#### **FCC Revamp Solutions**



- Chris Santner; Sr Director, Catalytic Cracking Technology Technip Stone & Webster Process Technology
- Coking and CatCracking Conference, New Delhi, October 2013 CatCracking.com





Total - Original developer of RFCC and operator of 14 FCC units, focused on R&D, safety, reliability, and plant economics





IFP - R&D firm dedicated to development of refining technology utilizing catalyst testing, pilot plants, and CFD modeling

Axens - Licensor of FCC and other refining technologies with a strong focus in refinery economics and basic design





Technip S&W – Licensor and Engineering Company providing safe, reliable and cost effective basic and detailed plant designs





## FCC Alliance - Leading the Way in FCC

- FCC Alliance with Total/Axens/IFP
- 55 FCC grassroots units licensed since 1981
  - 40 Resid FCC units
  - 20 FCCs with > 9 wt% propylene
  - 80% market share of resid and C3= FCCs in last 10 years (24 out of 30)
  - Highest customer satisfaction (34 units selected by 12 companies)
- Over 250 revamps worldwide
  - Process improvements
  - Mechanical reliability upgrades
  - Experience with every licensor's design xens





### 55 Grassroots FCC Units Licensed

250 Revamps Using the Same Technology

Fuels FCC – 35 Units

Propylene FCC – 20 Units



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## **High Efficiency Feed Injection**

- Increases conversion and reduces delta coke
- 113 units (55 grassroots, 58 revamps)
- 5.1 million bpd total capacity
- 10 -15 years typical life
- Used to upgrade other licensor's units





#### Feed Nozzle Installation







### Single Slotted Injectors After 10 Years







## **Riser Separator System (RS2)**

- Quickly separate catalyst from gas
- High particle collection efficiency
- No backmixing of vapor products
- Minimum coke and gas
- Maximum liquid yield
- Preserves olefinicity
- Smooth and easy operation
- No catalyst carry over to main fractionator, even during transient operations (contrary to Vortex/Cyclones technologies).







#### **RS<sup>2</sup> Riser Separator**



### **Cold Flow Modeling of Riser Separator**







#### Installation of RS2







### **Reaction System with Post Riser Quench**



External Roughcut Cyclone Internal Roughcut Cyclone

LD2 Axial Cyclone





### **Benefits of Post Riser Quench**

- Reduces dry gas and increases liquid yields
- No risk of catalyst carryover to MF
- Low cost installation
- Quench can be turned off
- Riser outlet can run higher temperature where reactor overhead design temperature is limiting









- Patented by Technip/Axens FCC Alliance
- Koch-Glitsch KFBE<sup>TM</sup> packing supplied exclusively by Technip/Axens
- One 30 cm layer is one equivalent stage
- 8 to 12 layers typical
- Steep blade angle for smooth catalyst flow
- Excellent lateral mixing achieved by:
  - Alternating blade direction
  - Alternating layers rotated 90°
- Wide passages, no plugging







## **Stripper Baffle Internals**



- Require a pinch point to force mixing to occur (50% open area)
- Pinch point creates high flux that induces formation of large bubbles
- Large bubbles prevent good contacting





## **Stripper Packing Internals**



- The packing is actually a mixing element
- Full cross-sectional area used (minus blade width is 95% open)
- Much lower flux is achieved, allowing small bubbles to rise
- Small bubbles promote good contacting





## **Stripper Packing Advantages**

- Higher capacity than baffles
- More equivalent stages than baffles
- Requires less steam
- Less hydrocarbon carry-under, cooler regenerator, higher cat/oil ratio
- Yield improvement with higher cat/oil
- Smoother catalyst flow
- Additional pressure build-up on spent cat standpipe
- Easy to install, less down time
- Lower maintenance



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## **Stripper Packing Fits Through Manway**







## **Reliability – Stripper Packing**

- No erosion, low maintenance
- Will not plug (large openings)
- Proven on heavy resid feeds
- Prevents refractory and coke pieces from blocking spent slide valve
- In the event of damaged steam distributor, steam is totally redistributed in 1 m of packing



Bottom layer after 5 year run





### **Combustion Air Ring**







# **Typical Air Ring Layout**







## Reliability – Regenerator Air Rings

- Robust design, long life
- Simplest geometry for expansion
- No cantilevered arms to avoid oscillations and cyclic fatigue
- Nozzle design minimizes erosion and attrition
- Special refractory and anchor details







## **Catalyst Cooler Features**



- Dense Phase, Downward Catalyst Flow
- Slide Valve Controlled Catalyst Circulation
- Turndown Capability From 0 to 100%
- Individual Tube Modules can be Isolated
- No Tube Sheet Required
- High Mechanical Reliability
- Cold Wall Design
- All Carbon Steel Construction
- High Heat Transfer-Low Tube Wall Temperature



## Cat Cooler Experience

- First installation in 1983
- 68 units in operation
- Over 300 unit-years of operation
- Designed for Atm. and Vac. Resids
- Design duty 8 to 200 Gcal/hr
- 12 to 60 Barg steam pressure



Catalyst Cooler





## Catalyst Cooler Modules







## Catalyst Cooler Bundle







### **Tesoro Mandan Model IV Revamp**

- New external vertical riser
- New feed injection nozzles
- New rough cut cyclone (external)
- Installed reactor vapor quench
- Longer catalyst stripper (more stages)
- 33 day TAR (oil out to oil in)







## Tesoro Mandan Model IV Revamp

#### <u>Results</u>

- Run 6 ½ years without a shutdown
- No major repairs required maintenance
- 8% reduction in dry gas
- Regen temp dropped 10° C
- Gasoline increased 21%
- Slurry gravity went from 0.95 to 1.08
- Smoother startup and operation
- Reduced maintenance







## Yaroslavl 1A/1M Revamp

- New external vertical riser
- New feed injection nozzles
- New rough-cut cyclone (external)
- Added reactor vapor quench
- New external withdrawal well and standpipe
- New air rings in regenerator
- New cyclones in reactor and regenerator







### Yaroslavl 1A/1M Revamp







## FCC Technology – Reactor Side



#### High efficiency feed injection nozzles (113 units)

- Best in the industry since 1981
- 10-plus years service life
- Effective in upgrading existing FCC units

#### Riser separation system (RS<sup>2</sup>) (28 units)

- Minimizes non-selective post-riser cracking
- Stabilizes operation, smooth startup and shutdown
- Eliminates risk of massive catalyst carry-over to main fractionator

#### Post Riser Quench (40 Units)

- Same benefits as RS<sup>2</sup>

#### Stripper Packing (65 units)

- Higher capacity and better contacting than baffles
- Reduces regenerator temperature and stripping steam rate
- Simple installation and less maintenance





## FCC Technology – Regenerator Side









#### Air Ring Distributors (96 regenerators)

- Simple installation and support
- Most resilient design for thermal excursions
- Bathtub Spent Catalyst Distributors (38 units)
  - Effectively distributes catalyst in gravity flow spent catalyst systems
  - Reduces after-burn and NOx

#### Mushroom Grid Spent Catalyst Distributors (56 units)

- In lift-air systems, effectively distributes catalyst and lift air with minimum bypassing and attrition
- Robust, erosion resistant construction

#### Catalyst Coolers (69 units)

- Uses individual tubular modules to eliminate tubesheet
- Single tube failure can be isolated to keep unit on-line
- 100% turn-down flexibility
- Low cost cold-wall carbon steel construction





# Conclusion

- Technology developed for new grassroots
  FCC units can be successfully installed in existing mature FCC units
- With this technology, the utility savings and yield performance of modern grassroots units can be achieved in existing units for a fraction of the installed cost
- Safety, operability, and mechanical reliability can be greatly improved in existing FCCs with the installation of this new technology







#### Technip Stone & Webster Process Technology







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