Computational time issues of AM process simulations with a view to large-scale topology optimization

Munro, Dirk; Ayas, Can; Langelaar, Matthijs; Van Keulen, Fred

Publication date
2017

Document Version
Final published version

Citation (APA)
Munro, D., Ayas, C., Langelaar, M., & Van Keulen, F. (2017). *Computational time issues of AM process simulations with a view to large-scale topology optimization*. 185-186. Abstract from Sim-AM 2017: 1st International Conference on Simulation for Additive Manufacturing, Munich, Germany.

Simulation for Additive Manufacturing 2017 Munich, Germany

Abstracts

11th-13th October, 2017

Simulation for Additive Manufacturing
11^{th}–13^{th} October 2017
Munich, Germany

Computational time issues of AM process simulations with a view to large-scale topology optimization

Dirk Munro, Can Ayas, Matthijs Langelaar and Fred van Keulen

Precision and Microsystems Engineering
Faculty of Mechanical, Maritime and Materials Engineering
Delft University of Technology, Mekelweg 2, 2628 CD Delft, The Netherlands
http://www.3me.tudelft.nl/over-de-faculteit/afdelingen/precision-and-microsystems-engineering/

Key Words: *AM process simulation, topology optimization, computation time*

Including detailed simulations of complex manufacturing processes in a design or optimization loop is gaining allot of attention, in particular with regard to additive manufacturing (AM). A key driving force behind AM is the geometric freedom granted to the designer, which enables innovative designs of high complexity. However, given (*i*) the high-energy input typically associated with AM processes, (*ii*) the multi-physics and multi-scale phenomena that need be accounted for, (*iii*) the necessity of support structures and subsequent machining steps and (*iv*) the complexity of the geometry itself; a human designer is no longer able to account for the sheer number and entanglement of design and manufacturing considerations. Therefore, in order to exploit the advantages of AM, large-scale structural optimization techniques—*i.e.*, topology optimization [1]—in combination with numerical process simulations, are required.

The feasibility of the automated avenue of design and manufacture, as outlined above, hinges first and foremost on the computational efficiency of the AM process simulation, and the associated design sensitivity computations. Moreover, AM process simulations in general follow the additive nature of the physical process itself, and therefore involve growing computational domains. In a finite element setting, new elements are added or activated in the FE model and the degrees of freedom increase in each time step of the process simulation. This aspect typically necessitates advanced computational implementations and has implications in terms of computational scalability of the simulation and, by implication, the optimization phase [3].

In this contribution, we consider options for reducing the computation– or wall-time of the AM process simulation part of the problem. The work is based on a layer-by-layer process model, with the energy input associated with the AM process simplified to thermomechanical loads [2]. Initially, geometric and material linearity is assumed, although the computational implications of including nonlinear phenomena and more complex loading conditions—including, for example, heat transfer simulations—are investigated as well.

References

[1] M.P. Bendsøe and O. Sigmund. *Topology optimization: Theory, methods and applications*. Springer, Berlin, Germany, 2003.

[2] Joshua D Deaton and Ramana V Grandhi. Stress-based design of thermal structures via topology optimization. *Structural and Multidisciplinary Optimization*, 53(2):253–270, 2016.

[3] C. Fleury. Structural optimisation methods for large scale problems: Computational time issues. In *8th World Congress on Structural and Multidisciplinary Optimisation*, Lisbon, Portugal, June 2009. WCSMO.