TECHNOLOGY DEVELOPMENT FOR ORE BASED METALLICS IN STEELMAKING

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Thomas Buergler
Climate Neutral Steelmaking
From Carbon to Hydrogen

2020

2035

2050

\( \text{CO}_2 \quad 100\% \)

\( \text{CO}_2 \quad < 70\% + \text{CCU/S} \)

\( \text{CO}_2 \quad \text{neutral + CCU/S} \)

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CLIMATE NEUTRAL STEELMAKING
FIRST STEP HYBRID PROCESS CONCEPT

voestalpine Linz site
Status Quo 2027

¬ Hybrid technology with EAF process additional to BF/DR/BOF until 2030
¬ Stepwise decrease of BF/BOF capacity at integrated sites
¬ Up to 30 % CO₂ reduction independent from green hydrogen
¬ High potential for further CO₂ decrease as soon as green hydrogen is economical available
¬ Concept ready for integration of breakthrough technologies 2035+

voestalpine Donawitz site
Status Quo 2027
Crude steel demand will be 30% higher in 2050 than today.

Much of this growth will be in emerging economies with declining demand in China, Europe, Japan, and South Korea.

Contribution of scrap in the total steel charge will likely grow up to 50% in 2050 from 30% than today.

Process technologies for OBM will have an important role in future CO₂ neutral steelmaking.

https://missionpossiblepartnership.org/
World iron ore market is dominated by low and medium grade iron ores.

Replacement BF/BOF by DR/EAF process route requires an adapted concept for steelmaking from low and medium grades iron ores.

<table>
<thead>
<tr>
<th>Iron Ore Grades</th>
<th>Seaborne Trade [Mt/y]</th>
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<tbody>
<tr>
<td>L (low grade)</td>
<td>58-62 %</td>
</tr>
<tr>
<td>M (medium grade)</td>
<td>62-65 %</td>
</tr>
<tr>
<td>H (high grade)</td>
<td>65-67 %</td>
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HYFOR is an alternative direct reduction process for ultrafine iron ores that will not require any agglomeration steps.

A combination with Smelter technology is used for melting and final reduction of direct reduced iron (DRI) based on low and medium grade iron ores with Fe < 65 %.

In that way green hot metal is produced with hydrogen for BOF or EAF steelmaking.
DIRECT REDUCTION TECHNOLOGY
PROCESS DEVELOPMENT HYFOR

- Test the performance of HYFOR reactor and preheating/oxidation cyclone under real operating conditions
- Direct reduction of magnetite/hematite iron ore fines with H\(_2\) in fluidized bed reactor at 700 °C up to a metallization degree of 97 %
- Typical grain size: 100 % < 150 µm
  Max. grain size: < 500 µm (up to 1 mm possible)
- Batch operation with 800 kg ultrafine iron ore is equal to 200 kg DRI per hour
- Pilot plant at voestalpine Donawitz site as technical basis for next development phase
Continuous operation from preheating iron ores to hot metal (HBI) in longer campaigns

Flexible Ore Basis – Utilization of multiple iron ore qualities (low to high grades)

Carbon addition – Based on bio-char and other carbon carriers

Hot link of DRI fines to Smelter (alternatively HCI) and addition of HBI/Scrap

Addition of slag forming materials → slag shall be utilized in the cement industry (cross-sectorial approach)

Autonomous operation of Smelter part
DEMONSTRATION PLANT
BASIC DESIGN HYFOR/SMELTER

Iron ore 2 – 3 t/h
Hydrogen 1.500 m³/h
Hot metal 2 – 3 t/h
Slag < 1 t/h

Location voestalpine Linz site
STEELMAKING PROCESS ROUTES
PROCESS DEVELOPMENT SUSTEEL

- Steelmaking from iron ores is a multi step process within the phase diagrams Fe-C and Fe-O.
- Scrap based EAF is the State-of-the-art process for direct steelmaking.
- Hydrogen Plasma Smelting Reduction (HPSR) is a breakthrough technology for direct steelmaking from iron ores.

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HYDROGEN PLASMA SMELTING REDUCTION
PROCESS DEVELOPMENT SUSTEEL

- Fundamental research project for direct steelmaking from iron oxides with $\text{H}_2$ plasma smelting reduction (HPSR)
- Verify of process concept with batch operation in a DC electric arc furnace (EAF) with 250 kVA
- Upscaling the technology from 100 g to 50 kg tapping weight
- Creating design parameters for an increased reactor size and continuous operation
- Demo plant located at voestalpine Donawitz
HYDROGEN PLASMA SMELTING REDUCTION
PILOT PLANT CONCEPT

- Iron ore and hydrogen enter the reactor via a hollow electrode
- Transferred arc for the energy input
- Hydrogen is ionised into plasma where iron ore is melted and reduced
- At the end of the process, crude steel is produced and only water vapour escapes
HYDROGEN PLASMA SMELTING REDUCTION
CURRENT STATUS SUSTEEL

- Plant Erected
- Stable Trials
- First 100% Pure Iron Produced
- Charging Higher loads
- First blocks
- First Rolled Plate

March 21 | May 22 | February 23 | April 23 | May 23
HYDROGEN PLASMA SMELTING REDUCTION
TASKS FOR FURTHER DEVELOPMENT

INTEGRATED ROUTE (STATE OF THE ART)
Integrated route consisting of raw material preparation, blast furnace (iron making) and basic oxygen furnace (steel making)

HYDROGEN PLASMA SMELTING REDUCTION
HPSR route consisting of green hydrogen supply, pre-reduction of fines and HPSR

SuS-F Objectives

Recycling of water
Continuous supply of green hydrogen (incl. desktop study of integrated hydrogen production)
Recycling & further use of off-gas
Continuous feeding of ultra fine ore
Automated and digitalized system
Semi-continuous tapping of carbon lean steel

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HYDROGEN PLASMA SMELTING REDUCTION
PILOT PLANT voestalpine DONAWITZ SITE
Thank you! Questions?

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