MaxH2DR newsletter

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Maximise H2 Enrichment in Direct Reduction Shaft furnaces

The project falls under the funding programme of Horizon Europe – Clean Steel Partnership.

The call topic is related to Carbon Direct Avoidance in steel: electricity and hydrogen-based metallurgy.

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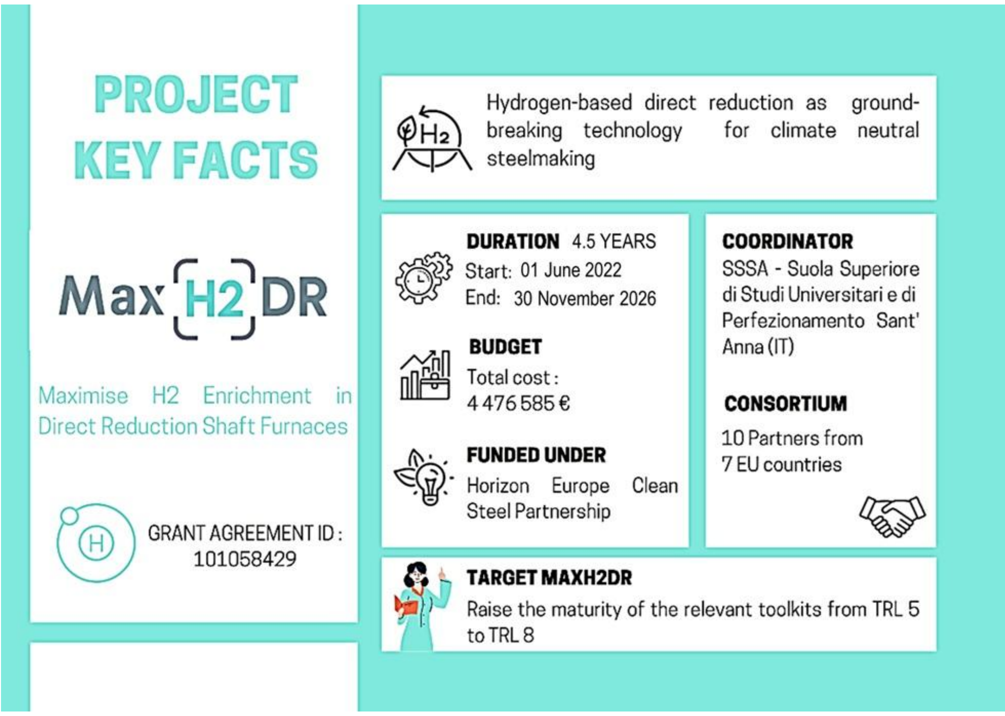
This project has received funding from the European Union under grant agreement n°101058429



Simulating Reduction Reactions in Steelmaking

As the steel industry shifts toward hydrogen-based processes, understanding how iron ore behaves inside a reactor becomes critical. At Ruhr-University Bochum (RUB), researchers are working closely with Tata Steel to simulate the reduction process inside a small hydrogen reactor using advanced digital models.

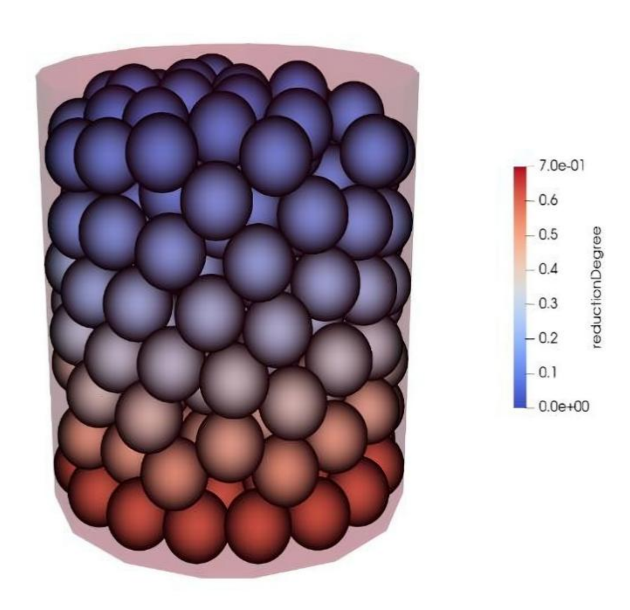
These simulations help scientists see how gases like hydrogen and water vapor move through the system, and how iron pellets inside the reactor chemically reduce and change over time. This work is part of a broader effort to make steelmaking cleaner, safer, and more efficient using hydrogen instead of coal.

To simulate real-world conditions, a Python-based chemical reduction model developed at the University of Lorraine was implemented into the in-house DEM-CFD simulation platform at RUB. The result is a powerful virtual environment where every particle movement and every reaction inside the particle can be tracked. In one key setup, the model simulates 200 iron ore particles inside a small cylindrical reactor. These are packed between two perforated plates and surrounded by aluminium oxide balls that help distribute heat evenly. The gas (a mix of 55%

hydrogen and nitrogen) enters from the top at 18.5 liters per minute, and the whole system is kept at a steady 900 °C.

The main goal is to track how iron ore pellets reduce under hydrogen flow. This is done by calculating the "reduction degree"—essentially, how much oxygen has been removed from the ore. The simulation results closely match experimental data from Tata Steel, especially in terms of mass loss over time, which is a key indicator of how much iron has been formed. The model also tracks the evolution of hydrogen (H_2) and water vapor (H_2O) during the reaction, offering a detailed picture of what's happening chemically.

What happens inside a hydrogen reactor?



A video has also been attached to this newsletter. It visually tracks the simulation over a period of 55 minutes, showing the reaction degree of each individual pellet. This time-based animation helps highlight how the reduction progresses through the bed, offering a clear view of how hydrogen gas interacts with the material in different regions of the reactor.

Watch the video of the Simulation

By combining physical experiments with virtual models, RUB researchers are helping Tata Steel and the broader industry reduce energy use, and accelerate the move to fossil-free steelmaking. These insights don't just save time and cost. They're laying the groundwork for the next generation of clean, hydrogen-powered steel production systems.

Related Publications

- Marsigny, O. Mirgaux, T. Quatravaux, F. Patisson: Influence of some operating parameters on the direct reduction of iron ore by hydrogen in a shaft furnace, *9th European Coke and Ironmaking Congress ECIC 2024*, Bardolino (Italy), October 16-18, 2024.
- 5. T. Hauck, V. Colla, P. Gupta, E. Illana, Y. Kaymak, S. La Manna, A. Marsigny, I. Matino, O- Mirgaux, M. Niesler, F. Patisson, T. Piontek, M. Poletto, H. Saxen, V. Scherer, A. Szemalikowska, J. van der Stel: Important aspects to optimise hydrogen enrichment in direct reduction, *7th European Steel Technology and Application Days (ESTAD 2025)*, Verona (Italy), October 6-9, 2025.
- R. . Béchara, H. Hamadeh, O. Mirgaux and F. Patisson: Optimization of the iron ore direct reduction process through multiscale process modeling, Materials, Vol. 11, No. 7, 2018, 1094, https://doi.org/10.3390/ma11071094

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