THERMAL CONDUCTIVITY OF GAS MIXTURES REACTING AT A FINITE RATE

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On the basis of an earlier investigation [2], it is noted that, in the presence in a gas mixture of chemical reactions proceeding at a finite rate, the effective thermal conductivity is not only a function of temperature and pressure (as pointed out in [3]) but also a function of the coordinates. It is concluded that the experimental data obtained for a certain measuring-tube geometry are conditional and may differ substantially from those obtained for another geometry.

In many practical problems, it is necessary to determine the thermal conductivity of reacting gas mixtures [3].

In the presence of chemical reactions proceeding at a finite rate, the effective thermal conductivity is a function not only of temperature and pressure but also of the coordinate. This can be shown, in particular, with the methods of nonequilibrium thermodynamics, as set forth in [1, 2]. For a three-component gas mixture we obtain

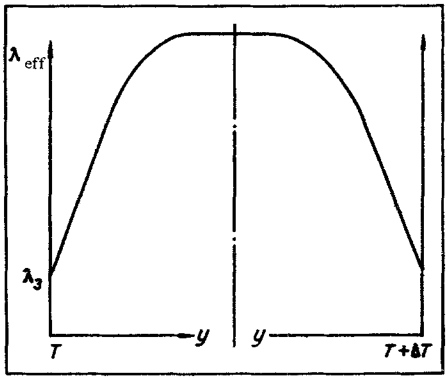
$$\lambda_{\text{eff}} = h^2 \Big/ T^2 \left[(c_2^*)^2 + (c_3^*)^2 + + (c_1^*)^2 \frac{\operatorname{ch}(2y/d_1)}{\operatorname{ch}(d/d_1)} \right]. \quad (1)$$

The reduced concentration c_1^* is found from the relation $c_1^* = c_1Q_{11} + c_2Q_{21} + c_3Q_{31}$, while c_2^*, c_3^*, and the elements of the matrix Q_{ij} are determined from the expressions obtained in [2].

The depth of penetration, which in the first approximation is proportional to the ratio of the diffusion rate to the reaction rate, can be found by the method described in [1].

The results of a calculation of the thermal conductivity in the wall region for the mixture $2NO_2 \rightleftarrows 2NO + O_2$ at a pressure of 1 atm and a temperature of 600° C are given in the figure. It is clear from the graph that at a distance of up to 50 μ from the wall the thermal conductivity varies hyperbolically from the "frozen" value to the value corresponding to chemical equilibrium. It is clear from expression (1) that, as the reaction rate decreases, the region in which λ_{eff} depends on the coordinates increases.

Thus, at identical temperatures and pressures the effective thermal conductivity averaged over the cross section of the cell will be different for different cell dimensions.



Variation of the thermal conductivity in the wall region.

Therefore, the data obtained for a particular measuring tube geometry are conditional and may differ by several times from those obtained for another tube geometry.

For the same reason, serious difficulties arise in connection with the use of experimental values of the thermal conductivity in criterial equations.

NOTATION

λ_{eff} is the thermal conductivity with account for transport by ordinary heat conduction and diffusion; T is the mean temperature over the cross section of the cell; y is the coordinate perpendicular to the wall; d is the distance between cell walls; h is the enthalpy.

REFERENCES

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