THERMAL CONDUCTIVITY AND THERMAL DIFFUSIVITY OF PLASMA-SPRAYED STAINLESS STEEL

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Results are shown of an experimental study concerning the thermal conductivity (over the temperature range 50–400°C) and the thermal diffusivity (over the temperature range 500-1100°C) of plasma-sprayed stainless steel.

In order to raise or lower thermal contact resistances and to protect metal products against corrosion, one widely applies metal cladding on the substrate by means of plasma spray. For calculating the temperature fields, wherever a thermocouple is installed, and for estimating the error introduced by a thermal contact resistance, it is necessary to know also the thermophysical properties, i.e., the thermal conductivity and the thermal diffusivity of the sprayed metal.

The authors studied the thermal conductivity and the thermal diffusivity of plasma-sprayed grade Kh18N9T steel. The thermal conductivity was measured at temperatures from 50 to 400°C under steady conditions by the plane-layer method and under transient conditions by the cooling-rate method [1].

The specimens of sprayed metal were rods 10 mm indiameter and 20 mm high. The end surfaces were ground before the measurement. Thermocouples were welded to the specimens by spot welding according to the technique shown in [2]. The thermal flux in either test mode was determined from the electric power drawn by a flat heater.

The thermal conductivity of sprayed metal is shown in Fig. 1a as a function of the temperature. The results indicate a thermal conductivity lower than that of monolithic metal.

The thermal diffusivity of sprayed metal was measured over the temperature range 500-1100°C. The measurements were made by the phase method in the regular mode of the third kind, the phase difference between oscillations of the heating power at one end and the temperature oscillations at the specimen surface on the other end being a uniquely determinate function of z and, in the final analysis, also a function of the thermal diffusivity [3] (the correction for Bi was small, with Bi < 10^{-4} during the measurements).

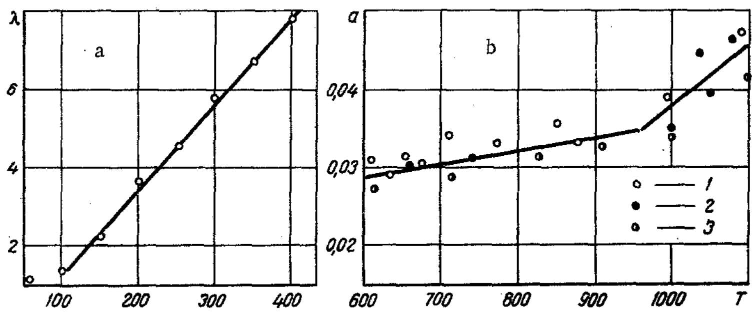

Fig. 1. a) Thermal conductivity (λ, W/m·deg); and b) thermal diffusivity ($a \cdot 10^4$ m^2/sec) as functions of the temperature (T, °C): 1) first measurement; 2, 3) repeated measurements.

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The thermal diffusivity was calculated according to the formula

$$a = \frac{\omega\delta^2}{z^2}.$$

A specimen in the shape of a disk, diameter d = 8-10 mm and thickness δ = 1-2 mm, was heated in vacuum with a modulated electric current. The oscillations of the specimen temperature were recorded through a thermocouple. The alternating component of the thermocouple emf was amplified and fed to a model N-700 light-beam oscillograph. At the same time, signals of heating power and control time markers of the heating and cooling period were also recorded.

Prior to measuring the thermal diffusivity of sprayed metal, the instrument was calibrated against Armco iron. The results agree closely with the data in [3], with the maximum discrepancy not exeeding 5%.

The results of measurements pertaining to thermal diffusivity as a function of the temperature for sprayed stainless steel are shown in Fig. 1b.

During the thermal diffusivity measurements, characteristically as in [4], the first reading and the subsequent readings (repeated measurement) differed, probably reflecting a breakdown of the oxide films between particles of sprayed metal due to heating.

The measurement error was 9% in the case of thermal conductivity and 6% in the case of thermal diffusivity.

NOTATION

d is the diameter of specimen;
δ is the thickness of specimen;
z is the characteristic parameter;
λ is the thermal conductivity;
a is the thermal diffusivity;
ω is the angular frequency;
Bi is the Biot number;
T is the temperature, °C.

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