METHOD FOR DETERMINING THE ACTUAL CONTACT AREA OF SURFACES UNDER PROLONGED STATIC LOADING AT HIGH TEMPERATURES

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For the solution of various technical problems it is necessary to measure the actual contact surface of machine components under conditions of high-temperature loading.

The existing methods for determining the actual contact surface [1-3] are based on the transfer of a substance from one surface to the other at the points of contact, on measuring the contact resistance, and on evaluating the approaching of one surface to the other. The observation of optical phenomena does not provide sufficiently precise measurements at high-temperature loading.

Below we suggest a method for measuring the actual contact surface of solid bodies over a wide range of their physicomechanical properties for different densities of heat flows in the contact area.

The method utilizes the specific nature of heat-transfer through the contact area [4] in the case when the heat flow is directed in high vacuum through the places of direct contact, thus producing a thermal resistance of the actual contact.

This resistance has a definite relationship to the actual contact area, the load, the exposure time to loading, and the physicomechanical properties of materials, and it is represented by the formula

$$\frac{1}{R_m} = 2 \cdot 12 \cdot 10^4 \lambda_m \eta, \tag{1}$$

where $\lambda_m = 2\lambda_{m1}\lambda_{m2}/(\lambda_{m1} + \lambda_{m2})$ is the referred heat-conduction coefficient of the contacting surfaces at the temperature of the contact area; $\eta = S_a/S_n$ is the actual relative contact surface; S_a and S_n are respectively the actual and the nominal contact surfaces.

In order to obtain the actual contact surface from (1) it is necessary to determine experimentally the thermal resistance for the given conditions of contact on special equipment.

The equipment (Fig. 1) comprises the working chamber 1, the ultrathermostats 2 and 3 with the heating and cooling agents respectively, the fore pump 4, the diffusion oil pump 5, the thermocouple vacuum gauge 6, and the control and measuring equipment which consists of the potentiometer 7, the terminal block 8, and eight-way switch 9, and the Dewar flask 10. The thermal condition and the efforts applied to the specimen are controlled respectively by the recording potentiometer 11 and the electronic deformations meter 12.

The working chamber of the equipment (Fig. 2) consists of the hermetically sealed cylinder 1 with its lid 2. It carries in its upper part the water heater 3, and in its lower part the refrigerator 4, between which the tested specimen 5 with incorporated thermocouples is placed. The specimen is loaded by means of the screw press 6 through the rod 7 with its ball bearing. The lateral screen 8 and the lagging 9 are placed on the sides of the specimen in order to eliminate radial heat losses.

Test specimens of two different shapes were made. For materials with $\lambda_m > 10$ W/m · °C they were provided with a diameter of d = 30 mm and a length of l = 58 mm, and for materials with $\lambda_m < 10$ W/m · °C were provided with a ratio of d/l = 5-12.

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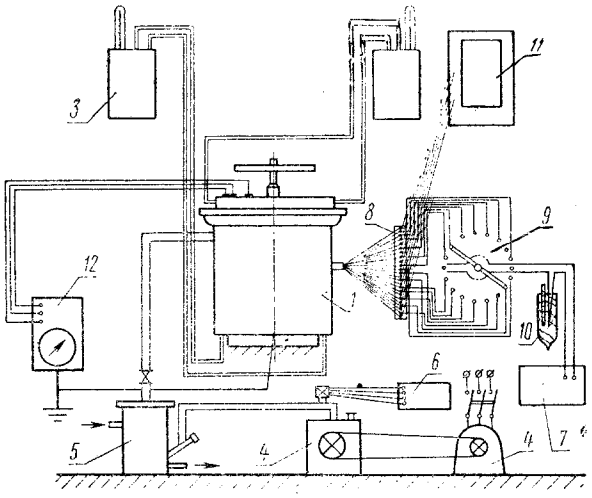

Fig. 1

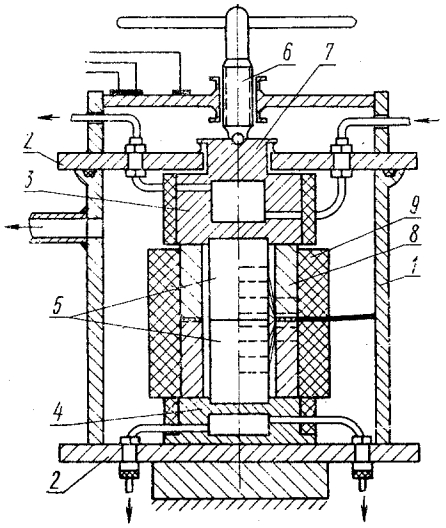

Fig. 2

The technique for measuring thermal resistance is described in [5].

The error in measuring the actual contact surface lies in the range of 8-10% in the case of a stationary thermal condition, and it is 10-15% for a transient condition. The above method can be widely used in factory laboratories and scientific-research institutes.

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