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Penetrative convection of water in cavities cooled from below. (English) Zbl 1390.76834

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Summary: Transient natural convection in water-filled square enclosures with the bottom wall cooled at $0°C$, and the top wall heated at a temperature spanning from 8 to $80°C$, is studied numerically for different widths of the cavity in the hypothesis of temperature-dependent physical properties, starting from the initial condition of motionless fluid at the uniform temperature of the top wall. The sidewalls are assumed to be adiabatic. A computational code based on the SIMPLE-C algorithm is used to solve the system of the mass, momentum and energy transfer governing equations. The propagation of convective motion from the bottom toward the top of the enclosure is investigated up to the achievement of a steady-state or a periodically-oscillating asymptotic solution. It is found that the ratio between the penetration depth and the cavity size increases as the temperature of the heated top wall decreases and the cavity size increases. Moreover, when the configuration is such that the buoyancy force in the water layer confined between the cooled bottom wall and the density-inversion isotherm is of the order of that required for the onset of convection, the asymptotic solution is periodical. Finally, the coefficient of convection decreases with increasing both the cavity width and the imposed temperature difference. Dimensionless correlations are developed for the calculation of the heat transfer rate across the enclosure and the penetration depth.

MSC:

76R10 Free convection
76M20 Finite difference methods applied to problems in fluid mechanics
65M06 Finite difference methods for initial value and initial-boundary value problems involving PDEs
80A20 Heat and mass transfer, heat flow (MSC2010)
80M20 Finite difference methods applied to problems in thermodynamics and heat transfer

Keywords:

penetrative convection of water; enclosure; cooling from below; numerical analysis; dimensionless correlations

Full Text: DOI

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