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NUMERICAL SIMULATIONS OF A SWIRLED-LIQUID IMPINGING THERMOELECTRIC COOLER (SLITEC)

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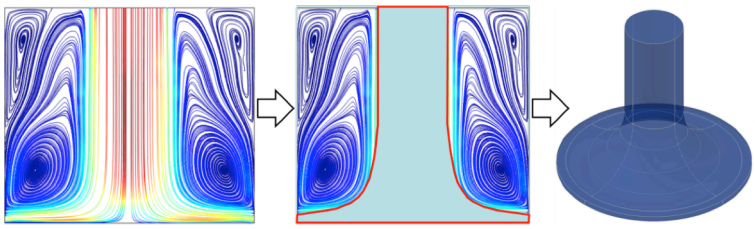
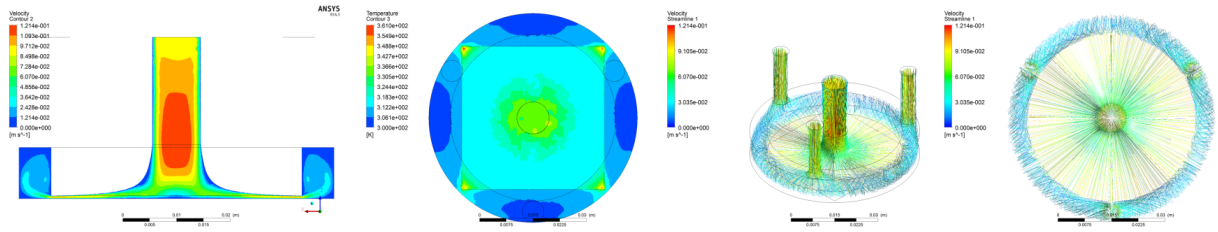
Liquid cooling is highly effective in removing dissipated heat compared to air cooling due to the higher specific heat capacity and thermal conductivity of working fluid, making it more suitable for high-performance applications such as electronics cooling. Impinging cooling manages a thin thermal boundary layer and achieves high heat transfer coefficients for convective flow; therefore, it has been viable for several applications [1]. Lin et al. [2] designed a liquid-impinging design (Fig. 1) to maintain the thin thermal boundary layer and avoid the vortex formation, which enhances mixing and heat transfer but keeps the heat in the design domain. Therefore, heat transfer enhancement is desirable for the said liquid impinging cooler. Huang and El-Genk [3] found that swirls increase radial uniformity and heat transfer of impinging jet. Furthermore, Hsu et al. [4] added a thermoelectric (TE) cooler between the liquid impinging cooler and the heat source to precisely control the cooling performance for various cooling conditions. In this paper, a swirled-liquid impinging thermoelectric cooler (SLITEC) is designed and investigated using numerical simulations. Simulations were made under the assumptions of non-slip walls, laminar flow, steady state, and inlet velocity of 0.09 m/s. Temperature-independent water was used as the working fluid. A 150-W heat was assumed conducted from the TE plate to the heat sink design over a 40-by-40-mm^2 area. Fig. 2 shows the results of an initial design of liquid impinging cooler. The temperature at the bottom was 8 degrees higher



(a) (b) (c)

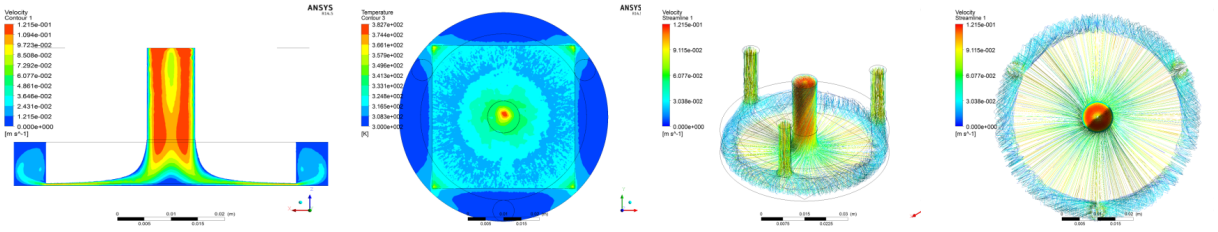
Fig. 1 Design concept of vortex-free liquid impinging cooler: (a) regular impinging jet, (b) expected channel design for vortex avoidance, (c) vortex-free liquid-impinging cooler.

than the entering liquid. Next, swirled inlet flows were induced with a constant angular velocity of 1 round per second and various attack angles of 15º, 30º, and 45º. The results in Fig. 3, however, show a mixing effect at the inlet piping without obvious enhancement of the heat transfer at the bottom. Lastly, a series of guiding geometries, as shown in Fig. 4, were designed to enforce swirling flow at the bottom of design domain where heat transfer matters.



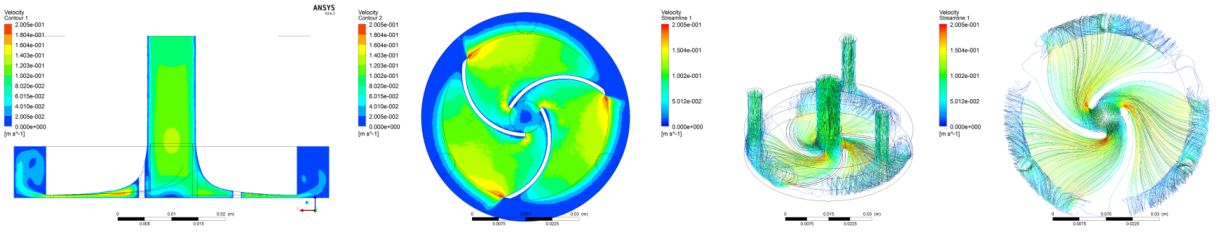
(a) (b) (c) (d)

Fig. 2 Results of impinging jet: (a) velocity contour, (b) temperature at bottom plate, (c) streamline, (d) top view.



(a) (b) (c) (d)

Fig. 3 Results of swirled inlet: (a) velocity contour, (b) temperature at bottom plate, (c) streamline, (d) top view.



(a) (b) (c) (d)

Fig. 4 Results with swirling flow via guided geometries: (a) velocity contour, (b) velocity at 250 μm from bottom, (c) streamline, (d) top view.

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