7TH ESTAD

ASSOCIAZIONE ITALIANA DI METALLURGIA

EUROPEAN STEEL TECHNOLOGY AND APPLICATION DAYS

VERONA, ITALY

6-9 OCTOBER 2025

Modular hybrid technology in steel plant production

ModiPlant

Funded by the European Union

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The challenge: steel industry emissions

6.7%

Global Production

European steel industry's contribution to global **crude steel production** (126.3 Mt in 2023)

4%

EU Emissions

Steel industry's **contribution** to total **EU greenhouse gas emissions**

23%

Manufacturing

Percentage of **manufacturing industry emissions** attributed to steel production

The steel industry is a cornerstone of the European economy but also a major source of greenhouse gas emissions, requiring innovative solutions to reduce dependency on fossil fuels.

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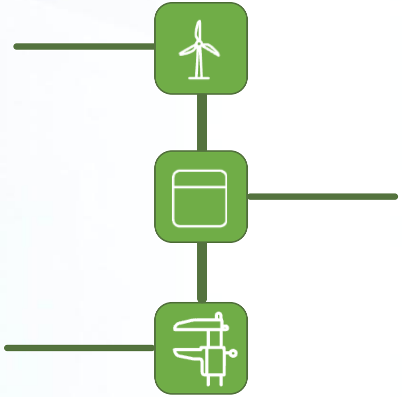
ModiPlant

- Integration of **induction heating furnace** for HDG lines and **conduction heating system** for billets.
- Definition of optimized operating windows for long and flat product **heating**, favouring **RES process electrification**
- Validating and optimizing **numerical models** against lab- and pilot-scale trials.
- Assessing **industrial feasibility**: hybrid layouts and CO_2 reduction potential.

The MODIPLANT project approach

Hybrid Heating Systems

Develop innovative **induction** and **conduction heating** technologies



RES-Based Electrification

Replace fossil fuels with renewable energy sources in **key downstream processes**

Maintain Quality

Ensure **product quality**, **productivity**, and **economic viability**

The project focuses on **decarbonizing reheating processes** while maintaining high **product quality**, **productivity**, and **economic viability** through two advanced technologies.

Key technologies under development

ModiPlant

Research and design phases → Electric heating system adoption in existing plant → Reduction of NG consumption

Key technologies under development

ModiPlant

- Research and design phases
- Electric heating system adoption in existing plant
- Reduction of NG consumption

Laboratory experiments: flat products

Steel Grades Tested

- Structural Steel (S)
- Dual Phase (DP)
- Interstitial Free (ULC-IF)

Heating parameters

Heating Rates (40-200°C/s) explored with target temperature of 700-850°C.

Testing methods

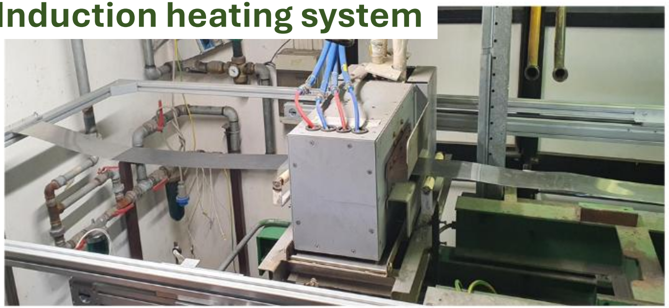
Induction heating pilot line, dilatometer, and Gleeble thermomechanical simulator.

Objectives

Explore new process parameters for heat treatment (annealing of cold rolled sheet) and support process modelling and upscaling.

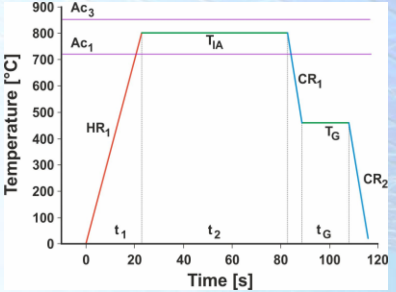
Gleeble simulator

Induction heating system



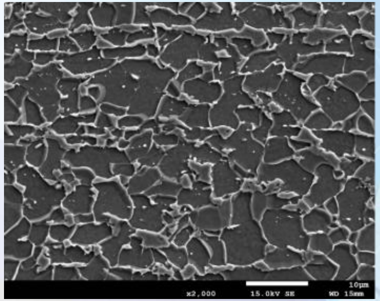
Key findings: flat products

	INDUCTION HEATING PILOT LINE	GLEEBLE MACHINE TESTS
Testing parameters	150–200 °C/s, no soaking time.	Two-level factorial experimental plan (HR, T_{IA}, t_{IA}, CR).
IF steel	Recrystallized microstructure with T ≥780 °C; low r-values to be investigated.	Heating Rate (HR) affected static recrystallization kinetics.
DP steel	Ferrite–martensite microstructure, full recrystallization at ~800 °C.	HR_1 and T_{IA} strongly affects $R_{p0.2}$. Increasing t_{IA}, CR_1 and CR_2 results in a R_m increase.
S steel	Recrystallized microstructure at 770 °C, properties within standards.	T_{IA} and CR_1 are the most significant parameters affecting yield stress ($R_{p0.2}$)



Legend
HR = heating rate
T_{IA} = soaking temperature
t_{IA} = soaking time
CR = cooling rate

HDG process cycle simulated (Gleeble simulator tests)



Resulting DP steel microstructure (after Gleeble tests)

Laboratory experiments: long products

Steel Grades Tested

Carbon steel alloys for long products.

Heating parameters

Target temperatures of 500, 1100, and 1200 °C in the different tests.

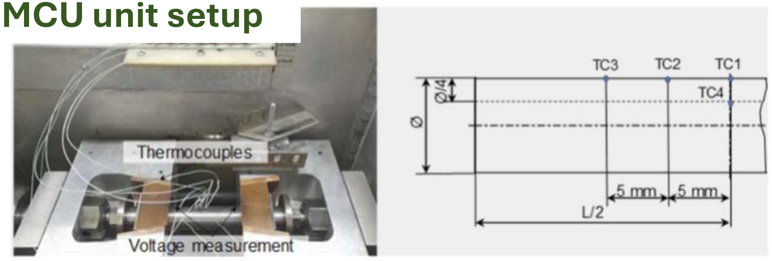
Testing methods

Induction and conduction heating systems test. Two testing setup were used.

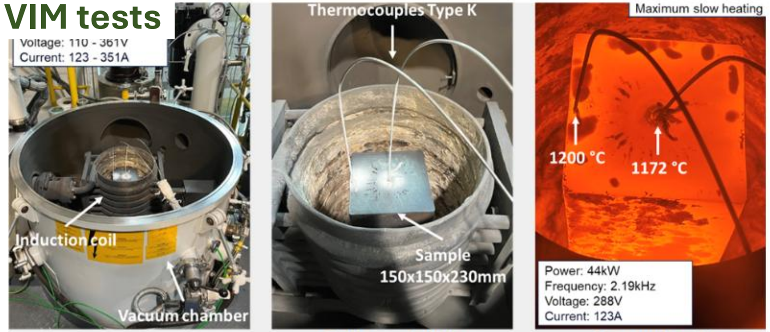
Objectives

Measurement of heating efficiency of both systems at lab scale.
Analysis of temperature gradients and microstructural evolution.
Validation of numerical models with experimental T–t profiles.

MCU unit setup



VIM tests



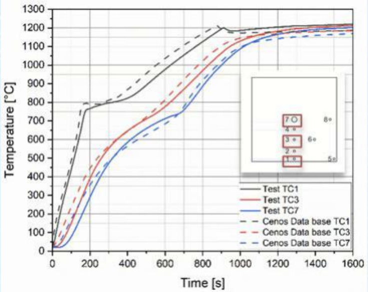
Vacuum Induction Furnace

Cold sample with two thermocouples

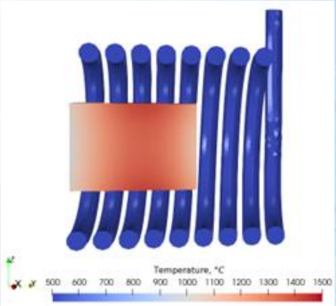
Hot sample with two thermocouples

Key findings: long products

	INDUCTION HEATING (VIM TESTS)	CONDUCTION HEATING (MCU TESTS)
Testing parameters	Variable frequency, power up to 150 kW, target temperatures up to 1200 °C.	Cylindrical samples Ø10–25 mm, heating rates 10–30 K/s, target 1100–1200 °C.
Findings	Maximum heating rates observed below the Curie point (~760 °C). Efficiency drastically decreases above the ferromagnetic–paramagnetic transition. Increasing power from 100 to 150 kW does not proportionally reduce heating time (saturation effect).	Strong thermal gradients detected (ΔT up to 530 °C in small samples). Current distribution and clamp contact conditions critical for uniform heating. Numerical simulations well validated by experimental T–t profiles.



Comparison of measured and calculated t-T at different position.



T distribution across the cross section of the billet.

Key technologies under development

Flat products

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Research and design phases

Electric heating system adoption in existing plant

Induction heating system + **NG heating** → **Plant: HDG line**

Objective: assess hybrid electrification of HDG line furnaces

Method: thermal/CFD models + techno-economic OPEX analysis on HDG lines

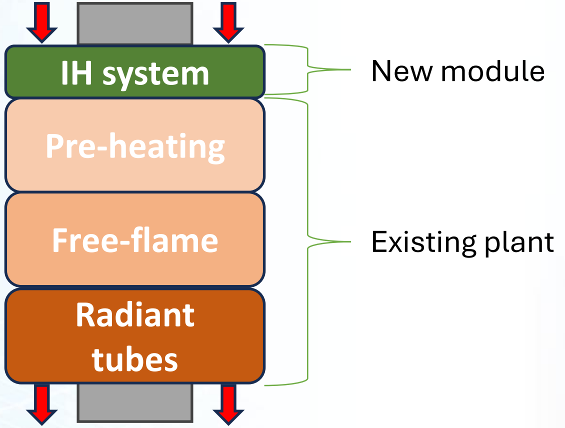
Key technologies under development

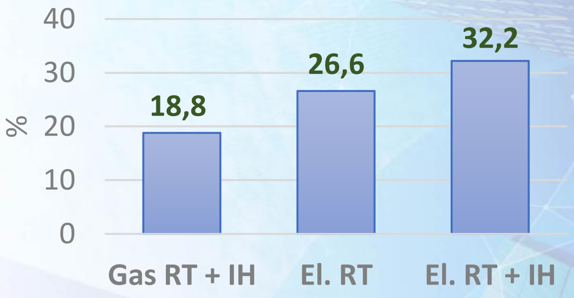
Feasibility of hybrid heating in HDG furnaces (flat products)

1. Simulation of furnace energy balance and OPEX

2. Comparison: NG tubes vs. electric tubes + induction

HDG line sections





Hybrid layout (inductor + electric RTs) enables up to 32% CO_2 reduction with competitive OPEX.

Key technologies under development

Long products

ModiPlant

Research and design phases

Electric heating system adoption in existing plant

Conduction heating system + **NG heating** → Plant: rolling mill for billets

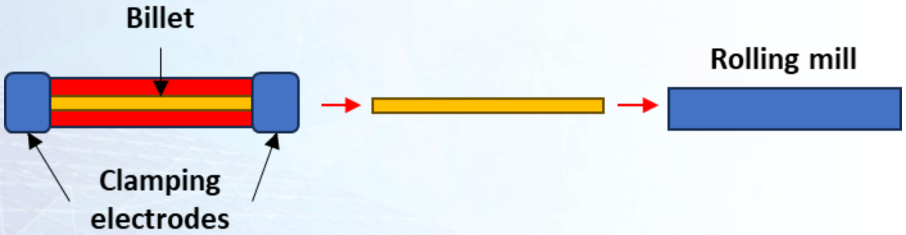
Objective: evaluate electrical reheating routes.

Method: techno-economic and plant layout analysis on reheating systems of rolling mill plants.

Key technologies under development

Feasibility of electrical reheating for billets (long products)

Rolling mill reheating sections



- Validated by simulations and design studies (conduction + hot charging/induction).
- Capable of reaching target billet temperatures with reduced NG use and CO_2 emissions.
- Real conditions and performances will be tested during pilot experimental trials.

Electrical conduction heating is a viable route for billet reheating, with hybrid layouts identified as the most promising solution.

Conclusions and next steps

Conclusions

- Hybrid induction & conduction heating proven as viable routes for downstream processes decarbonisation.
- Ultra-fast heating (150÷200 °C/s) validated without affecting metallurgical quality. Further investigation needed for IF steel.
- Significant potential for **CO_2 reduction (up to 32%)** and OPEX competitiveness.
- MODIPLANT provides **scientific validation + industrial feasibility** for green steel transition.

Next Steps

- Pilot tests on flat products in controlled atmosphere with improved soaking section.
- Induction heating plant installation.
- Industrial-scale validation of billet induction heating models.
- Pilot conduction heating experimental trials at Feralpi.
- Optimization of **hybrid heating layouts** (induction/conduction + electric/gas).

Thank you for your attention!

LinkedIn: www.linkedin.com/company/modiplant-rfcs-project

www.modiplant.eu

Funded by the European Union

This work was carried out with support from the European Union's Research Fund for Coal and Steel (RFCS) research program under the ongoing project: MODular hybrId technology in the Steel PLANT production - MODIPLANT - GA number: 101099118.