Feature-driven topology optimization method with enclosed voids restriction for additive manufacturing structures

Lu Zhou[1],*, Weihong Zhang[1],# and Tong Gao[1]

[1]ESAC Laboratory, State IJR Center of Aerospace Design and Additive Manufacturing
Northwestern Polytechnical University
710072 Xi'an, Shaanxi, China
*Presenter: zhoulu@mail.nwpu.edu.cn
#Corresponding author: zhangwh@nwpu.edu.cn

ABSTRACT

Additive manufacturing (AM), which provides a great flexibility for the fabrication of structures with highly complex geometries, has received significant attention. The extended design space of AM makes it well integrated with the advanced topology optimization method to attain the lightweightness and high performance of a structure both in design and manufacturing. However, for more practical applications, the manufacturing constraints of AM should not be ignored in the design process. Enclosed voids acting as a typical one of AM-specific limitations which will lead to the accumulation of unmelted powders and the difficulty of removing internal supports are investigated in this work.

We present a simple side constraint scheme to eliminate enclosed voids in topology optimization. Void features are used as basic design primitives with their movements and shape changes to control the structural topology. In the meanwhile, the centers of all void features are bounded outside the borders of the design domain so that these void features cannot completely enter the interior to form enclosed voids. This scheme can be effectively achieved by limiting the ranges of design variables without introducing any additional constraint. The topology description of the whole structure is hierarchically constructed by means of Kreisselmeier-Steinhauser (KS) functions through Boolean operations of the level-set function (LSF) of each void feature. Besides, fixed mesh technique is adopted for structural analysis and sensitivity analysis.

The effectiveness of the proposed method is validated with several numerical examples in both two and three dimensions. It is found that the the suppression of enclosed voids always comes at the cost of increasing structure compliance. Moreover, our study investigates the influences of different numbers and types of void features on the optimized results.

Keywords: Topology optimizaiton; Void features; Enclosed voids; Additive manufacturing.

REFERENCES

[1] L. Zhou and W. H. Zhang, "Topology optimization method with elimination of enclosed voids", *Struct. Multidiscip. Optim.*, https://doi.org/10.1007/ s00158-019-02204-y, 2019.