THERMAL CONDUCTIVITY OF TUNGSTEN AT HIGH TEMPERATURES

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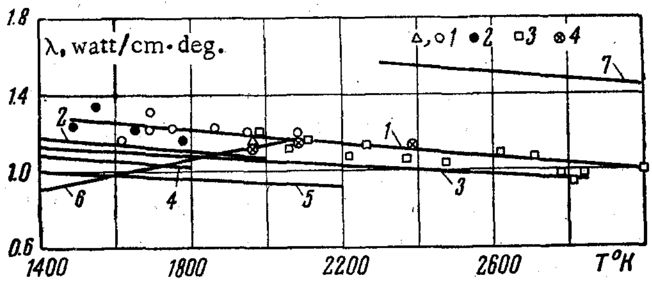
Zhurnal prikladnoi mekhaniki i tekhnicheskoi fiziki, No. 1, pp. 111-112, 1965

The expansion of studies of the thermal properties of solids involving detailed measurements is of importance even for materials for which experimental data are already available in the literature. New results are needed to obtain reliable standard values for thermal properties, particularly in the high-temperature region. The authors therefore undertook to measure the thermal conductivity of tungsten at 1500-3000°K. The procedure and apparatus have already been described [1, 2]. The measurements were reduced to a determination of the temperature distribution along a wire or a strip of foil, heated by a current, at a section where this distribution is exponential. In order to obtain such a temperature distribution, from a section of wire (foil) at constant temperature we hung a rider to create a local temperature inhomogeneity. The temperature distribution was measured by means of a specially designed differential optical pyrometer [1]. The thermal conductivity was determined from the formula

$$\lambda = \frac{4I^2\rho}{S^2 T_0 k^2}(1-\Delta) \qquad \left(\Delta = \frac{1}{2}\frac{d\ln T_0^2/I}{d\ln T_0}, \qquad k = \frac{d\ln(T-T_0)}{dx}\right) \tag{1}$$

where k is the exponent of the law of the temperature distribution along the wire (foil); T_0 is the temperature without the rider; I is the current; ρ is the resistivity; and S is the cross-sectional area. The quantity Δ represents a small correction for the temperature dependence of the electrical conductivity and the total emissivity.



The procedure was as follows: The temperature distribution without the rider was first determined by means of the differential pyrometer. This made it possible to detect small distortions due to defects (these temperature irregularities usually did not exceed a fraction of a degree). The rider was then hung from the specimen, and the resulting temperature distribution determined. The values obtained were deducted from the results of the measurements without the rider. The temperature distribution measurements were made on a section about 20 mm long; the maximum temperature difference was 20°. The results of measuring the relation between the temperature difference $T - T_0$ and the coordinate x along the specimen were plotted to a semilog scale. The value of k was determined from the slope of the straight line thus obtained.

The results obtained for the thermal conductivity of tungsten are presented in the figure. The experimental points marked 1 were obtained for strips of foil measuring 2 mm × 60 μ, the points marked 2 for strips measuring 3 mm × 60 μ, and points 3 and 4 for wires 0.3 and 0.2 mm in diameter. All these results are in quite good agreement, and there is no systematic difference. The maximum deviation of the individual points from the mean curve 1 is 7%, and the average deviation is 4%. The curves in the figure are based on literature data: (2) – [4]; (3) – [3]; (4) – [8]; (5) – [6]; (6) – [5], and (7) – [7]. The results of Timrot and Peletskii [3], Osborne [4], Cuttler and Cheney [8] were found to come closest to ours.

The results of the measurements were used to determine the temperature dependence of the Lorentz number for tungsten. It was found that over the range of temperatures studied, the Lorentz number decreases monotonically from a value of 3.40×10^{-8} at 1500°K to 2.81×10^{-8} watt · ohm/deg^2 at 3000°K. These values point to a significant contribution from the lattice conductivity.

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15 October 1964 Moscow