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Heat transfer in particle-dispersed two phase flows considering temperature gradient within the particles

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ABSTRACT Heat transfer problem in solid-dispersed two-phase flow is numerically studied, and the effects of temperature gradient within the finite-sized particles on the flow structure and heat transfer are discussed. The interaction between fluid and particles is treated by our original immersed solid approach. To consider the temperature distribution within the particles and heat exchange between the fluid and particles, an interfacial heat flux model is developed. Also, heat conduction due to interparticle and particle-wall contacts is considered based on a newly developed contact heat transfer model. The heat conduction models are thoroughly validated through comparisons with the analytical solutions of heat conduction problems and conjugate heat transport problems reported in the literature. The method is applied to 2-D and 3-D natural convection problems including multiple particles in a confined domain under relatively low Rayleigh numbers ($10^4 \sim 10^6$). Heat transfer and particle behaviours are studied for different solid volume fractions and heat conductivity ratios (solid to fluid) ranging between 10^{-2} and 10^2. Under relatively low heat conductivity ratios, the particles show a simple circulating flow around the domain center, while, by increasing the heat conductivity ratio, a transition is observed in the particulate flow structure to oscillatory modes around the domain center. It is found that the oscillation is resulted from the difference in the time scales of heat transfer through the fluid and solid. Also, under high solid volume fraction conditions, the particles are observed to form densely concentrated regions, where heat flow tends to channel through the contacting points. The results highlight the importance of temperature distributions within finite-sized particles.