Title:

Thermal Performance Evaluation of Lattice Topologies for Aerospace Heat Sink Applications

Abstract:

Lattice materials are emerging as promising candidates for lightweight thermal management in aerospace and electronic cooling applications due to their high surface-area-to-volume ratios and tunable geometries. This seminar presents a systematic computational study on the thermal performance of 24 lattice topologies over a wide range of relative densities (10–90%). Using high-fidelity CFD simulations in ANSYS Fluent, we quantify topology-dependent thermal resistance and identify how geometry influences the balance between conduction through the strut network and convection through internal flow channels. The results classify the lattices into high, medium, and low-performance groups. Topologies such as FBCC, Diamond, and Rhombic Dodecahedron exhibit superior thermal efficiency, while Cube, Tetrahedron, and Truncated Cube consistently show poor performance due to fluid obstruction and limited conduction pathways. This work builds on our earlier Cube lattice studies, which have already led to two accepted AIAA conference papers, and expands the scope to provide general guidelines for selecting optimal lattice structures. The findings demonstrate that careful topology selection can reduce thermal resistance by up to 90%, offering new insights for the design of advanced heat sinks. This body of work has been submitted as two journal manuscripts, and current efforts focus on integrating these datasets into a PETSc-based multiscale topology optimization framework.

Bio:

Ossama Hafeez is a Ph.D. student in Mechanical and Aerospace Engineering at Carleton University, Ottawa, Canada, supervised by Professor Mostafa El Sayed. His research focuses on the multiscale design optimization of aerospace heat sinks, with an emphasis on lattice structures, permeability modeling, and thermal-fluid simulations using CFD. He is currently developing a PETSc-based topology optimization framework that integrates real lattice performance data into design algorithms for advanced thermal management systems. During his master's research at SMME, NUST. He worked in collaboration with the defense sector, gaining exposure to defense-related R&D. He has authored two AIAA conference papers and has submitted two journal manuscripts on lattice permeability and thermal performance. He also worked as a Mitacs Globalink Research Intern with Bombardier Aerospace in Canada, gaining valuable industry experience in aerospace systems and applications.