Reducing the impact of microstructural porosity in additive manufacturing via structural shape optimization

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Porosity is a well-known phenomenon occurring during various manufacturing processes (casting, welding, additive manufacturing) of solid structures, which undermines their reliability and mechanical performance. The main purpose of this talk is to introduce a new constraint functional of the domain which controls the adverse effect of microstructural porosity on mechanical properties of elastic structures in the framework of shape and topology optimization. The main ingredient of our modeling is the notion of topological derivative, which is used in a slightly unusual way: instead of being an indicator of where to nucleate holes in the course of the optimization process, it is a component of a new constraint functional which assesses the influence of pores on the mechanical performance of structures. The shape derivative of this constraint is calculated and incorporated into a level set based shape optimization algorithm. This approach will be illustrated by several two- and three-dimensional numerical experiments of topology optimization problems constrained by a control on the porosity effect. These works have been conducted together with Grégoire Allaire, Charles Dapogny and Francisco Periago.