



Shaw® a world of **Solutions**™

The Shaw Group Inc.®

FCC Enhancements to Improve Financial Production and Environmental Emissions

**South Texas Section (STS) of the
American Institute of Chemical Engineers**

**Harvey McQuiston
FCC Program Manager
The Shaw Group**

Leading the Way in FCC Technology

- 48 Shaw/Axens FCC units licensed since 1981
- 2.06 million BPD of licensed
- 1.01 million BPD in operation
- 13 FCCs with > 10 wt% propylene
- Advanced Technologies:
 - FCC for VGO feeds
 - RFCC for resid feeds
 - Resid to Propylene (RTP)
 - Deep Catalytic Cracking (DCC)
 - Catalytic Pyrolysis Process (CPP)
 - C₂/C₃ Olefin Recovery and Purification



Shaw FCC Technologies

- **Fluid Catalytic Cracking (FCC)** – transportation fuels plus some propylene from VGO type feedstocks
- **Residual Fluidized Catalytic Cracking (RFCC)** - transportation fuels from heavy feedstocks
- **Residual to Propylene Cracking (RTP)** - transportation fuels plus some propylene from heavy feedstocks
- **Deep Catalytic Cracking** - Propylene plus transportation fuels from high quality VGO type feedstocks
- **Catalytic Pyrolysis Process (CPP)** - Ethylene and propylene plus transportation fuels from good quality heavier feedstocks

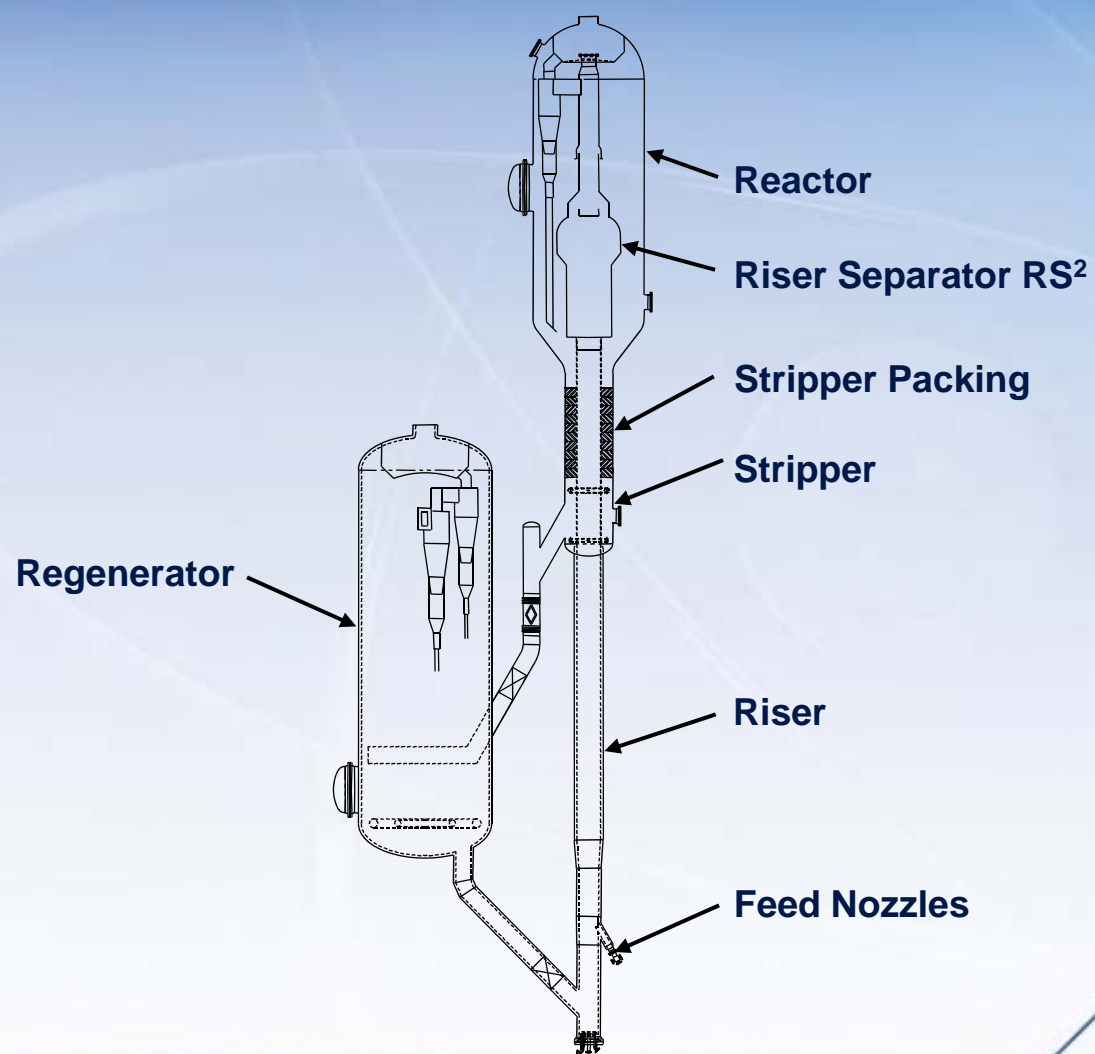
Shaw/Axens FCCs

48 FCC Units Licensed



85M102006D

Shaw FCC Unit



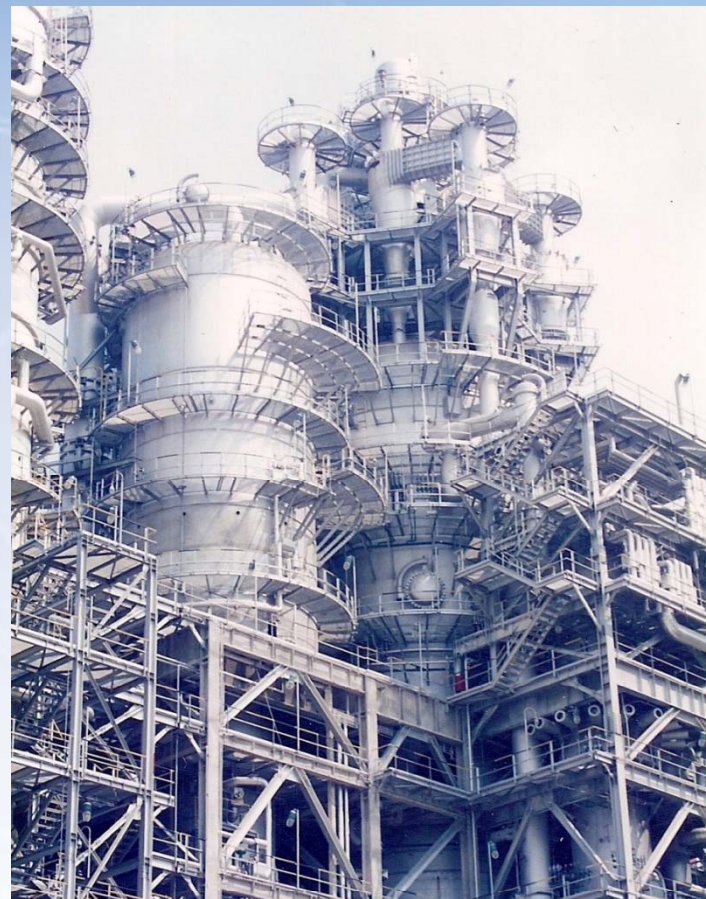
85M1102006D

Global Trends in FCC

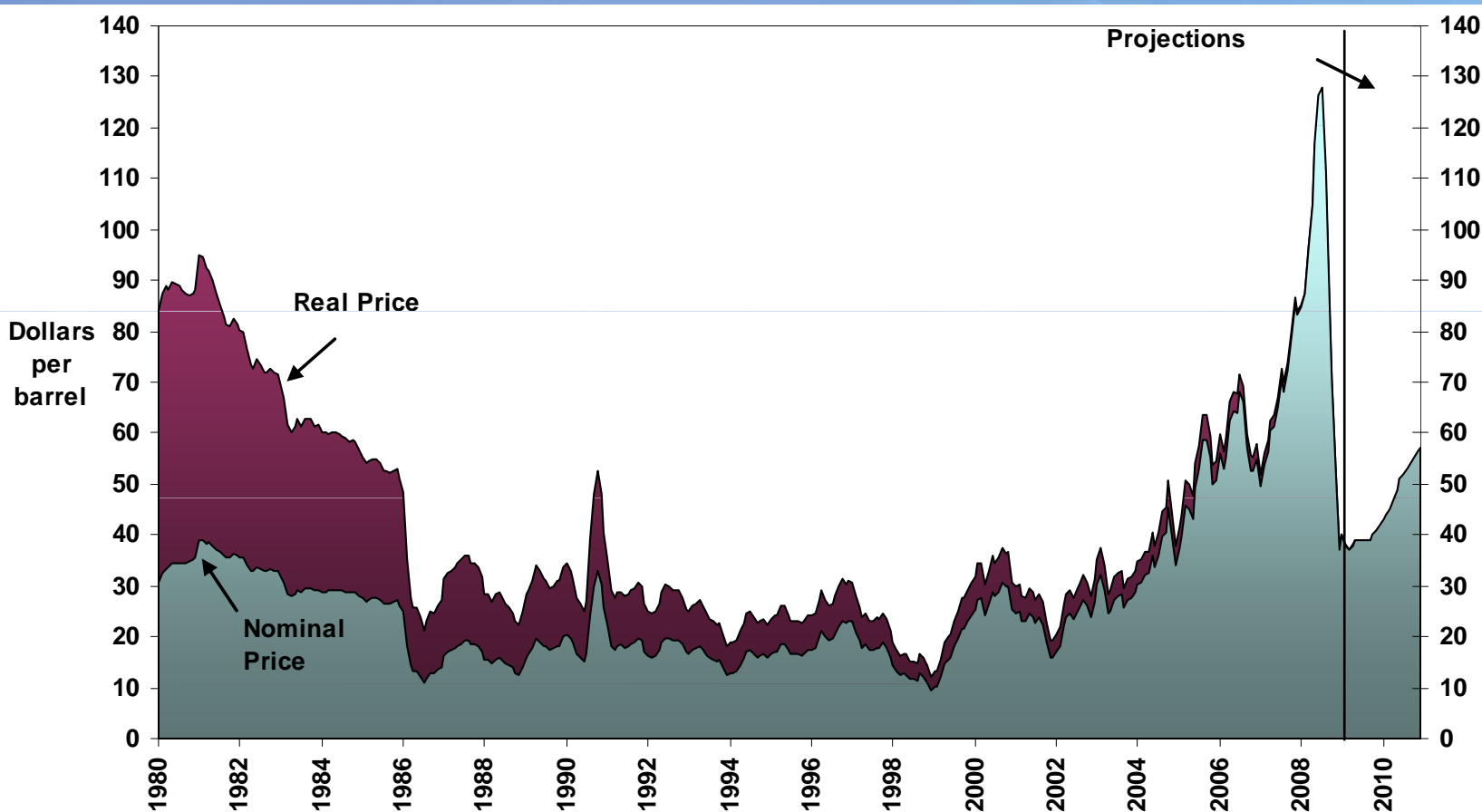
85M1102006D

Why Resid FCC?

- Well-proven since 1981
- Low cost atmospheric residue feedstock
- Low cost catalyst
- Low construction cost
 - Moderate pressure (<2 barg)
 - Mostly carbon steel cold-wall construction
- Non-hydrogen conversion promotes olefin production



Resid FCC Emerged with High Crude Prices



Short Term Energy Outlook-January 2009



1981 – The First 2-Stage Resid FCC



- TOTAL refinery Arkansas City, Kansas
- Revamp of existing FCC unit
 - New reactor
 - New second stage regenerator
- Process and mechanical design by Total
- Detail engineering by The Shaw Group

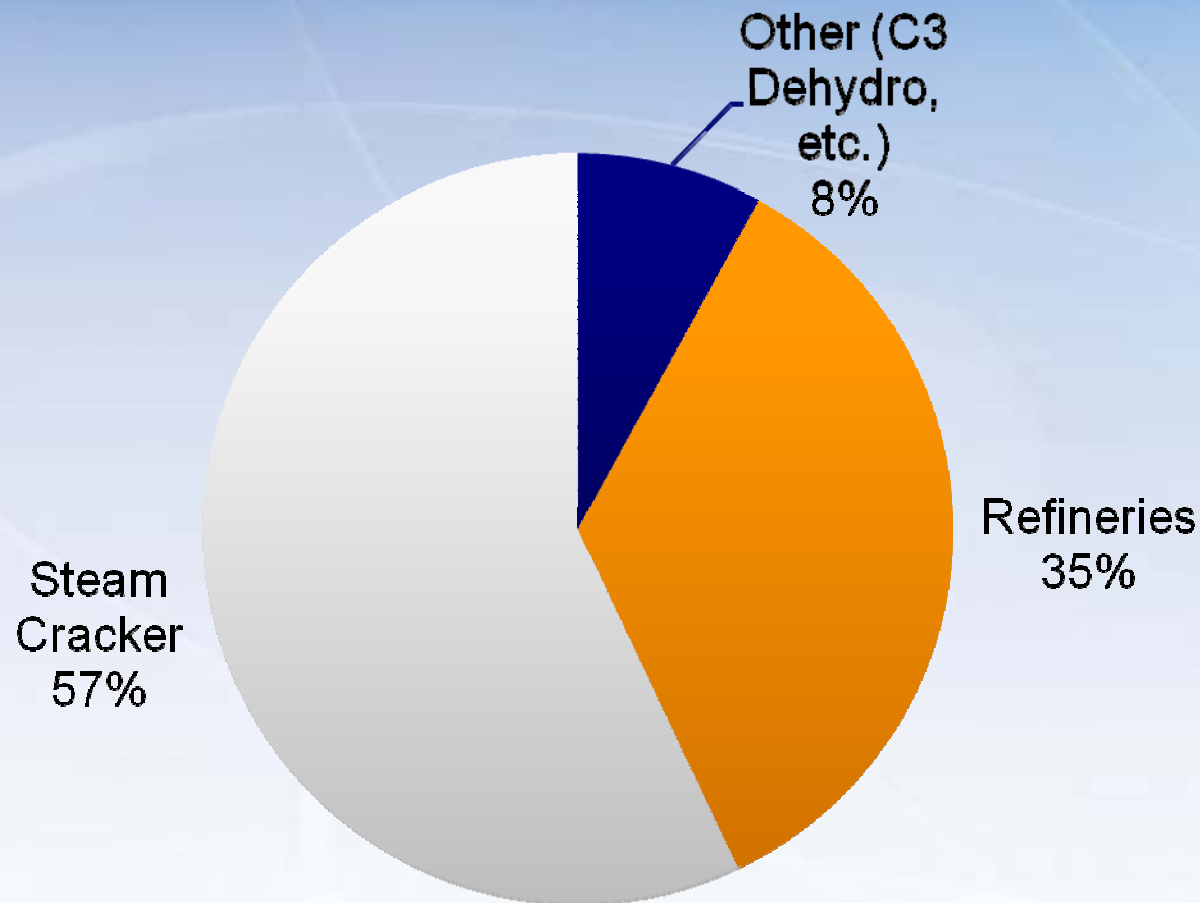
Why Propylene?

- It is the most valuable product
- Propylene is a natural product of catalytic cracking (β -Scission)
- ZSM-5 propylene catalyst additive has been proven since the 1960s
- Synergisms with resid FCC:
 - The higher heat required for propylene mode can be supplied by resid FCC
 - Propylene mode improves vaporization of resid feeds
 - Gasoline mode flexibility
- Petrochemical propylene is a carbon captured product, unlike fuels



Propylene Production

2007 Production ~ 74 Million tons (Mt)



Source: Nexant + CEH SRI

Propylene Production Forecast

- Global additional demand 2008-2015: 34 million tons/yr
- Average annual growth rate (AAGR): 4.5 percent
- Additional demand from FCC: 13 million tons/yr



Source: Nexant + CEH SRI

FCC Regenerator Design to Minimize Emissions

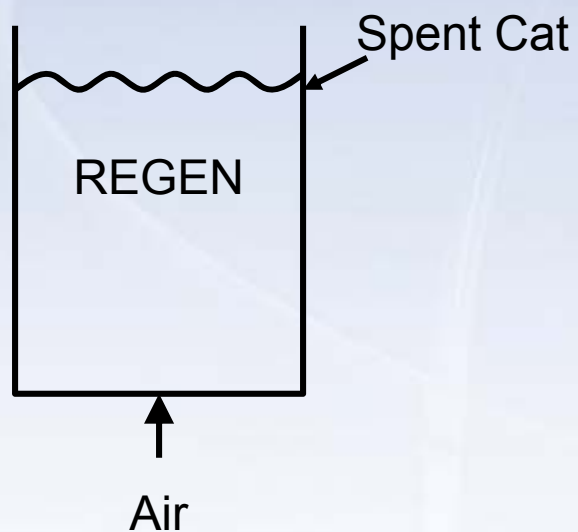
85M1102006D

Regenerator Design Objectives

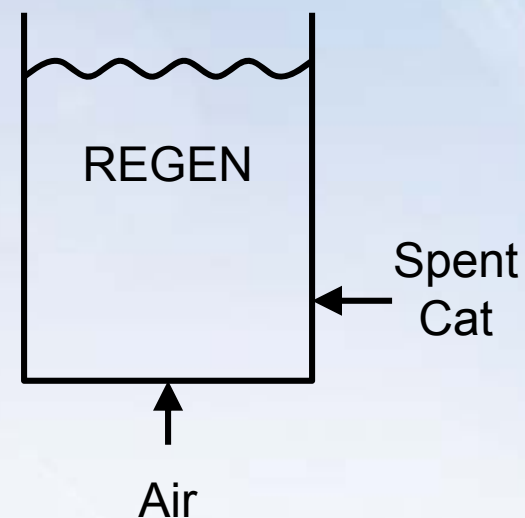
- Effective regeneration of catalyst
- Minimum catalyst deactivation
- Efficient use of available air blower capacity
- Minimum damage to equipment
- Minimum toxic emissions

Typical Regenerator Designs

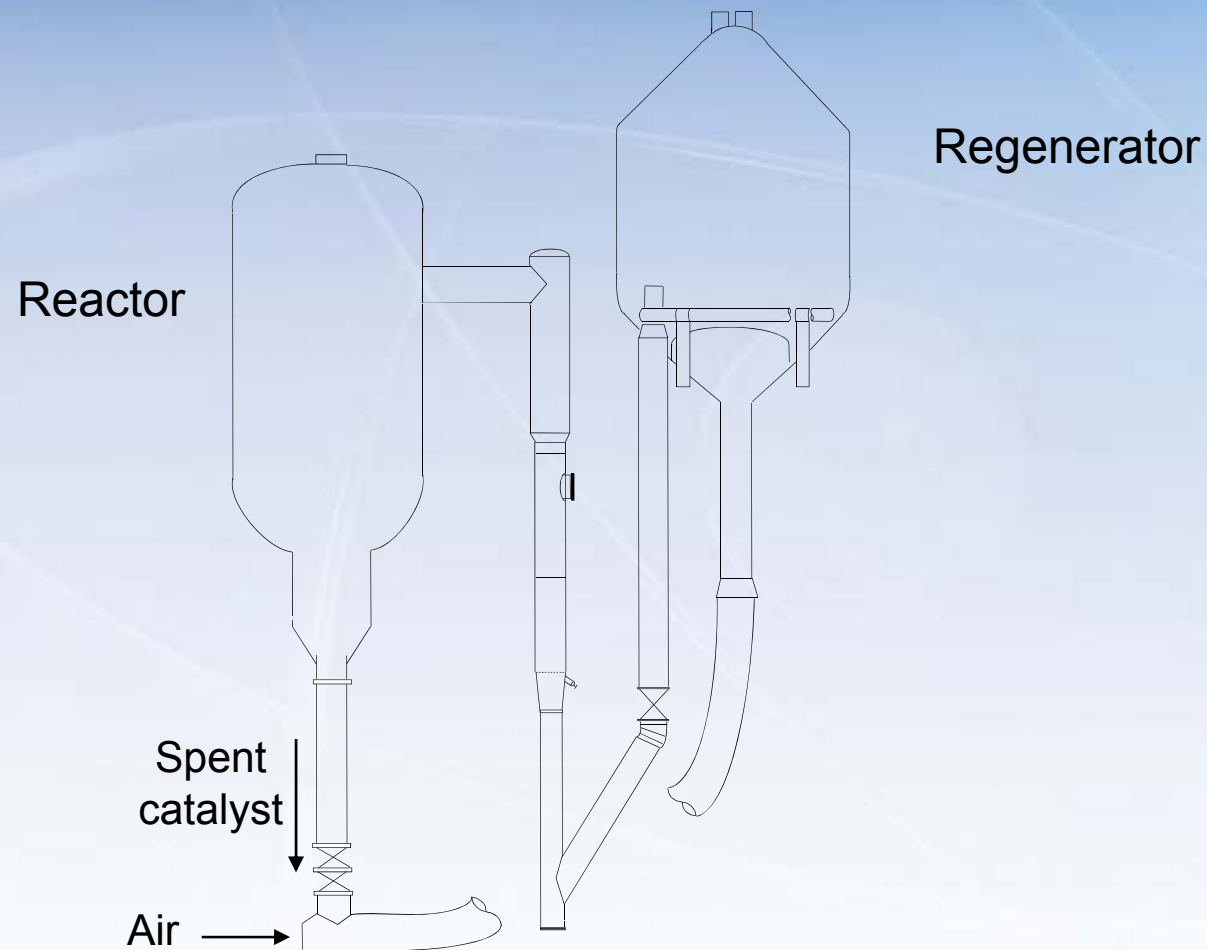
**Counter
Current**



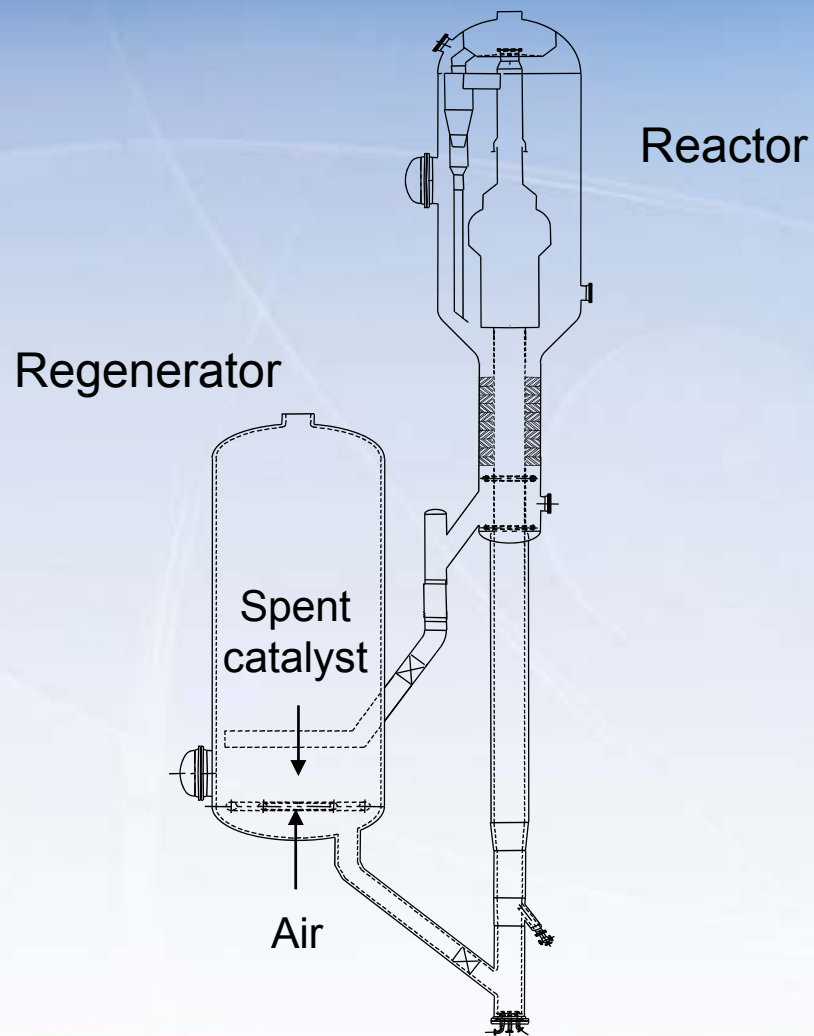
**Co-
Current**



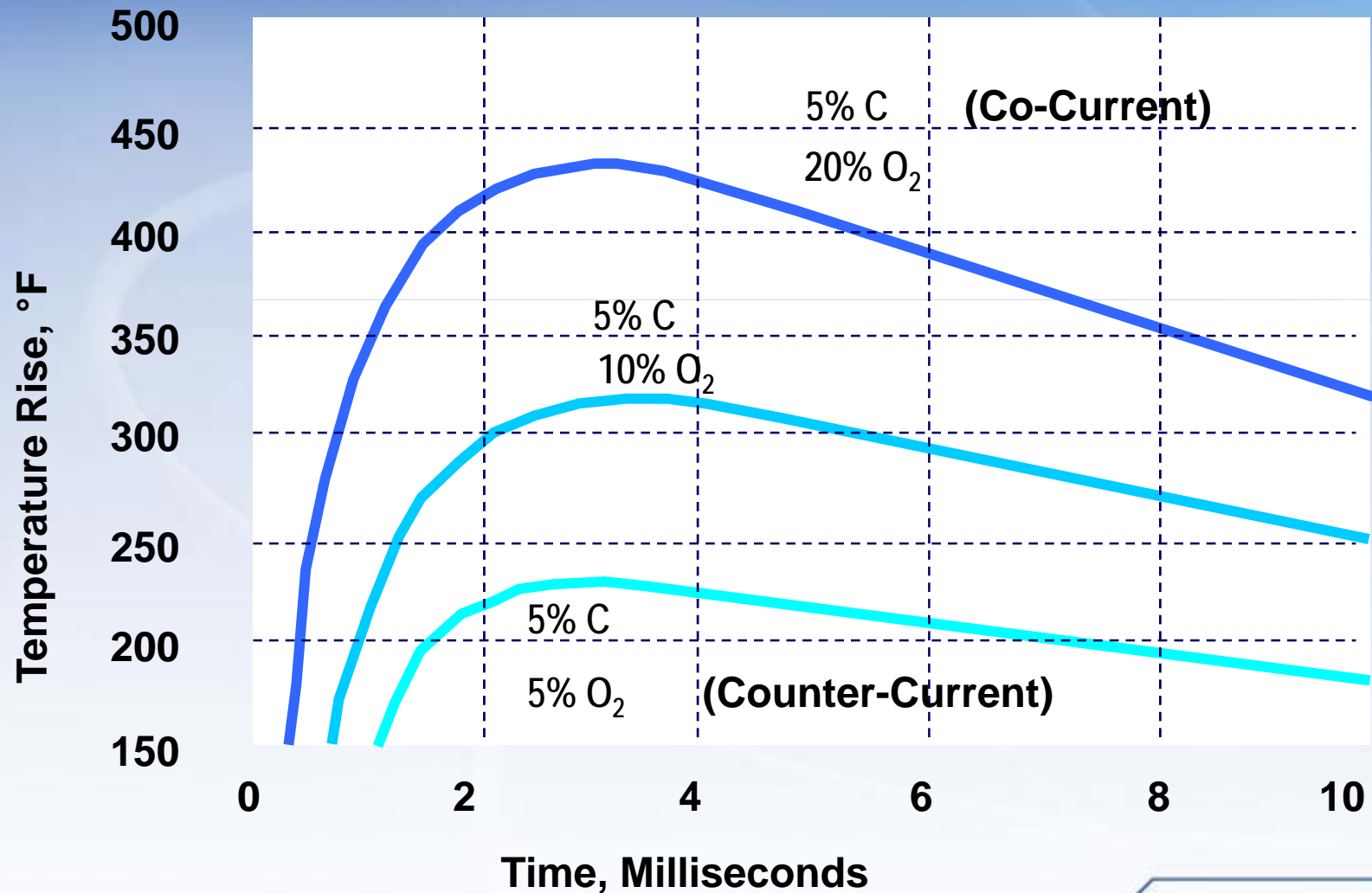
Typical Co-Current Regenerator



Typical Counter-Current Regenerator

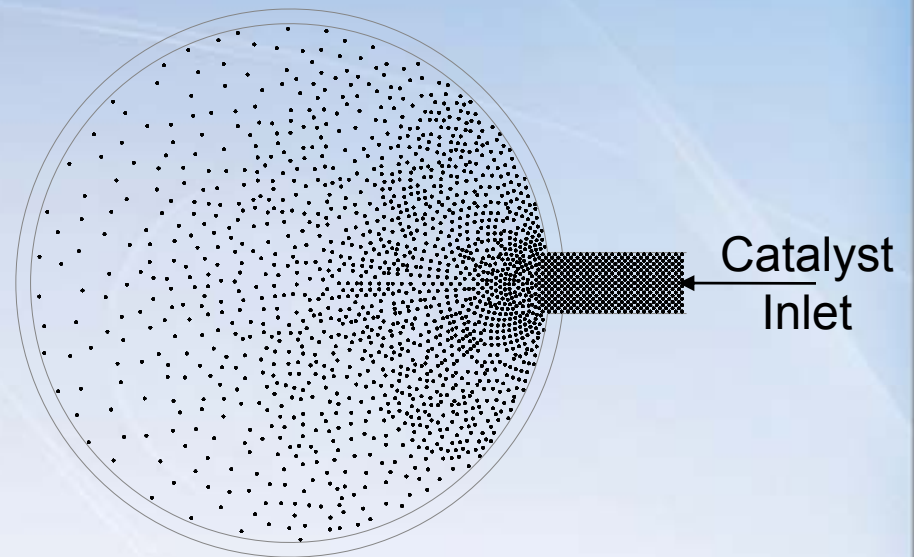


Interior Particle Temperature Rise

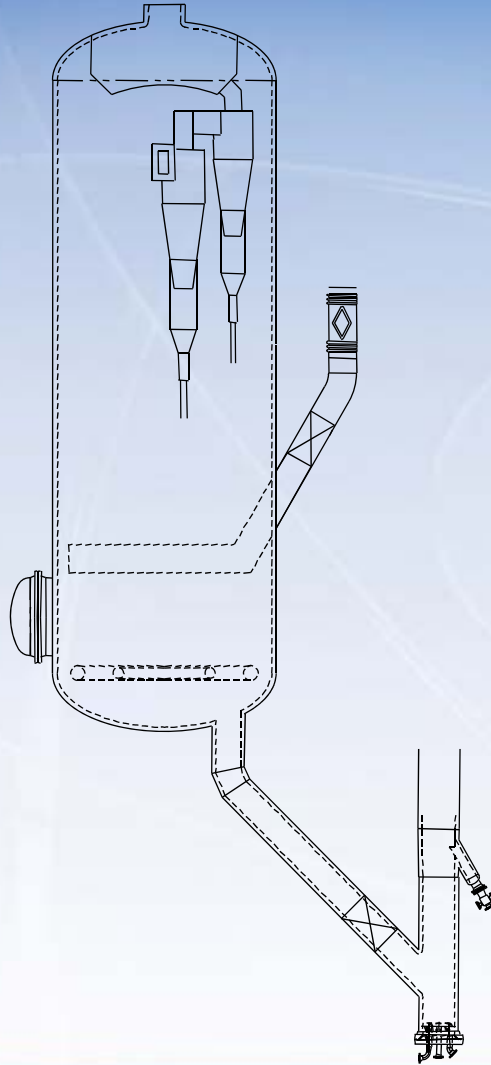


Poor Spent Catalyst Distribution

- Afterburn (burning of CO above the bed) can occur
- CO level can be exceeded
- NOx formation is increased
- High temperatures can damage catalyst



Counter-Current Regenerator with Bathtub Distributor for Low NOx



85M102006D

Regenerator Emissions

- CO
- SO_x
- NO_x
- Particulates (catalyst fines)

SOx Strategies

- Hydrotreatment of the FCC feed
- Minimize coke yield (Reaction technology)
- Use DeSox catalyst additive to control small amounts SOx
- Use wet gas scrubber to control large amounts SOx

NOx Strategies

- Hydrotreatment of the FCC feed
- Minimize coke yield (Reaction technology)
- Ammonia or urea injection (SCR, SNCR)
- Ozone injection

Current Technology for FCC Particulate Removal

- 3rd stage cyclonic separation (80 mg/Nm^3)
- 3rd stage cyclonic separation with 4th stage underflow filter (50 mg/Nm^3)
- Wet gas scrubbing ($10 \text{ to } 20 \text{ mg/Nm}^3$)
- Electrostatic precipitation (10 mg/Nm^3)
- Physical barrier filtration (less than 10 mg/Nm^3)

Current Particulate Requirements

- Developed countries typically 50 mg/Nm³
- FCC power expanders require < 50 mg/Nm³
- Australia moving to 10 mg/Nm³
- Sweden and Switzerland moving to 20 mg/Nm³
- Regulators are pushing for “Best Available Control Technology”

Conclusion

- FCC technology has been enhanced to allow the processing of lower cost, resid-containing feeds
- FCC technology has been improved to produce lighter more valuable products such as propylene and ethylene
- Improved flue gas emissions have been achieved in FCC units by
 - Feed hydrotreating
 - Lower coke yield
 - Regenerator technology
 - FCC catalyst additives
 - Flue gas filtration or scrubbing