

# Topology optimization under casting and milling constraints

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## Abstract

Projection-based methods have been successfully used in literature to restrict the minimum length scale of topology optimization-designed features. In most works, this length scale is defined as a radial length scale, making it an appropriate restriction for components and devices fabricated by solid deposition or out-of-plane etching processes. This paper extends the projection-based logic to consider components fabricated by milling or casting processes. Such processes severely restrict the phase composition along an axis. For example, fabrication by CNC machining requires all points from the tip of the drill bit to the external boundary to be void. Casting processes, on the other hand, require element phase to be solid all the way along the axis of the drilled molding cavity. Both of these processes then preclude the formation of enclosed voids, a restriction that must be included in the topology optimization formulation. One option is to impose a system of topological and/or geometric constraints. This, however, requires a large number of local constraints or a global constraint in the form of a parameterized estimation of feasibility. The approach taken here is to adapt the projection-based topology optimization methodology such that these restrictions are automatically satisfied. Multiple independent design variables are introduced into the design domain and are projected onto the finite element space using regularized Heaviside operators. By strategically tailoring the length scale, shape and interaction of these projections, optimized topologies naturally satisfy milling and casting constraints. The optimization problem is solved using gradient-based optimizers with sensitivities readily available via the adjoint method. Several design examples are presented, including 3d design domains.