DTMI 2025

International Workshop Carlo Longaretti
on Digital Tools for the Metallurgical Industry

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A simulation-based digital tool for optimizing the steel heating process

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Why digital tools matter in modern metallurgy?

A collaborative initiative aiming to **integrate digital tools** into the metallurgical industry for a more efficient process management.

Supporting innovation in energy usage, emissions reduction, and product quality through advanced, **simulation-drive decision** support system.

Representation of a dynamic and interactive **simulation for stakeholders** closely connected to the production process.

Why digital tools matter in modern metallurgy?

- **Complexity of industrial processes:** steel billet heating involves a defined number of stages and physical pheanomena – making it challenging to optimize without comprehensive modeling.
- **Need for efficiency and sustainability:** following the EU Green Deal, the metallurgical industry is under increased regulatory and societal pressure to improve energy efficiency as a lever to reduce emissions and meeting climate targets.
- **Limits of traditional optimization:** conventional trial-and-error methods lack agility and insight, making them insufficient in a modern production environment.
- **Digital tools enable data-driven decisions:** simulation models like the one developed in MODIPLANT bridge the gap between physical operations and smart process control.

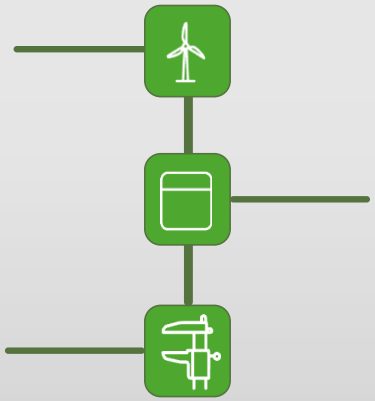
Digital transformation in steel manufacturing

Hybrid Heating Systems

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

Maintain Quality

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



RES-Based Electrification

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

The development of a **digital tool** will help:

- simulating and optimize the billet processing phases.
- Providing a platform for testing process parameters.
- Introducing decision support systems that combine real-time data with predictive simulations.

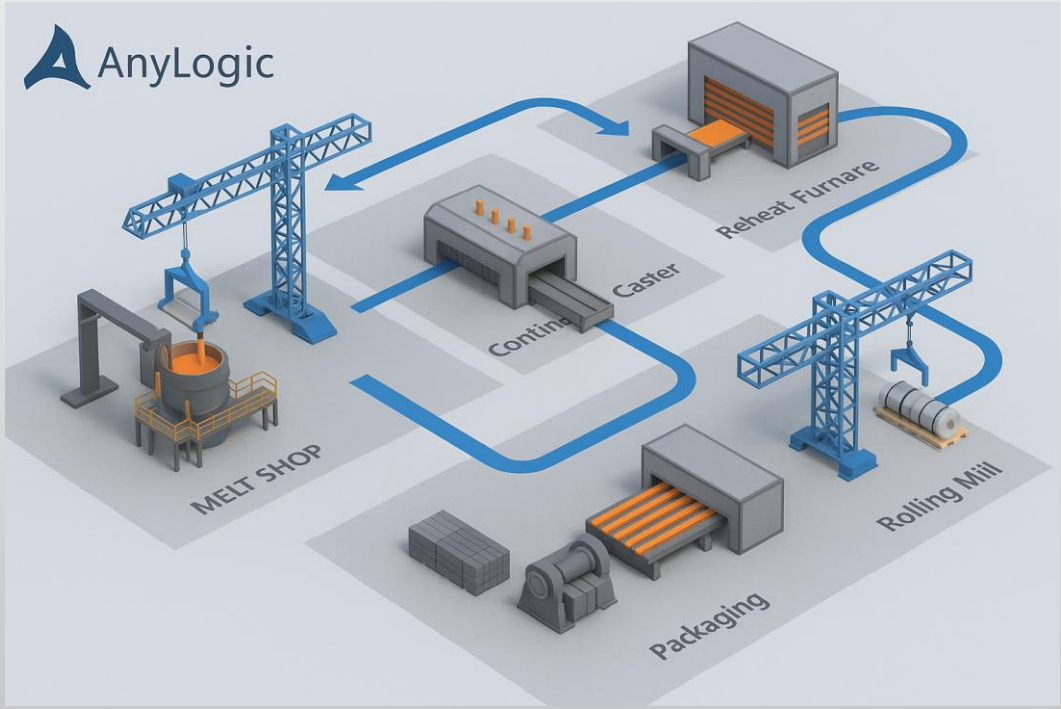
Funded by the European Union

ModiPlant

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

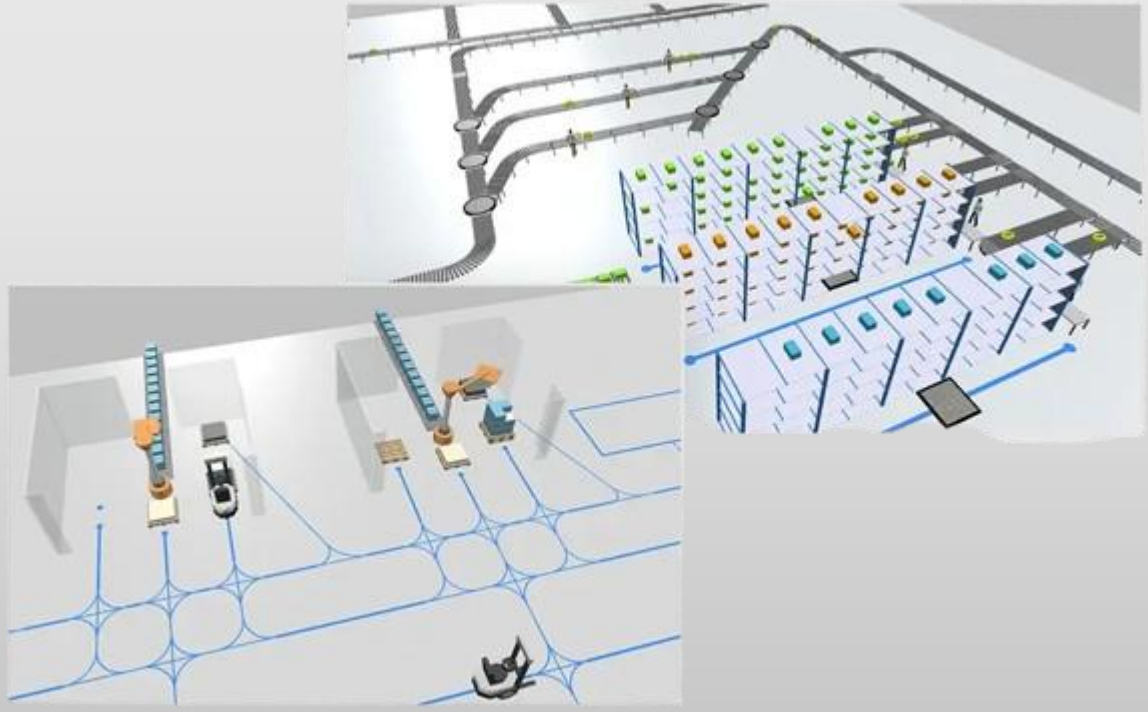
AnyLogic: multi-method simulation for manufacturing systems

- Combines **Discrete-Event**, **Agent-Based**, and **System Dynamics modelling** in one tool.
- Dedicated **libraries** for manufacturing, logistics, and process optimization.
- Enables "**what-if**" **simulations** to test layouts, resource use, and production strategies.
- Visualise processes in **2D** and **3D**, from material flow to product output.



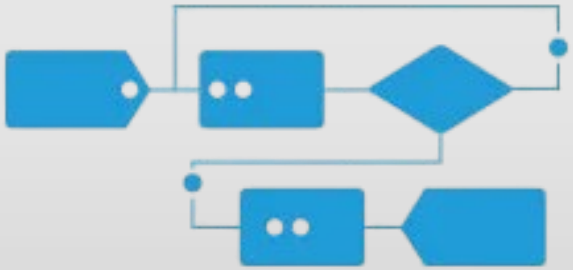
From factory layout to 3D process simulation

- **Material handling library**: conveyors, AGVs, buffers, storages, sensors, etc.
- Import real plant layouts (e.g. DXF) for realistic 3D modelling
- Build **end-to-end metallurgical process chains**: from raw material feed to cooling and packaging
- Communicate results effectively through **realistic visual animation**



Event-driven simulation for process optimization

- Model industrial operations as a **sequence of time-based events**
- Each event affects **resources**, **queues**, and **process flow**
- Enables detailed **performance analysis** — throughput, utilization, bottlenecks
- Supports **decision-making** through flexible “what-if” scenarios



Resources

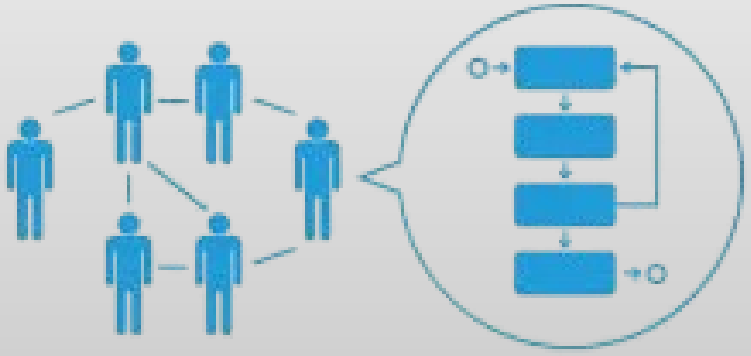
Process flow

Decision making support

Evaluation of process performances

Agent-Based Modelling

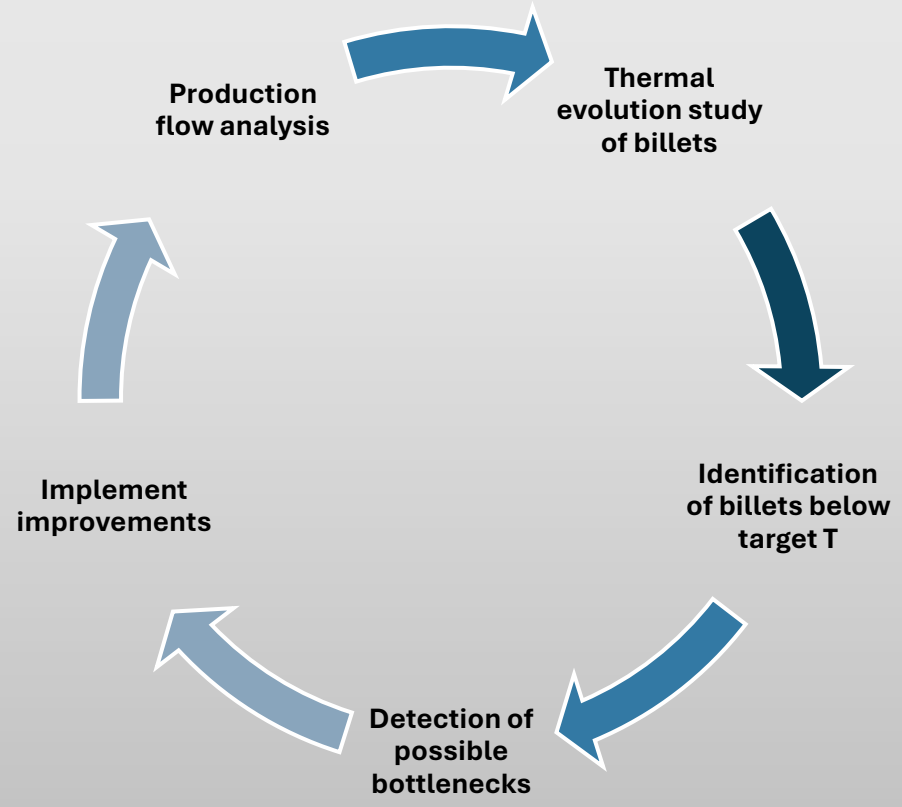
- Represents **systems as collections of autonomous agents** interacting with each other and their environment
- Each agent has **individual behaviour, goals, and decision rules**
- Captures **emergent system dynamics** that arise from many local interactions
- Ideal for modeling **complex, adaptive, or human-centric systems**
- Well-suited for **industrial systems** involving **machines, AGVs, and human operators**



Digital simulation of billet heating and rolling processes

Main simulation objectives

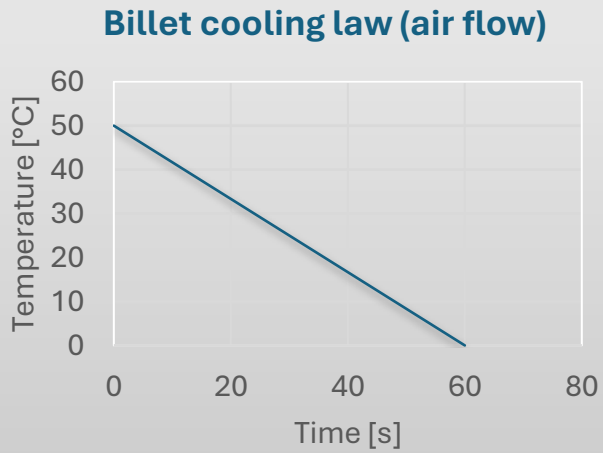
- Analysis of production flows under different layout configurations at Feralpi Siderurgica plants.
- Thermal evolution study of billets during the production cycle
- Identification of billets not meeting minimum temperature targets after the heating phase and before the rolling mill entry.
- Detection of bottlenecks along the production line.



Digital simulation of billet heating and rolling processes

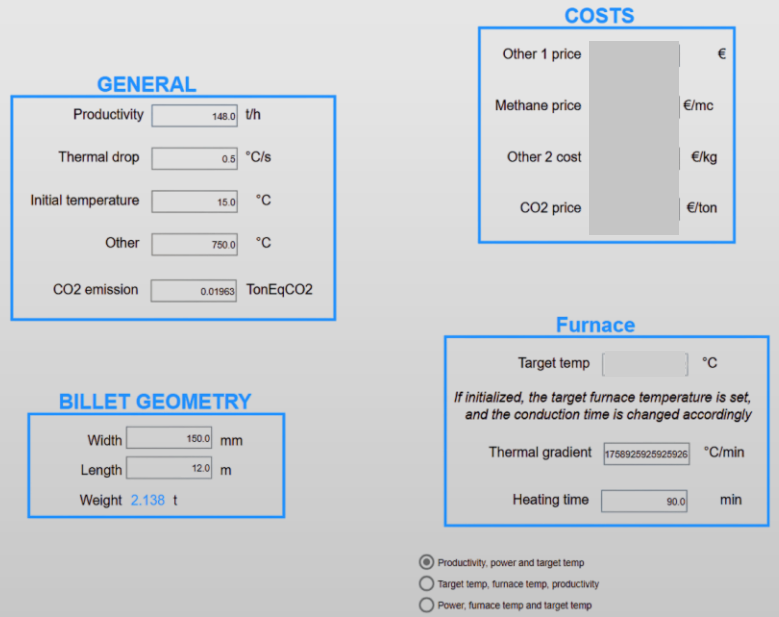
Industrial case study setup

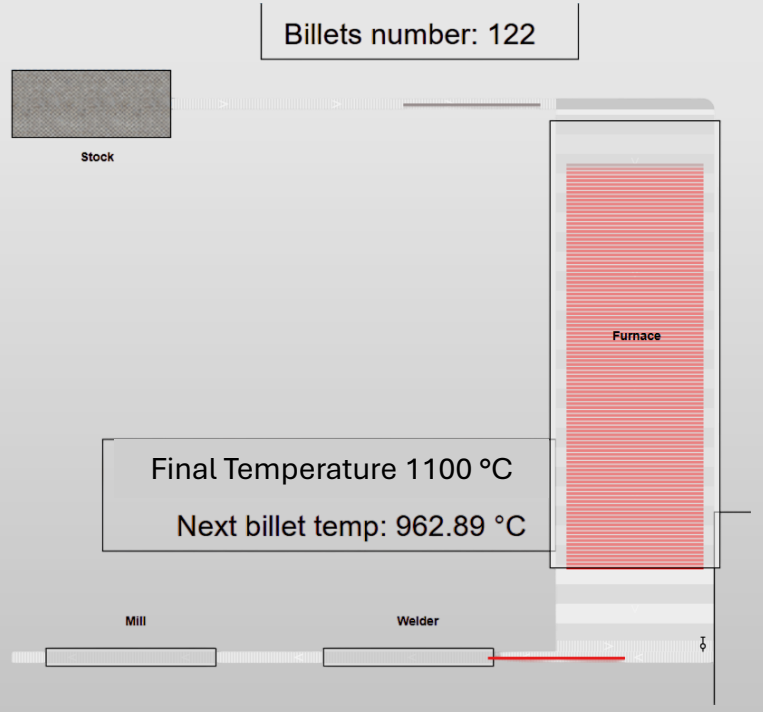
- Definition of model entitites:
  - **Billet entity**: diameter, length, and weight.
  - **Thermal evolution logic** implemented within the billet entity for both heating and cooling phases.
- **Production line reproduced** with realistic dimensions and layout.
- **Model inputs established**, covering the process from continuous casting up to the rolling mill.
- **Validation**, comparison with real case results or with behaviour expected.



Digital simulation of billet heating and rolling processes

At startup, a **parameter entry** screen is displayed (left image); subsequently, the simulation starts with a **graphical view** of the industrial layout (right image)



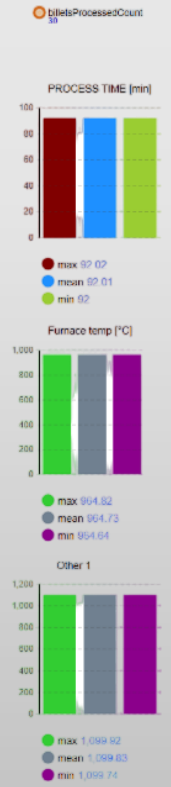


The user can **pause**, **resume**, **speed up** and **slow down** the simulation. It is also possible to select a specific element for getting its info

Digital simulation of billet heating and rolling processes

A dedicated **statistics page** displays all the information on times, consumption, and costs, allowing for a graphical comparison.

This will allow process engineers to find the ideal combination of parameters.



Digital simulation of billet heating and rolling processes

Dynamic variable coupling for furnace simulation
The model allows different combinations of input and output variables to explore furnace behavior. Depending on the chosen parameters, the model automatically computes the dependent variable.

Three possible configurations:

User defined parameters

Set 1:
Productivity + Power + Target T

Set 2:
Productivity + Target T + Furnace T

Set 3:
Power + Target T + Furnace T

Derived values

Set 1: output
Furnace output T

Set 2: output
Heater power

Set 3: output
Productivity

Digital simulation of billet heating and rolling processes

Post-processing and use of extracted information

Three main objectives:

- **Technical goal** – Evaluate **energy and methane consumption**; verify whether the current layout meets expectations and identify **opportunities for efficiency improvement**.
- **Automation goal** – **Simulate the production cycle** to identify **bottlenecks** and **productivity issues**.
- **Economic goal** – Assess **costs, revenues, and technical-economic feasibility scenarios**, focusing on **OPEX optimization**.

Industrial case study setup

Digital simulation of billet heating and rolling processes

Type of output	Evaluation for layout and plant design	Evaluation during plant production
Energy evaluation: - Energy consumption - Efficiency - CO2 emissions	High relevance	Very high relevance
Automation: - Billets motion - Heating permanences times - Constrains/Bottleneck - Productivity	Low relevance	Very high relevance
Costs: - Energies, ETS, losses - Loss of productivity - CAPEX, OPEX	Very high relevance	Medium relevance

Next steps in industrial case study setup

	Layout & plant design	During plant production
When to adopt	Adopted during plant layout and component design phase	During final assessment or production phase
Users	Design offices, Technologists	Automation & Production managers, Technologists
Benefits	Evaluate optimal layout and ROI	Optimize cycle, reduce costs, increase productivity

Outlook and next steps

Conclusions
Used digital tool: Anylogic for modelling, simulated data gathering and process improvement.

Next Steps

- Increase **awareness among technical departments** regarding the use of simulation tools already during the quotation and design phases.
- Enhance **collaboration with automation teams** to further **optimize production processes**.
- Run **case-based simulations** using **real production cycles**, performed **before investments** (during the design phase) and in close cooperation with automation.

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Thank you for your attention!

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