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A new multi-material level set topology optimization method with the length scale control capability

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Abstract

Multi-material level set topology optimization methods conventionally rely on the overlap of multiple level set functions to realize the multi-material structural representation. However, this representation may produce redundant material phases and the signed distance information is no longer available within the individual material regions. To fix these issues, a new multi-material level set topology optimization method is proposed in this paper, where *m* level set functions represent *m* material phases plus the void, and the signed distance information is straightforwardly available in each material phase. To be specific, each level set function corresponds to a material phase and the overlapping areas are filled with an artificial material plays the role of penalizing the overlap areas to vanish, which is different from the close-to-zero property material type for the void. Hence, the optimization process starts with any multi-level set interpolated input and the overlapping areas will gradually vanish. Based on this new method, we have successfully realized the component length scale control on multi-material structures and innovatively, an approach has been proposed to realize the uniform component thickness control without need of pre-specifying the thickness target.

Keywords: Multi-material; Level set; Topology optimization; Length scale control

1. Introduction

Multi-material structure is a type of composite, and because of the combined multiple material properties, it has the potential to produce creative structural design with multi-functionality. On the other hand, because of the enlarged design space, it is impractical to perform the multi-material structural design through the conventional trial-and-error approach. Therefore, multi-material topology optimization has attracted a great deal of attention. Also, owing to the rapid development of additive manufacturing, physically producing the multi-material component at a reasonable cost is no longer a major issue. So far, multi-material topology optimization has been implemented under the main topology optimization frameworks, including SIMP (Solid Isotropic Material with Penalization) [1], ESO (Evolutionary Structural Optimization) [2], and level set [3,4], and a brief literature survey is presented in the rest of this section.

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