Topology optimization of convective fluid flow with additive manufacturing constraints

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ABSTRACT

The determination of optimal structures is a relevant issue in many engineering problems. The corresponding geometry to satisfy a given objective can be obtained via topology optimization. This method has been applied first in structural mechanics and then to a large range of physics as heat transfer and fluid flow for example. The strength of topology optimization relies in the important number of degrees of freedom involved in the search of an optimal design, which allows the creation of complex geometries. Nowadays, additive manufacturing (AM) can be useful to build such geometries but some additional constraints needs to be considered in the topology optimization framework to do it. One example of such constraint is the solid connectivity needed for the layer-by-layer process. Therefore, this communication aims to propose a optimized structure for a convective heat transfer application with AM constraints. A gradient-based method is used to find the optimal geometry. The calculation of the cost function gradient, with respect to design variables, involves the solution of the forward problem at each iteration of the optimization. The forward problem can be solved via classical methods with Navier-Stokes and energy equations, but the Lattice Boltzmann method (LBM) [1] is an interesting alternative to solve this problem. LBM has an explicit formulation and its algorithm is well suitable for high parallel computing [2]. Added to that, LBM can treat in a simple way the boundary conditions, which is another interesting feature for topology optimization where the geometry can be complex. The numerical application is based on 3D laminar flow with heat transfer. The computational domain is composed of $100 \times 100 \times 100$ elements. The objective of the topology optimization problem is to increase the heat transfer efficiency of the fluid/solid structure. A constraint on the geometry connectivity is introduced in the topology optimization algorithm in order to ensure the fabrication of the obtained geometry by AM directly form the optimization results.

REFERENCES

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