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Numerical determination of effective thermal conductivity of porous materials manufactured by FAST/SPS

Abstract

Numerical model aimed to determine the effective thermal conductivity of porous materials manufactured by FAST/SPS will be presented. The model will be developed within the discrete element method (DEM). The DEM is a relatively new modelling method in which material is represented by an assembly of spherical particles interacting with one another. Sintered porous media can be considered as sphere particles connected by necks, which are created during sintering process. Therefore the discrete element method employing bonded spherical particles is a suitable tool to model thermal problems of such systems.

The authors' own formulation of the discrete element method for heat conduction analysis has been developed. The model is based on the thermal pipe-network approach. It employs lumped capacitances concentrated at the particles centres which are connected by heat conducting bars (thermal pipes). The governing equations are based on the balance of the rate of heat storing in the lumped capacitances and rate of heat flow through the pipes and any other contributions of heat transfer.

The heat flux in a thermal pipe is expressed in terms of the temperatures in the connected nodes and the effective thermal conductance. The effective thermal conductance of the pipe is determined using the analytical approximation of finite element results obtained in simulations of heat flow in systems consisting of two spheres connected by a cylinder. The radius of cylinder equivalent to the neck radius is determined from the criterion of volume conservation during sintering.

The DEM is applied to simulation of transient heat flow in cylindrical samples built from spherical particles representing NiAl powder particles at different stage of sintering. The steady state temperature field is used to determine the effective thermal conductivity from the Fourier law of heat conduction. Different particle configurations corresponding to different porosities are considered. Numerical results are validated using own experimental results.

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