A new inductively heated mini reactor for biomass pyrolysis and gasification tests

Cedric Briens
ICFAR

Mohammad Latifi
ICFAR

Franco Berruti
ICFAR

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A New Inductively Heated Mini Reactor for Biomass Pyrolysis and Gasification Tests

Mohammad Latifi, Franco Berruti, Cedric Briens

London, Ontario CANADA
Many important catalytic reactions are endothermic e.g.:
  • Catalytic cracking
  • Gasification

Issues with traditional test reactors:
  • Heat is transferred from the wall into reactor
    • Low heat transfer coefficient:
      → High temperature gradient
      → Parasitic thermal cracking reactions
  • Seals for agitator may leak
Solutions

- Batch reactor
  → good control of residence time
Solutions

- Batch reactor
  → good control of residence time

- Low temperature difference between heating surface and catalyst bed:
  → induction heating of rods within bed
Solutions

• Batch reactor
  → good control of residence time

• Low temperature difference between heating surface and catalyst bed:
  → induction heating

• No mechanical seal
  → jiggle bed
  (up and down motion)
• Batch reactor
  → good control of residence time

• Low temperature difference between heating surface and catalyst bed:
  → induction heating

• No mechanical seal
  → jiggle bed
  (up and down motion)
Optimum frequency and amplitude

- Analysis of color variations
Heat transfer performance

Heat transfer coefficient from metal rods to catalyst bed

For various conditions:

\[ h_w \left( \frac{w}{m^2 \cdot ^\circ C} \right) \]

<p>| | |</p>
<table>
<thead>
<tr>
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<tr>
<td>45</td>
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<td>220</td>
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</table>

→ similar to what can be obtained in a fluidized bed
Comparing with studies with pilot plant fluidized catalytic reactors

- Catalytic cracking of acetic acid

<table>
<thead>
<tr>
<th>Molar steam to carbon ratio = 6</th>
<th>Molar steam to carbon ratio = 3</th>
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<tbody>
<tr>
<td><strong>Catalysts tested by Medrano et al. (2009)</strong></td>
<td><strong>Catalysts tested by Vagia and Lemonidou (2010)</strong></td>
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<tr>
<td><strong>Catalyst</strong></td>
<td><strong>Ni/Al, Ca0.5</strong></td>
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<tr>
<td>H2</td>
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<tr>
<td>CO</td>
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<tr>
<td>C2H4+C2H6</td>
<td>0.00</td>
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<tr>
<td>Conversion</td>
<td>0.90</td>
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</tbody>
</table>

→ excellent agreement between JBR results and pilot plant fluidized beds
Gasification of bio-oil

- **Bed:**
  - 10 g of sand (106-220 µm)
  - commercial catalyst (two catalysts were tested)

- **Liquid feedstock:**
  - 4 µl injected
  - Two types of bio-oils from wood pyrolysis:
    - Oak bio-oil produced by Dynamotive (DMB)
    - Birch wood bio-oil produced at 475 °C at ICFAR (BWB)
Gasification of bio-oil

30 s residence time

No catalyst

Catalyst

0.5 g

1 g
Gasification of bio-oil

30 s residence time

No catalyst

Catalyst

1 g

0.5 g

molar H₂/CO

Temperature, °C

Temperature, °C
Gasification of bio-oil

800 °C, 30 s residence time

Birch wood bio-oil

Carbon conversion

Catalyst mass, g

Catalyst X
Catalyst Y
Conclusions

- The jiggle bed reactor:
  - effective batch micro reactor for catalyst testing
  - convenient
  - ideal for endothermic reactions

- Simulates typical fluidized bed reactors