FCC Feed Injection Technology

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CatCracking.com Safety & Reliability Seminar
Galveston, May 2012

Feed Injection Technology

• Why So Important?
• Process Objectives
• Development History
• Key Design Considerations
• Micro-Jet™ Injector Features
• Commercial Examples
• Areas of Focus
FCC Feed Injection - The Big Picture

• Critical starting point for the conversion process
  – Difficult to recover from a non-optimal starting point
• Continuously impacts the value generation from the unit
• Easy to operate and monitor
• Multiple technology advances across 70 years of FCC history
• Typically easy to revamp and upgrade
• Relatively low investment cost and quick payouts

Effect on FCC Performance

• Directly impacts the conversion and overall yield performance of the unit
  – Dry Gas yield
  – Liquid yield
  – Delta coke / Regenerator temperature
• Feed circuit capacity / hydraulics
• Steam usage / sour water production
• Equipment erosion
• Equipment coking
• Catalyst attrition
Process Objectives

• Provide thorough and uniform contact of the feed with the regenerated catalyst
  – Essential for the required heat transfer
  – Provides access of the feed molecules to the catalyst active sites

• Provide instantaneous feed vaporization
  – Critical to achieve desired reaction paths and yields
  – Inhibits thermal cracking reactions that increase dry gas and coke

• Minimize oil side pressure drop
  – Maintain capacity through the feed preheat circuit

• Provide wide range of operation
  – Maintain performance from turndown to max throughput

Process Objectives

• Maximize the surface area contact between the oil feed and circulating catalyst
  – Surface area maximized by dividing the liquid feed into small droplets
  – Condition of circulating regenerated catalyst also critical
There has been considerable evolution in feed injection technology over the last 7 decades:

- **Open pipes**
  - Used in early FCC unit designs
  - Axial injection at bottom of the riser
  - Single pipe, multiple pipes (i.e. Christmas Tree)
  - Multiple pipes with common cap (Showerhead)

- **Open pipes, radial injection**
  - Multiple open pipes located farther up the riser
  - Lift or fluidization steam at riser bottom
  - Cone spray

- **Slotted cap, radial injection**
  - Flat fan spray, single point contact of the catalyst and feed
Development History

• Slotted caps, two levels, radial injection
  – Second level to contact the catalyst that might escape the first level

• Slotted caps atomizing Injectors
  – Impact-type of injectors, use of high pressure to atomize the feed
  – Single level radial injection
  – Two slots in the cap instead of one

• Multiple openings in the cap, atomization with moderate feed pressure
  – Multiple orifices in the cap to distribute feed evenly across the cap
  – Flat fan spray
  – Use energy of steam to atomize the feed

Key Design Considerations

• Efficient feed atomization
  – Formation of smaller droplets to support catalytic reactions and heat transfer
  – Uniform droplet size for consistency

• Low oil side pressure drop to produce the atomization
Key Design Considerations

- Thorough contact of the feed and catalyst across entire riser cross-section
  - Optimal number of injectors
  - Optimal injection angle
  - Injector spray pattern
- Optimal exit velocity
  - Provide velocity for required jet penetration
  - Minimize catalyst attrition and erosion
- Efficient use of steam
- Minimize potential to plug
- Protection of the injector tip

Key Design Considerations

- Minimize injector erosion (internal and external) to maximize reliability
  - Optimal exit velocity
  - Robust mechanical design
  - Account for specific riser design and operation
- Provide for ease of injector extraction from nozzle / sleeve
- Condition of circulating catalyst is critical to effectiveness of the feed injectors
  - Catalyst density and fluidization profile across riser
  - Uniform mixing and cat/oil across riser
  - Must evaluate in unison with the injectors
**Micro-Jet™ Feed Injector**

- Proprietary tip design to deliver flat spray pattern
- Three stage atomization
  - Liquid atomization
  - Liquid droplets further sheared by steam
  - Flat fan spray into catalyst stream
- No use of lift steam – only minimal fluffing steam
- Low oil feed injection pressure
- Special metallurgy and tip design for improved reliability

Benefits include:
- Increased conversion and yield of valuable light products
- Low delta coke – ability to process heavier feed and / or similar advantages
- No loss of performance at turndown
- Robust and durable
- Every injector spray tested
Micro-Jet Feed Injector Spray Test

Potential Injector Layout

SECTION A-A
**Commercial Examples**

### Refinery A
Replaced atomizing feed injector with high dP requirement

<table>
<thead>
<tr>
<th></th>
<th>Pre-Revamp</th>
<th>Post-revamp</th>
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<tbody>
<tr>
<td>Yields, vol%</td>
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<td></td>
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<tr>
<td>LPG</td>
<td>Base</td>
<td>+1.7</td>
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<tr>
<td>Gasoline</td>
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<tr>
<td>Conversion</td>
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<tr>
<td>Feed Booster</td>
<td>In use</td>
<td>Shutdown</td>
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<tr>
<td>Pump</td>
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### Refinery B
Replaced atomizing feed injector and riser

<table>
<thead>
<tr>
<th></th>
<th>Pre-revamp</th>
<th>Post-revamp</th>
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<tbody>
<tr>
<td>Yields, vol%:</td>
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</tr>
<tr>
<td>LPG</td>
<td>Base</td>
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<tr>
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<tr>
<td>Reg. Temp</td>
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<tr>
<td>Lift Steam</td>
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<td>not needed</td>
</tr>
</tbody>
</table>
Commercial Examples

Refinery C
Replaced multiple pipe, non-atomizing injectors

Areas of Focus

• Further reliability improvements to mitigate injector erosion
  – Extend run times before replacement
  – Metallurgical advancements
  – Ceramics
• Use of CFD modeling in design practices
  – Advancement in CFD tools have made this practical
  – Also used to validate field observations
• Ease of injector extraction
• Next generation advancements
Thank You!

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