ESTEP SPRING DISSEMINATION EVENT

5-6 JUNE 2025 KRAKOW (POLAND)

HBI C-Flex

Reoxidation behaviour and stability of direct reduced and hot briquetted iron with variable iron and carbon content

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ESTEP

K1-MET metallurgical competence center

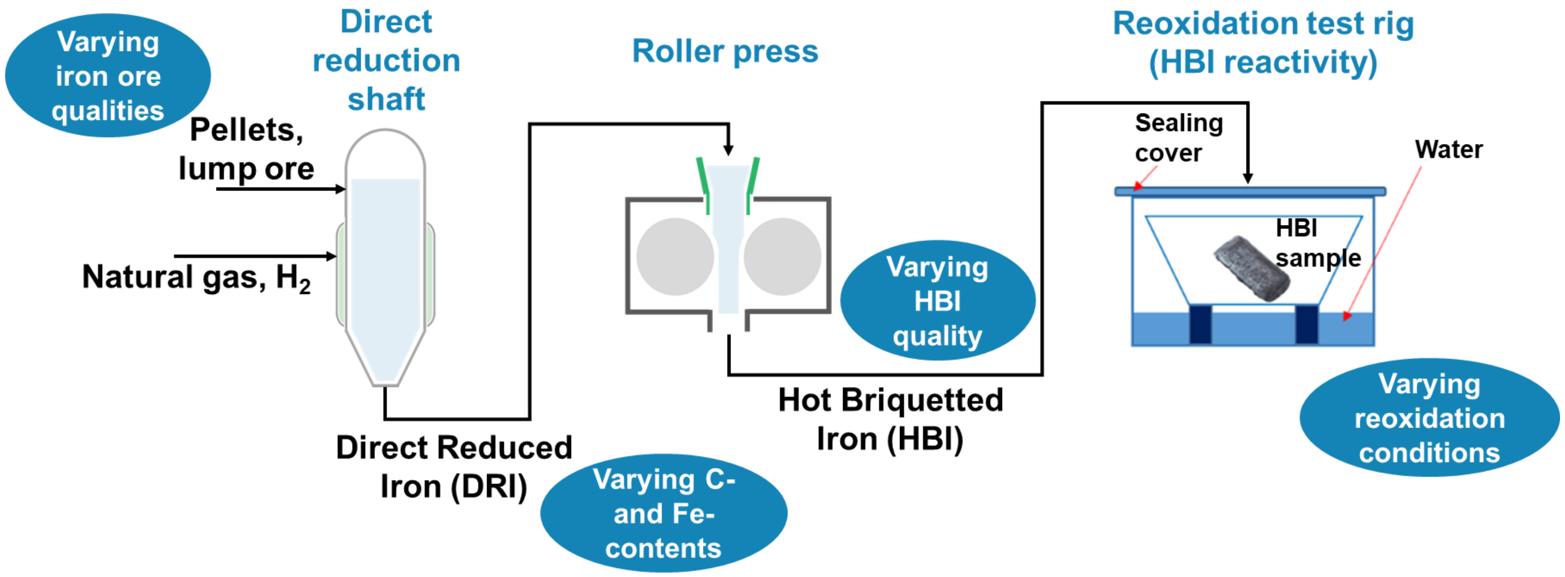
HBI C-Flex

HOTEL GALAXY JORDAN GROUP

Łukasiewicz GIT

Project overview
Key facts

- **Goal:** Determination of the influence of various parameters on the reactivity and reoxidation behaviour during HBI production, storage and transport
- **Boundaries:** Consideration and examination of the whole reduction process, briquetting, storage and transport at laboratory scale



This project has received funding from the Research Fund for Coal and Steel under grant agreement No 101112479.

Project overview
Key facts

HBI C-Flex

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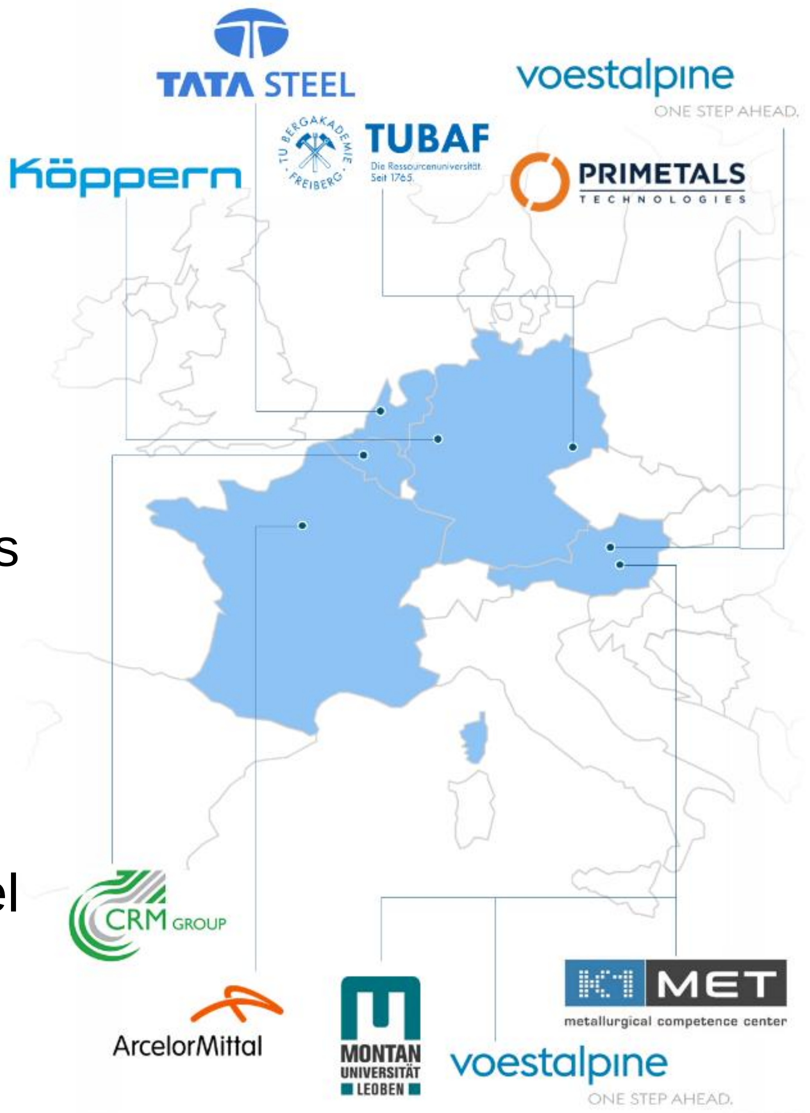
- **Start date:**
  July 1st, 2023
- **Duration:**
  42 months
- **Consortium:**
  10 partners and 14 SAB members
- **Coordination:**
  K1-MET (Austria)
- **Funding:**
  Research Fund for Coal and Steel (RFCS)



Supportive Advisory Board (SAB)

- iima International Iron Metallics Association
- posco
- VALE
- ENERGIRON DRI TECHNOLOGY BY TENOVA AND DANIELI
- MIDREX
- BHP
- ROGESA
- NUCOR
- RioTinto
- Stegra
- Mitsubishi Corporation
- MITSUI & CO.
- The Japan Iron and Steel Federation
- SAMARCO

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HBI production for future steelmaking
Current status

- Primary steel production remains essential to meet global demand
- Rising production and use of HBI in low-carbon production routes
- Current practice uses >5,000 kg/m³ density as a safety limit, yet lacks clear scientific validation
- Lower-density HBI (e.g., from low-grade ores) or HBI with low-carbon (from direct reduction based on 100% hydrogen) may present higher reoxidation risks
- Exposure to humidity, water or heat during transport can cause self-heating, ignition, or explosion
- Global ore diversity and the shift to low-carbon HBI require updated guidelines and safety knowledge

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HBI production for future steelmaking
Project objectives

Production parameters within the HBI C-Flex project:

- Flexible carbon contents (down to 0%)
- Varying iron ores (high-grade and low-grade pellets, lump ore)
- Alternating briquetting parameters (compression temperature, pressure, duration)

Open research questions:

- Reoxidation behaviour during HBI handling and storage (dry/wet storage using distilled and salt water, humid air, enhanced temperature)
- Reactivity trends of HBI

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Project objectives
Ensuring safe HBI use and enabling decarbonisation

New knowledge enables safe storage and handling of HBI with flexible carbon contents at steelmaking sites

Broadening the iron ore base supports a more circular and sustainable resource use

Project results will support updates to maritime transport regulations, ensuring safety based on validated, scientific findings

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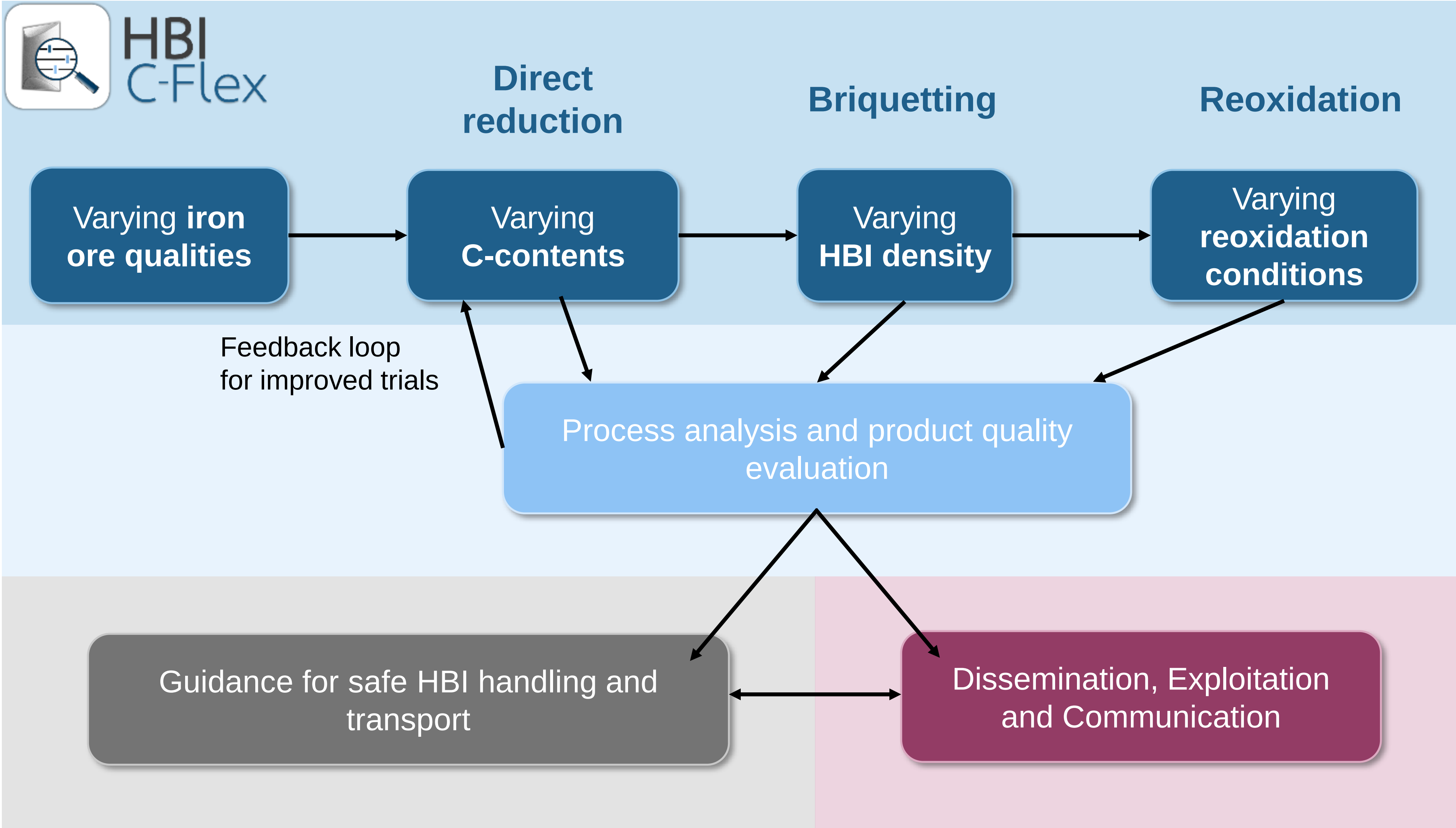
Organisational structure - Pert chart

HBI C-Flex Work Packages



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Direct reduction of selected pellets

Pellets reduction campaigns

HBI C-Flex

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6 materials

- 3 DR grade pellets
- 3 BF grade pellets

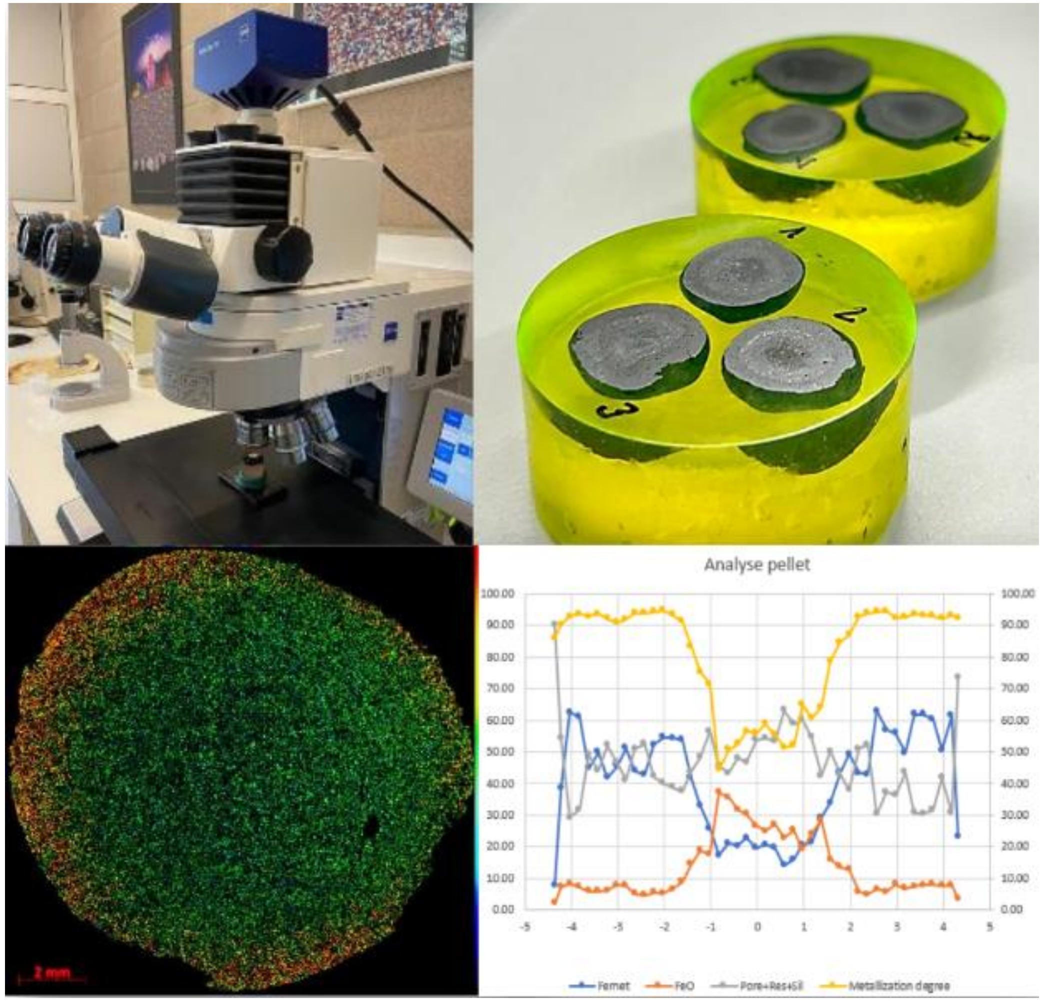
Pilot trials with:

- Parameters to simulate the Energiron process
- Parameters to simulate the Midrex process
- Pure Hydrogen

3 laboratory furnaces

- BORIS
- DRSIM
- HUGE

→ DRI with varying C and Fe content



Reduction profile of a partially reduced pellet

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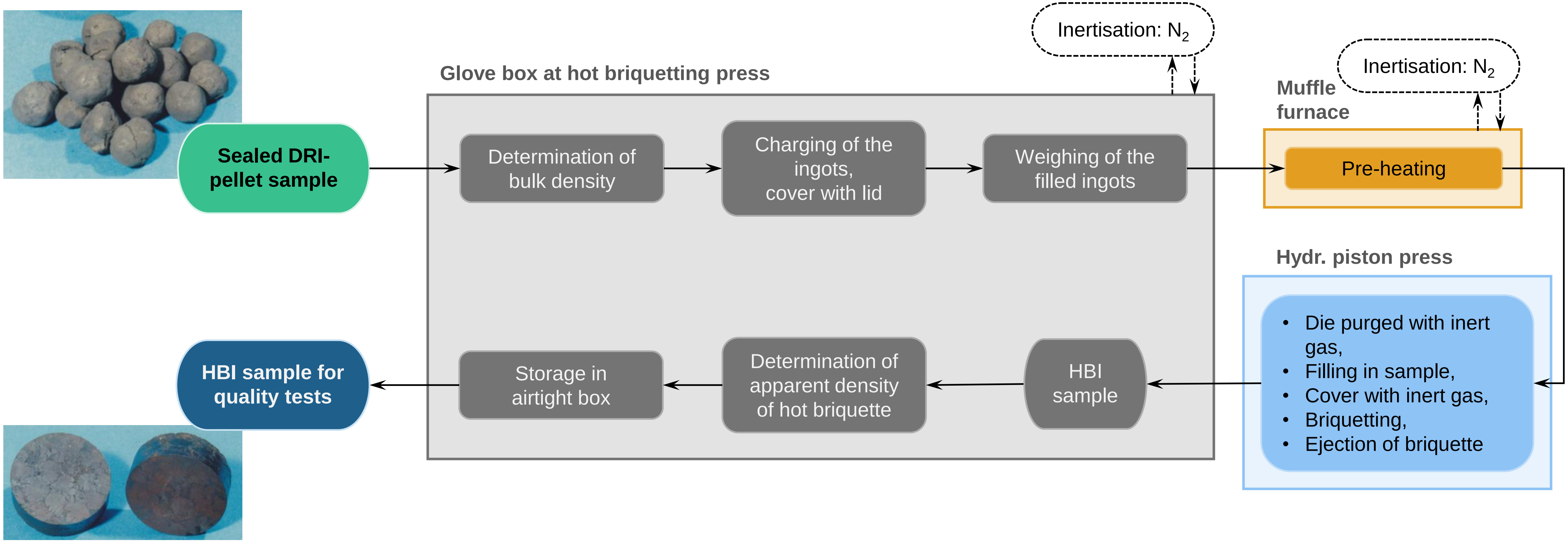
Briquetting tests
Setup, method and material



- Variation of compression pressure: 150 MPa, 200 MPa, 300 MPa
- Variation of compression temperature: 600 °C, 800 °C, 900 °C
- 6 briquettes for each trial

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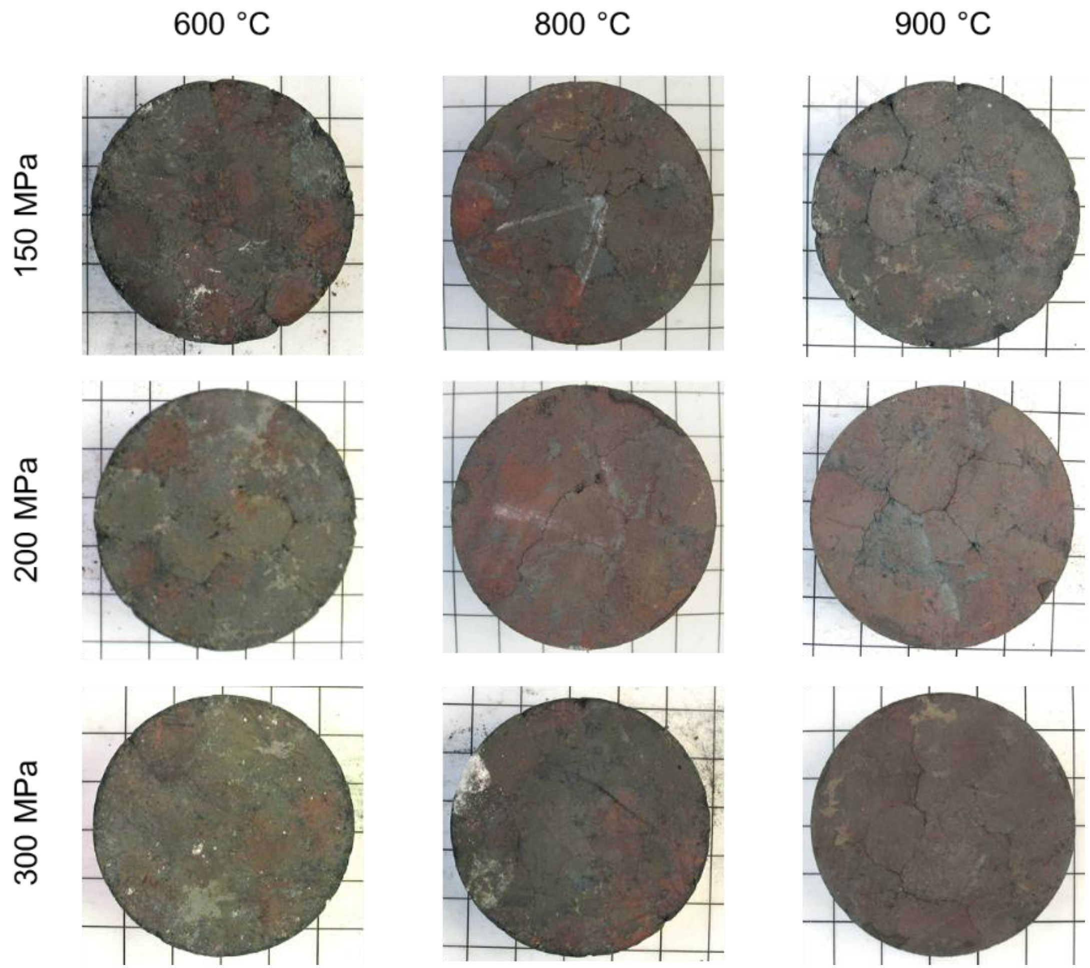
Briquetting tests
First results



- Chemical composition of DRI samples:
  - C 2.03 wt.%
  - Fe_{met} 86.18 wt.%
  - SiO_2 2.18 wt.%
  - Al_2O_3 0.26 wt.%
- Briquettes with smooth surface and clear edges without chips
- Higher pressure and temperature lead to higher apparent density
- At low compression temperature and pressure grain boundaries partially visible

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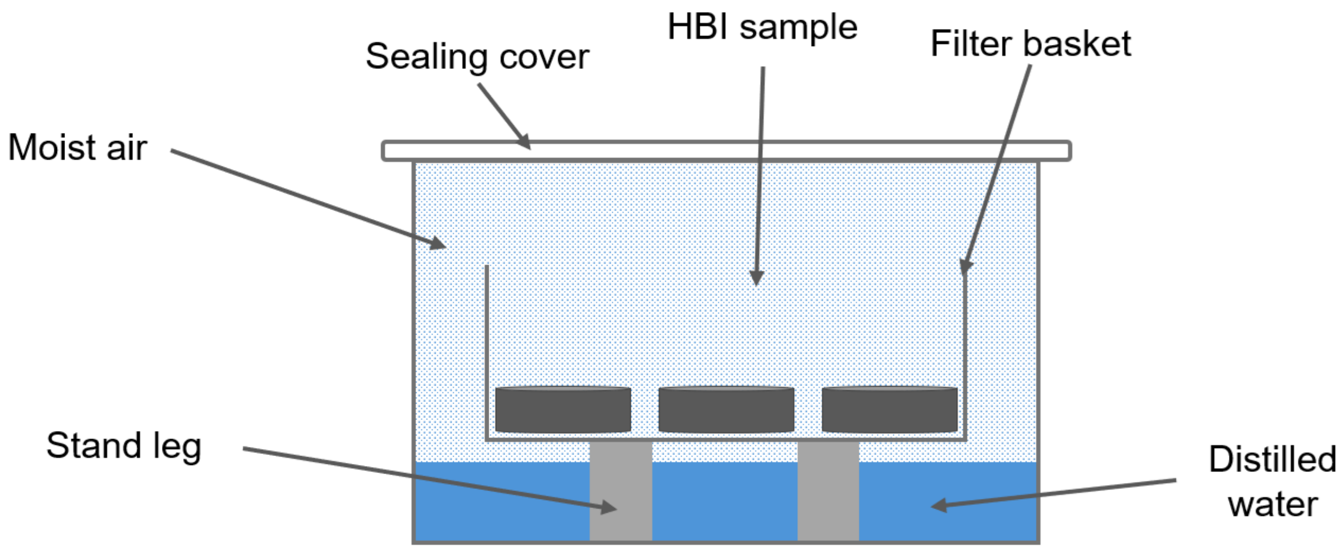
Reoxidation tests
Setup of lab-scale corrosion system



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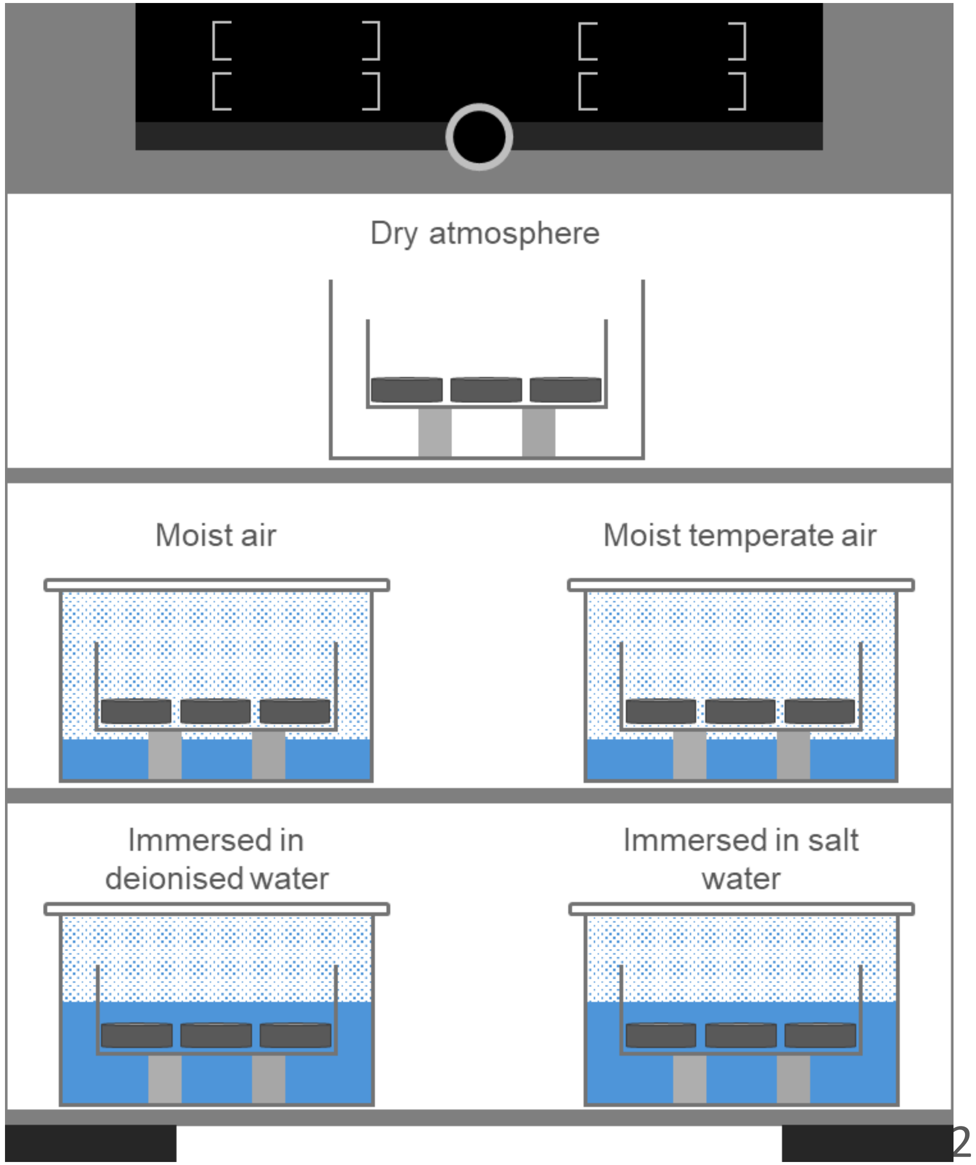
Reoxidation tests
Setup of lab-scale corrosion system

- Test boxes in climate chamber
- Test duration: 12 weeks
- Process audit of individual boxes:
  - Check moisture and temperature in each box – data digitalisation
  - Measure individual pH value
  - Testing hydrogen measurement

- Drying HBI samples
- Characterisation of HBI samples



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First results

From lab-scale experiments

Direct reduction

- Reducibility is good for all pellets reduced in Boris with H_2
  - Metallisation > 97.5%
- Fines generation is low
- At higher temperature:
  - Fines quantities decrease with metallisation

Briquetting test

- Higher pressure and temperature lead to higher apparent density

Reoxidation experiments

- Test series finished end of May
  - Data evaluation ongoing

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Thank you!

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ESTEP Spring Dissemination Event, June 5th, 2025

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