HTW™ Gasification of High Volatile Bituminous Coal

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Structure of Presentation

- Introduction of the HTW™ Process
- Brief description of the test setup
- Feedstock
- Test results
  - Continuous operation
  - Compact results
- Optimization
- Summary and Outlook
Introduction of the HTW™ Process

a) Continuous extraction of bed material

b) Injection of gasification agents (O₂, Steam, CO₂)

c) T below ash softening point (850 – 950 °C)

d) High T → conversion of heavy hydrocarbons up to 1,200 °C

e) Recirculation of particles separated in cyclone to the fluidized bed
Pilot Plant

- 2015 retrofitting of a fluidized bed reactor into a HTW™ gasifier
- Investigation of
  - Feedstock suitability
  - Equipment for large-scale plant usage
- Gasifier
  - Inner diameter of 400 mm
  - Height of 11 m
  - Temperatures up to 1,200 °C
  - Operating at atmospheric pressure level
Pilot Plant

feed

HTW™ gasifier

raw gas cooler

feeding system

combustion air

gasification medium

bottom ash

combustion chamber

bag filter

induced draft fan

stack

Source: ESTTU Darmstadt

Energy Systems and Technology
Prof. Dr.-Ing. B. Epple

Source: ESTTU Darmstadt

feed HTW™ gasifier

combustion air

gasification medium

bottom ash

combustion chamber

bag filter

induced draft fan

stack

Source: ESTTU Darmstadt
Feedstock

- High Volatile Bituminous Coal (HVBC) prepared by grinding
- Continious operation for 5 days (7.4 tons)

<table>
<thead>
<tr>
<th></th>
<th>HVBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Heating Value</td>
<td>MJ/kg</td>
</tr>
<tr>
<td>Ash Softening Point</td>
<td>°C</td>
</tr>
<tr>
<td>Water Content</td>
<td>wt.-%</td>
</tr>
<tr>
<td>Ash Content</td>
<td>wt.-%</td>
</tr>
<tr>
<td>C-fix</td>
<td>wt.-%</td>
</tr>
<tr>
<td>Volatile Content</td>
<td>wt.-%</td>
</tr>
<tr>
<td>D50</td>
<td>µm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Heating Value</td>
<td>29.1</td>
</tr>
<tr>
<td>Ash Softening Point</td>
<td>1,100</td>
</tr>
<tr>
<td>Water Content</td>
<td>5.7</td>
</tr>
<tr>
<td>Ash Content</td>
<td>7.0</td>
</tr>
<tr>
<td>C-fix</td>
<td>52.6</td>
</tr>
<tr>
<td>Volatile Content</td>
<td>34.7</td>
</tr>
<tr>
<td>D50</td>
<td>402</td>
</tr>
</tbody>
</table>

Source: Wuhan Erun technology co.,ltd
Operation with high volatile bituminous coal

- Continuous operation

- $T_{\text{Bed}} \approx 915 \, ^\circ\text{C}$
- $\Delta p_{\text{total}} \approx 110 \, \text{mbar} - 120 \, \text{mbar}$
- $T_{\text{PGZ}} \approx 945 \, ^\circ\text{C}$
Operation with high volatile bituminous coal

- Continuous operation
### Summary of results

**Comparison of test results with High Volatile Bituminous Coal and Lignite Energy Grained**

<table>
<thead>
<tr>
<th></th>
<th>HVBC</th>
<th>LEG</th>
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<tbody>
<tr>
<td><strong>Coal mass flow</strong></td>
<td>kg/h</td>
<td>61.0</td>
</tr>
<tr>
<td><strong>Gasifier performance</strong></td>
<td>kW&lt;sub&gt;th&lt;/sub&gt;</td>
<td>493</td>
</tr>
<tr>
<td><strong>Raw gas quantity</strong></td>
<td>kg/h</td>
<td>221.4</td>
</tr>
<tr>
<td><strong>Gas composition (dry)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Vol.-%</td>
<td>48.7</td>
</tr>
<tr>
<td>CO</td>
<td>Vol.-%</td>
<td>23.1</td>
</tr>
<tr>
<td>CH&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Vol.-%</td>
<td>1.9</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Vol.-%</td>
<td>26.3</td>
</tr>
<tr>
<td><strong>Lower heating value raw gas (dry)</strong></td>
<td>MJ/m³</td>
<td>6.4</td>
</tr>
<tr>
<td><strong>Carbon conversion rate</strong></td>
<td>%</td>
<td>75.7</td>
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</table>
Optimization

Original

Cyclone

Loop Seal

Gasification agents

Optimization

New Design

Source: EST TU Darmstadt
# Optimization

## Impact of the optimization

<table>
<thead>
<tr>
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<th>Campaign</th>
<th>Optimization</th>
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<tr>
<td>CO₂ Vol.-%</td>
<td>48.7</td>
<td>36.4</td>
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<td>CO Vol.-%</td>
<td>23.1</td>
<td>28.8</td>
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<tr>
<td>CH₄ Vol.-%</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>H₂ Vol.-%</td>
<td>26.3</td>
<td>32.7</td>
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<tr>
<td><strong>Lower heating value raw gas (dry)</strong> MJ/m³</td>
<td>6.4</td>
<td>7.9</td>
</tr>
<tr>
<td><strong>Carbon conversion rate</strong></td>
<td>%</td>
<td>94</td>
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</tbody>
</table>
Summary and Outlook

- Gasification test
  - Continuous operation for 5 days with high volatile bituminous coal (gasification of 7.4 tons)
  - Stable process, resilient to disruptions

- Optimization for the pilot plant operation include:
  - New design of cyclone
  - Removal of loop seal
  - Increasing preheating temperature of the gasification agents

- Prove that the HTW™ gasification is applicable to the High Volatile Bituminous Coal
Summary and Outlook

FABIENE:
Flexible Supply of Electricity and Fuels from Gasification of Lignite in a Fluidized Bed

- Erection of a gas purification unit
- Coupling with the existing HTW™ gasification pilot plant and a catalysis test rig of RWE
- 4 two-week test campaigns
- Techno-Economic assessment of polygeneration based on fluidized bed gasification
- Christian Heinze, TU Darmstadt
- 11:50 – 12:10
- Room: Pavillon
Thank you for your kind attention!