ABSTRACT

Flow and heat transfer in porous media finds applications in diverse fields. The research works related to this topic have been studied extensively. The Darcy flow model was the first one proposed for describing the flow in a porous medium. Several non-Darcian models were also proposed later. This work numerically studies forced convection in a parallel-plate channel of finite plate thickness filled with a porous medium. Attention is given to local non-thermal equilibrium, wall effect, and non-Darcian effects. The flow field is assumed to be steady and fully developed. The momentum equation in the porous region can be solved independently since forced convection is considered. In addition to the energy equation of the plate slab, the energy equations for the porous matrix and the fluid in the porous region are formulated separately . These equations along with the entrance, initial, outer wall heating and matching conditions at the wall/porous region interface are solved altogether. The numerical results obtained in this paper are verified by comparing them with the literature. The effects of several controlling parameters are investigated in depth. It was found that as the Biot number (wall parameter) increases, the difference between the fluid temperature and the solid phase temperature becomes more observable, while the increase in the solid/fluid heat exchange parameter displays the opposite trend. The ratio between the conductivity of the solid phase and that of the fluid phase affects the slope of the temperature of each phase at the wall/porous region interface. It was also found that the Nusselt number based on the non-Darcian flow model is smaller than that based on the Darcy model, when the Darcy number is large, say, $Da=10^{-3}$. However, it is true only for the case of large porosity when the Darcy number is small, say, $Da=10^{-8}$.