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A MULTI-SCALE APPROACH TO CHARACTERIZING FLUID CONTRIBUTION TO CONDUCTIVE HEAT TRANSFER IN DENSE GRANULAR SYSTEMS

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Heat transfer in a granular medium is an important mechanism in many industrial applications. For some applications conduction is the dominant mode of heat transfer. There are many proposed models to describe particle scale conduction both between particles (particle-particle) and also walls (particle-wall). Within these conduction models are several distinct modes: conduction through physical contact [1], conduction through surface roughness [2], and conduction through the stagnant gas film surrounding each particle often called particle-fluid-particle or particle-fluid-wall [3]. For materials with low thermal conductivity conduction through interstitial gases is the dominant mode of heat transfer [4]. While gas film models have been well developed in literature [3,4], the applicability of these models to dense systems is doubtful given that these models are derived from an isolated, binary particle collision. In this work we adopt a multi-scale approach to investigate the contribution of interstitial gases to overall heat transfer in a randomly packed bed using CFD with both the particles and fluid fully resolved in the mesh. Based on the results we propose a new dimensionless variable which we call the proximity number. The proximity number is shown to provide a good correlation between the packing structure and the relative contribution of the fluid to the overall heat transfer. Using this variable as a means of evaluating the contribution of interstitial gas conduction provides the opportunity to include the fluid effects in a particle based DEM calculation without the need to explicitly include the surrounding fluid thereby reducing the computational effort required to accurately represent these systems.

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