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Effect of Variable Viscosity on Vortex Instability of Mixed Convection Boundary Layer Flow Adjacent to a Non-isothermal Horizontal Surface in a Porous Medium

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Abstract In this paper, we study the effect of variable viscosity on the vortex instability of horizontal mixed convection boundary layer flow in a saturated porous medium with variable wall temperature. The variation of viscosity is expressed as an exponential function of temperature. The analysis of the disturbance flow is based on linear stability theory. The entire mixed convection regime is divided into two regions. The first region covers the forced convection dominated regime, which is characterized by the parameter $\xi_f = Ra_x/Pe_x^{3/2}$ and the eigenvalue Peclet number. The second region covers the free convection dominated regime, which is characterized by the parameter $\xi_n = Pe_x/Ra_x^{2/3}$ and the eigenvalue Rayleigh number. The two solutions provide results that cover the entire mixed-convection regime from pure-forced to pure-free convection. The local Nusselt number, critical Peclet and Rayleigh numbers and the associated wave numbers at the onset of vortex instability are presented over a wide range of wall to ambient viscosity ratio parameters $\mu^* = \mu_w/\mu_\infty$. The variable viscosity effect is found to enhance the heat transfer rate and destabilize the flow for liquid heating, while the opposite trend is true for gas heating.

Keywords Vortex instability · Porous media · Variable viscosity · Mixed convection · Finite difference method

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