Investigation of high-strength lump coke from lignite and sub-bituminous coals

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International Freiberg/Inner Mongolia Conference on IGCC & XtL Technologies, Coal Conversion and Syngas
Hohhot, June 8th, 2015
OUTLINE

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INTRODUCTION

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

- alternatives for coking coals:
  - sub-bituminous coals
  - lignite

**requirement:**
Production of lump coke is only possible after briquetting of the coal!
BHT – HIGH TEMPERATURE COKE FROM LIGNITE

- 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
    \[ \Delta d = 1/0 \text{ mm} \quad p \geq 120 \text{ MPa} \]
    \[ w = 11 \% \quad \vartheta_p = 65 \ldots 75 \ ^\circ \text{C} \]
  - pyrolysis in vertical chamber furnace
    gentle pyrolysis 0.83 K/min and 2.85 K/min
    \[ \vartheta_{Py} = 1000 \ ^\circ \text{C} \]
- limited strength of BHT coke:
  \[ \sigma_{PK} = 17 \text{ MPa} \]
  \[ R \ 30 \ (100) = 80 \% \]
HIGH-STRENGTH LIGNITE BRIQUETTES AND COKE

- influencing variables:
  - specifications of the pyrolysis briquette (selection)
    - high compressive strength and abrasion resistance (e.g. $\sigma_{PB} \gg 30$ MPa)
    - low moisture content
  - specifications of the coke
    - mass-loss-conformal volume shrinkage behaviour
    - high compressive strength and abrasion resistance (e.g. $\sigma_{PC} > 50$ MPa, $R_{30\%} (100) > 95\%$)
    - high thermal stability
    - custom-designed coke reactivity
NEW APPROACH FOR PRODUCTION OF HIGH-STRENGTH PYROLYSIS BRIQUETTES (LABORATORY SCALE)

- Lusatian Lignite
- moisture content: 52 %
- ash content: 5.98 % (d)
- calorific value: 25028 kJ/kg (daf)
NEW APPROACH FOR PRODUCTION OF HIGH-STRENGTH PYROLYSIS BRIQUETTES (LABORATORY SCALE)

- fine comminution by compressive stress and shear stress between roller and die
- modified die for slight agglomeration
NEW APPROACH FOR PRODUCTION OF HIGH-STRENGTH PYROLYSIS BRIQUETTES (LABORATORY SCALE)

- Pre-comminuted raw lignite
- Fine Comminution
  - Modified flat die press
- Granulation
  - Intensive mixer
- Drying
- Granule
- Briquetting
  - Hydraulic stamp press
- Pyrolysis briquette

- high energy impact by mixing tool
- strong agglomerates with narrow particle size distribution
- variation of steam ratio
  - granulation time
  - peripheral speed of mixing tool
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- densification in heatable closed die
- constant briquetting parameters:
  - $p = 140 \text{ MPa}$
  - $\vartheta_p = 80 \degree \text{ C}$
  - $w = 11 \%$
  - $t_p = 10 \text{ s}$
- briquette geometry: $\varnothing 50 \text{ mm} \times 20 \text{ mm}$
- gentle pyrolysis in laboratory retort
- coking up to 320 °C with 0.83 K/min for slow release of volatile matter
- afterwards increasing up to 2.85 K/min for higher coke strength
PARAMETERS OF CHARACTERISATION

- Particle size distribution of granules by sieving analysis
- Compressive Strength (according to TGL 9491)
- Raw density
- Shrinking quality of coke
- Abrasion resistance (according to DIN 51717)

- 5 briquettes are loaded for 100 revolutions at 25 min\(^{-1}\)
- residue on 30 mm-sieve

\[
R30(100) = \frac{m_{30}}{m_{tot}} \times 100 \%
\]
higher steam ratio leads to coarser granules, due to more liquid bridges

- reduction of fines:
  - at $a_{st} = 14\%$ $Q_3(d = 0.1 \text{ mm}) = 5\%$
  - at $a_{st} = 20\%$ $Q_3(d = 0.1 \text{ mm}) = 1\%$
INFLUENCE OF THE STEAM RATIO – COMPRESSION STRENGTH

- linear increasing of compression strength with increasing steam ratio
- for $a_{St} > 10\%$ coke compression strength exceeds briquette compression strength $\rightarrow$ modification of coal, better shrinking behaviour
INFLUENCE OF THE STEAM RATIO – ABRASION RESISTANCE

- high briquette and coke abrasion resistance for $a_{st} \geq 10\%$,
  $\rightarrow R 30 (100) = 95\%$ (only edges are flaked off)
INFLUENCE OF MIXING TOOL SPEED – PSD

- \( a_{St} = 20\%: \) higher speed of mixing tool leads to coarser particle size distribution due to higher interaction between particles.
INFLUENCE OF MIXING TOOL SPEED – BRIQUETTE AND COKE QUALITY

- Increasing mixing tool speed leads to decreasing briquette and coke strength
  - Higher speed causes stronger granules, compression energy is needed for partial comminution before briquetting
- Steam ratio has higher effect on briquette and coke strength than mixing tool speed
SUMMARY

- successful briquetting of Lusatian lignite granules in laboratory scale by variation of granulation parameters
- efficient method for production of high strength pyrolysis briquettes and cokes
- briquetting of granules offer coke with high compressive strength and abrasion resistance
- vaporisation has highest effect on briquette and coke quality
- also suitable for sub-bituminous coals (e.g. China, Indonesia) → different parameter set
- modification of the coal by steam needs to be investigated
- investigations on the determination and reduction of coke reactivity
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