Radiotracer Investigations in an Industrial-scale Fluid Catalytic Cracking Unit (FCCU)

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Fluid Catalytic Cracking

Fluidized Catalytic Cracking is a process used in petroleum refining for production of petrol, diesel, naphtha, ATF and LPG.

The process utilizes a micro-spherical zeolitic catalyst which fluidizes when it comes in contact with heated crude oil resulting in conversion high-boiling petroleum fractions to more useful products.

The process is carried out in a unit called Fluid Catalytic Cracking Units (FCCU), consisting of four sub-systems named as riser reactor, stripper, disengager and regenerator.
Why Radiotracer Investigations?

- The efficiency and quality of the products produced in a FCCU depends upon flow parameters such as residence times, velocities, slip factor, axial and radial mixing of the flowing phases.

- A radiotracer investigation was carried in an industrial FCCU in a refinery in INDIA to measure the various flow parameters before revamping, stepping up the production and modification of design of some of the components.
## Radiotracer Investigations

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Section (Sub-system)</th>
<th>Phase</th>
<th>Tracer</th>
<th>Activity used</th>
<th>Det. points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Riser</td>
<td>Catalyst</td>
<td>La-140</td>
<td>60 mCi</td>
<td>15</td>
</tr>
<tr>
<td>2.</td>
<td>Riser</td>
<td>Catalyst</td>
<td>La-140</td>
<td>50 mCi</td>
<td>15</td>
</tr>
<tr>
<td>3.</td>
<td>Riser</td>
<td>Gas</td>
<td>Kr-79</td>
<td>213 mCi</td>
<td>15</td>
</tr>
<tr>
<td>4.</td>
<td>Stripper (N)</td>
<td>Gas</td>
<td>Kr-79</td>
<td>192 mCi</td>
<td>13</td>
</tr>
<tr>
<td>5.</td>
<td>Stripper (S)</td>
<td>Gas</td>
<td>Kr-79</td>
<td>188 mCi</td>
<td>13</td>
</tr>
<tr>
<td>6.</td>
<td>Stripper (S)</td>
<td>Catalyst</td>
<td>La-140</td>
<td>40 mCi</td>
<td>13</td>
</tr>
<tr>
<td>7.</td>
<td>Stripper (N)</td>
<td>Catalyst</td>
<td>La-140</td>
<td>40 mCi</td>
<td>13</td>
</tr>
<tr>
<td>8.</td>
<td>Regenerator</td>
<td>Gas</td>
<td>Kr-79</td>
<td>115 mCi</td>
<td>10</td>
</tr>
<tr>
<td>9.</td>
<td>Regenerator</td>
<td>Catalyst</td>
<td>La-140</td>
<td>10 mCi</td>
<td>10</td>
</tr>
<tr>
<td>10.</td>
<td>Regenerator</td>
<td>Catalyst</td>
<td>La-140</td>
<td>20 mCi</td>
<td>10</td>
</tr>
</tbody>
</table>

**Krypton-79,**  
*Half-life: 36 hrs, Gamma energy: 0.52 Mev*

**Lantanum-140 as irradiated catalyst**  
*(Half-life: 40 hrs, Gamma energies: 0.92 Mev, 2.54 Mev)*
Radiotracer Injection and Monitoring

b. Detector orientation for disengager

La-140 injection for regenerator

Kr-79 and La-140 injection for stripper

D13a, D8b
D11a, D6a
D13a, D8b
D9b
D7a
D5a
Combustion air

Kr-79 injection for regenerator

Kr-79 and La-140 injection for riser and reactor

Disengager

Stripper

La-140 injection for regenerator

D7a
D5, D2
D11, D6, D3
Typical Radiotracer Curves (Solid Phase)

![Graph showing radiotracer curves for different phases.](image)

- Peak due to washing of injection system.
Results: Radial Distribution

- Riser reactor: Gas phase (Good)
- Stripper: Gas phase (Poor)
- Disengager: Gas phase (Poor)
- Regenerator: Gas phase (Poor)
- Disengager: Catalyst (Poor)
Results (Riser): MRT, velocities, Slip factor

<table>
<thead>
<tr>
<th>Detector Nos. Table</th>
<th>Distance (m)</th>
<th>MRT(s)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(2,3,4)-D(5,6,7)</td>
<td>15.87</td>
<td>2.4</td>
<td>6.6</td>
</tr>
<tr>
<td><strong>Gas phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(2,3,4)-D(5,6,7)</td>
<td>15.87</td>
<td>1.5</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Slip factor = Velocity of gas phase/Velocity of solid phase = 1.6

Axial dispersion (Riser)

<table>
<thead>
<tr>
<th>Solid phase</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectors</td>
<td>T</td>
<td>Pe</td>
</tr>
<tr>
<td>D3 – D6</td>
<td>2.1</td>
<td>7.4</td>
</tr>
</tbody>
</table>
Results of Model Simulations (ADM)

Solid phase in riser

Experimental MRT: 2.4 s
- Mean of D2, D3, D4
- Mean of D5, D6, D7
- ADM Simulated
  MRT: 2.1 s, Pe: 8

Gas phase in riser

Experimental MRT: 1.47 s
- Mean of D2, D3, D4
- Mean of D5, D6, D7
- ADM Simulated
  MRT: 1.41 s, Pe: 84

Gas phase in regenerator

Experimental (D13)
- ADP Model simulated
  ($\tau=14.6$ s, $P=17.3$)

Gas phase in Stripper

Experimental
- Model
Conclusions

• Radiotracer investigations were successfully carried out to measure flow parameters in an industrial-scale FCCU.

• The results of the investigation were utilized for process intensification, design modification and process optimization.