Processing of hard coal fines by binder briquetting for use in smelting reduction processes

Motivation
- Hot metal production in 2013: about 1,165 million tons
- Routes of hot metal production by smelting reduction:
  - Conventional BF-Route
  - COREX® Route

Background
Advantages of COREX®/FINEX® smelting reduction processes in comparison to blast furnace:
- Higher flexibility against the raw materials quality
- Reduction of costs through retrenchment of coking and sinter plant
- Environmentally friendly production route for hot metal

Challenges:
- COREX®/FINEX® melter-gasifier needs lumpy fuel for stable operation
- But up to 50 % fines (grain size under 8 mm) due to transport & handling
Coals (High Volatile Bituminous Coals):

- Blumen (Sh)
- Molasses with Calcium hydroxide and Water
- Polyvinyl alcohol (Mowiol 47-88G2)

Briquetting conditions:
- Coal particle size distribution: 4/0 mm, 2/0 mm, 0.5/0 mm
- Briquetting pressure: 140 MPa
- Briquetting temperature: 60°C

Binders:
- Bitumen (Shell SBT)
- Molasses with Calcium hydroxide and Water
- Polyvinyl alcohol (Mowiol 47-88G2)

Test and qualification for briquettes:
- Cold strength
- Determination of Crushing Strength
- Drop Shatter Test according to ISO 616
- Tumbler test
- Hot strength
- Char-Strength after Pyrolysis
- Thermo-mechanical strength
- Reactivity
- Determination of CRI and CSR according to ISO 18894

Outline | Motivation | Background | Methods & Materials | Results & Discussion | Summary & Outlook

METHODS & MATERIALS

Coals (High Volatile Bituminous Coals):

<table>
<thead>
<tr>
<th>Name</th>
<th>Ash in %(d)</th>
<th>VM in %(d)</th>
<th>FC in %(d)</th>
<th>HGI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total South African</td>
<td>15.2%</td>
<td>29.2%</td>
<td>55.6%</td>
<td>62</td>
</tr>
<tr>
<td>Ensham</td>
<td>11.2%</td>
<td>29.3%</td>
<td>59.4%</td>
<td>75</td>
</tr>
<tr>
<td>South Black Water</td>
<td>9.2%</td>
<td>26.2%</td>
<td>64.5%</td>
<td>88</td>
</tr>
</tbody>
</table>

Intermediate results:
- Best fit to FULLER Parable for Ensham with particle size 2/0 mm.
- Best cold crushing strength with binders.
- Binder releases show best cold crushing strength for coals TSA and Ensham with binders.

RESULTS AND DISCUSSION

Influence of particle size distribution on the briquettes strength:
RESULTS AND DISCUSSION

• Correlation between briquette strength and strength of char:
  - Qualitative correlation often found in literature
  - But: Impact of heating procedure according to coal and binder
  - Ideal curves of the applied heating procedures:

RESULTS AND DISCUSSION

Intermediate results:
- Fast heating procedure tends to result in higher crushing strength and adequate shatter strength → Positive for usage of briquettes in COREX®/FINEX® melter-gasifier
- Slow heating procedure done for comparison → No support of char crushing strength (except with binder molasses → explanation: generation of strong "sugar coke")
- Both char structures strong against dynamic mechanical load like impact

Parameter values:
- Particle size distribution: 0.5-1 mm
- Binder: 1% Polyvinyl alcohol (Mowiol 47-8802)
- Pressure: 140 MPa, Temperature: 60°C, Duration: 3 s
- Curing temperature: 150°C

Intermediate results:
- Raise of crushing strength by curing
- Duration of curing controls strength → Screening for optimal length necessary
- No support of shatter strength → Embrittlement of briquettes structure through curing

SUMMARY AND OUTLOOK

Summary:
- Laboratory briquetting tests show that generation of stable briquettes from hard coal fines by binder briquetting is possible
- One matrix-type binder as well as two film-type binders are investigated about their impact on briquettes strength and char quality
- Effect of "Curing" helps to stabilize briquettes structure controlled by duration of curing which affects the briquettes water content

Outlook:
- Additional tests on different types and amounts of binders related to economical aspects
- Scale-up tests with industrial roller press
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