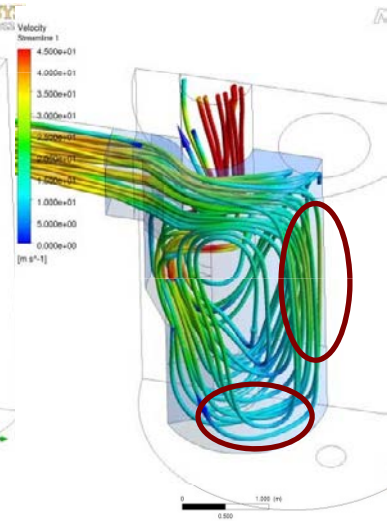
Concept



CFD Optimization

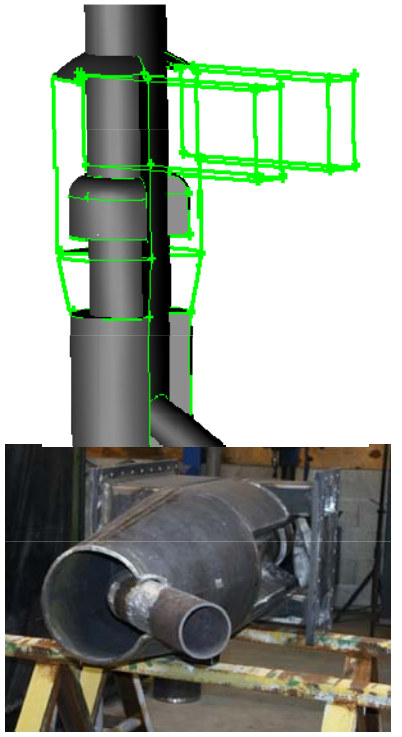


Initial Design Concept



Improved Design

Pilot Plant

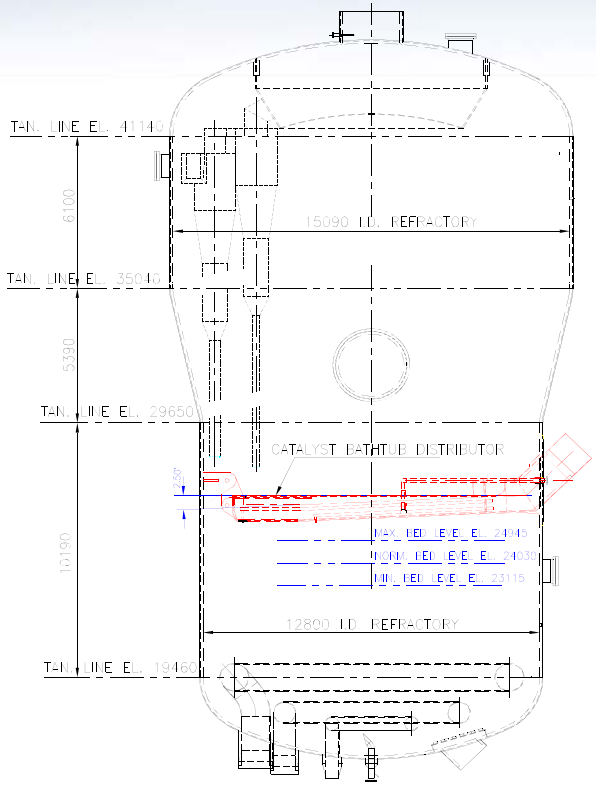


Tracking No. 00.00.2010

Axens

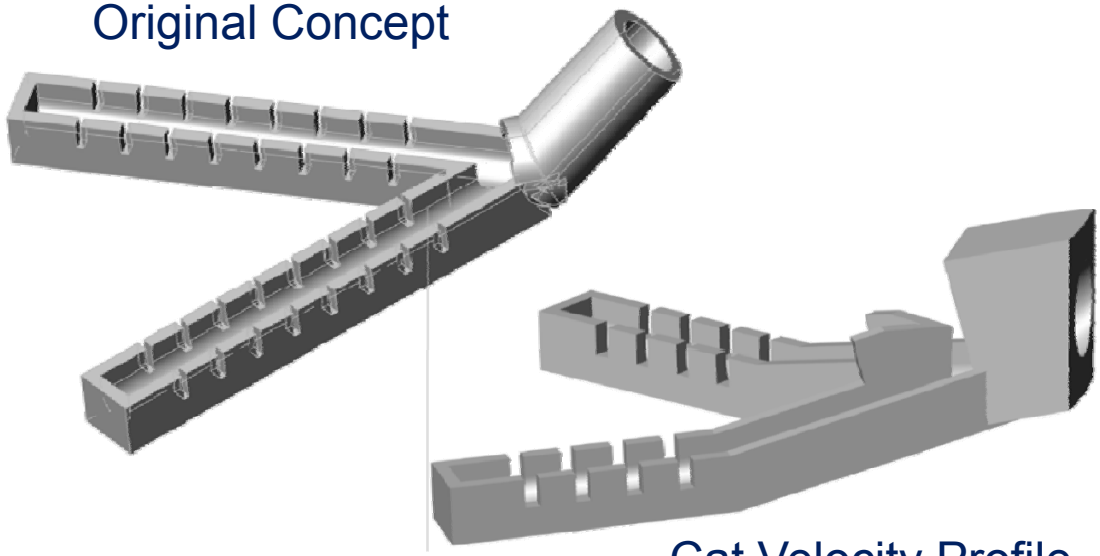
Shaw® a world of Solutions™

Spent Catalyst Wye Bathtub Distributor Design Optimization



Cat Density Profile

Original Concept



Cat Velocity Profile

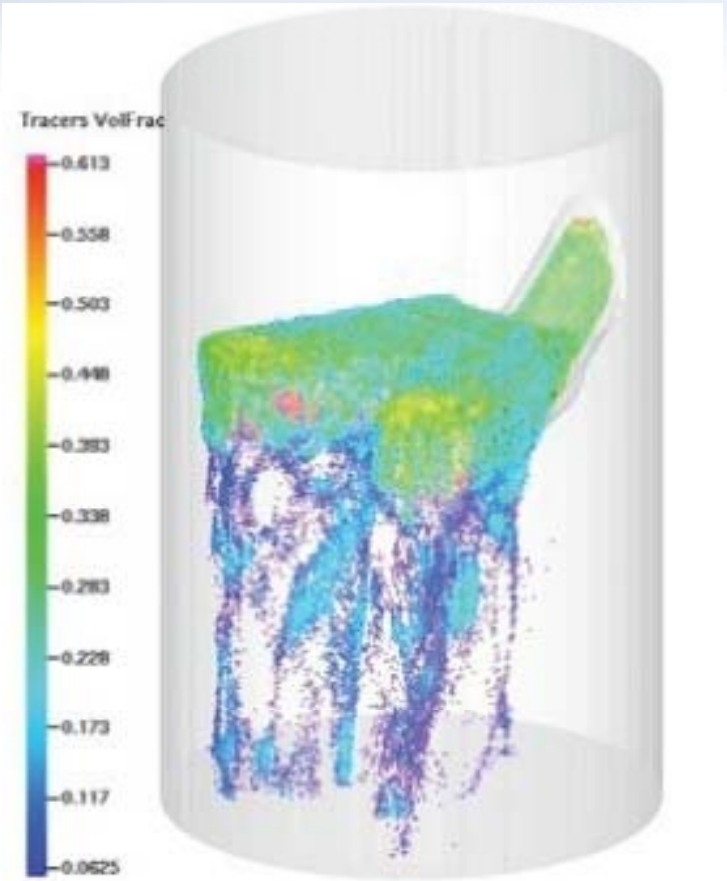
Optimized Design

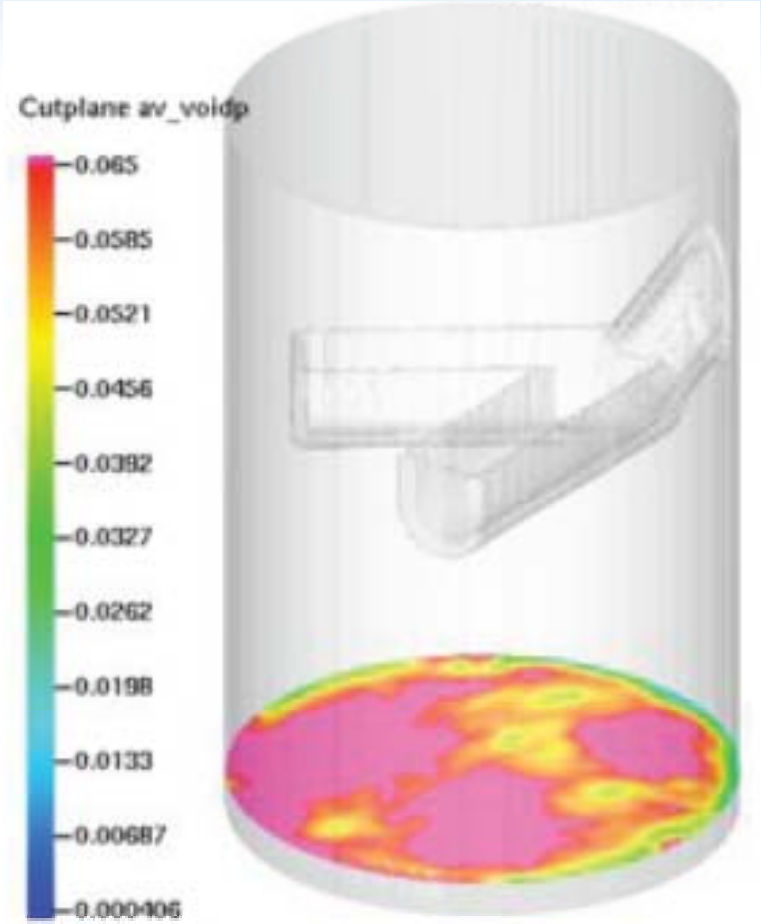
Tracking No. 00.00.2010

Axens

Shaw® a world of Solutions™

Spent Catalyst Distributor CFD Modeling



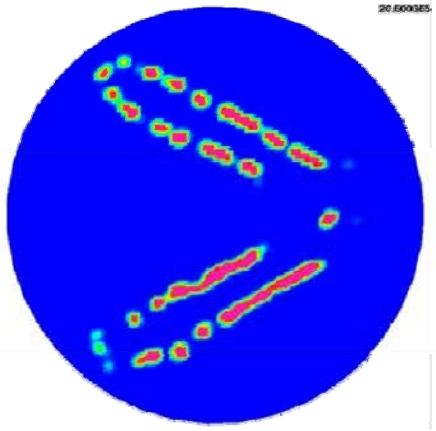


Tracking No.: 00.00.2010

Spent Catalyst Wye Bathtub Distributor Design Optimization

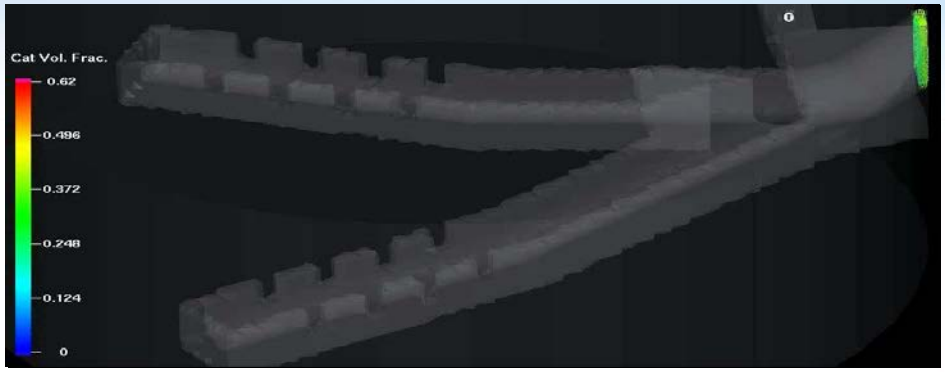
CFD used to determine optimum design parameters

- Improved catalyst distribution along its length

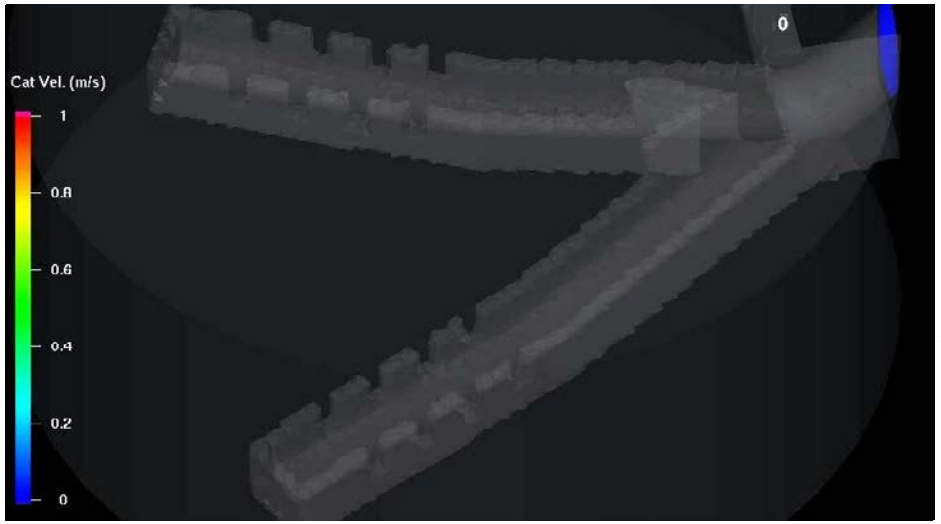


Plan view showing uniform distribution of catalyst

Cat Density Profile



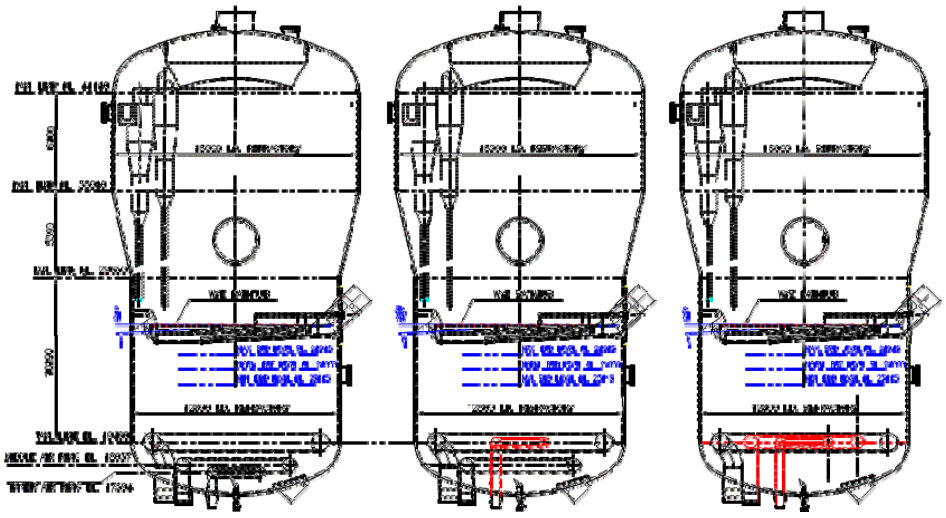
Cat Velocity Profile



Tracking No.: 00.00.2010

Regenerator Fluidization Optimization

CFD Modeling to study the effect of air ring location on fluid bed hydraulics



Staggered

Inner ring relocated to BTL

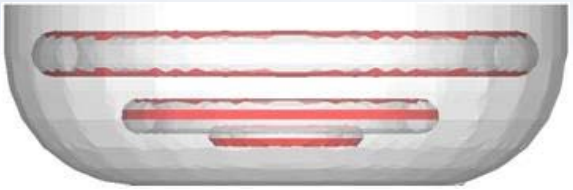
All rings at same elevation.

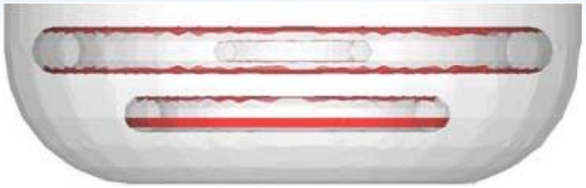
Regenerator Fluidization Optimization

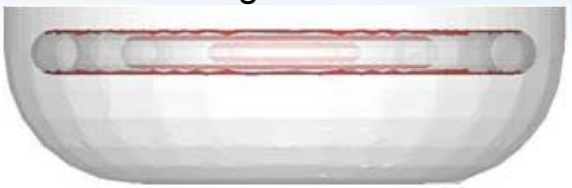
Staggered ring

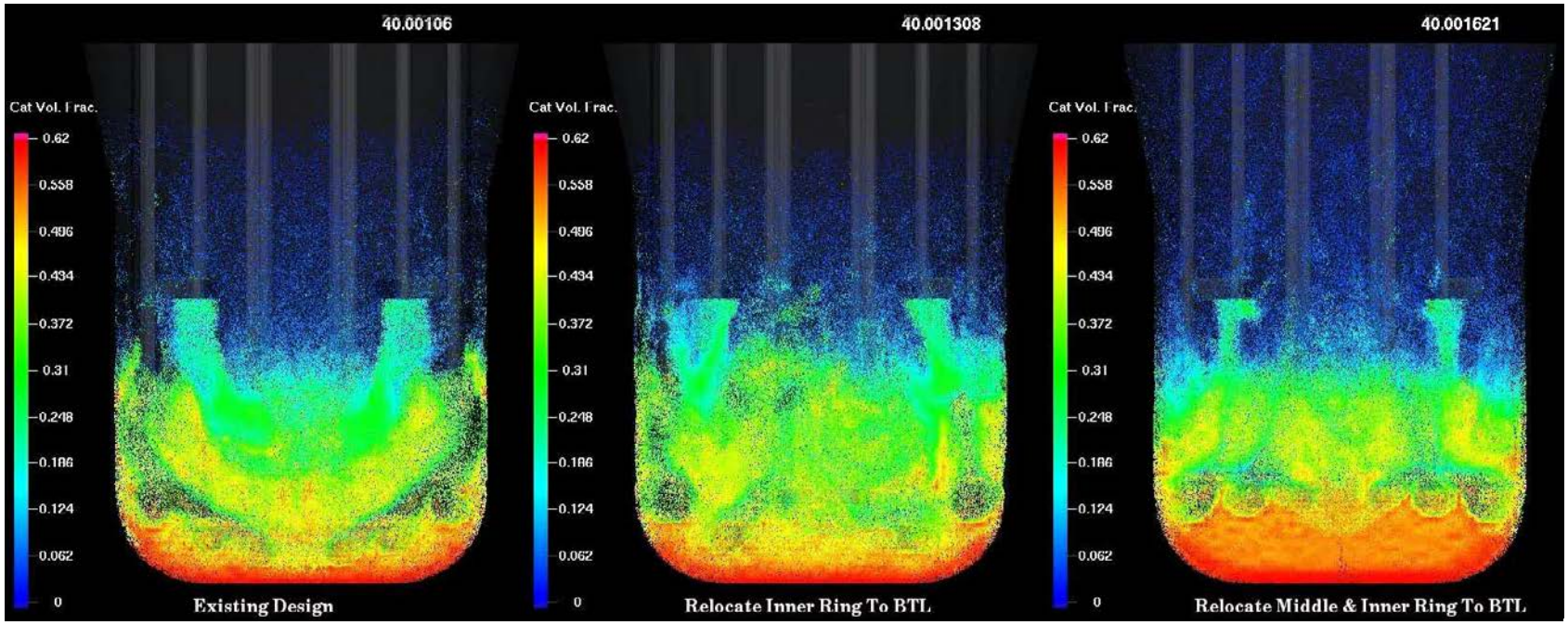
Relocate inner ring to BTL

Relocate middle and inner ring To BTL









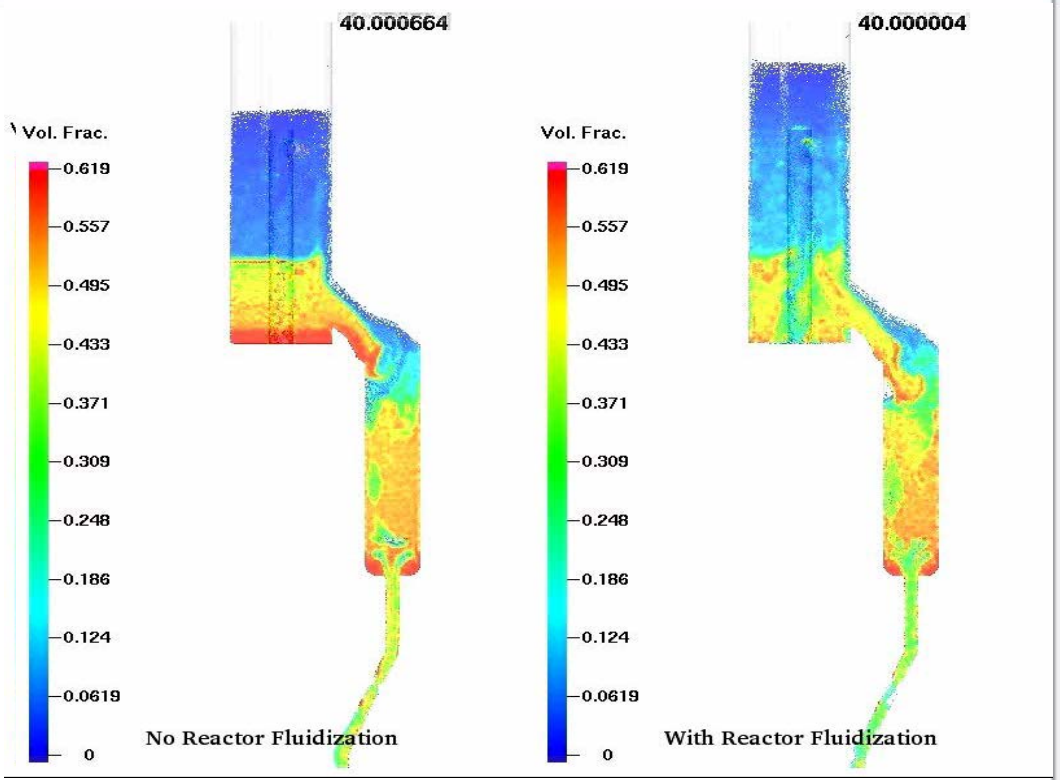
Tracking No. 00.00.2010

Axens

Shaw® a world of Solutions™

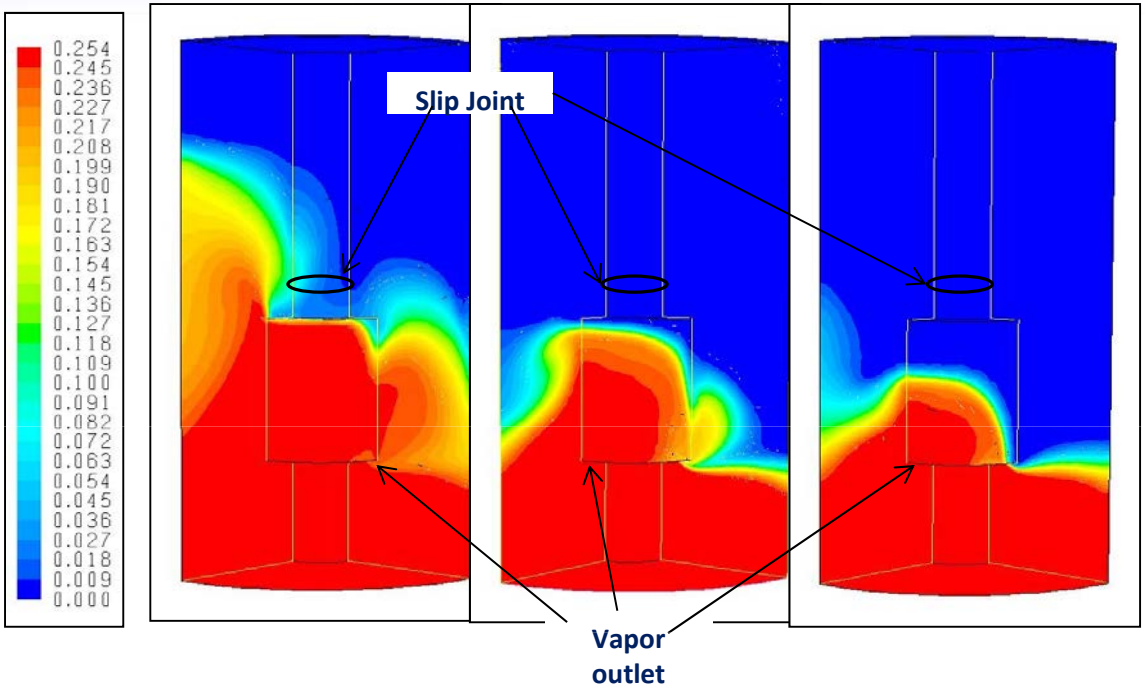
Stripper Troubleshooting

- Influence of reactor fluidization on stripper performance
- CFD used to study effect of reactor fluidization on stripper operation
- Stripper upset caused by de-fluidized catalyst entering stripper



Reactor RS^2 Dome Steam Specifications

Contours of mole fraction of HC vapor (red).
Steam is blue.



Increase dome steam flow

CFD used to develop new design criteria for dome steam flowrate.

Conclusions

- FCC Alliance committed to improving FCC hardware through increased use of CFD
  - Reduce technology development cost
  - Bring new technologies to market faster
  - Improve FCC hardware design
  - Verify design without cold flow testing
  - Increase reliability
  - One of the key troubleshooting tools
- CFD is a cost-effective tool that is useful in most aspects of FCC design

Shaw® a world of Solutions™

Tracking No. 00.00.2010