Weight reduction by multi-material topology optimization expecting advanced additive manufacturing

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ABSTRACT

Multi-materialization attracts attention in advanced structure designs and is promoted to satisfy various mechanical properties such as strength, rigidity and weight of materials in industries. This trend has been enhanced and accelerated by expecting to the future development of the Additive Manufacturing (AM) technologies, capable to use different kinds of materials into single mechanical products. For this reason, many multi-material topology optimization techniques have been proposed so far, such as SIMP extended to three phases [1], density-based method using normalized weight of each material as design variables [2], level-set method adapted into a multi-phase level-set model [3] etc. However, there are some problems to overcome in multi-materialization in practical design. One is the mechanical influence due to difference in thermal expansion under certain high temperature environments. In the latest paper, Liu et al.[4] proposed the stiffness maximization topology optimization problem considering the interface between multi-phase materials using level set method and XFEM. In the density method like SIMP method, the boundary can not be described explicitly, so in order to cope with such a problem, some contrivance is necessary. The other is difficulty in design to satisfy the allowable criteria of each material during optimization process. In addition, consideration of strength in interface between different materials may be the most critical issue in reality. From this background, the present study focuses on a problem, weight reduction of mechanical products, by multi-materialization. If aiming at weight reduction, it is necessary to maximize mechanical performance satisfying allowable stress of each material. However, these methodologies have yet to be established in the current multi-material topology optimization methods, to the best of the authors' knowledge. We propose a preliminary multi-material topology optimization method aiming at weight reduction while ensuring mechanical performance.

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