The Importance of Process Integration in the Iron and Steel industry

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Swerea MEFOS

- Metallurgical Research Institute
- Performs joint research for Member Companies
- Performs contract research for clients worldwide
- Pilot plant facilities for iron & steel making
- Hosting LKAB Experimental Blast Furnace

LKAB’s Experimental BF
PRISMA
Centre for Process Integration in Steelmaking

Institute Excellence Centres

"to bring together industry, institutes and universities in research of international standing in well defined, new areas to the benefit of the Swedish industry"

- Joint activities at a research institute
- Involvement of personnel from industry and university on a significant scale
- Much of the work done by senior researchers
- Doctoral work is included to, among other things, create sustainable relationships between research institutes, universities, and the industry
The PRISMA research programme

- Applies Process Integration in the ore processing, ironmaking and steelmaking processes,
- Builds a solid foundation of techniques and tools, by the pursuit of implementing projects in collaboration with industrial partners,
- Have a focus on effective use of resources with a system perspective, where resources can be energy, materials, environment, costs, etc.,
- Based primarily on the established process knowledge and is a complement to the traditional process development.

8 partners, 4 programme areas

AREA 1: Future production and process systems
AREA 2: Optimum raw material design
AREA 3: Sustainable energy strategies
AREA 4: Residual products and recycling systems
Process Integration

Optimization Methodology

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General Procedure

1. Define system boundary
2. Develop/adapt sub-process models
3. Apply optimization routine: ReMIND, Mixed Integer Linear Programming

Layout of SSAB Luleå Works in Luleå
Different ways to reduce CO₂ emission at SSAB Luleå Works

Process improvements:
- 100% yield hot metal to crude steel
- 100% yield crude steel to slabs
- Balanced liquid flow
- Melting of scrap
- Increased PCI rate
- Reductant rate -20 kg/THM
- Recycling +5 kg
- Reduced flaring of BF-gas
- More efficient heating of coke oven

Investments:
- Preheating hot stoves
- Top pressure recovery

External cooperation:
- BF slag for cement production
- Increased district heating
PI Example: Increase scrap in converter?

Ask the BF Manager: 😊
- requires increase in HM Si & temp.
- increases BF coke rate & cost/thm
- reduces BF production

Ask the BOF Manager: 😊
- increases productivity
- lowers raw material cost

Ask the environment manager: 😊
- lowers CO$_2$ emission/ton steel

Ask the shareholders: 😊
- increases profit

Global implication with limited scrap supply:

The most sustainable solution, from an energy perspective, can be to use the scrap in a converter at a steelplant with a lower efficiency blast furnace!

The Oxygen Blast Furnace

Coke c.200 kg
Ores

Top gas

CO$_2$ Stripping

CO$_2$ to CCS

No export gas
For minimum coke rate

Recycle gas
70% CO

Blast Furnace

O$_2$ c. 230 Nm$^3$
Coal c. 170 kg

Hot metal slag

Ores

CO$_2$ to CCS

No export gas
For minimum coke rate

Recycle gas
70% CO

Blast Furnace

O$_2$ c. 230 Nm$^3$
Coal c. 170 kg

Hot metal slag
Example Process gas balance

<table>
<thead>
<tr>
<th>Process</th>
<th>Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke Ovens</td>
<td>700 MJ (cowpers)</td>
</tr>
<tr>
<td>Conventional Blast Furnace</td>
<td>140 MJ</td>
</tr>
<tr>
<td>BOF</td>
<td></td>
</tr>
<tr>
<td>CHP Plant</td>
<td>240 MJ</td>
</tr>
<tr>
<td></td>
<td>2800 MJ</td>
</tr>
<tr>
<td></td>
<td>470 MJ</td>
</tr>
<tr>
<td>Distance heat</td>
<td>1200 MJ</td>
</tr>
<tr>
<td>Electricity</td>
<td>880 MJ</td>
</tr>
<tr>
<td>3510 MJ/thm</td>
<td></td>
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</tbody>
</table>

Impact of OBF on Process gas balance

<table>
<thead>
<tr>
<th>Process</th>
<th>Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke Ovens</td>
<td>940 MJ</td>
</tr>
<tr>
<td>Blast Furnace</td>
<td>240 MJ</td>
</tr>
<tr>
<td></td>
<td>2800 MJ</td>
</tr>
<tr>
<td></td>
<td>470 MJ</td>
</tr>
<tr>
<td>CHP Plant</td>
<td>0 MJ</td>
</tr>
<tr>
<td></td>
<td>470 MJ</td>
</tr>
<tr>
<td>BOF</td>
<td>1410 MJ/thm</td>
</tr>
<tr>
<td>Extra energy</td>
<td>1000+ MJ/thm</td>
</tr>
</tbody>
</table>

What are electrical CO₂ emissions?
Replacement energy for CHP?
**Common Nordic Solution - Background**

- The annual production for the Nordic steelmaking sites are between 600–2800 kton
- Landfill volumes ~20-100 kton/a per site
- Investment in alternative process is capital intense and requires larger treatment volumes
Centralised handling of residues

**Idea**
Invest in one installation for treatment of all residues
Allows for an economy of scale
Logistics are suitable for the main integrated works

**Possible Technologies**
RHF
Cupola Furnace
*Detailed studies are underway*

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**Conclusions**

- A process integration approach is important when evaluating different ways of operating an integrated steel plant and for evaluation of new technology
- The result of an optimization can be quite different depending on the selection of system boundary
- E.g. The blast furnace compared to blast furnace + ancillary operations + energy production in CHP plant
- Communication of PI analyses to effectively convey the results to all stakeholders must be further developed
Thank you for your kind attention