



Delft University of Technology

## Overhang free topology optimization applied to flow optimization

Van De Ven, Emiel; Verboom, Jeroen; Ayas, Can; Langelaar, Matthijs; Maas, Robert; Van Keulen, Fred

### Publication date

2017

### Document Version

Final published version

### Citation (APA)

Van De Ven, E., Verboom, J., Ayas, C., Langelaar, M., Maas, R., & Van Keulen, F. (2017). *Overhang free topology optimization applied to flow optimization*. 198-199. Abstract from Sim-AM 2017: 1st International Conference on Simulation for Additive Manufacturing, Munich, Germany.

### Important note

To cite this publication, please use the final published version (if applicable). Please check the document version above.

### Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

### Takedown policy

Please contact us and provide details if you believe this document breaches copyrights. We will remove access to the work immediately and investigate your claim.

**Simulation for Additive  
Manufacturing  
2017  
Munich, Germany**

**Abstracts**

*11<sup>th</sup>-13<sup>th</sup> October, 2017*

## Overhang free topology optimization applied to flow optimization

Emiel van de Ven<sup>1,2</sup>, Jeroen Verboom<sup>1,2</sup>, Can Ayas<sup>2</sup>, Matthijs Langelaar<sup>2</sup>, Robert Maas<sup>1</sup>, Fred van Keulen<sup>2</sup>

Netherlands Aerospace Centre  
Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands  
emieli.van.de.ven@nlr.nl

Delft University of Technology  
Mekelweg 2, 2628CD Delft, The Netherlands

**Key Words:** *Topology optimization, Additive manufacturing, Overhang, Flow optimization*

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.