Meas. Tech. (USSR), 1970, 1862-4 (1970)

ERRORS IN TEMPERATURE MEASUREMENT IN INTERNALLY HEATED HIGH-PRESSURE CHAMBERS

V. N. Chernikov

UDC 536.532.088.2

To measure temperatures in internally heated high-pressure apparatus, thermocouples are usually used which, most often, are introduced into the high-pressure chamber by means of tapered fittings (cones) [1, 2].(Fig. 1a, b, c). Here the branches of a thermocouple are either broken at the fitting and joined by soldering to the ends of the cone (Fig. 1a), or passed into the high pressure zone without interruption. In the latter case, hermeticity is achieved by various methods, particularly pressing of the thermoelectrodes into the channels of the conical fittings (Fig. 1b), soldering the contacting surfaces of the thermoelectrodes and the fittings (Fig. 1c), etc.

The use of heaters situated inside a high-pressure chamber gives rise to the appearance of a temperature drop at the conical fittings which, in turn, leads to the appearance of additional thermal emf's in the thermocouple circuit.

We shall examine the case where both branches of a thermocouple (which we shall denote by A and B, respectively) are introduced into a chamber as indicated in Fig. 1a, for which the fittings are made of the same material and the same temperature drop ΔT is realized at each. The total thermo-emf in the circuit under consideration will be equal to the algebraic sum of the thermo-emf's of its separate parts, taken with respect to some arbitrarily chosen positive direction. Here, the thermo-emf's generated at the cones belonging to branch A and to branch B will be equal in magnitude and opposite in direction. Consequently, the readings of such a circuit will differ from the readings of an ordinary thermocouple consisting of uninterrupted branches A and B by the value of an additional thermo-emf, equal to

$$E_{AB}^{ad} = E_A - E_B, \tag{1}$$

where E_A and E_B are the mean-integral thermo-emf's of the branches A and B.

Having taken as the positive direction of the thermo-emf in the thermocouple circuit A-B the direction from A to B through the high pressure chamber, one can describe the relationship between the measured value of the thermo-emf of the thermocouple and its true value as:

$$E^{true}{}_{AB} = E^{m}{}_{AB} + E^{ad}{}_{AB}. \tag{2}$$

It is obvious that the magnitude of the additional thermo-emf $E^{ad}{}_{AB}$, given by Eq. (1), being converted into degrees by means of the standard calibration curve of the thermocouple A-B, turns out exactly equal to the temperature drop $\Delta T = T_2 - T_1$ at the cones, independent of the material from which they are made.

Let us turn now to the case represented in Fig. 1b. We shall consider separately the conical fitting (denoting the material of the fitting by M) and the section of branch A of the thermocouple A-B which is pressed into it. As above, let a temperature drop ΔT be realized at the cone under consideration.

A series of simple considerations justifies substitution of the equivalent electrical circuit presented in Fig. 2 for the system being examined. Here R_A is the total resistance of the pressed-in section of branch A, R_M is the total

Translated from Izmeritel'naya Tekhnika, No. 12, pp. 38-40, December, 1970. Original article submitted March 3, 1969.