Integrated Optimization of Structure and Fabrication Process for Minimizing Distortion

Weiming Wang[1,3], Fred van Keulen[2] and Jun Wu[1,*]

[1] Department of Design Engineering, Delft University of Technology
Landbergstraat 15, 2628 CE Delft, The Netherlands
[*] E-mail: j.wu-1@tudelft.nl

[2] Department of Precision and Microsystems Engineering, Delft University of Technology
Mekelweg 2, 2628 CD Delft, The Netherlands

[3]School of Mathematical Sciences, Dalian University of Technology,
Linggong road 2, Ganjingzi, 116024, Dalian, China

ABSTRACT

In metal additive manufacturing (AM) structures are formed layer-upon-layer by melting and fusing material powder (e.g. selective laser melting, SLM) or wire (e.g. wire-arc additive manufacturing, WAAM). This process involves high temperature transients and phase transformations, and consequently distortions of the fabricated components. Distortions have a great influence on the structural performance and dimensional accuracy. It is therefore of paramount importance to model, predict and reduce distortion.

In this paper we present numerical methods to reduce distortion by optimizing the fabrication process in the design phase. Our approach simultaneously optimizes the structural layout and the manufacturing process order, which we call space-time topology optimization [1]. This is partially motivated by recent progress in robotic additive manufacturing technologies (e.g. WAAM) which increase manufacturing flexibility by allowing accumulation of material along curved layers.

We first show numerically that the manufacturing process order has a great influence on the distortion of a given structure. This numerical study makes use of a simplified model to mimic the contraction during manufacturing and to predict the distortion [2]. Based on this model, we propose a method to optimize the manufacturing process order for minimizing the resulting distortion of a given structure. One step further, by optimizing the structural layout and at the same time its fabrication process (i.e. manufacturing process order), this ultimately improves the structural stiffness while the distortion is kept small.

REFERENCES

[1] Weiming Wang, Dirk Munro, Charlie C.L. Wang, Fred van Keulen, and Jun Wu. Space time topology optimization for additive manufacturing: concrurent optimization of structural layout and fabrication sequence. *In preparation*, 2019.

[2] Dirk Munro, Can Ayas, Matthijs Langelaar, and Fred van Keulen. On process-step parallel computability and linear superposition of mechanical responses in additive manufacturing process simulation. *Under review*, 2019.