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EDITORIAL

Bridging science, sustainability and industry: insights from ESTAD 2025

Carlo Mapelli* and Davide Mombelli

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This special issue of *Metallurgical Research & Technologiy* presents a curated selection of papers originating from the European Steel Technology[r1] and Application Days (ESTAD) 2025, organized by the Italian Association for Metallurgy (AIM). For over a century, MR&T has served as a cornerstone for the dissemination of fundamental and applied research in the metallurgical sciences. The papers gathered here reflect the enduring relevance of this mission, showcasing how cutting-edge research continues to address the evolving challenges of process efficiency, product quality and sustainability in the metals industry.

The connection between ESTAD 2025 and MR&T is deeply rooted in a shared commitment to the rigorous scientific exploration of metallurgical processes. ESTAD has established itself as a premier forum where the global steel community converges to discuss advancements across the entire value chain—from ironmaking to downstream processing. The selection presented in this issue captures the breadth and depth of these discussions, offering insights into the complex interplay between process parameters, material behavior, and final product properties.

A dominant theme throughout this collection is the centrality of continuous casting and solidification science. Several contributions address the persistent challenges of inclusion control, microsegregation and breakout prediction, employing advanced numerical simulation, dynamic temperature criteria and electromagnetic stirring techniques. These works demonstrate how the integration of real-time data and sophisticated modeling is enabling unprecedented control over casting stability and internal quality—a core competency of the modern steelmaker and a long-standing area of interest for this journal.

Complementing these process-focused studies is a strong emphasis on physical metallurgy and materials development. Papers exploring the role of rare earth microalloying, the optimization of heat treatment routes and the formation of non-metallic inclusions reflect the ongoing quest for steels freatured by superior mechanical performance. Whether addressing medium-Mn automotive steels or non-oriented electrical steels, these contributions highlight the critical importance of understanding microstructure–property relationships—a foundational pillar of metallurgical research that MR&T has championed for generations.

The issue also gives substantial attention to the digitalization and automation of metallurgical processes. From feedback control systems for modern manufacturing to data-driven analysis of blast furnace gas utilization, these papers illustrate the sector progressive embrace of Industry 4.0 principles. Such advancements not only enhance productivity and quality but also contribute to the operational stability required for the integration of increasingly complex raw material streams and energy sources.

Sustainability, in its many forms, emerges as a unifying thread. Research on hydrogen-based burners for the electric arc furnace, the carbothermic reduction of rolling mill sludge using microwave heating, and the optimization of self-reducing briquettes for iron recovery all speak to the industry's multifaceted strategy for reducing its environmental footprint. Notably, contributions exploring the development of carbon-free mold powders and the smelting of secondary raw materials point toward a future where circular economy principles are embedded within core process technologies.

Finally, this collection reaffirms the value of integrating experimental investigation with thermodynamic and kinetic modeling. Whether simulating precipitation phases, analyzing slag viscosity, or modeling fluid flow in complex geometries, the authors demonstrate a methodological rigor that is essential for translating laboratory insights into industrial application.

Taken together, these papers offer a representative snapshot of the contemporary metallurgical landscape: one where fundamental science, process engineering and sustainability imperatives converge. We extend our sincere gratitude to the authors for their contributions, to the

* e-mail: carlo.mapelli@polimi.it

Italian Association for Metallurgy for their partnership and to the reviewers whose expertise ensured the quality of this special issue. It is our hope that this collection will serve as a valuable resource for researchers and practitioners alike, inspiring continued innovation across the metallurgical community.

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