From coking coal to coke - perspectives for met coke production in European Union

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Contents

- Introduction
- Coal&coke market – EU over world
- EU environmental protection provisions
- Technology for coke quality improvement
- Conclusions
Introduction

Steel ⇒ still main construction material in XXI century

Blast-furnace ⇒ still main production technology

Coke ⇒ still indispensable charge material

Coal ⇒ good quality coal still indispensable for production of good quality coke

Technology ⇒ there is still place for further improvement of coke quality
Location of the world’s main fossil fuel reserves (billion tonnes of oil equivalent)

Source: BP Statistical Review of World Energy 2011
Europe’s hard coal and lignite production and imports in 2012

Source: EURACOAL Annual Report 2012
Hard coal production in EU27

Coke consumption in years 2009-2013 [mln ton]

Source: Polski Koks S.A. – presentation during conference Koksoownictwo 2013
Coke production in EU

![Graph showing coke production in EU for 1990 and 2011, comparing countries B, CZ+SK, F, D, PL, and GB.](image)

**Coke production [t]**

- **1990**: Blue bars
- **2011**: Red bars

**Number of ovens**

- **2002**: Blue bars
- **2011**: Red bars

Countries included:
- B
- CZ+SK
- F
- D
- PL
- GB
Environmental EU policy

Where UE goes?

- Own raw materials
- Import of raw material (coal, ore)
- Import of semi-products (coke, concentrate)
- Import of raw products

Import of highly processed market ready products??
Environmental EU policy

Sustainable development? YES
BAT (Best Available Technology)

EU governments representatives

NGO, green parties representatives

Industry representatives

BAT conclusions
BAT (Best Available Technology)

Negotiations

community representatives

producers

Decisions

Process of acts preparation

Best Available Techniques Reference Document
## New coke production capacities

<table>
<thead>
<tr>
<th>Lp.</th>
<th>Country</th>
<th>Location</th>
<th>Production capacity [t.t./rok]</th>
<th>Height [m]</th>
<th>Type</th>
<th>Date of modernisation / construction</th>
<th>Type of modernisation /construction</th>
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<tr>
<td>1</td>
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<td>gravity</td>
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<td>Germany</td>
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<td>SAIL (Rourkela)</td>
<td>420</td>
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<td>foundations</td>
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<td>Bokaro</td>
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<td>ground</td>
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<td>11</td>
<td>Indonesia</td>
<td>PT Gunung Raja Paksi</td>
<td>755</td>
<td>5.50</td>
<td>stamped</td>
<td>2015</td>
<td>ground</td>
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<td>WZK Victoria</td>
<td>103</td>
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<td>2016</td>
<td>ground</td>
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<td>VIZAG (Visakhapatnam)</td>
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<td>gravity</td>
<td>2016</td>
<td>ground</td>
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<td>gravity</td>
<td>2016</td>
<td>foundations</td>
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<tr>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>13 352</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Polski Koks S.A. – presentation during conference Koksonictwo 2013*
Introduction
DILLEMA: produce coke or buy coke

Pros and cons:
• coke plant operation: investment and operational cost
• feedstock delivery safety: (coal or coke)
• one’s own COG
• environmental protection issues
• coke production profit
Introduction
DILLEMA: produce coke or buy coke

1 tonne of coal charge (average moisture content)

0.75 tonne of coke (wet basis)
Introduction

DILEMA: produce coke or buy coke

Coke/coking coal price relation
Utilisation of production capacity in EU 27

Coke production capacity utilisation [%]

Austria  Belgium  Czech  Finland  France  Germany  Hungary  Italy  Netherlands  Poland  Slovakia  Spain  Sweden  UK

70  75  80  85  90  95  100
## Coal quality versus blend composition
### Coke quality requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Country of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poland</td>
</tr>
<tr>
<td><strong>Mechanical strength</strong> M$_{40}$, %</td>
<td>75 – 82</td>
</tr>
<tr>
<td><strong>Abrasion</strong> M$_{10}$, %</td>
<td>6.0 - 7.0</td>
</tr>
<tr>
<td><strong>Reactivity</strong> CRI, %</td>
<td>28 – 35</td>
</tr>
<tr>
<td><strong>Strength after reaction</strong> CSR,%</td>
<td>57 – 63</td>
</tr>
<tr>
<td><strong>Ash content</strong> A$_d$, %</td>
<td>8.5 - 10.0</td>
</tr>
<tr>
<td><strong>Sulphur content</strong> S$_d$, %</td>
<td>0.5 - 0.7</td>
</tr>
<tr>
<td><strong>Phosphorus content</strong> P$_d$, %</td>
<td>0.055 - 0.065</td>
</tr>
<tr>
<td><strong>Alkalis content (Na$_2$O, K$_2$O)</strong></td>
<td>0.35 - 0.45</td>
</tr>
</tbody>
</table>
Factors influencing coke quality

- Coal components quality
- Coal charge preparation
- Coking process parameters
- Coke treatment
## Coal charge preparation

<table>
<thead>
<tr>
<th>Method</th>
<th>DISADVANTAGE</th>
<th>ADVANTAGE</th>
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</thead>
<tbody>
<tr>
<td>Stamping</td>
<td>high investment cost</td>
<td>proved coke quality improvement</td>
</tr>
<tr>
<td></td>
<td>need significant modernisation of existing technological lines</td>
<td>possibility to use weaker coals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>battery capacity increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>technology positively verified</td>
</tr>
<tr>
<td>Heat-Recovery</td>
<td>need to built new coke oven plant</td>
<td>possibility to use weaker coals</td>
</tr>
<tr>
<td></td>
<td>need to provide heat consumer</td>
<td>lower gas emission</td>
</tr>
<tr>
<td></td>
<td>lower coke yield</td>
<td>simple technological operation</td>
</tr>
<tr>
<td></td>
<td>no references in EU</td>
<td></td>
</tr>
<tr>
<td>CDQ</td>
<td>high investment and operational cost</td>
<td>battery capacity increase</td>
</tr>
<tr>
<td></td>
<td>shorter CDQ chamber refractory life expectancy</td>
<td>heat consumption decrease</td>
</tr>
<tr>
<td></td>
<td>need for surplus gas utilisation</td>
<td>lower amount of waste water</td>
</tr>
</tbody>
</table>
Stamp charging technology

Description:
- wet coal charge is stamped (on the charging machine or under coal tower)
- increased bulk density (wet charge) to 1100 kg/m³
- recommended for blend with poorer coking parameters

Technical characteristics (example):
- Capacity: 750,000 Mg/y
- No. of chambers: 86
- Chamber height: 5,0 m
- Chamber length: 15,90 m
- Chamber width: 0,51/0,49 m
- Coking time: 25,5 h

Remarks: the first 5-meter high stamp charging coke oven battery in Poland in Kombinat Koksochemiczny "Zabrze" PLC Coke Plant Radlin - start-up 2008
the first stationary stamp charging in EU
the only other new coke oven battery in EU 15 since 2000 is Dillingen Coke Plant

Possible quality improvement:
CSR ⇒ +5 ÷ +9%
M40 ⇒ +6 ÷ +8%
Heat recovery technology

Description:
- Heating direct and indirect
- Heating by coking gas combustion directly inside coking chamber
- Production only of coke and energy

Technical characteristics (example):
- No. of chambers: 86
- Chamber height: 2.4 m
- Chamber length: 13.7 m
- Chamber width: 4.5 m
- Coking time - extended (typically 48 h)
- By-products - none (heat and power production)

Remarks:
- Production of big lumps of coke - need for crushing
- Bigger coke quality improvement for blends with higher volatile matter content

Possible quality improvement:
- CSR ⇒ +2÷+10%
- M40 ⇒ +2%
**CDQ technology**

**Description:**
- hot coke goes to cooling chamber where is quenched with circulating inert gas
- slow cooling down - cooling time ~1 h
- possibility for waste heat recovery (production of steam and electricity)
- technology popular in Northern and Central European countries, Russia and Japan

**Technical characteristics (example):**
- Capacity: 52-56 t\(_{\text{coke}}\)/h
- Chamber volume: 100/150 m\(^3\)
- Steam production: 25 t/h

**Remarks:** slow cooling down - smaller stress in coke lump
smaller water ballast in coke

**Possible quality improvement:**
- CSR ⇒ +3%
- M40 ⇒ +1 ÷ +2%
Challenges for cokemaking industry

1. The necessity to keep the quality requirements demanded by coke import traders with production based on the Polish coking coals stocks.

2. Implementation and common use of high-tech tools for controlling and operating the technological process.

3. Ensuring the production competitiveness:

   How to cost effectively produce a high quality coke?
Conclusions

• In recent years there is noticed continuous increase of coke production but mainly outside Europe.

• Blast-furnace is still main technology for steel production.

• BF operator faces dilemma either buy coking coal for own coke plant or buy coke on free market. Both are subjects to the risks.

• The most often situation for BF operator is: own coke production (100% own battery capacity) what supplies 70-80% of maximum coke consumption plus supplementary coke purchase on the market up to full coke consumption.

• Coke production is profitable when relation between coke price $C_c$ and coal blend price $C_b$ is $\geq 1.75$. Highly profitable results is when $C_c/C_b > 2.5$. 
Conclusions

• There are observed difficulties in „hard” coking coals purchase on global market. At the same time price trend is raising. It forces to find technological actions capable to increase coke quality produced from poor blend.

• Well known and very good method for coke quality improvement is also use of charge stamping. New erected coke oven batteries in EU are usually equipped with stamping system (Diilingen, Radlin, Czestochowa, Przyjazn).

• Environmental protection restrictions in EU caused difficulties in new investment plans on new coke oven batteries erection. Producers are constrained to renovation of existing batteries only. This situation opens market for merchant coke plants.

• EU environmental protection policy has immense influence on coke market.
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