15th World Congress on Computational Mechanics (WCCM-XV)
8th Asian Pacific Congress on Computational Mechanics (APCOM-VIII)
31 July – 5 August 2022, Yokohama, Japan

Toward Concurrent Multiscale Topology Optimization for High Heat Conductive and Light Weight Structure

Musaddiq Al Ali[1*], Masatoshi Shimoda[1]

[1] Department of Advanced Science and Technology, Toyota Technological Institute, 2-12-1 Hisakata, Tenpaku-ku, Nagoya, Aichi 468-8511, Japan

Key Words: *Concurrent topology optimization, Heat conductvity, homogenization method, periodic microstructure.*

In several disciplines of engineering, high heat conductive solid structures of lightweight solid structures play a significant role. Due to advancements in computer-aided design and quick growth in additive manufacturing, topology optimization uses in designing high heat conductive structures has grown significantly in recent decades and remains a very appealing issue to be tackled. However, achieving optimal high conductive structure with utilizing topology optimization is a challenging task such that, it is quite sensitive to optimization factors such as the searching step and initial conditions. In this work, an investigation of maximizing heat conductivity with minimizing weight is conducted, with adopting heat compliance minimization as the objective function. The optimization first addressed the macro scale point of view of the structure, by investigating the optimization parameter's effect on the performance of the optimized resulted structure. Furthermore, we extended the examination toward multiscale topology optimization to achieve excessive light-weighting of heat-conductive structures. During the concurrent optimization process, the numerical homogenization approach was utilized to compute the effective heat conductivity of the microstructure and concurrently updating the macrostructure system. As a result, the periodic boundary conditions are simulated on a microscale with a dedicated finite element model, while the effective characteristics are implemented on a macroscale. the suggested design methodology of this work in several examples which showed good responses of the microscale design for the macroscale design domain boundaries conditions. This response is shown through the varied designs of multiple examples of different boundary conditions. This research showed that, utilizing weight reduction with considering the total volume reduction on macro and microscale gave better performance compared to limited the weight minimization on the macroscale alone. The volume-to-point approach was successfully expressed for the macroscale design by obtaining the micro channeling of the conductive material for the macro design domain, which is associated with better performance than single microstructure concurrent optimization, according to the studied cases of optimizing multiple micro design domains. This is because the increased freedom of attaining robust design variable distribution on both the microscale and macroscale allows for this.

REFERENCES

[1] Zhang Y, Liu S. The optimization model of the heat conduction structure. Prog Nat Sci 2008;18:665–70.