Natural convection compound heat transfer enhancement by discrete rings and the chimney effect in a vertical cylinder

Abstract

Natural convection is an indispensable heat transfer process considered in the design of advanced autonomous nuclear reactors. The renaissance of inherently safe micro nuclear reactors calls for increased post shut down heat rejection rates by passive means. This study numerically investigated heat transfer enhancement in a heated cylinder by discrete rings and the chimney effect. Five equally spaced rings of varying thicknesses and heights were fitted in the heated channel to effect enhancement by flow interruption. The chimney effect was studied by appending adiabatic chimney extensions of different heights, giving rise to extension ratios of 1.5, 1.6, 1.65, and 1.75. Compound enhancement was achieved by attaching chimney extensions to a ringed channel. Nusselt number ratios, mass flow rates, temperature, and velocity profiles were presented. The results showed that compound heat transfer enhancement could increase Nusselt numbers by between 44 and 54% and lower temperatures by over 30% depending on the chimney height. Furthermore, very short chimney heights would be required in the compound setup in comparison to the tall chimneys in the chimney-only cases, for the same target heat transfer rates. The resulting compactness could greatly influence the design of very small reactors and contribute to improvements of other air-cooled passive systems.