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DATA-DRIVEN MODELLING AND SIMULATION IN ADDITIVE MANUFACTURING

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ABSTRACT

Numerical simulation plays an important role in understanding and predicting the behaviour of additive manufacturing (AM) processes. However, detailed physics-based simulations are often computationally demanding, particularly when considering complex geometries, multiple physical phenomena, or large numbers of process parameter combinations. Data-driven approaches offer an alternative or complementary way of modelling these processes by making use of experimental measurements, numerical simulation results, and process monitoring data.

This invited session focuses on data-driven modelling and simulation methods for additive manufacturing, with particular emphasis on metal AM processes, such as laser powder bed fusion (PBF-LB/M) and directed energy deposition (DED). The session aims to present recent developments in the use of machine learning, data-driven surrogate and reduced-order models, and hybrid approaches combining physics-based models with data-driven methods.

Contributions may address different aspects of AM process modelling, including temperature evolution, melt pool behaviour, defect formation, residual stresses and distortions, microstructure development, and mechanical properties. Of particular interest are approaches that reduce computational effort while maintaining sufficient predictive accuracy, as well as methods that combine experimental data with numerical simulations. Issues related to model validation, data requirements, and the applicability of trained models to different process conditions are also within the scope of the session.

The session will also provide a forum for discussing the capabilities and limitations of data-driven approaches in AM simulation and their integration into existing modelling frameworks. Although the main focus is on metal additive manufacturing, contributions dealing with other AM technologies are also welcome.

Invited Session Topics

- Data-driven and machine-learning-based modelling of AM processes
- Data-driven surrogate and reduced-order modelling
- Hybrid physics-based and data-driven modelling approaches
- Prediction of thermal, mechanical, and microstructural behaviour
- Data-driven modelling of defects and process–structure–property relationships
- Integration of experimental, monitoring, and simulation data
- Model validation, generalisation, and uncertainty quantification
- Data-driven process optimisation and computational efficiency