

LOW-CARBON AND CIRCULAR VALORISATION OF SECONDARY MATERIALS IN ELECTRIC FURNACES FOR HIGH-QUALITY STEELMAKING

Tilen Balaško¹, Jožef Medved¹, Maja Vončina¹, David Bombač¹, Goran Kugler¹,
Matjaž Knap¹, Johanes Rieger², Alexander Halwax², Mojca Lončnar³

*¹ University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Materials and Metallurgy, Ljubljana, Slovenia; ² K1-MET GmbH, Leoben, Austria, ³ SIJ Acroni, Jesenice, Slovenia
(corresponding author: tilen.balasko@ntf.uni-lj.si)*

Main topic: Experimental and theoretical thermodynamics – new results and techniques

The CircSmeltSteel project funded by the European Union within the Clean Steel Partnership (Grant Agreement no. 101294187) validates the use of metallurgical by-products as secondary sources in low-carbon iron and steelmaking (Electric Smelting Furnace/ESF; Electric Arc Furnace/EAF). The project aims to clarify the impact of steel quality on product properties, while contributing to EU objectives related to net-zero manufacturing, sustainability, and competitiveness in the Net-Zero Industry Act, Clean Industrial Deal, Steel and Metals Action Plan.

The research encompasses the entire steelmaking value chain, from primary and secondary metallurgy and continuous casting to hot rolling, cold rolling and annealing. A low-CO₂ production route based on the ESF-EAF route and EAF as stand-alone recycling route is investigated using a system-level approach that incorporates metallurgical by-products as alternative feedstock at both, pilot and industrial scales. The resulting steel will be evaluated at elevated levels of tramp and residual elements including nitrogen, phosphorus, sulphur, copper, molybdenum and tin. Advanced experimental techniques, such as Gleeble simulations and dilatometry, will be employed to support the EU zero-defect manufacturing objectives.

CircSmeltSteel project also supports the EU's zero-waste and industrial symbiosis goals by promoting classification of the ESF and EAF slags as secondary raw materials for use in other industrial sectors. In addition, a skills development strategy aligned with the Industry 5.0 paradigm will enhance societal readiness for the adoption of lower-quality materials in low-carbon steelmaking technologies.

All data and models generated within the project will be integrated into a digital platform, providing a robust data management framework for R&D projects in the steel industry. The consortium combines expertise in metallurgy, plant technology, process automation, and circularity, supported by leading scientific partners. CircSmeltSteel project will increase awareness of the importance of utilizing lower quality metallurgical by-products in green steel production and facilitate their large-scale implementation, thereby contributing to a resource-efficient and competitive economy. The business potential is substantial, with an estimated 80 million tonnes of metallurgical by-product recycled annually through the ESF-EAF route and the potential to replace conventional blast furnace-based production routes in integrated steel plants.

Keywords: *Green steelmaking process chain, low-quality metallurgical by-products, Electric Furnace, material and process modelling*