RELATIONSHIP BETWEEN EMISSIVITY OF METALS AND THEIR THERMOPHYSICAL PROPERTIES

I. P. Zhuk* and N. I. Stetyukevich

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Available experimental data are used to correlate the hemispherical integral emissivity of metals to their thermal conductivity. The dependence is approximated by an exponential function.

Thermal radiation from a substance can provide general information on molecular structure and thermophysical properties. Moreover, thermal radiation can affect the value of thermodynamic parameters, as was indicated in [1], which considered the case in which one must deal with the contribution of thermal radiation to the pressure of a rarefied gas. The relationship between the heats of phase transitions and radiation characteristics was considered in [2]. Further study of possible correlations between thermal radiation characteristics and thermophysical properties of a given material is of obvious interest.

With this purpose in mind, the authors attempted to relate the thermal conductivity of various metals to their emissivities, using data available in the literature [3-7]. The specific quantity chosen for study was the hemispheric integral emissivity ε_{th} from [4]. The thermal conductivity values were taken from [3-5]. To decrease the effect of ε_{th} measurement errors on the character of the dependence the values of the parameters studied were taken at T = 1000 K, while metals from the fourth, fifth, and sixth periods of the period table with quite high melting points were chosen.

The function used to approximate the original dependence (Fig. 1) was an exponential relationship between emissivity and thermal conductivity: $\varepsilon_{th}(\lambda) = A \exp (B\lambda^C)$. Approximation of the data from the literature by the method of least squares yielded the following constant values: A = 2.09, B = −1.23, C = 0.189.

The results obtained may be of interest for study of the physical basis of thermal radiation and can be used to evaluate radiation properties.

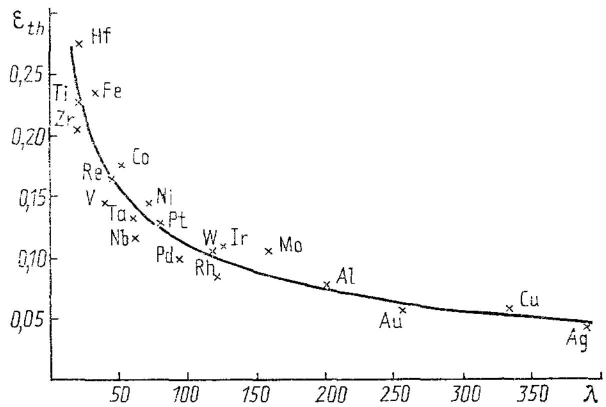

Fig. 1. Hemispherical integral emissivity of metals vs thermal conductivity at T = 1000 K. Points, data from literature; curve, approximation. λ, W/(m·K).

*Deceased.

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MEASUREMENT OF THE TEMPERATURE OF A SURFACE IRRADIATED BY CONCENTRATED LIGHT

V. V. Kan, T. T. Riskiev, and T. P. Salikhov

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A new method is proposed for determining the thermodynamic temperature of a surface irradiated by concentrated light.

INTRODUCTION

The development of studies of interaction between concentrated light radiation and materials requires reliable measurements of the parameters of the process. The basic experimental parameter characterizing the interaction process is the temperature of the irradiated surface. However measurement of the thermodynamic temperature of material surfaces during action of concentrated light radiation involves significant methodological difficulties related to pyrometry of an open surface, complicated by the need to eliminate powerful reflected light fluxes. Thus it was only in 1979 that M. Bober (West Germany) developed a method for correct solution of the problem of measurement of the thermodynamic temperature of the diffusely reflecting surface of refractory materials subjected to high power laser radiation [1, 2]. Analysis of Soviet and foreign sources for the subsequent decade [3, 4] showed that the majority of researchers used Bober's method for measuring the temperature of the irradiated surface of various materials. It should be noted here that Bober's method is valid only for diffusely reflecting materials and is inapplicable to materials with specular and mixed reflection, which class includes the majority of modern technology materials actively used in intense light fluxes. The latter class includes the resonators of high power modern lasers with specular type reflection, composition thermal insulation materials with fiber and dispersed fillers, oxides with a mixed type reflection (although in the latter case powder metallurgy methods permit creation of parts with surfaces having close to diffuse reflection).

The present study will develop a method for measuring the thermodynamic temperature of a surface with arbitrary reflection indicatrix under the action of concentrated light.

MEASUREMENT METHOD

Pyrometry in the visible wavelength range is based on Wien's expression

$$E^0_{\lambda,T} = C_1\lambda^{-5}\exp\left(-\frac{C_2}{\lambda T}\right). \tag{1}$$

Using the concepts of brightness temperature and spectral emissivity, we write the equation

S. V. Starodubtsev Physicotechnical Institute, Academy of Sciences of the Uzbek SSR, Tashkent. Translated from Inzhenerno-fizicheskii Zhurnal, Vol. 61, No. 4, pp. 658-662, October, 1991. Original article submitted December 18, 1990.

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