Science 4 Technology – Poster Exhibition 2024

Department of Environmental and Energy Process Engineering

Chair of Thermal Processing Technology

MONTAN UNIVERSITÄT LEOBEN

Table of contents

Nr.	Name	Title	Page
1	Doschek-Held Klaus	High-temperature processing technology	2
2	Doschek-Held Klaus	ReMFra: REcovering Metals and Mineral FRAction from steelmaking residues	3
3	Wiszniewski Lukas	Advanced Lithium-Ion battery recycling: Development steps towards a continuous recycling approach	4

High-temperature processing technology

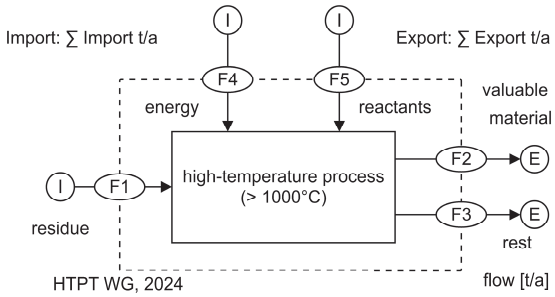
Working Group @ Chair of Thermal Processing Technology

INTRODUCTION

The desired defossilisation and climate neutrality of energy-intensive industries requires the reduction of the CO_2 intensity of products and the development of disruptive technologies. The "High-Temperature Process Technology" working group (HTPT WG) focuses on promoting a sustainable circular economy. The research concentrates on the resource-efficient valorisation of residues using high-temperature processes above 1000 °C. Knowledge of the physical properties of materials, such as melting behaviour and dynamic viscosity as a function of temperature and the chemical composition of the input materials and resulting products, are of crucial importance here. The fluctuating quality and variability of the input materials and the novelty of the processes and products lead to a research gap, which is closed by measurements and deepened by description and prediction models.

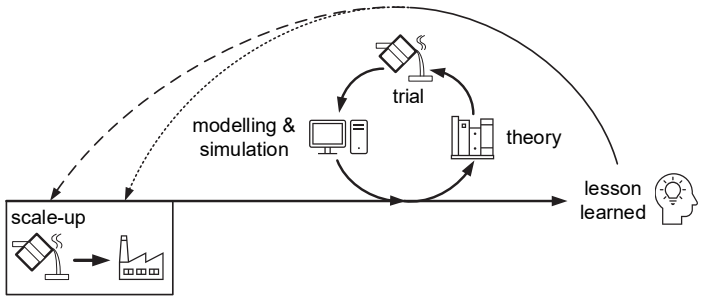
OBJECTIVES

- defossilisation and climate neutrality of energy-intensive industries
  - reducing the CO_2 intensity of products
  - development of disruptive technologies
- promoting a sustainable circular economy
  - resource-efficient valorisation of residues using high-temperature processes
- collaboration scientific and/or industrial partners
- education for sustainable development



SCIENTIFIC COMPETENCES

- material characterisation
  - physical & chemical properties
- high-temperature processes
  - process development & optimisation
- modelling & simulation
  - prediction model development



CURRENT PROJECTS – EXCERPT

acronym (link)	project	duration	funding
H2PlasmaRed	Hydrogen Plasma Reduction for Steelmaking and Circular Economy	01/24 – 03/28	EU
BitKOIN	CO_2-reduced Binding Agents through Thermochemical Conversion of Mineral Wool Waste Combinations	03/23 – 03/26	FFG
ReMFra	Recovering Metals and Mineral Fraction from Steelmaking Residues	12/22 – 05/26	EU
FuLIBatteR	Future Lithium Ion Battery Recycling for Recovery of Critical Raw Materials	07/22 – 06/26	FFG
Recover-Met-Binder	Valuable Metal Recovery and Binder Provision from the Electric Furnace Route as a Contribution to Cross-Sector Circular Economy	02/23 – 12/24	Zukunftsfonds Steiermark
UpcycSlag-Binder	Upcycling of slag residues to new, sustainable binders in the construction materials cycle	01/21 – 06/23	Zukunftsfonds Steiermark

Dipl.-Ing. Dr.mont., BSc
Klaus Doschek-Held
HTPT working group leader
Department of Environmental and Energy Process Engineering
Chair of Thermal Processing Technology
klaus.doschek-held@unileoben.ac.at*

*scan me

Horizon Europe Grant Agreement No. 101138228

Horizon European Clean Steel Partnership Grant Agreement No. 101058362

ReMFra

REcovering Metals and Mineral FRAction from steelmaking residues

INTRODUCTION

ReMFra is a research project within the Clean Steel Partnership (Horizon Europe) to develop and validate a highly efficient, industrial-scale pyrometallurgical smelting and reduction process for recovering metal and mineral fractions contained in various steelmaking residues. The treatment route is based on two sub-processes: a plasma reactor for processing coarse residues such as scale, sludge and secondary metallurgical slag and the RecoDust process for processing fine-grain residues, see Figure 1.

OBJECTIVES

The specific objectives of the ReMFra project are:

- Development and implementation of highly efficient technologies for recovering metals and mineral fractions from steelmaking residues
- Full by-product testing and evaluation
- Use of smart-sensors and dedicated Big Data analytics to develop and optimize decision-supported systems
- Enabling the use of obtained slag in higher-value applications
- Reduction of CO_2 emissions

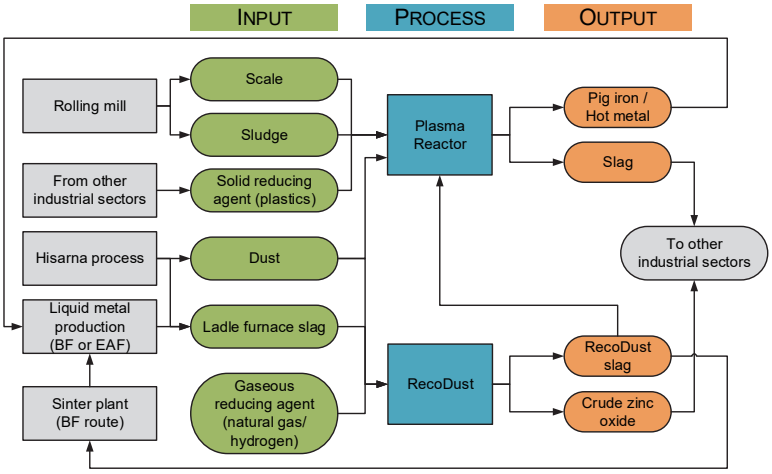


Figure 1: ReMFra concept

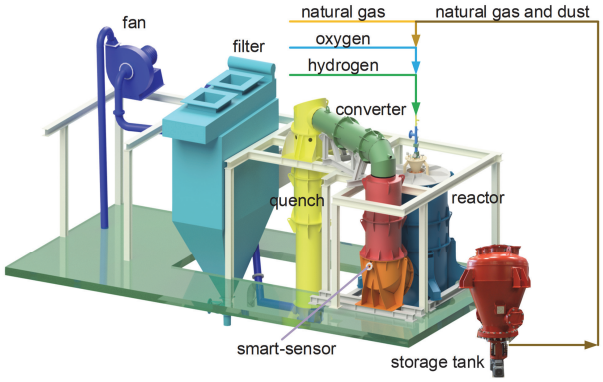


Figure 2: RecoDust pilot plant at the Chair of Thermal Processing Technology

RECODUST

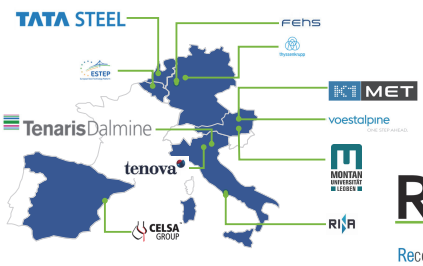
The RecoDust process is an innovative pyrometallurgical approach for treating heavy metal-containing dust. It is the central part of the MUL, K1-MET and voestalpine Stahl in this project, including the pilot plant's adaptation, smelting campaigns, and further development towards upscaling. The pilot plant is installed at the Chair of Thermal Processing Technology and will be operated by MUL and K1-MET with the support of the voestalpine Stahl, see Figure 2.

[1] Reiter, W., & Simoni, M. (2023). ReMFra – possibilities for residues from steel plants. In ESTEP Annual Event 2023-A Circular Economy driven by the European Steel

*scan me

Dipl.-Ing. Dr.mont., BSc
Klaus Doschek-Held
Department of Environmental and Energy Process Engineering
Chair of Thermal Processing Technology
klaus.doschek-held@unileoben.ac.at*

Dipl.-Ing., BSc
Wolfgang Reiter
Metallurgical Process Efficiency and Circularity
K1-MET GmbH
wolfgang.reiter@K1-MET.com



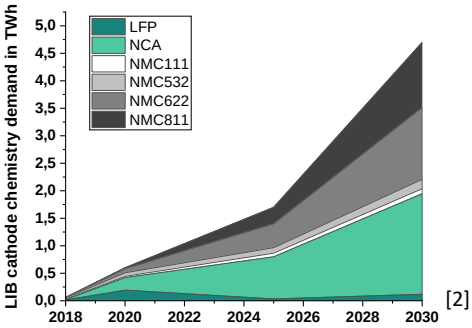
Co-funded by the European Union
Horizon European Clean Steel Partnership
Grant Agreemnt No. 101058362

ReMFra
Recovering metals and mineral fraction from steelmaking residues

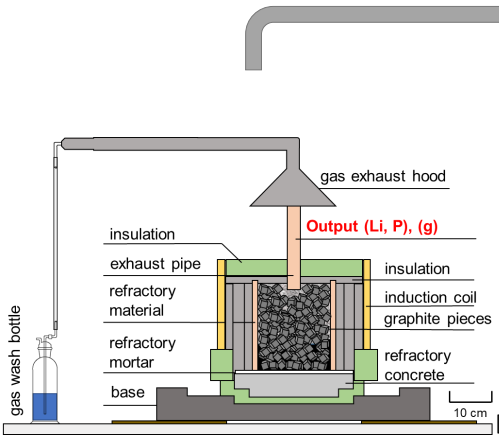
Advanced Lithium-Ion Battery Recycling: Development steps towards a continuous recycling approach

Lukas Wiszniewski, Thomas Hochsteiner, Klaus Doschek-Held and Harald Raupenstrauch

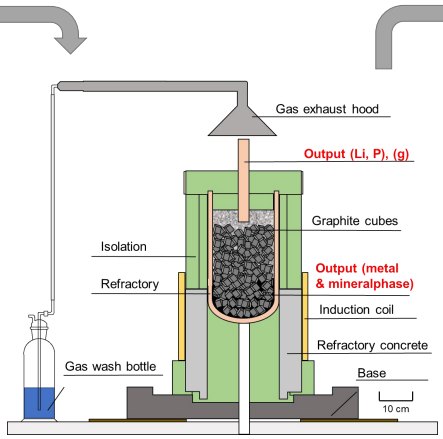
Introduction: Current recycling methods for Lithium-Ion batteries, fall short in achieving desired recovery rates and face significant challenges, including Lithium loss [1]. To address these issues, the Chair of Thermal Processing Technologies at Montanuniversität Leoben has introduced an innovative pyrometallurgical recycling approach, the so-called InduRed reactor. The InduRed reactor is an inductively heated carbon bed reactor with a high CO partial pressure, ideally to reduce the metal oxides from lithium-ion battery cathodes [2]. An adjustable radial and horizontal temperature profile, provides the possibility to extract volatile elements such as Li and P via the gas phase, while simultaneously recovering elements such as Ni and Co via an alloy. For this process, the formation of a thin melting film is needed.



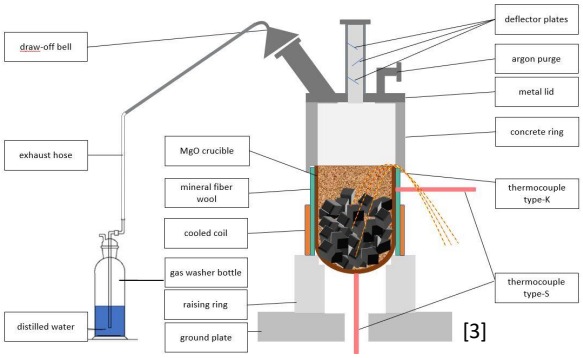
[2]



[4]

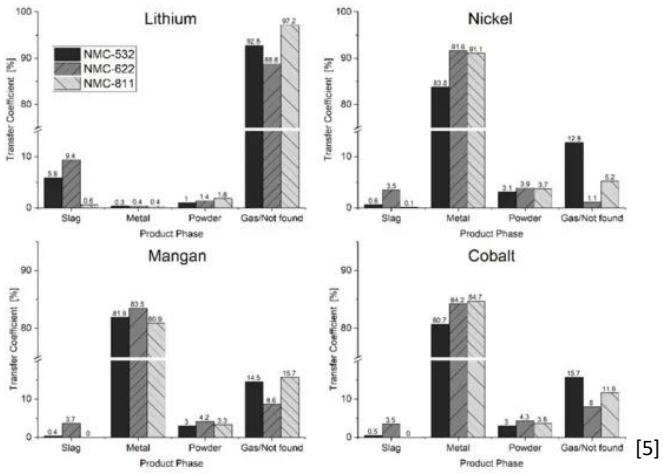


[2]



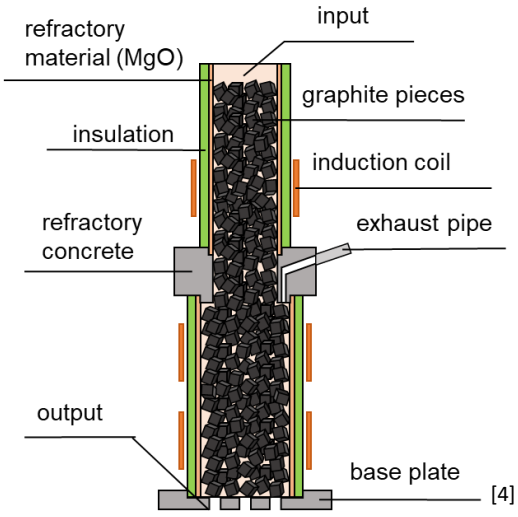
[3]

Results: Synthesized black mass to simulate real battery waste stream was operated in the batch versions to quantify the transfer coefficients of specific elements after carbothermal reduction of the metal oxides. It demonstrated a successfully recovery of more than 90% of lithium in all cases and nearly meets the 95% recovery goals for nickel, cobalt, and copper.



[5]

Outlook: As part of the scale-up strategy for the InduRed reactor, a dual approach is being adopted that encompasses both fundamental research and engineering design. The immediate goal is to scale the reactor to handle a capacity of 50 kg/h, continuing to processing 500 kg/h, signifying a fully commercial scale that is ready for industry adoption.



[4]

Dipl.-Ing
Lukas Wiszniewski
Chair of Thermal Processing Technology
lukas.wiszniewski@unileoben.ac.at

1. Nurdiawati, A. and Urban, F. (2021). Towards Deep Decarbonisation of Energy-Intensive Industries: A Review of Current Status, Technologies and Policies. Energies 14 (9), 2408. https://doi.org/10.3390/en14092408.
2. Holzer, A., Zimmermann, J., Wiszniewski, L., Necke, T., Gatschlhofer, C., Öfner, W., & Raupenstrauch, H. (2022). A Combined Hydro-Mechanical and Pyrometallurgical Recycling Approach to Recover Valuable Metals from Lithium-Ion Batteries Avoiding Lithium Slagging. Batteries, 9.2023(1). https://doi.org/10.3390/batteries9010015.
3. Hochsteiner T.: Vorversuche eines kontinuierlichen, pyrometallurgischen Lithium-Ionen Batterie Recyclingverfahrens. Master thesis. Leoben, Montanuniversität Leoben (2023)
4. Ponak, C. (2019). Carbo-thermal reduction of basic oxygen furnace slags with simultaneous removal of phosphorus via the gas phase [Dissertation]. Montanuniversitaet Leoben, Leoben.
5. Windisch-Kern, S.; Holzer, A.; Wiszniewski, L.; Raupenstrauch, H. Investigation of Potential Recovery Rates of Nickel, Manganese, Cobalt, and Particularly Lithium from NMC-Type Cathode Materials ($LiNi_xMn_yCo_zO_2$) by Carbo-Thermal Reduction in an Inductively Heated Carbon Bed Reactor. *Metals* **2021**, *11*, 1844. https://doi.org/10.3390/met11111844