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Architected Thermal Structure Design utilizing Dual-material Topology Optimization for Natural and Forced Cooling Enhancement

박사과정 WANG MINLIANG / 지도교수 강현욱

Abstract

This dissertation presents a progressive exploration of topology optimization in advanced thermal engineering, extending from programmable thermal shaping in heat-conduction systems to cooling enhancement in both natural- and forced-convection thermal-fluid systems.

A dual-material topology optimization framework is developed for programmable thermal shaping under transient heat conduction. A non-dimensional thermal-fluid topology optimization framework is then established for cooling-channel design under liquid-cooled cold plate configurations, where a log-sum objective is introduced to balance heat-transfer enhancement and pumping-power reduction. This framework is further extended to natural-convection passive heat sinks under diverse geometric and operating conditions, and subsequently to thermo-fluid-structure coupling for improving both cooling performance and structural reliability. Finally, a CNN-embedded optimization framework is introduced to accelerate all self-developed topology optimization procedures through online learning and adaptive FEM replacement.

Extensive numerical simulations and experimental tests validate the optimized structures and demonstrate the effectiveness of the proposed frameworks for advanced thermal engineering design.

[사용언어: 영어]