THERMAL CONDUCTIVITY OF STATISTICAL MIXTURES

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A statistical mixture is a system of two or more components, the elements of which may have irregular forms and be randomly distributed in the system. On the assumption that the volumes of the components do not differ much, Odelevskii has suggested a relation connecting the effective generalized conduction (thermal conductivity, electrical conductivity, dielectric constant, magnetic permeability) with the conductivities of the components and their concentrations [1]. In particular, for a system consisting of two components with thermal conductivities λ_1 and λ_2 and porosity $p = V_2/V$, Odelevskii's equation takes the form

$$\frac{\lambda}{\lambda_1} = \frac{(2-3p)+\nu(3p-1)}{4} + \sqrt{\frac{[(2-3p)+\nu(3p-1)]^2}{16}+\frac{\nu}{2}}, \qquad (1)$$

where $\nu = \lambda_2/\lambda_1$; V_2 is the volume of inclusions; V is total volume of the system.

Equation (1) has gone into a handbook and the specialized literature on thermophysical properties of materials, and is recommended for practical calculations [2, 3]. However, investigation of (1) for various limiting cases leads to conflicting results.

The following limiting conversions

$$p = 0, \; p = 1, \; \nu = 1$$

reduce (1) to correct and obvious relations. We shall examine a solid porous body under conditions when there are practically no transfer processes in the pores (high vacuum, low temperature), i.e., $\lambda_2 = 0$ or $\nu = 0$. Then (1) takes the form

$$\lambda/\lambda_1 = 1 - 1.5p. \qquad (2)$$

Equation (2) has lost its physical meaning, since, when $p = 1/1.5 = 0.66$, the thermal conductivity of the system becomes zero, while when $p > 0.66$ it becomes negative, which contradicts the second law of thermodynamics. This leads us to conclude that Eq. (1) is not true for statistical mixtures, and cannot be recommended for practical calculations over a wide range of variations of ν and p.

REFERENCES

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