Development of a Vertical Chamber Coking Oven for upgrading Lignites or Sub-Bituminous Coal

ECIC 2016 | Cokemaking, Design and Equipment

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Technische Universität Bergakademie Freiberg
Vertical Chamber Oven – VCO

Content

- Motivation for VCO
- Coke plant portfolio
- Process
- Development of the VCO
- Summary and Outlook
Vertical Chamber Oven – VCO

Content

Motivation for VCO

Coke plant portfolio

Process

Development of the VCO

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Motivation for VCO

### Volatiles [% daf]

<table>
<thead>
<tr>
<th>UN-ECE</th>
<th>Germany (DIN)</th>
<th>Volatiles [% daf]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat</td>
<td>Peat</td>
<td>&gt; 45</td>
</tr>
<tr>
<td>Ortho-Lignite</td>
<td>Brown Lignite</td>
<td></td>
</tr>
<tr>
<td>Meta-Lignite</td>
<td>Black Lignite</td>
<td></td>
</tr>
<tr>
<td>Sub-bituminous coal</td>
<td>Steam coal</td>
<td>45-40</td>
</tr>
<tr>
<td>Bituminous coal</td>
<td>Free-Burning Coal</td>
<td>40-35</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>High-Volatile Coal</td>
<td>35-28</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>Bituminous Coal</td>
<td>28-19</td>
</tr>
<tr>
<td>Dry Steam Coal</td>
<td>Lean Coal</td>
<td>19-14</td>
</tr>
<tr>
<td>Anthracite</td>
<td>Anthracite</td>
<td>14-12</td>
</tr>
</tbody>
</table>

- high-grade coke is still important for the blast furnace process
- there is a decrease in supply of **good coking coal** (i.e. medium volatile coals) for natural, technical and economical reasons

alternatives for coking coals:
- sub-bituminous coals
- brown coal, lignite

briquetting
processing
pyrolysis
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tkIS – coke plant portfolio

#### Future, 2017+

<table>
<thead>
<tr>
<th>Basis, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Chamber Oven</td>
</tr>
<tr>
<td>Heat Recovery-Coke Oven</td>
</tr>
<tr>
<td>Horizontal Coke Oven</td>
</tr>
</tbody>
</table>

### Vertical Chamber Oven

#### Appropriate feedstock

| Hard coal – blends including shares of gas coal & petrol coke | Hard coals & low-grade hard coal shares (anthracites) or petrol coal |
| ~23 % < VM (d.b.) < ~28 % | ~20 % < VM (d.b.) < ~26 % |

#### Lignite, low-grade and low baking hard coals or coal blends from all grades of coal

| Lignite-coke for blast furnace and direct reduction processes; SNG; methanol |

### Product spectrum

| BF/foundry-coke; sulfur; ammonia; ammonium bicarbonate; sulfur acid; benzene; tar | BF/foundry-coke; steam; electricity |

| BF/foundry-coke; steam; electricity | Lignite-coke for blast furnace and direct reduction processes; SNG; methanol |

thyssenkrupp Industrial Solutions – Process Technologies – coke plant division

6 | 12:15 pm / 14. September 2016 | Vertical Chamber Oven | Tschirmer, Spöttle, Dr. Kim | Dr. Schröder, Dr. Herdegen, Fr. Rosin, Fehse
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Process block diagram

Coal → Briquetting → Bunker-Dryer → VCO

Energy → Coking chamber-heating → CDQ → Coke

Utility media → RawGas → Coke dust
Vertical Chamber Oven – VCO
Advantages and flexibility of the new process

- Ash content < 7 wt.%
- Sulphur < 1,2 wt.%

- Agglomeration parameters
- Briquetting parameters

- Drying regimes
- Cooling regimes
- Heating regimes
- Coking time

- High strength - CSR
- Low ash & sulphur contents
- Low reactivity - CRI
Vertical Chamber Oven – VCO

Process description

<table>
<thead>
<tr>
<th>Stage</th>
<th>Temperature</th>
<th>Process</th>
<th>Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preprocessing</td>
<td>T\text{\textsubscript{amb}}</td>
<td>Grinding</td>
<td>~ 20%</td>
</tr>
<tr>
<td>Shaping</td>
<td>T\text{\textsubscript{60°C}}</td>
<td>Briquetting</td>
<td>~ 11%</td>
</tr>
<tr>
<td>Predrying</td>
<td>T\text{\textsubscript{150°C}}</td>
<td></td>
<td>~ 3%</td>
</tr>
<tr>
<td>Coking process</td>
<td>T\text{\textsubscript{1050°C}}</td>
<td>Transformation</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>T\text{&lt;200°C}</td>
<td>By CDQ</td>
<td>~ 3%</td>
</tr>
</tbody>
</table>

Ensures stability
Gentle drying
Briquette pyrolysis
Gentle cooling
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Development of the VCO

<table>
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<tr>
<th>Research (since 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Literature Research</td>
</tr>
<tr>
<td>- Laboratory examinations at the TU BA Freiberg &amp; TU Clausthal</td>
</tr>
<tr>
<td>→ Investigation of various feed coals</td>
</tr>
<tr>
<td>→ Heating regimes (drying / coking coal)</td>
</tr>
<tr>
<td>→ Physical and chemical investigations</td>
</tr>
</tbody>
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<tr>
<th>Design (2014/16)</th>
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<tbody>
<tr>
<td>- Mass and Energy Balance</td>
</tr>
<tr>
<td>→ oven design (refractory, mechanical)</td>
</tr>
<tr>
<td>→ process flow charts (P&amp;ID, EMSR, ...)</td>
</tr>
<tr>
<td>- Components</td>
</tr>
<tr>
<td>→ Layout equipment, machines</td>
</tr>
<tr>
<td>→ Enquiries</td>
</tr>
<tr>
<td>→ cost finding for VCO</td>
</tr>
<tr>
<td>- Operation Manual</td>
</tr>
<tr>
<td>→ Functional descriptions</td>
</tr>
<tr>
<td>→ Cause-and-Effect-Diagrams</td>
</tr>
<tr>
<td>- Cost-Effectiveness-Analysis</td>
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<th>Projecting (2017+)</th>
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<tr>
<td>- Construction and Operation of a Test-Oven at the IEC, TU BAF</td>
</tr>
<tr>
<td>→ Optimization of current process and equipment</td>
</tr>
<tr>
<td>→ Validation of mathematical models</td>
</tr>
<tr>
<td>→ Investigation of various feed coals</td>
</tr>
<tr>
<td>- ASG – locational study</td>
</tr>
<tr>
<td>→ Pilot Plant Lausitz (400-800 kt/a)</td>
</tr>
<tr>
<td>- Techn. Acquisition (speeches and publications)</td>
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Possible products

- **grain size > 45 mm**
  - blast furnace
  - pig-iron production
  - shaft furnace
  - lime burning
  - dolomite burning
  - melting of lead scrap
  - production of magnesium oxide
  - cupola oven
  - melting of slag

- **grain size 10 – 20 mm**
  - preparation of ferrosilicon and ferro-alloys

- **grain size 0 – 3 mm**
  - sintering of iron ore
  - sintering von non-ferrous metal ore
  - rotary furnace
  - enrichment of nickel blooming
  - enrichment of zinc-containing materials
  - winkler-generator
  - generation of syngas

- **dust**
  - blast furnace
  - combustible for pig-iron production
  - rotary furnace
  - production of cement

- **grain size 30 – 45 mm**
  - smokeless fuel (heating coke) for household and business

- **grain size 10 – 30 mm**
  - carbid production
  - phosphorus production
Vertical Chamber Oven – VCO

Summary and Outlook

**new products – new applications**
- extension of product range
- acquiring new customers
- opening markets for new feed coals by refining them
- value addition – new applications

**coal feedstock**
- extension of applicable raw materials
- decreasing coal qualities
- unstable prices and availability of good coking coals – "critical raw material"
- reduce dependency to coal or coke supplier
- gain experience of wide coal blend range
- determine new sets of parameters

**tkIS – specialized in coke technology**
- design early 20th century former tkIS companies
  - former GDR – high temperature lignite coke
  - adaptable process control according to desired products or changing educts
  - state of the art design in automation/operation with focus on the environment
  - customized process design, management and control
WE make something out of your coal!

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september 2016 | thyssenkrupp Industrial Solutions AG