Functionally Graded Material Design for Plane Stress Structures using Phase Field Method

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ABSTRACT

We present a possible workflow to produce plane stress structures with a graded density distribution using a phase field based topology optimization procedure.

Additive manufacturing (AM) technology allows a radical shift in engineering design, from contour modelling to performance modelling [1]. In fact, with AM technology, the classical design for manufacturing, in which an homogeneous material is assigned to a pre-shaped domain, is not required, allowing the designer to primarily focus on the performance of the component itself. Functionally graded material design (FGMD) additionally extends the design possibilities by having the performance-driven functionality built directly into the material [2]. FGMD can be seen as a result of this change in the design perspective, where the component is optimized with respect to its specific application relying on enhanced material distribution at sub-millimeter scale. Nevertheless, even if AM technologies allow this possibility, the development of numerical methods suitable to generate FGMD components is still an open issue for researchers. Moreover, implementation of an automated workflow including all the steps from numerical result to manufacturing is still an active field of research [3].

We present a numerical method to obtain topologically optimized FGMD and discuss a possible pipeline to realize such kind of structures, using AM technologies. In particular, we present a topology optimization routine based on a phase field method which leads to structures with graded material distribution. Starting from the numerical results, we developed a workflow to generate the optimized components, also accounting for technological constraints due to Selective Laser Melting (SLM) process. Moreover, the proposed approach can be extended to the majority of AM technologies. Numerical verification and experimental validation of the presented methodology will be also discussed.

References

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