Numerical simulation of hydrothermal behavior in a concentric curved annular tube

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Abstract

This study performs a numerical investigation of the steady-state fully developed laminar flow and forced convection heat transfer characteristics in a concentric curved annular tube with two different curvature angles, a 90°-bend annular tube and a U-bend annular tube. A wide range of aspect ratios (r* = 0.1, 0.25, 0.5, and 0.75) and three curvature ratios (δc = 0.1, 0.2, and 0.5) were adopted in this study. The governing equations consisting of continuity, momentum, and energy equations are solved by considering the outer wall to be insulated (adiabatic), and a constant temperature is applied at the inner wall by using the finite-volume method (FVM) to investigate the hydrothermal performance for these two different bend angles.Features of axial velocity contours, temperature patterns, and secondary flow streamlines at different cross-sectional locations along the angular coordinate of curved annulus are observed with a Dean number range of (De = 32-632). Additionally, the circumferential friction factor and averaged Nusselt number are obtained along the concentric curved annulus flow direction. The numerical results indicate that the normalized average Nusselt number and Performance Evaluation Criteria (PEC) increase with increasing De and curvature ratio for both curvature angles of concentric curved annular tube. Moreover, the normalized average Nusselt number, normalized friction factor-Reynolds number product, and PEC increase with decreasing the aspect ratio because the annular gap between the surfaces of the inner and outer tubes (the boundaries of annulus) increases with decreasing aspect ratio. The hydrothermal performance of the concentric curved annular tube is higher than that of the straight annular tube attributed to the formation of secondary flows (Dean's vortices) in a cross-sectional direction and the impact of the inner tube wall boundary. The value of PEC for both curvature angles of the curved annular tube at aspect ratio = 0.1 and De = 632 is approximately two-fold of the straight annular tube under the same conditions while at aspect ratio = 0.75, it increases by nearly 80%.

Keywords

90°

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