Influence of draff as coking additive on the quality of lump coke using non-baking coals

F. Fehse¹, H.-W. Schröder¹, R. Kim²
¹) TU Bergakademie Freiberg, ²) ThyssenKrupp Industrial Solutions

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OUTLINE

- Motivation
- Raw materials
- Methods
- Experimental results
- Summary
DEVELOPMENT OF AN ENHANCED VERTICAL CHAMBER OVEN

Motivation | Raw Materials | Methods | Experimental results | Summary

DEVELOPMENT OF AN ENHANCED VERTICAL CHAMBER OVEN

Improvement of the process of Rammler und Bilkenroth for the production of high-temperature coke using low-rank coals

High-quality briquette is a basic requirement for the production of lump coke
HIGH-STRENGTH LUMP COKE

influencing variables:

- specifications of the pyrolysis briquette (selection)
  - high compressive strength and abrasion resistance low moisture content

- specifications of the coke (selection)
  - high compressive strength and abrasion resistance high thermal stability
  - matching reactivity
ALTERNATIVE COKING ADDITIVES

- additives for modification of coke quality
- new approach: using process by-products with high local availability instead of conventional binders and coking additives
- potential coking additives:
  - molassis with lime stone → „sugar coke“
  - draff → denaturated proteins
  - grass → pectin
  - black liquor → lignin compounds
  - HSC-ROSE → residues of cracking process
COKE QUALITY REQUIREMENTS

- compressive strength: $\sigma_{pc} \geq 50$ MPa
- abrasion resistance: $R30 \ (100) \approx 95 \%$, $R30 \ (300) \approx 92 \%$
- reactivity (Corex): $CRI \leq 55 \%$
  
  \[ CSR \ (d \geq 3,15 \ \text{mm}) \geq 35 \% \]
- reactivity (blast furnace): $CRI \leq 23 \%$
  
  \[ CSR \ (d \geq 10 \ \text{mm}) \geq 65 \% \]
# RAW MATERIALS

- Indonesian brown coal
- German brown coal
- daff (spent grains)

<table>
<thead>
<tr>
<th>Coal</th>
<th>A</th>
<th>C</th>
<th>H</th>
<th>O</th>
<th>S</th>
<th>N</th>
<th>$H_s$</th>
<th>$H_i$</th>
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<tbody>
<tr>
<td></td>
<td>daf</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>wt.-%</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesian brown coal</td>
<td>2.96</td>
<td>69.03</td>
<td>4.44</td>
<td>25.26</td>
<td>0.55</td>
<td>0.72</td>
<td>25691</td>
<td>26661</td>
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<tr>
<td>German brown coal</td>
<td>5.33</td>
<td>70.17</td>
<td>4.68</td>
<td>23.90</td>
<td>0.90</td>
<td>0.29</td>
<td>27061</td>
<td>26124</td>
</tr>
</tbody>
</table>

- Indonesian brown coal: 2.96 wt.-% A, 69.03 wt.-% C, 4.44 wt.-% H, 25.26 wt.-% O, 0.55 wt.-% S, 0.72 wt.-% N, 25691 kJ/kg $H_s$, 26661 kJ/kg $H_i$
- German brown coal: 5.33 wt.-% A, 70.17 wt.-% C, 4.68 wt.-% H, 23.90 wt.-% O, 0.90 wt.-% S, 0.29 wt.-% N, 27061 kJ/kg $H_s$, 26124 kJ/kg $H_i$
APPROACHES FOR COAL PROCESSING

pre-comminuted raw coal

- drying

fine comminution
  hammer mill

sizing

briquetting
  hydraulic stamp press

pyrolysis
  laboratory retort

lump coke
  conventional

$\Delta d = 1/0 \text{ mm}, \ w = 11 \%, \ p = 140 \text{ MPa}, \ \theta_P = 80 \degree \text{C}, \ t_P = 10 \text{s}$
APPROACHES FOR COAL PROCESSING

- pre-comminuted raw coal
- drying
- fine comminution
  - hammer mill
- sizing
- briquetting
  - hydraulic stamp press
- pyrolysis
  - laboratory retort
- lump coke
  - conventional

Heating regime: Vollmaier
APPROACHES FOR COAL PROCESSING

- **pre-comminuted raw coal**
  - drying
  - fine comminution
    - hammer mill
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke
    - conventional

- **raw coal**
  - mixing
    - Eirich intensive mixer
  - disintegration/defibration
  - drying
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke
    - new

Eirich R02

- $t_{\text{Mix}} = 3$ min,
- $u_{\text{Stir}} = 11.1$ m/s
APPROACHES FOR COAL PROCESSING

- pre-commminuted raw coal
  - drying
  - fine comminution
    - hammer mill
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke
    - conventional

- raw coal
  - mixing
    - Eirich intensive mixer
  - disintegration/defibration
  - drying
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke
    - new

- 5% draff

- Twin-screw extruder
  - defibration and denaturation of proteins
- Swing mill
  - Disintegration and denaturation of proteins
APPROACHES FOR COAL PROCESSING

- **pre-comminuted raw coal**
  - drying
  - **fine comminution**
    - hammer mill
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - **lump coke**
    - conventional

- **raw coal**
  - mixing
    - Eirich intensive mixer
  - disintegration/defibration
  - drying
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - **lump coke**
    - new

\[ w = 11 \%, \ p = 140 \text{ MPa}, \ \vartheta = 80 \text{ °C}, \ \tau = 9 \text{ s} \]
**APPROACHES FOR COAL PROCESSING**

- **pre-comminuted raw coal**
  - drying
  - fine comminution
    - hammer mill
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke

- **raw coal 5 % draff**
  - mixing
    - Eirich intensive mixer
  - disintegration/defibration
  - drying
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke

Heating regime: Vollmaier
PARAMETERS OF CHARACTERISATION

- **Raw density**
- **Compressive Strength (according to TGL 9491)**
  - core compressive strength between two stamps

- **Abrasion resistance (according to DIN 51717)**
  - 5 briquettes are loaded for 100 revolutions at 25 min⁻¹
  - residue on 30 mm-sieve

\[
R_{30}(100) = \frac{m_{30}}{m_{tot}} \times 100 \%
\]
The INFLUENCE OF THE COKING ADDITIVE – INDONESIAN COAL study highlights the benefits of adding draff to the process:

- **Higher quality of briquettes and coke** by adding draff
- **Partial melted bridges** between coal and coke particles

The experimental results show improvements in:

- **Density ($\rho_{\text{Roh}}$)**
- **Compressive strength ($\sigma_p$)**
- **Reduced Shrinkage ($R_{30}$)**
**INFLUENCE OF THE COKING ADDITIVE – INDONESIAN COAL**

- higher quality of briquettes and coke by adding draff
  - partial melted bridges between coal and coke particles
INFLUENCE OF THE COKING ADDITIVE – GERMAN COAL

- Increase in briquette and coke strength for usage of draff
- Compressive strength of coke on lower level than for Indonesian coal
  - Influence of raw material
INFLUENCE OF THE HEATING REGIME (INDONESIAN COAL)

- Slightly increase of heating rate is possible without decrease in raw density and abrasion resistance.
- 10% decrease in compressive strength by using higher heating rate.
SUMMARY

- briquetting and coking investigation in laboratory scale for Indonesian and a German brown coal
- addition of draff as coking additive leads to higher briquette and coke quality
- slightly increase of heating rate is possible without quality decrease
- investigation and reduction of reactivity
- investigation of briquetting in pilot plant scale
Dipl.-Wi.-Ing. Franz Fehse
TU Bergakademie Freiberg
Institute of Thermal, Environmental and Natural Products Process Engineering (ITUN)
franz.fehse@tun.tu-freiberg.de