Combustion of Biomass Pellets in Fluidized Bed Reactor

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Background

• Is the world getting warmer?

• If so, what are the causes of this global climate change.

• Are the actions of mankind to blame for earth’s temperature increases?

• What should be done about these issues?
Key Indicators

- 10 of the warmest years occurring in the past 12 years.

- The oceans have absorbed much heat, with the top 700 m of ocean showing warming of 0.302°F since 1969.

- Thickness of Arctic sea ice has declined rapidly over the last several decades.
Key Indicators

- Global sea-level rose about 17 cm in the last century.
- The Greenland and Antarctic ice sheets have decreased in mass.
- Greenland lost 150–250 km$^3$ of ice per year.
- Antarctica lost about 152 km$^3$ of ice between 2002 and 2005.
The current warming trend is of particular significance because most of it is very likely human-induced.

Carbon dioxide (CO$_2$) is the largest contributor, accounting for more than 63% of the total that contributes to global warming.

The CO$_2$ is released in the atmosphere due to direct burning of fossil fuels.
Global Energy Usage

- Today world’s 84% energy comes from oil, coal, and natural gas all of which are fossil fuels.
- Power plants account major source for the CO₂ emissions about 41% of the total emissions.
- Capturing CO₂ at large point sources where it is quite concentrated makes sense.
- Now it’s need to increase the use of renewable fuels.
Experimental Setup

Pilot scale bubbling fluidized bed reactor (BFBR) was designed, manufactured and commissioned.

- Capacity 20 kW
- Sand diameter \((d_{32})\) 0.78 mm.
- Bed height 250 mm
- Feed rate 3-5 kg/h
- Air flow rate 350 L/min
- Biomass pellet size 10-20 mm
- Average bed temperatures 750-850 °C
Biomass Fuels

Biomass fuel samples tested in the feeder; a) Miscanthus pellets, b) Wood pellets, c) Straw pellets.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>N</th>
<th>C</th>
<th>H</th>
<th>S</th>
<th>O</th>
<th>Moisture</th>
<th>Volatiles</th>
<th>Fixed Carbon</th>
<th>Ash</th>
<th>HHV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscanthus Pellets</td>
<td>0.36</td>
<td>46.87</td>
<td>6.12</td>
<td>0.00</td>
<td>46.65</td>
<td>3.34</td>
<td>80.09</td>
<td>14.86</td>
<td>1.77</td>
<td>18.71</td>
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<tr>
<td>Straw Pellets</td>
<td>0.53</td>
<td>43.38</td>
<td>5.98</td>
<td>0.00</td>
<td>50.11</td>
<td>5.22</td>
<td>72.33</td>
<td>16.63</td>
<td>6.15</td>
<td>16.87</td>
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<tr>
<td>Wood Pellet</td>
<td>0.22</td>
<td>48.30</td>
<td>6.31</td>
<td>0.00</td>
<td>45.17</td>
<td>3.94</td>
<td>81.76</td>
<td>13.63</td>
<td>0.70</td>
<td>19.61</td>
</tr>
</tbody>
</table>

*Channiwala, S. and P. Parikh, 2002
Results: Feeding System

- Linear feeding rates were observed with all types of tested fuels.
- MP feed rate was the highest, followed by SP and WP at the end.
Results: Temperature Profiles

- Temperature profiles under different conditions 10, 15, 30 and 45% excess air.

- Smooth profiles were observed even beyond 5 hours of continuous feeding.
Results: Miscanthus Pellets

- Temperatures show increasing trend increase with decrease of oxygen in flue gas.
Results: Miscanthus Pellets

- CO$_2$ and CO concentrations decrease with an increase in oxygen level in flue gas.
- NOx concentration increases with increase of oxygen in flue gas.

Oxygen in flue gas against gas composition, NOx corrected at 6% Oxygen.

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- CO$_2$ and CO concentrations decrease with an increase in oxygen level in flue gas.
- NOx concentration increases with increase of oxygen in flue gas.
Conclusions

- The Temperature are almost similar due to same amount of fuel input.

- The $\text{CO}_2$ concentration is higher due to fines in the biomass pellets.

- NO$\text{x}$ emission are associated with the fuel NO$\text{x}$.

- The CO concentration is higher in wood pellets about 0.6 vol%.

- The higher CO contends are also due not enough residence time.
Future Work

• Different biomass fuels will be tested under air with different conditions.

• The air staging studies will be carried out with different fuels to control the NOx emissions.

• The studied fuels will also be tested under Oxy-fuel conditions.
Thank You!
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