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Abstracts

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Manifolds often have suboptimal fluid flow because the manifold is composed of tubes or because it is manufactured by drilling and then partially plugging holes in a solid block of metal. With topology optimization, the manifold design can be optimized for e.g. minimal pressure drop. However, the resulting complex designs often cannot be manufactured by the conventional production processes. Consequently, post-processing of the design is required to allow for clearance or tool access, compromising the optimality. Using additive manufacturing, these complex designs can be produced. However, there are also some process limitations associated with additive manufacturing that need to be accounted for.

In additive manufacturing a three-dimensional component is realized by building layer upon layer. Thus there should be sufficient support for each layer built. This limits the angle a down-facing surface can make with the base plate: the minimum overhang angle. If this angle is below the critical minimum, supports need to be added during the build, and removed after the build. For manifolds, this is especially problematic as fluid channels need to be clear of support material. Because there are typically multiple channels in a single piece, it is often impossible to orient the manifold such that all the channels are free of overhang. Therefore, an overhang constraint is used during the optimization to obtain an optimal, but printable design.

Multiple overhang constraints have been presented recently, most notably those by Gaynor and Guest [1], and Langelaar [2]. However, these constraints seem either highly non-linear [1] or mesh dependent [2]. In this study a constraint based on front propagation is used. The front propagation mimics the printing process; with every printed layer, the boundary of the product is propagated. This gives an indication for the printability of the topology, and the sensitivities of the propagation are used in the optimizer to enforce overhang-free topologies. The evaluation of the constraint and its sensitivities is computationally inexpensive, and the constraint can be applied for an arbitrary overhang angle.

Results of the overhang constraint applied to a 3D manifold optimization will be shown.

References

[1] A.T. Gaynor, J.K. Guest. Topology optimization considering overhang constraints: Eliminating sacrificial support material in additive manufacturing through design. *Structural and Multidisciplinary Optimization*, 54(5), 1157-1172, 2016.

[2] M. Langelaar. An additive manufacturing filter for topology optimization of print-ready designs. *Structural and Multidisciplinary Optimization*, 1-13, 2016.