FEMPAR-AM: A parallel FE framework for the simulation of powder-bed metal additive manufacturing processes.

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ABSTRACT

Numerical simulation of metal Additive Manufacturing (AM) processes involves dealing with multiple scales in space and time, coupled multiphysics, and complex and growing-in-time geometries. Among metal technologies, Powder-Bed Fusion (PBF) adds an extra layer of computational complexity to the simulation. Indeed, PBF features very thin layers, leading to long build jobs of thousands of layers. In this sense, High Performance Computing (HPC) tools have the potential to handle fully-resolved analyses in time frames compatible with time-to-market.

The presentation will describe recent advances and contributions by the authors towards the design of HPC tools for metal AM. A (fully distributed) parallel FE framework for the high-fidelity heat transfer analysis of PBF metal AM at the component scale has been already developed [1]. It is grounded on four building blocks: (1) a parallelized element-birth method to model the metal fusion process, supported by a parallel search algorithm and a dynamic load balance strategy; (2) octree-based adaptive mesh refinement endowed by space-filling curves [2]; (3) a novel unfitted FEM formulation, referred to as AgFEM [3], able to take control over the ill-conditioning issues of standard unfitted FEM; (4) state-of-the-art parallel iterative linear solvers.

The parallel FE framework has been implemented in FEMPAR [4], an advanced object-oriented parallel FE library for large scale computational science and engineering. Numerical experiments will be presented to verify the model and assess the capabilities and efficiency of the framework in large scale scenarios. Afterwards, the thermal model will be tested against physical experiments carried out at the Monash Centre for Additive Manufacturing in Melbourne, Australia [5]. In this case, the sensitivity analysis and calibration is supported by iterative mathematical and statistical tools. The numerical results are in good agreement with the experimental data.

REFERENCES

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