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ABSTRACT:

Theoretical and Numerical Investigation on Heat and Mass Transfer Driven Mixed Convective Flow in Rectangular Enclosure

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Theoretical and Numerical investigation on heat and mass transfer driven mixed convective flow in horizontal rectangular enclosure is studied in this work. The governing equations, which are the continuity, momentum, energy, and mass transfer equations, along with boundary conditions, are solved numerically by using the control volume method. Furthermore, on theoretical front, the heat and mass transfer effects of a mixed convective flow in horizontal rectangular enclosure are investigated by using the empirical correlations. The novelty of this study is to investigate the temperature and concentration gradients between the top wall and the fluid within the rectangular enclosure. All dimensionless parameters of heat and mass transfer are chosen appropriately to calculate the average Nusselt numbers, Richardson numbers for different fluids. In case these calculated Richardson numbers are revealed as $Ri \ll 1$ and $Ri \gg 1$, it is concluded that pure and negligible free convection effects prevail between the top wall and the fluid within the horizontal rectangle. However, for $Ri \approx 1$, mixed convection results between the top wall and fluid within the horizontal rectangle. An empirical correlation for calculating the average Nusselt and Sherwood numbers $\overline{(Nu)}$ and $\overline{(Sh)}$ for specific fluids at different heat and mass transfer Rayleigh numbers is suggested in this research, and thereby the heat and mass transfer from the top wall to these fluids within the horizontal rectangle is examined and validated. The average Nusselt and Sherwood numbers $\overline{(Nu)}$ and $\overline{(Sh)}$ for different fluids are calculated and hence the heat and mass transfer from the bottom wall to the fluid and from the left wall to the fluid within the horizontal rectangle is analyzed. Furthermore, the behavior of the horizontal and vertical components of velocity from the bottom wall to the mid point and then from the mid point to the upper boundary of the rectangular domain is analyzed. Similarly, from the left boundary to the right boundary via mid point is also analyzed. This is investigated at different ranges of the Reynolds numbers, average Nusselt numbers, and the Richardson numbers. Furthermore, the pressure profiles

at different Reynolds numbers (Re) in the rectangular domain are analyzed. The novelty of the current work is to examine the effect of temperature and concentration gradients on heat and mass transfer between the top wall and the fluid within the horizontal rectangular enclosure. The average Nusselt and Richardson numbers (Ri) for specific fluids at various Re and Rayleigh numbers are calculated. The numerical solutions of the u and v components of velocities obtained in the present study have been compared with the available benchmark solutions of Ghia et al in the literature. It has been found that our present results are in agreement with the benchmark results.
Keywords: horizontal rectangular enclosure; control volume method; empirical correlation; Reynolds number; Rayleigh number; heat transfer, mass transfer; mixed convection, average Nusselt number, average Sherwood number.