

TOPOLOGY OPTIMIZATION INCLUDING WELD LINE CONTROL

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Abstract

Topology optimization has become a powerful and widely adopted design methodology for maximizing or minimizing performance indicators of engineering components. However, the resulting optimal layouts frequently exhibit complex geometries with multiple branches and intricate junctions which are challenging to manufacture using e.g. casting or injection molding. One critical issue in these processes is the formation of weld lines, which arise when multiple melt fronts meet during mold filling and can significantly reduce the mechanical strength and durability of the formed part. In this work, a density-based topology optimization framework is proposed that explicitly incorporates weld line control into the optimization process. The framework aims to maximize structural performance while simultaneously reducing the presence and severity of weld lines. To achieve this, a multi-physics approach is employed: a structural analysis is performed to evaluate mechanical performance, while a fluid flow simulation is conducted in each iteration to estimate the formation and location of weld lines during the manufacturing process. The weld line information obtained from the flow analysis is integrated into the optimization problem, either as a constraint or as a direct stiffness penalization. Numerical examples demonstrate that the resulting optimized topologies exhibit a reduced number of weld lines and more favorable weld line distributions, while maintaining the overall structural performance compared to conventional topology optimization results.