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Research article

Numerical simulations of mixed convection in the upward flow of liquid metal in a circular heated pipe affected by a transverse magnetic field

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Hydrodynamics and heat transfer in mixed convection of liquid metal (Pr=0.025) in a vertical pipe with an upward flow in a transverse magnetic field are considered. The study was carried out using a direct numerical simulation method. Simulations were performed at Reynolds numbers up to 12,000, Richardson numbers from 0 to 2.4 and Hartmann numbers up to 550 for two limiting cases of pipe wall conductivity. The simulation results for an isolated pipe were compared with the measurement data from the mercury experiments. The effect of the transverse magnetic field is manifested in the suppression of turbulent transfer and flow laminarization with the formation of strong inhomogeneity of the longitudinal velocity profile by angle and gradients of the streamwise velocity in the transverse direction. Depending on the pipe wall conductivity and the ratios of such parameters as Richardson and Hartmann numbers, the resulting flows with different topology of the longitudinal velocity profile determine the wall temperature distribution in the wall and the values of the heat transfer coefficients. It is shown that in a magnetic field in the case of isolated walls with an increase in the Richardson number the flow has a tendency to instability, which develops in the jets formed in the region of Roberts layers. The periodic process of development and breakage of jets leads to the emergence and development of vortex structures that persist in the magnetic field and cause fluctuations in the velocity and temperature components in the flow. The dependence of the friction factor and heat transfer (Nusselt number) on the Richardson number is obtained.

Keywords: mixed convection, liquid metal, heat transfer, transverse magnetic field

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