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Effect of Radiation on the Thermal Performance of Triangular-Fin Heat Sinks

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Triangular-fin heat sinks are investigated for lightweight, compact CPU thermal management in constrained enclosures dominated by natural convection. A persistent deficiency in fin-array modelling is the omission or surrogate treatment of inter-fin radiative exchange via view factors; prior evidence indicates that neglecting radiation view factors in fin arrays "should be prohibited," as the error may exceed that of omitting radiation altogether [1]. Graduate-level investigations of natural-convection fin arrays further show that buoyancy-driven transport is acutely sensitive to spacing, interruptions and tip shape, implying that radiation–convection coupling is geometry dependent [2]. From a least-material perspective, triangular profiles are especially attractive for compact CPU heat sinks and motivate explicit treatment of geometry–emissivity interactions in design [3]. In high-emissivity enclosures typical of motherboard–chassis assemblies, surface radiation can compete with and suppress buoyant driving, reshaping plumes and the convective pathway [4]. Classical guidance on triangular fins underscores the heat-dissipation-per-volume advantage relative to rectangular profiles, reinforcing the material-efficiency motivation for Triangular-fin heat sinks in CPU cooling [5].

We develop a computational conjugate heat-transfer framework in ANSYS Fluent tailored to CPU scenarios, representing the die as a volumetric heat source with realistic boundary conditions. The fluid field solves the incompressible Navier–Stokes and energy equations with Boussinesq buoyancy; simulations run in both steady-state and transient modes to capture plume unsteadiness in natural convection. Surface-to-surface radiation is modelled with a gray, diffuse radiosity–view-factor formulation; the configuration-factor matrix satisfies reciprocity/closure and the net radiative heat flux couples to the energy equation at fin surfaces. Crucially, the fins are constructed from anisotropic graphite and represented by a full thermal-conductivity tensor oriented with the fin principal axes; in contrast to isotropic graphite, this formulation reflects substantially elevated axial (streamwise) and in-plane conductivities with respect to the cross-plane component. This allows us to quantify how directional conduction modifies fin temperature gradients, inter-fin radiosity paths, and the balance between radiation and buoyancy. The design space spans fin pitch, fin height, tip angle, array-to-wall spacing, surface emissivity. Performance measures include base-to-ambient thermal resistance, spatially averaged convective heat-transfer coefficient, temperature field uniformity, and heat removal per unit fin volume/mass; mesh-independence, domain-extent, and continuum-validity checks are documented. Verification recovers view-factor sensitivity in straight-fin arrays [1] and radiation–buoyancy interaction in enclosures [4], while least-material insights [3] and textbook guidance on triangular fins [5] frame interpretation for CPU-relevant trade-offs.

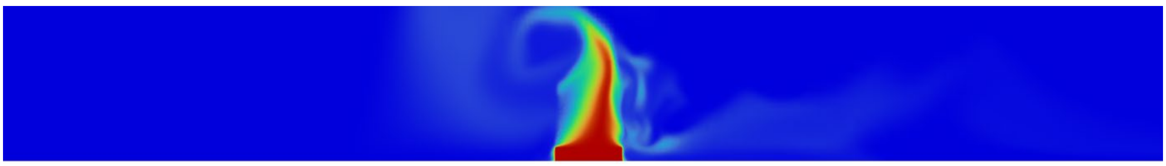

Figure 1. Temperature contour plot on the side of the heat sink

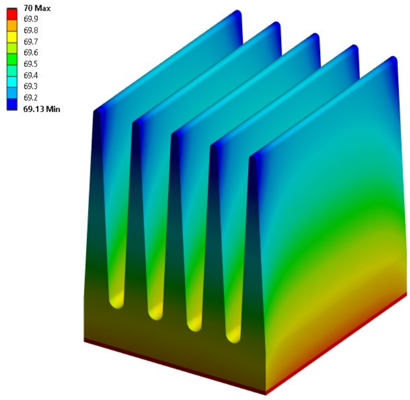

Figure 2. Temperature contour plot on the surface of the heat sink

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