Corex®
An ideal concept for economic and environmental friendly steel production
Outline

Corex
- Corex general
- Corex export gas
- Use of Corex gas for DRI production
- Advantages of HM charging to the EAF

Oxide/DRI Briquetting

Conclusions
Finex® / Corex® / Blast furnace
Process comparison for hot metal production

**Finex® route**
- Non-coking coal
- Fine ore
- Export gas
- Hot metal
- Slag
- Oxygen

**Corex® route**
- Non-coking coal
- Lump ore
- Pellets
- Export gas
- Hot metal
- Slag
- Oxygen

**Blast furnace route**
- Fine ore
- Coking coal
- Sinter plant
- Hot Blast
- Hot metal
- Slag
- Reduction Zone
- Melting Zone
- Gasification Zone

Non-coking coal
Fine ore
Oxygen
Export gas
Hot metal
Slag

Corex® / Finex®
Plants in operation and under construction

- JSW India: 2 x C-2000+DR
- Essar India: 2 x C-2000
- Baosteel China: 2 x C-3000
- Posco Korea: 1 x C-2000/Finex Demo Plant
- Posco Korea: 1 x F-1.5M
- Posco Korea: 1 x F-2.0M
- AM South Africa: 1 x C-2000+DR
- ArcelorMittal South Africa: 1 x C-2000+DR
- Essar India: 2 x C-2000
- Posco：1 x C-2000/Finex Demo Plant
- Posco：1 x F-1.5M
- Posco：1 x F-2.0M
- Baosteel：2 x C-3000
- Corex plant is relocated to XinJiang, (Northwest of China)
Corex® Technology
Available Modules

<table>
<thead>
<tr>
<th>Modules</th>
<th>Diameter</th>
<th>Production Rate</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1000 C-0.5M</td>
<td>5m</td>
<td>40 - 50 t/h</td>
<td>300,000 - 500,000 t/a</td>
</tr>
<tr>
<td>C-2000 C-1.0M</td>
<td>7.3m</td>
<td>100 - 125 t/h</td>
<td>800,000 - 1,000,000 t/a</td>
</tr>
<tr>
<td>C-3000 C-1.5M</td>
<td>8.6m</td>
<td>160 - 180 t/h</td>
<td>1,300,000 - 1,500,000 t/a</td>
</tr>
<tr>
<td>C-2.0M</td>
<td>11.5m</td>
<td>210 - 240 t/h</td>
<td>1,700,000 - 2,000,000 t/a</td>
</tr>
</tbody>
</table>
Outline

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  • **Corex export gas**
  • Use of Corex gas for DRI production
  • Advantages of HM charging to the EAF

**Oxide/DRI Briquetting**

Conclusions
Corex® Process characteristics

- Single process without the need of coking or sinter plant
- Direct use of non-coking coal and low quality nut coke as reducing agent
- Direct use of run of mine lump ore and pellets
- High dome temperature (>1000 °C) leads to decomposition of higher hydrocarbons and tar
- Usage of oxygen generates a high valuable, low nitrogen containing export gas
### Corex® Export Gas Utilization

#### Options for Export Gas Utilization

- DRI/HBI for BF, steelmaking
- LRI for BF
- Combustion, Heating
- Power / Steam Generation
- Chemical Processes

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### Typical Specification

**Corex Export Gas**

<table>
<thead>
<tr>
<th>Flow</th>
<th>m³(STP)/h</th>
<th>~</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1.0 M</td>
<td>200,000</td>
<td></td>
</tr>
<tr>
<td>C-1.5 M</td>
<td>290,000</td>
<td></td>
</tr>
<tr>
<td>C-2.0 M</td>
<td>380,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature °C</td>
<td>30 – 50</td>
</tr>
<tr>
<td>Pressure kPa g.</td>
<td>5 – 180</td>
</tr>
<tr>
<td>CO %</td>
<td>38 – 45</td>
</tr>
<tr>
<td>CO₂ %</td>
<td>30 – 35</td>
</tr>
<tr>
<td>H₂ %</td>
<td>15 – 23</td>
</tr>
<tr>
<td>H₂O %</td>
<td>saturated</td>
</tr>
<tr>
<td>CH₄ %</td>
<td>1 – 2</td>
</tr>
<tr>
<td>N₂/Ar %</td>
<td>Balance</td>
</tr>
<tr>
<td>H₂S ppmv</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Net Calorific Value</td>
<td>kJ/m³(STP)</td>
</tr>
<tr>
<td></td>
<td>Up to 8000</td>
</tr>
<tr>
<td>Dust mg/m³(STP)</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>
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Oxide/DRI Briquetting

Conclusions
Midrex™ process options and flexibility

Beside reformed natural gas as reduction gas, also coal gas based reduction / syngases from different sources such as:

- Corex® export-gas
- Finex® export-gas
- Coke oven gas
- Gasifier syngas

or mixtures of above mentioned gases can be utilized
Use of Corex gas for DRI production
Alternative 1: Corex gas used for heating in the reformer

Corex® Plant

COREX plant

HM

Corex® Gas

CO₂ Removal

Reformer

NG

Midrex™ DR Plant

DR plant

DRI

DR Export Gas
Use of export gas for DRI production
Alternative 2: no recycling of DR export gas

Corex® Plant

COREX plant
Corex® Gas

HM

Gas treatment

Heater

Corex® Gas based Midrex® TM DR Plant

H₂/CO= 0.55

DR Export Gas

DR Plant

DRI
Use of export gas for DRI production
Alternative 3: with recycling of DR export gas

Corex® Plant

COREX plant

HM

Corex® Gas

Gas treatment

Heater

Recycle Gas

H₂/CO = 0.55

Corex® Gas based Midrex™ DR Plant

DR Export Gas

DRI

DR Plant

Gas treatment

Recycle Gas
Use of export gas for DRI production
Alternative 4: with additional Corex gas treatment and recycling of DR export gas

Corex® Gas based Midrex™ DR Plant

Corex® Plant

COREX plant

HM

Gas treatment

Recycle Gas

Heater

H₂/CO = 0.55–2.5

DR Export Gas

DR Plant

DRI
Use of export gas for DRI production
Alternative 4: with additional Corex gas treatment and recycling of DR export gas for existing plants

Corex® Plant to DR Plant

Corex® Gas → Gas treatment → Heater → DR plant → DRI

HM

DR Export Gas

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Seite 15  April 2014  2nd World DRI and Pellet Congress Abu Dhabi  Böhm
Use of Corex export gas for DRI production
Advantages of the alternatives

**Alternative 1** (Corex gas used for reformer heating)
- Low investment cost
- Reduction of specific NG consumption at DR plant by approx. 30%

**Alternative 2** (no DR export gas recycling)
- Lower investment compared to Alt. 3 and 4
- More suitable for smaller DR plant capacities

**Alternative 3** (with DR export gas recycling)
- Lower investment compared to Alt. 4
- Best application for greenfield plants

**Alternative 4** (with additional Corex gas treatment and DR export gas recycling)
- Concept available to add Corex gas as reduction gas to existing DR plant without changing DR plant operation practice
- Concept allows to produce DRI to substitute 100% NG for all existing DR plant technologies
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Oxide/DRI Briquetting

Conclusions
EAF Steelmaking based on HM and HDRI

Coal → Additives → Lump ore

Lump ore → Corex® Export Gas

Corex® Export Gas → Pellets → CPT

CPT → Export Gas

Export Gas → Hot DRI

Hot DRI → EAF

EAF → Crude Steel

Hot Metal → EAF

Crude Steel → Export Gas
Percentage of hot metal in the charge increases beyond 30%, the rate of oxygen input for decarburization becomes the rate limiting part of the process.

If installing a new EAF, the design can be changed to move the maximum productivity peak to higher HM amounts, even higher than 50%
EAF Steelmaking based on HM and HDRI
Impact of HM on electricity and electrode consumption

**Approx. 3.5 kWh reduction per % of Hot Metal input replacing scrap**

**Electrical Energy Reduction**

**Electrode consumption with Hot Metal and/or DRI**

Approx. 3.5 kWh reduction per % of Hot Metal input replacing scrap
HDRI and hot transport and charging into EAF
Hadeed Solution

- Temperature of HDRI out of HDRI bins continuously above 580 °C
- HDRI quality: 2.5% Carbon and up to 96% Met

Benefits for the EAF:
- Increased productivity determined to be 15-20%
- Power savings of 130-150 kWh/t liquid steel
- Electrode savings of 0.5-0.6 kg/t liquid steel
Advantages of DRI production based on Corex gas

plus

Advantage for all 4 alternatives –
(HM charging to the EAF)
- Decrease of electric power consumption
- Decrease electrode consumption
- Increase of the EAF productivity
- Less dependency from scrap quality
Outline

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Oxide/DRI Briquetting

Conclusions
Ferrous material briquetting – benefits of recycling

Challenge
- Shortage of raw materials
- Steady price increase of raw materials over the last 10 years
- Industry is forced to increase recycling rate
- Dumping costs are major cost factor nowadays

Solution
- Cold briquetting process using well established equipment
- Application of different binder to ensure highest possible product quality
- Briquettes to be charged into Midrex, BF, COREX and BOF

Typical customer benefits
- Recycling of fine ores & waste material leading to reduction in raw material costs
- Short pay back (1-3 years)
- Minimize dumping costs and volume
- Low capital expenditure
- Saving of raw materials

Typical quality impact
- Recycling of fine ores
- Recycling of waste materials
- Oxide briquettes have similar properties as pellets, lump ore or sinter
- Saving of energy since no pre-treatment of materials is required
Ferrous material cold briquetting
Typical process flow

Ore Fines / Dust / DRI Fines / Mill Scale

Sludge → Drying

Binder → Mixing

Water <5% H₂O

Briquetting → Curing / Storage

COREX plant
DR plant
Blast furnace
LD (BOF) converter
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Oxide/DRI Briquetting

Conclusions
Conclusions

• Corex still the best industrial utilized coal gasifier – gas cleaning included in the process
• 4 different alternatives available to produce DRI from Corex gas
  • Heating in the DR plant
  • “Once through concept” at DR plant
  • “Recycling concept” at DR plant
  • Concept for adding Corex gas and/or substituting NG to existing DR plants
• Corex export gas can substitute natural gas at existing Midrex or HYL DR plants where no NG is available or cost of NG is high
• Significant advantages for EAF operation with hot metal and hot DRI compared to other charge mixtures:
  • Decrease of electric power, electrode consumption
  • Increase of the EAF productivity
  • Less dependency from scrap quality
• Oxide/DRI fines briquetting technology for recycling into shaft furnace available
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