Effective Thermal Conductivity of Two-Phase Systems using Green's Function with Spherical Inclusions

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A theoretical expression for predicting the effective thermal conductivity (ETC) of highly porous two-phase systems has been developed, assuming spherical particles arranged in a three dimensional cylindrical array. The arrangement has been divided into cylinders, each of which contains a sphere. Green's function technique has been applied to determine the ETC. The flux-generating source is set along the axis of the sample, where there is no dispersion. The potential and field are constant throughout the sample. Upon allowing the dispersion of the second phase, a penetration creeps in, which alters the values of the field and potential at the center of each cube. The flux lines form concentrated or rarefied fields in the vicinity of the dispersed grains. The degree of concentration or rarefaction depends upon the thermal conductivity ratio of the constituent phases. In order to take the non-uniform shape of the particles and random packing of the phases in real systems into account, a correction term, F, is suggested, in place of the physical porosity, and this term is derived from experimental results reported in literature. The correction term is found to depend on the ratio of thermal conductivities of the constituent phases of the system. The expression so obtained for the correction in the physical porosity gives a better agreement of the predicted ETC values with the experimental results. A comparison between our model an different two-phase models cited in the literature has also been made.