LMS Seminar

4 April 2024 at 2:00 pm - Room Jean Mandel

A highly efficient computational approach for fast scan-resolved simulations of metal additive manufacturing processes on the scale of real parts

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ABSTRACT

The talk presents a fast computational method to simulate metal powder bed fusion additive manufacturing (PBFAM) processes on the part-scale to predict quantities of interest (QOI) such as temperature evolution, microstructural phase composition, and residual stresses. The fundamental computational challenge for part-scale simulations lies not so much in the requirements of the spatial discretization but rather in the large number of time steps necessary to resolve the fast-moving laser path. In contrast to many existing approaches in the literature, the proposed model consistently resolves the physical scan path, enabling new and detailed insights into the scan-strategy- dependent evolution of QOIs, especially for complex geometries. Starting from a highly efficient thermal model [1], efficient solution schemes and implementation techniques are presented to predict the thermally induced microstructural composition and the residual stress distribution. A performance analysis demonstrates the high degree of optimization of the presented approach. Among others, the computational framework allows to perform a coupled thermal microstructure simulation with a resolved laser beam path for the complete build process of the AM Bench 2022 cantilever specimen (312 layers, 30 million spatial degrees of freedom, 50 million time steps) with a time-to-solution below two days.

BIOGRAPHY

In 2016 Christoph Meier received his PhD from TU Munich, focusing on finite element formulations for highly slender beams and their interactions. From 2016 to 2018 he stayed as postdoc at the Mechanosynthesis Group at MIT. There, he worked on modeling and simulation approaches for additive manufacturing (AM) processes, a second core topic of his research. Since 2018, Christoph Meier is lecturer and deputy head of the Institute for Computational Mechanics at TU Munich. Moreover, since 2024, Christoph Meier is leading a junior research group associated with his ERC starting grant “Accelerated Additive Manufacturing: Digital Discovery of a New Process Generation”. He received various awards for his work in research and teaching, including the Dr.-Klaus-Körper Prize for the Best PhD Thesis of 2016 in the Fields of Applied Mathematics and Mechanics (International Association of Applied Mathematics and Mechanics, GAMM), the Rudolf Schmidt-Burkhardt Memorial Prize of TU Munich, the Teaching Award of the Bavarian State Government as well as scholarships from, e.g., the German Academic Exchange Service (DAAD) and the International Association of Applied Mathematics and Mechanics (GAMM).

REFERENCES

[1] Proell, S.D., Munch, P., Kronbichler, M., Wall, W.A., Meier, C. A highly efficient computational approach for fast scan-resolved simulations of metal additive manufacturing processes on the scale of real parts, Addit. Manuf. (2024) 79