The blast furnace – fit for the future?

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The blast furnace – Fit for the future?

Introduction

- Metallurgical efficiency
- Alternative “benchmark” process modes
- Cross-industrial network
- Conclusions
Introduction
Steel production in the world, 2015

Dominant position of the blast furnace route ….
Introduction
Shares of metallic charge

... with increasing shares in the last years
Introduction

Blast furnace seize as inner volume

Inner volume: Volume between 1 m below chute in vertical position and taphole level

... but the biggest blast furnaces in Asia!
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Metallurgical efficiency
Energy consumption – Real vs. ideal case

Today the blast furnace is operated close to thermodynamic equilibria
Metallurgical efficiency

Energy consumption – Real vs. ideal case

Today the blast furnace is operated close to thermodynamic equilibria
Metallurgical efficiency
Energy consumption – Real vs. ideal case

Today the blast furnace is operated close to thermodynamic equilibria
Metallurgical efficiency
Consumption of reducing agents – BF’s in Germany

Asymptotic pattern to a minimum at the end of the 1990th
Metallurgical efficiency
Sinter composition, thyssenkrupp SE

Higher silica input via fine ores \(\Rightarrow\) Lower Fe contents in sinter
Metallurgical efficiency
Carbon and ash contents in BF coke, thyssenkrupp SE

Higher ash contents ➔ Lower C content in coke
Metallurgical efficiency
BF slag volume, thyssenkrupp SE

Increasing slag volumes ➔ Higher consumption of reducing agents
The BF is operated at 96 to 93 % efficiency level.
(State of the art operation related to a non-realistic process at the thermodynamic equilibrium and w/o heat losses)

Since end of 1990th the cumulated reducing agents consumption increases caused by
- higher slag volumes
- lower C contents in coke
- change from oil / natural gas to pulverized coal injection.
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## Alternative “benchmark” process modes
Different auxiliary reducing agents, HBI charging

<table>
<thead>
<tr>
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<th>PC</th>
<th>HBI</th>
<th>NG</th>
<th>H₂</th>
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<tbody>
<tr>
<td>Coke</td>
<td>kg / t HM</td>
<td>295</td>
<td>235</td>
<td>367</td>
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<tr>
<td>PC</td>
<td>kg / t HM</td>
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<tr>
<td>NG</td>
<td>kg / t HM</td>
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<tr>
<td>H₂</td>
<td>kg / t HM</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HBI</td>
<td>kg / t HM</td>
<td></td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

PC = Pulverized Coal  
HBI = Hot Briquetted Iron  
NG = Natural Gas  
H₂ = Hydrogen
Alternative “benchmark” process modes

Energy input **without** energy for HBI production

To suppress the energy for HBI production is an ecological prestidigitation.
Alternative “benchmark” process modes

Energy input with energy for HBI production

In total higher energy input included energy for HBI production.
Alternative “benchmark” process modes
Use of HBI in the blast furnace

From the energetic point of view it is cockeyed to cut the upper part of the BF, to shift the indirect reduction to an external process and to lose the sensible heat of the HBI in-between.

To report only the energy consumption and/or the CO\textsubscript{2} emissions of the BF and to “forget” energy need and CO\textsubscript{2} emissions for HBI production creates something like an perpetual motion machine.
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

Steps from C to more H$_2$ based reduction process

- **PC**: 200 kg PC / t HM
- **NG**: 100 kg NG / t HM
- **H2**: 40 kg H$_2$ / t HM
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

Steps from C to more H₂ based reduction process with changing gas compositions
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

Steps from C to more H₂ based reduction process with changing gas compositions
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

That’s a little bit like gas generation with associated hot metal production
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

Steps to hydrogen metallurgy effect decreasing CO₂ emissions …..
Alternative “benchmark” process modes
Auxiliary reducing agents with increasing hydrogen input

… with exploding CO₂ abatement costs
Charging of cold HBI is contra-productive from the energetic point of view.

With higher hydrogen input the energy need and also the energy export increase.

Shifting the reduction reactions from carbon to hydrogen causes lower CO$_2$ emissions, but exploding CO$_2$ abatement costs.
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Cross-industrial network
thyssenkrupp project Carbon2Chem – Chemical use of gases

State of the art
Blast furnace
Converter
Coke plant
Top gases
Power plant
CO₂
Electrical energy
Steel production

Chemical use of top gases
Blast furnace
Converter
Coke plant
Top gases
Power plant
Synthesis
Methanol
Synthetic fuel
Fertilizer
Alcohol
Polyalcohol
Polymers
Steel production

Significant reduction of CO₂ emissions and high value by-products
Cross-industrial network

Today ➔ Electric power

Carbon to CO₂, “internal” production of electric power
Cross-industrial network
Future ➔ Chemical products

Integrated iron and steel works

Chemical raw materials

Synthesis

COG, BFG, BOFG

Injection coal

Coking coal

Oxygen

Iron ore

Power plant

Steel

“Green” electric power

High value by-products, carbon to chemicals, use of “excess” green electric power
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Conclusion
State of the art, potentials and new ideas

- **Blast furnace as world champion in energy efficiency**
  No chances for further energetic improvements from the metallurgical point of view

- **“Hydrogen blast furnace”**
  Increasing energy consumption, lower CO\textsubscript{2} emissions, non-competitive costs

- **Rethinking the bounds**
  Cross-industrial network of steelmaking, chemicals industry and energy sectors to create an integrated economic and ecological optimum
Conclusion

Statements of clerical and political experts

Pope Francesco, 2015: “Climate change is a global problem.”

Chancellor Merkel, 2015: “The G7 leaders had committed themselves to the need to decarbonise the global economy in the course of this century.”
**Conclusion**

To realise this “decarbonisation” of the global economy we need steel .....
Conclusion

... and blast furnaces

Steelmaking without fossil energy based blast furnaces ..... the touchdown will be a disaster!
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