Leveraging Data Models for Real-Time Predictions in Material Process Digitalization

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Abstract

AI-based data models and real-time predictions play a crucial role in the digitalization of material processes and their associated digital twins. These data models serve as the foundation for predicting and understanding the outcomes of material processes under various processing conditions. By enhancing process efficiency, prediction accuracy, and adaptability to changing conditions, these techniques lead to more cost-effective manufacturing and improved product quality. This research work addresses different aspects of data model creation, database building, snapshot preparation, model validation, and model updating. Various applications of these models for material processes are considered, including predictions for thermal fields, multi-scale microstructure evolution, mechanical states, process boundaries, and generative buildup processes.

Some of the key issues affecting the accuracy and efficiency of data models include data availability, the size and dimension of the search space, data distribution, and data processing and filtering. In the current research work, data from various sources, including experimental trials, numerical simulations, and verified literature, have been considered. The size and dimension of the search space were defined using the most influential process parameters. Databases were generated from snapshot scenarios using different variations of process parameters. The best combination of data solvers and interpolators was determined through performance analyses, which considered normal near-boundary and extreme process conditions.

Various process applications of real-time data models have been considered, including casting, extrusion, and additive manufacturing. Predictive models were generated for the design of new processes as well as the optimization of existing ones. The integration of these models into offline and online process advisory systems, along with digital twins and shadows, has been explored and appropriate data filtering and translations were implemented. Finally, it has been demonstrated that by employing the right combinations of data solvers and interpolators, along with further machine learning exercises, it is possible to achieve accurate predictions for complex material processes.

References

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