A VOLUME AVERAGING THEORY FOR CONVECTIVE FLOW IN A NANOFLUID SATURATED METAL FOAM

Abstract

The set of the macroscopic governing equations appropriate for convective heat transfer in nanofluid saturated metal foam were derived rigorously applying a volume averaging theory to the microscopic set of the modified Buongiorno equations. The unknown terms are mathematically modelled so as to close the set of the governing equations. The mechanical dispersion terms, namely, thermal dispersion term and particle mechanical dispersion term, were considered analytically using a pore scale conduit model. Thus, the dispersion coefficients for both thermal dispersion and particle mechanical dispersion were estimated, using pore scale profiles for velocity and temperature. It has been found that the present analytical expression for the transverse thermal dispersion based on the pore scale analysis closely follows Calmid-Mahajan's empirical correlation. The longitudinal particle mechanical dispersion works either to suppress or to enhance the effective diffusion depending on the sign of the local phase temperature difference, while the transverse counterpart is insignificant and therefore can be neglected. Moreover, a comparison under equal pumping power revealed that a high level of the heat transfer rate (about 80 times more than the case of base fluid convection without a metal foam) may be achieved by combination of the metal foam and nanofluid.