Influence of briquetting and coking parameters on the lump coke production using non-baking coals

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MOTIVATION

- about 15 % of world wide mined coal used for pig iron production (1.2 bn t*) → “coking coal”
  - coals with baking capacity for lump coke production: medium volatile coals

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

requirements:
- briquetting of the coal,
- gentle pyrolysis of the briquette

LUMP COKE FROM BROWN COAL

- invented by E. Rammler and G. Bilkenroth (1952)
- industrial scale production in Schwarze Pumpe and Lauchhammer (2.5 Mio. t/a) until 1992
- BHT technology:
  - briquetting parameters
    \[ \Delta d = 1/0 \text{ mm} \quad p \geq 120 \text{ MPa} \]
    \[ w = 11 \% \quad \vartheta_p = 65 \ldots 75 \degree C \]
  - pyrolysis in vertical chamber furnace
    gentle pyrolysis 0.83 K/min and 2.85 K/min
    \[ \vartheta_{py} = 1000 \degree C \]
- limited strength of BHT coke:
  \[ \sigma_{PK} = 17 \text{ MPa} \]
  \[ R_30 (100) = 80 \% \]
HIGH-STRENGTH LUMP COKE

influencing variables:

- specifications of the pyrolysis briquette (selection)
  - high compressive strength and abrasion resistance (e. g. $\sigma_{PB} \gg 30$ MPa)
  - high thermal stability

- specifications of the coke (selection)
  - high compressive strength and abrasion resistance (e. g. $\sigma_{PC} > 50$ MPa, $R_{30} (100) > 95\%$)

- matching reactivity
RAW MATERIALS

- Lusatian brown coal
- Indonesian brown coal

<table>
<thead>
<tr>
<th>Coal</th>
<th>Huminite</th>
<th>Inertinite</th>
<th>Densinit</th>
<th>Textinit</th>
<th>Gelinit</th>
<th>Fusinit</th>
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<tbody>
<tr>
<td>Lusatian brown coal</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Indonesian brown coal</td>
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<td></td>
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<tr>
<td>GD GBC</td>
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<td>1.0</td>
<td>8.5</td>
<td>0.3</td>
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<td>12.3</td>
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<table>
<thead>
<tr>
<th>Coal</th>
<th>A wt.-%</th>
<th>C daf</th>
<th>H daf</th>
<th>O daf</th>
<th>S_c</th>
<th>N</th>
<th>H_o</th>
<th>H_u</th>
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<tbody>
<tr>
<td>Lusatian brown coal</td>
<td>5.98</td>
<td>67.94</td>
<td>4.92</td>
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<td>25.26</td>
<td>0.55</td>
<td>0.72</td>
<td>25691</td>
<td>26661</td>
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NEW APPROACHES FOR COAL PROCESSING

- pre-comminuted raw coal
  - drying
    - $w = 11\%$
  - fine comminution
    - hammer mill
    - $\Delta d = 1/0\text{ mm}$
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke
  - $p = 140\text{ MPa, } \theta_P = 80\text{ °C, } t_P = 10\text{ s}$
  - Heating regime: Vollmaier
NEW APPROACHES FOR COAL PROCESSING

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  - drying
  - fine comminution
    - hammer mill
  - sizing
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke

- (pre-comminuted) raw coal
  - fine comminution
    - modified flat die press
  - granulation
    - intensive mixer
  - drying
  - briquetting
    - hydraulic stamp press
  - pyrolysis
    - laboratory retort
  - lump coke

- fine comminution by compressive stress and shear stress between roller and die
- modified die for slight agglomeration
NEW APPROACHES FOR COAL PROCESSING

pre-comminuted raw coal

- Drying
- fine comminution
  - hammer mill
- sizing
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- pyrolysis
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- lump coke

(pre-comminuted) raw coal

- fine comminution
  - modified flat die press
- granulation
  - intensive mixer
- drying
- briquetting
  - hydraulic stamp press
- pyrolysis
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- high energy impact by mixing tool
- strong agglomerates with narrow particle size distribution
NEW APPROACHES FOR COAL PROCESSING

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

2. (pre-comminuted) raw coal
   - fine comminution
     - modified flat die press
   - granulation
     - intensive mixer
   - drying
   - briquetting
     - hydraulic stamp press
   - pyrolysis
     - laboratory retort
   - lump coke

3. (pre-comminuted) raw coal
   - fine comminution
     - modified flat die press
   - drying
   - briquetting
     - hydraulic stamp press
   - pyrolysis
     - laboratory retort
   - lump coke
PARAMETERS OF CHARACTERISATION

- **Particle size distribution of granules by sieving analysis**
- **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

\[ R_{30(100)} = \frac{m_{30}}{m_{tot}} \times 100 \% \]
Motivation | Raw Materials | Methods | Experimental results | Summary

PSD: INFLUENCE OF PROCESSING PARAMETERS

- comminution in impact mill → High amount of fines
- coarsening and narrowing of PSD by comminution/agglomeration in modified flat die press
- granulation in intensive mixer leads to widening of the PSD

| comminution in impact mill | coarsening and narrowing of PSD by comminution/agglomeration in modified flat die press | granulation in intensive mixer leads to widening of the PSD |

$Q_d(d)$ in %

$d$ in mm

Lusatian Brown Coal:
- Comminution FIM, $\Delta d = 1/0$ mm
- Granules, IM, $a_D = 20\%$, $t_{Gr} = 180$ s, $u_W = 11.1$ m s$^{-1}$
- Granules, mod. FDP, $d_{pC} = 2$ mm, $b_{SP} = 3$ mm
Motivation | Raw Materials | Methods | Experimental results | Summary

**MAXIMUM COMPRESSIVE STRENGTH: INFLUENCE OF PROCESSING PARAMETERS**

- Increasing briquette and coke quality by using new processing approaches
- GBC: Highest coke compressive strength for coal from mod. FDP
- IBC: > 20% increasing of coke compressive strength by briquetting coal granules
INFLUENCE OF THE PYROLYSIS REGIME (BHT TECHNOLOGY)

- modified Vollmaier regime: only slight influence on coke quality
- degassing leads to reduced coke quality at 320 °C and 520 °C
- single stage heating with 2.85 K/min could be an option to reduce coking time
SUMMARY

- new processing approach leads to increasing coke quality
  
  - high comminution in modified FDP improves lump coke creation
  
  - grain size of granules does not show any influence on the coking behaviour

  - Raman spectroskopy investigating briquette and coke structure

- High coke quality using Vollmaier regime
  
  - modification (0.83 K/min up to 520 °C) shows only slight effects on coke quality

  - single stage heating regimes (e.g. 2.85 K/min) for various coals should be investigated
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