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ORIGINAL ARTICLE

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Numerical investigation of mixed convection heat transfer from two isothermal circular cylinders in tandem arrangement: buoyancy, spacing ratio, and confinement effects

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Abstract This paper presents a two-dimensional numerical study for mixed convection in a laminar cross-flow with a pair of stationary equal-sized isothermal cylinders in tandem arrangement confined in a channel. The governing equations are solved using the control volume method on a nonuniform orthogonal Cartesian grid, and the immersed boundary method is employed to identify the cylinders placed in the flow field. The numerical scheme is first validated against standard cases of symmetrically confined isothermal circular cylinders in plane channels, and grid convergence tests were also examined. The objective of the present study was to investigate the influence of buoyancy and the blockage ratio constraint on the flow and heat transfer characteristics of the immersed cylinder array. Using a fixed Reynolds number based on cylinder diameter of $Re_D = 200$, a fixed value of the Prandtl number of $Pr = 7$, and a blockage ratio of $D/H = 0.2$, all possible flow regimes are considered by setting the longitudinal spacing ratio ($\sigma = L/D$) between the cylinder axes to 2, 3, and 5 for values of the buoyancy parameter (Richardson number) in the range $-1 \leq Ri \leq 4$. The interference effects and complex flow features are presented in the form of mean and instantaneous velocity, vorticity, and temperature distributions. The results demonstrate how the buoyancy, spacing ratio, and wall confinement affect the wake structure and vortex dynamics. In addition, local and average heat transfer characteristics of both cylinders are comprehensively presented for a wide range in the parametric space.

Keywords Mixed convection · Tandem cylinders · Blockage ratio · Interference effects · Bimodal vortex shedding

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