Adding Process Physics to Topology Optimization for Additive Manufacturing

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Topology optimization (TO) is a generative computational design approach that has formed a strong connection to additive manufacturing (AM). The combination enables designers to extract maximum benefits from the enormous design freedom both technologies offer. In recent years, there have been numerous developments to include specific AM restrictions into TO, in order to avoid designs that are costly or impossible to print. Typically, these approaches have been focusing on geometric AM design rules, such as imposing an overhang angle constraint. While certainly useful and computationally efficient, these geometry-based methods lack information to control AM phenomena that can only be captured through process simulation.

The focus of this contribution is on recent developments in TO approaches where not only geometric design rules are imposed during part generation, but also selected aspects of the AM process physics are included. Certain phenomena, such as e.g. excessive local heat accumulation, distortion-induced recoater jamming or step defects in printed parts are not readily captured by geometric design rules. It is of high importance to control these undesired effects, as they can lead to catastrophic build failures or part rejection. We explore ways to address their root causes already at the design stage, by including suitably simplified AM process simulations in the iterative TO process. In all cases, finding a good compromise between computational cost and quality of the obtained predictions is a key challenge. Both thermal and mechanical approaches will be covered and illustrated with numerical examples.