

ADVANCED MODELLING OF EXTRUSION-BASED ADDITIVE MANUFACTURING: PHYSICS-BASED, DATA-DRIVEN AND HYBRID APPROACHES

MASSIMILIANO CREMONESI* AND GIACOMO RIZZIERI*

* Department of Civil and Environmental Engineering
Politecnico di Milano

Piazza Leonardo da Vinci, 32 – 20133 Milano, Italy
massimiliano.cremonesi@polimi.it; giacomo.rizzieri@polimi.it

ABSTRACT

Extrusion-based additive manufacturing is gaining increasing attention across a wide range of applications, involving diverse materials and spanning from industrial processing to large-scale construction. However, the accurate prediction of the manufacturing process remains challenging due to the complex interactions between material behaviour, processing conditions, and evolving geometries. Understanding and predicting material flow, deposited geometry, interlayer interactions, and structural stability are essential for improving process reliability and the quality of manufactured components.

Advanced computational modelling provides valuable tools to address these challenges. Physics-based approaches enable detailed simulations of extrusion and deposition processes, accounting for complex rheological behaviour, free-surface evolution, time-dependent material properties, and interactions between successive layers. Nevertheless, the computational cost of high-fidelity simulations often limits their application to large-scale problems, extensive parametric studies, and process optimization. Data-driven and hybrid approaches offer promising alternatives, combining the predictive capabilities of numerical simulations with the computational efficiency of machine learning and reduced-order models.

This invited session aims to bring together researchers developing advanced modelling strategies for extrusion-based additive manufacturing, including high-fidelity numerical methods, surrogate modelling, machine learning, physics-informed approaches, and hybrid physics-data-driven frameworks. Contributions addressing material and process modelling, geometric accuracy, interlayer interactions, buildability, process optimization, and uncertainty quantification are particularly encouraged.

The session seeks to foster discussion on the development of reliable, efficient, and predictive computational tools, highlighting the opportunities offered by integrating physics-based and data-driven methodologies to advance the simulation and optimization of extrusion-based additive manufacturing.