Topology optimization of supports for thermo-mechanical constraints in additive manufacturing

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ABSTRACT

Support structures are often required in additive manufacturing for ensuring the quality of the final built part. Indeed, overhanging subparts may be hard to manufacture and thermal residual stresses induce deformed final configurations, far from the desired design. Building on our previous works [1], [2] we propose mathematical models and optimization constraints to implement in a level set topology optimization process, which allow us to design optimal support structures. Our models are derived with the requirement that they should be as simple as possible, computationally cheap and yet based on a realistic physical modeling. Supports are optimized with respect to various physical properties. They must support overhanging regions of the structure for improving the stiffness of the supported structure during the building process. They must mitigate the thermal deformations induced by the large heat flux produced by the heat source (typically a laser beam). They should reduce the amount of thermal residual stresses and help in channeling the heat flux created by the laser beam. We also introduce a geometric accessibility constraint in order to ensure the removability of supports. Of course, our simple constraints and manufacturability conditions should be tested with more precise and involved numerical simulations, as well as with experiments.

Our optimization algorithm relies on the level set method and on the computation of shape derivatives by the Hadamard method. In a first approach, only the shape and topology of the supports are optimized, for a given and fixed structure. In second and more elaborated strategy, both the supports and the structure are optimized, which amounts to a specific multiphase optimization problem. Numerical examples are given in 2-d and 3-d.

Acknowledgements. This work was partially supported by the SOFIA project, funded by BPI (Banque Publique d'Investissement).

REFERENCES

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