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Surface roughness and deformation effects on the thermal characterization of granular porous media

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Heat conduction in porous materials is of great interest for geological and engineering studies including geothermal reservoirs, insulating layers, composite materials, to name a few. In the absence of flow, thermal energy is transferred through the constituting materials of porous media with different capabilities in conducting heat. Thus, the structure of phase boundaries, the contact area between the grains in a granular porous medium for example, becomes essential in the accurate modeling of heat transfer. In the present study, we adopted a fractal contact model of rough surfaces that is based on the Weierstrass and Mandel function (W-M model) to estimate roughness deformation and contact areas in granular porous media. The roughness deformation is a function of roughness fractal parameters, grains'Young modulus, and compressing pressure. Heat conduction in a packing of particles under compressive pressure is studied. It is revealed that grains with smoother surfaces and lower Young's moduli experience the highest deformation for a given compressing pressure. Effective thermal conductivity is an increasing function of compressing pressure where the effect of compressing pressure is more noticeable in media with the high ratio of thermal conductivity of solid to that of fluid.

References

Askari, R., S.H. Hejazi and M. Sahimi (2017). Thermal contact resistance in unconsolidated porous media: A roughness simulation approach: Geophysical Research Letters, 44(16), 8285–8293.

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