Solid recovered fuel gasification in sliding bed reactor

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Motivation for WtE

- Waste minimalisation
- Economic feasibility
- Energy demand
  - Heat
  - Electricity
Gasification technology

Sliding bed over circular grate

Cross/Updraft

Atmospheric air

10-60 kg/h

200 kW power input

650-950 °C

Autothermal
**Fuel**

60 % - Unrecyclable **plastics, wood, paper** and **textiles** from municipal and industrial waste

40 % - Soft-wood pellets

### SRF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plastics</th>
<th>Wood</th>
<th>Paper</th>
<th>Textiles</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>45 %</td>
<td>30 %</td>
<td>20 %</td>
<td>4 %</td>
<td>1 %</td>
</tr>
</tbody>
</table>

### SRF/wood mixture

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Volatile</th>
<th>Water</th>
<th>Ash</th>
<th>Carbon</th>
<th>Oxygen</th>
<th>Hydrogen</th>
<th>Nitrogen</th>
<th>Sulphur</th>
<th>LHV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>77.3 %</td>
<td>7.1 %</td>
<td>3.9 %</td>
<td>48.2 %</td>
<td>33.6 %</td>
<td>6.2 %</td>
<td>1.0 %</td>
<td>0.1 %</td>
<td>18.2 MJ/kg</td>
</tr>
</tbody>
</table>
1) Raw gas duct
2) Heated sampling probe
3) Heated glass filter unit
4) Impinger bottles (cooling)
5) Tar analysis
6) Impinger bottles (freezing)
7) Active coal filtration
8) Pump
9) Flow regulator
10) Chemical composition analyser
11) Flowmeter
12) Gas outlet
# Experiment

The experimental conditions in four different rounds

<table>
<thead>
<tr>
<th>Experiment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalence ratio</td>
<td>0.04</td>
<td>0.06</td>
<td>0.08</td>
<td>0.12</td>
<td>[-]</td>
</tr>
<tr>
<td>Temperature</td>
<td>938.8</td>
<td>941.9</td>
<td>1005.4</td>
<td>935.8</td>
<td>[K]</td>
</tr>
<tr>
<td>Relative pressure</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.1</td>
<td>[kPa]</td>
</tr>
<tr>
<td>Fuel flow</td>
<td>48.5</td>
<td>48.6</td>
<td>50.3</td>
<td>14.2</td>
<td>[kg/h]</td>
</tr>
<tr>
<td>Air flow</td>
<td>9.0</td>
<td>14.8</td>
<td>18.3</td>
<td>9.8</td>
<td>[m³/h]</td>
</tr>
</tbody>
</table>
Results

Process

Char

Syngas

Pollutants
# Results - Syngas

<table>
<thead>
<tr>
<th>Experiment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>[m³/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas flow</td>
<td>41</td>
<td>50</td>
<td>48</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>15.7</td>
<td>9.3</td>
<td>9.3</td>
<td>5.8</td>
<td>[% vol.]</td>
</tr>
<tr>
<td>H₂</td>
<td>0</td>
<td>2.9</td>
<td>3.3</td>
<td>1.8</td>
<td>[% vol.]</td>
</tr>
<tr>
<td>CH₄</td>
<td>8.8</td>
<td>3.6</td>
<td>3.5</td>
<td>4.3</td>
<td>[% vol.]</td>
</tr>
<tr>
<td>LHV</td>
<td>5.0</td>
<td>2.7</td>
<td>2.7</td>
<td>2.4</td>
<td>[MJ/m³]</td>
</tr>
</tbody>
</table>

T = 293 K and p = 101325 Pa
Results - Char

Char yield = 10-20% (of the initial material weight)

\[ C^d = 75.5 \pm 6.2\% \text{ wt.} \]

\[ A^d = 10.3 \pm 4.8\% \text{ wt.} \]
## Results - Pollutants

<table>
<thead>
<tr>
<th>Experiment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling flow rate</strong></td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Particulate matter</strong></td>
<td>1.7</td>
<td>1.9</td>
<td>5.0</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Tar compounds</strong></td>
<td>n.a.</td>
<td>2.2</td>
<td>1.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

T = 293 K and p = 101325 Pa
Results - Pollutants

The chart depicts the results of a study on various pollutants, showing both the concentration (quantity) and peak area (quality) for Benzene, Toluene, C8H10, Styrene, Phenol, Indene, and Naphthalene. The pollutants are measured against a concentration scale in grams per cubic meter (g/m³).
Process efficiency in terms of syngas production

**Equivalence Ratio**

Cold Gas Efficiency - Hot Gas Efficiency

\[ y = 21193x^2 - 2844.3x + 128.82 \]

\[ R^2 = 0.9949 \]

\[ y = 18523x^2 - 2642.3x + 118.27 \]

\[ R^2 = 0.9995 \]
Conclusion

Solid waste gasification can be performed

- In combination with wood
- In very low ER regime – down to 0.04
- With satisfying syngas quality – up to 5 MJ/m$^3$
- With interesting char production
- With promising production of polluting agents
  - Tars below 2.3 g/m$^3$
Thank you for your attention

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