DEM model for heat conduction in partially sintered porous materials

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ABSTRACT

A discrete element model (DEM) to simulate transient state heat conduction in porous materials will be presented. The thermal pipe network model for heat conduction is based on the sintering geometry of two particles connected by the neck [1]. It employs lumped capacitances concentrated at the centres of the particles which are connected by thermal pipes. The governing equations are based on heat balance law implied by the first law of thermodynamics. Particle-to-particle conductance is the dominant heat conduction mechanism in sintered porous materials. Therefore, accurate evaluation of neck size is essential to determine conductance. Neck size is evaluated using volume preservation criterion. Addtionally, the model is enhanced by neck size correction to compensate for non-physical overlaps at higher densities and by adding grain-boundary resistance to account for porosity in the necks. The DEM model is applied to simulate transient heat flow in porous samples with heterogeneous microstructure created by simulating hot-pressing of NiAl. Steady-state solution is used to determine effective thermal conductivity by Fourier's law. Effect of densification on contribution of grain boundary resistance and effective thermal conductivity is analysed. The numerical results are compared with experimentally measured thermal conductivity of partially sintered porous NiAl samples manufactured using Spark Plasma Sintering [2].

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REFERENCES

[1] J. Rojek, R. Kasztelan, and R. Tharmaraj, Discrete element thermal conductance model for sintered particles. *Powder Technology*, Vol. 405(117521), 2022

[2] S. Nosewicz, G. Jurczak, T. Wejrzanowski, S.H. Ibrahim, A. Grabias, W. Węglewski, K. Kaszyca, J. Rojek, and M. Chmielewski, Thermal conductivity analysis of porous NiAl materials manufactured by spark plasma sintering: Experimental studies and modelling, *Int. J. Heat Mass Transf.*, 194(123070), 2022