FCC Feed Injection Technology

Paul D. Wendt
FCC Technology Manager
Lummus Technology

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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

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- 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

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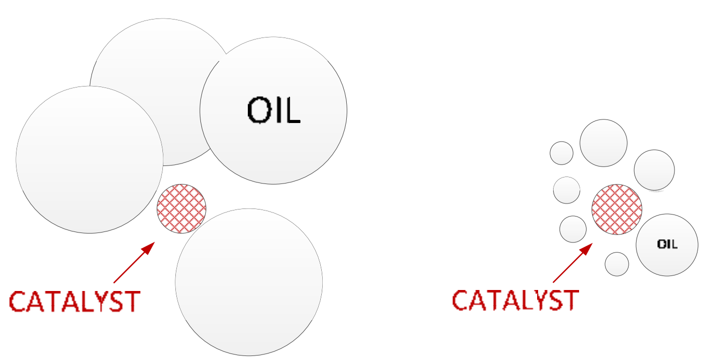
- Directly impacts the conversion and overall yield performance of the unit
  - Dry Gas yield
  - Liquid yield
  - Delta coke / Regenerator temperature
- Feed circuit capacity / hydraulics
- Steam usage / sour water production
- Equipment erosion
- Equipment coking
- Catalyst attrition

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

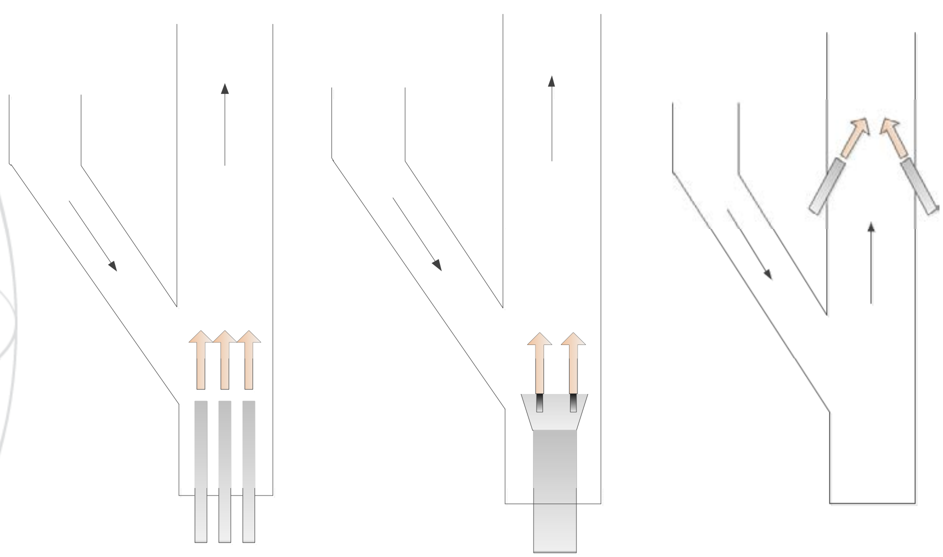


Development History

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



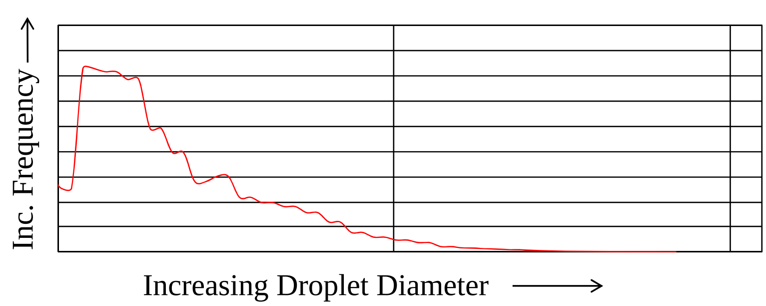
Open Pipes, Axial   Showerhead, Axial   Elevated, Radial

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

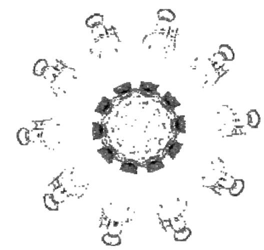
Key Design Considerations

- 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

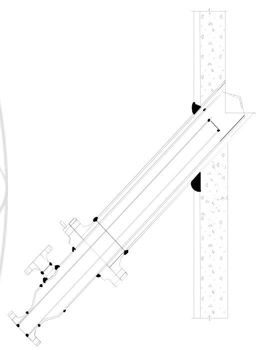
- Thorough contact of the feed and catalyst across entire riser cross-section
  - Optimal number of injectors
  - Optimal injection angle
  - Injector spray pattern
- Optimal exit velocity
  - Provide velocity for required jet penetration
  - Minimize catalyst attrition and erosion
- Efficient use of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

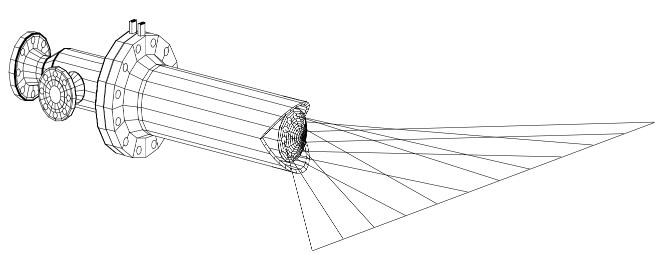


- Proprietary tip design to deliver flat spray pattern
- Three stage atomization
  - Liquid atomization
  - Liquid droplets further sheared by steam
  - Flat fan spray into catalyst stream
- No use of lift steam – only minimal fluffing steam
- Low oil feed injection pressure
- Special metallurgy and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

Micro-Jet Feed Injector

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

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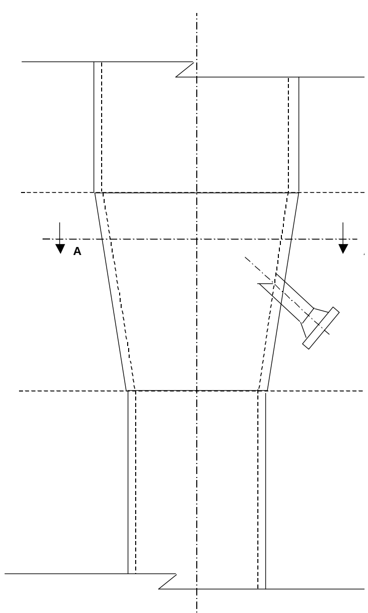
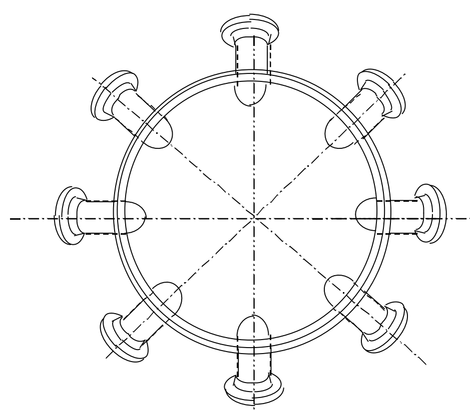
Potential Injector Layout





SECTION A-A

3D Piping Model Shot

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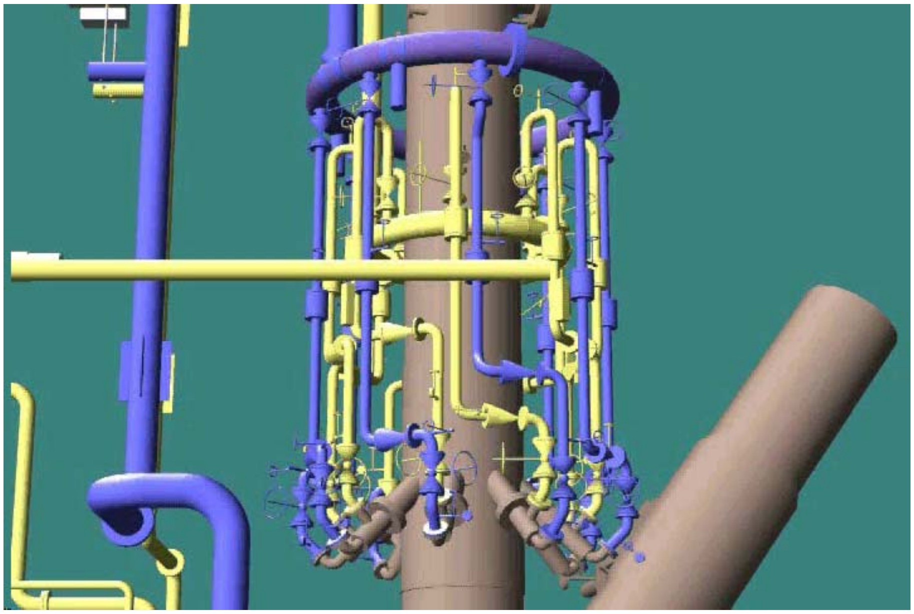

Feed Injector Revamp

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Commercial Examples

Refinery A

Replaced atomizing feed injector with high dP requirement

	Pre-Revamp	Post-revamp
Yields, vol%		
LPG	Base	+1.7
Gasoline	Base	+1.3
Conversion	Base	+2.1
Feed Booster Pump	In use	Shutdown

Commercial Examples

Refinery B

Replaced atomizing feed injector and riser

	Pre-revamp	Post-revamp
Yields, vol%:		
LPG	Base	+2.0
Gasoline	Base	+4.5
Conversion	Base	+4.1
Reg. Temp	Base	-10 F
Lift Steam	in use	not needed

Commercial Examples

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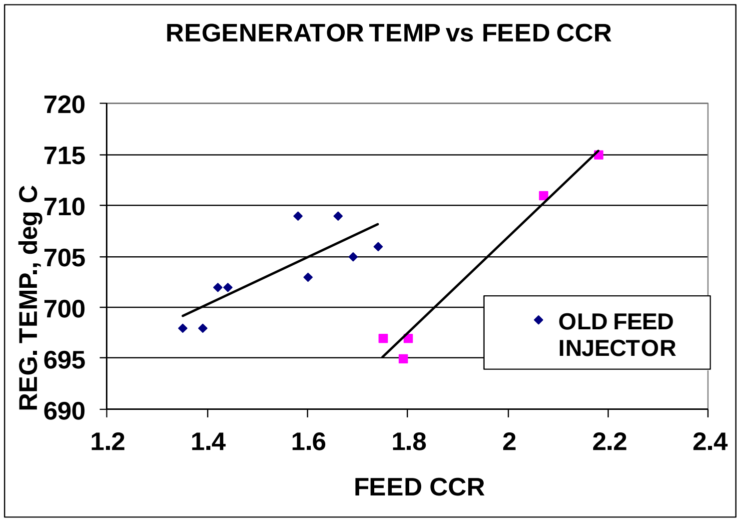
Refinery C

Replaced multiple pipe, non-atomizing injectors



Areas of Focus

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- 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!

Paul D. Wendt
FCC Technology Manager
Lummus Technology

pwendt@cbi.com
(713)375-8358