On structural optimization for metal 3d printing

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ABSTRACT

Wire-and-Arc Additive Manufacturing (WAAM) is a metal 3D printing technique that allows fabricating elements ranging from simple to extremely complex shapes [1]. Among the others, layer-by-layer manufacturing can be used to produce plates of printed material which are found to exhibit significant elastic anisotropy, whereas dot-by-dot printing is employed to build lattices made of bars whose mechanical properties are affected by the fabrication direction.

Within this context, the design of WAAM components is addressed by formulating problems of structural optimizations [2] that take into account peculiar features of the printing process. Topology optimization by distribution of anisotropic material is exploited to perform the simultaneous design of the shape and the printing orientation of stiff beams and I-beams conceived for production by layer-by-layer manufacturing. Shape optimization based on the force density method is implemented to design funicular geometries for fabrication of reticulated shells via dot-by-dot printing, accounting for manufacturing and failure constraints.

In both cases, the arising multi-constrained formulation of optimal design may be efficiently tackled through methods of mathematical programming [3]. Applications are shown, pointing out the peculiar features of the achieved optimal layouts and of the proposed numerical methods.

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