A parallel immersed finite element framework for numerical computations of metal additive manufacturing processes and products

J. Jomo*, N. Korshunova*, M. Carraturo*,†, S. Kollmannsberger,* R. P. Mundani * and E. Rank*,‡

* Chair for Computation in Engineering
Technical University of Munich
Arcisstr. 21, 80333 Munich, Germany

† Department of Civil Engineering and Architecture
University of Pavia
via Ferrate 3, 27100 Pavia, Italy

‡ Institute for Advanced Study
Technical University of Munich
Lichtenbergstr. 2a, 85748 Garching, Germany

ABSTRACT

Additive manufacturing technology has revolutionized the production of metal parts due to its high design freedom that allows the fabrication of custom complex-shaped objects. Nevertheless, several open questions regarding this technology, e.g. process parameters, product quality and reproducibility, still remain with various research topics centered on their experimental and numerical investigation. Numerical simulation of these processes is a particularly demanding task since a wide-range of spatial and temporal scales need to be resolved in order to obtain conclusive results. An integral aspect of such simulations is the use of adaptive mesh refinement and high performance computing to achieve fast and efficient simulations.

In this contribution, we present a parallel finite element framework for process and product simulations in metal additive manufacturing. The underlying numerical methods used are the multi-level *hp*-refinement [2], which aids in dynamic mesh adaptation and the efficient resolution of the different spatial scales, as well as the finite cell method (FCM) [1], a high-order immersed FE-method. FCM provides a flexible discretization that does not need to conform to the boundary of the object being printed and is beneficial for the simulation of objects with a complex shape.

Our contribution will include the presentation of the computational framework as well as an array of numerical examples that show the interplay and benefit of adaptive finite element techniques, immersed methods and parallel computing in the simulation of metal additive manufacturing processes and products.

REFERENCES

[1] J. Parvizian, A. Düster and E. Rank: Finite Cell Method, h- and p-extension for embedded domain problems in solid mechanics. Computational Mechanics, 2007.

[2] Zander, N. and Bog, T. and Kollmannsberger, S. and Schillinger, D. and Rank E. *Multi-level hp-adaptivity: high-order mesh adaptivity without the difficulties of constraining hanging nodes.* Computational Mechanics 2015.