Thermo-elastic topology optimization and additive manufacturing of an aerospace bracket

Guanghui Shi[1], **Chengqi Guan**[1], **Dongliang Quan**[1], **Dongtao Wu**[1], **Lei Tang**[2,*], **Tong Gao**[2,3,#]

[1] Beijing Aerospace Technology Institute, 100074 Beijing, China
E-mail: shgh5@126.com
[2] State IJR Center of Aerospace Design and Additive Manufacturing, Northwestern Polytechnical University, 710072 Xi'an, China
[3] Institute of Intelligence Material and Structure, Unmanned System Technologies, Northwestern Polytechnical University, Xi'an 710072, China

* Presenter: leitang@mail.nwpu.edu.cn
[#] Corresponding author: gaotong@nwpu.edu.cn

ABSTRACT

Topology optimization has long been a powerful tool in structural design for its ultimate design freedom, which always leading to weight-competitive structures. Recently, additive manufacturing (AM), one of the rising manufacturing technologies, is drawing more and more attention for its unprecedented ability to fabricate parts with complex geometries, further clearing the path for topology optimization [1].

In this work, a heavy-loaded aerospace bracket is designed by topology optimization and manufactured by AM technology. Considering that the bracket endures both mechanical forces and temperature loads, a formulation of thermo-elastic topology optimization is firstly proposed to minimize the global structural compliance and corresponding sensitivity analysis is derived in detail for adopting gradient-based optimization algorithm. Then the procedure of numerical optimization design and AM of the aerospace bracket is presented. Benefiting from topology and size optimization, the total mass of the optimized design is reduced by over 18% compared with the original design, while finite element analysis shows that constraints on displacement, von-Mises stress and buckling factor are all satisfied. Finally, the mechanical performance of the 3D printed bracket under the extreme loading condition is validated through a tri-axial tensile test. This work indicates that the integration of thermo-elastic topology optimization and AM technologies can be a rather powerful tool kit for the light-weight design of structures under thermal-mechanical loading.

Keywords: topology optimization; thermo-elastic; additive manufacturing; SLM; aerospace bracket

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