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E-ECO DOWNSTREAM

Development of Heating Technologies for the Efficient Renewable Energy Consumption of CO_2-Neutral Downstream-Processes

Material Testing for CO_2-Neutral Downstream Steel Processing

The transition from natural gas to hydrogen and other renewable energy carriers is one of the key challenges for the future decarbonisation of the steel industry. While alternative fuels can significantly reduce CO_2 emissions, they also change the atmosphere inside reheating furnaces. These changes may influence steel surfaces, scale formation, material properties and the durability of furnace components.

Within E-ECO DOWNSTREAM, BFI and Acciaierie d'Italia in A.S. (ADI) are investigating how future reheating strategies affect materials and product quality. The objective is to provide reliable data that supports the transition towards hydrogen-based steel production while maintaining process stability and product performance.

There are three key questions:

- How do hydrogen-rich furnace atmospheres influence oxidation and scale formation?
- How does the changed atmosphere affect descaling behaviour and final surface quality?
- Can hydrogen exposure influence material properties and the integrity of furnace components?

This project has received funding from the European Union under grant agreement NUMBER — **101178210**

Methodologies for investigations

To answer the questions mentioned above, laboratory investigations are carried out under controlled atmospheres ranging from conventional natural-gas combustion products to hydrogen-rich combustion gases. The studies focus on scale formation, decarburisation, hydrogen uptake and high-temperature corrosion phenomena.

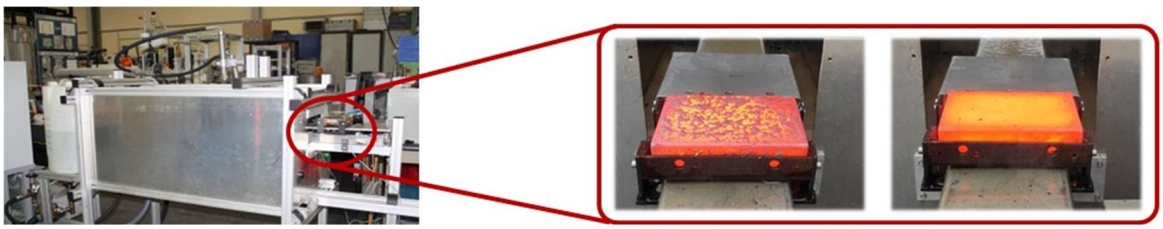
Hydrogen can affect the mechanical behaviour of metallic materials. Therefore, fracture-mechanics investigations are performed to evaluate hydrogen embrittlement and the reduction of fracture toughness. Combined with metallography, microscopy and fractography, these studies provide detailed information about degradation mechanisms under future hydrogen-rich conditions.

Thermogravimetric analysis (BFI)

A large-scale thermogravimetric analysis (TGA) facility is used to reproduce industrial reheating conditions. During testing, the oxidation process is continuously monitored, allowing us to determine scale growth, material losses and decarburisation behaviour. These investigations provide valuable insight into how future furnace atmospheres may affect steel quality during reheating.

Descaling investigations (BFI)

Scale formation alone is not sufficient to evaluate product quality. Therefore, BFI also investigates the removability of scale using a dedicated hot descaling test stand. The influence of water vapour from hydrogen combustion on residual scale is analysed. The results help identify operating conditions that ensure good surface quality after rolling.



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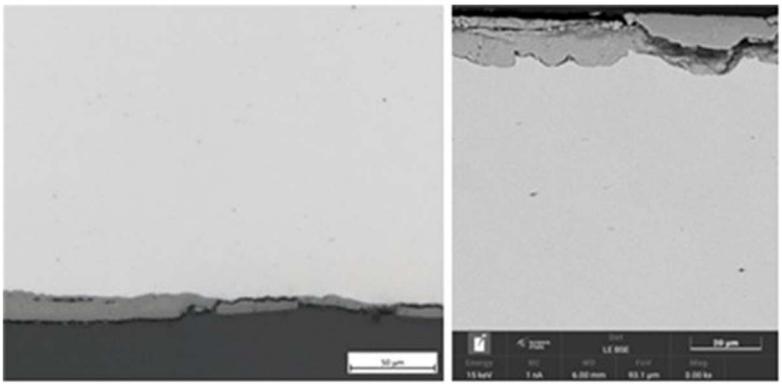
Methodologies for investigations

Surface and oxide layer analysis (ADI)

ADI contributes optical microscopy (OM) and scanning electron microscopy (SEM) to characterize the interactions between steel surfaces, oxide layers, and future combustion atmospheres. Optical microscopy will be used to evaluate the extent of oxidation, the adhesion at the oxide-metal interface, and the morphology of the scale (including voids and cracks). At the same time, SEM equipped with EDX will enable the study of oxygen concentration and the influence of the combustion atmosphere (in terms of oxygen and water vapor content) on the adhesion of the oxide layer at the interface with the steel substrate. These results support the interpretation of oxidation and reduction mechanisms occurring during reheating.



Example images of the interface (left: OM; right: SEM)

Hydrogen and Material Integrity (BFI, ADI)

Hydrogen can affect the mechanical behaviour of metallic materials. Therefore, fracture mechanics investigations are performed to evaluate hydrogen embrittlement and the reduction of fracture toughness. Combined with metallography, microscopy (OM, SEM) and fractography, these studies provide detailed information about degradation mechanisms under future hydrogen-rich conditions.

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Next steps

The ongoing investigations within E-ECO DOWNSTREAM will continue to generate valuable insights into the behaviour of steel products and furnace materials under hydrogen-rich reheating conditions. In the coming months, further laboratory testing and data evaluation will be carried out to deepen the understanding of oxidation, descaling behaviour, hydrogen uptake and material integrity.

The results obtained in these activities will contribute directly to the assessment of future furnace retrofit strategies. By integrating the experimental findings into the overall project framework, E-ECO DOWNSTREAM supports the development of reliable and efficient pathways towards CO_2-neutral downstream steel processing.

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