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Effect of Two Radial Fins on Heat Transfer and Flow Structure in a Horizontal Annulus

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Abstract : Laminar natural convection in a cylindrical annular cavity filled with air and provided with two fins is studied numerically using the discretization of the governing equations with the Centered Finite Difference method based on the Alternating Direction Implicit (ADI) scheme. The fins are attached to the inner cylinder of radius r_i (hot wall of temperature T_i). The outer cylinder of radius r_o is maintained at a temperature T_o (T_o < T_i). Two values of the dimensionless thickness of the fins are considered: 0.015 and 0.203. We consider a low fin height equal to 0.078 and medium fin heights equal to 0.093 and 0.203. The position of the fin is 0.82π and the radius ratio is equal to 2. The effect of Rayleigh number, Ra, on the flow structure and heat transfer is analyzed for a range of Ra from 10³ to 10⁴. The results for established flow structures and heat transfer at low height indicate that the flow regime that occurs is unicellular for all Ra and fin thickness; in addition, the heat transfer rate increases with increasing Rayleigh number and is the same for both thicknesses. At median fin heights 0.093 and 0.203, the increase of Rayleigh number leads to transitions of flow structure which correspond to significant variations of the heat transfer. The critical Rayleigh numbers, Ra_{c.app} and Ra_{c.disp} corresponding to the appearance of the bicellular flow regime and its disappearance, are determined and their influence on the change of heat transfer rate is analyzed.

Keywords : natural convection, fins, critical Rayleigh number, heat transfer, fluid flow regime, horizontal annulus
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