A parallel finite-element framework for the heat transfer analysis of metal additive manufacturing

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ABSTRACT

In this work the numerical simulation of metal Additive Manufacturing (AM) processes is addressed [1]. In most metal AM systems, a high energy and focused laser melts metal powder or wire to sinter each layer of the object. A layer of added material is created according to the scanning path defined by the user. As a result, a layer-by-layer metal deposition (with titanium, Inconel, steel, or other metals) can be carried out to build complex shapes for components such as turbine blades, aircraft stiffeners, cooling systems, medical implants, among others. The advantage of these kind of processes is the rapid cooling of each deposited layer that results in a finer grain size of the material, if compared to other metal forming technologies such as casting or forming.

The Finite-Element (FE) framework developed to simulate the metal deposition process has already been addressed and experimentally validated for both wire-feeding [3,4] and blown-powder technologies [5]. However, in the case of powder technologies (powder bed or blown powder), the number of layers to be simulated is much higher than in other technologies, leading to massively large problems that must be dealt with in a computationally efficient manner.

This work enhances the FE framework presented in [5] to run it in a HPC platform. This is achieved by adopting a parallel FE activation technique to follow in time the growth of the geometry driven by the movement of the laser. Moreover, the global linear system of equations is preconditioned with the weakly-scalable Balancing Domain Decomposition by Constraints (BDDC) [2]. The BDDC solver has been implemented in such a way that it can dynamically handle the growth of the geometry in an efficient way. This solution strategy has been implemented in FEMPAR, an advanced high-performance and object-oriented research software. A weak scalability analysis to show the performance of this new framework is shown.

REFERENCES

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