DETERMINATION OF TEMPERATURE PULSATIONS IN THE CROSS SECTION OF A PLASMA JET

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UDC 533.9

A method of constructing the radial distribution of temperature pulsations across a plasma jet is described. Some results obtained by this method are examined.

Data concerning the determination of the mean diametral temperature fluctuations in a jet are given in [1]. Of interest, however, is also the radial distribution of temperature fluctuations. To study this question, we used a plasmatron without a mixing chamber. The emission of the jet at a distance of 2 cm from the nozzle exit section was employed. The mean values of the current and voltage were 400 A and 220 V, respectively. The working fluid was nitrogen gas. The gas flow rate was 3 g/sec.

The temperature was measured from the relative intensity of the spectral lines of copper (λ_1 = 5153 Å, λ_2 = 5105 Å), using a special photoelectric attachment which had a time resolution of on the order of $5 \cdot 10^{-4}$ sec, and whose output voltage was proportional to the quantity $\ln(I_1/I_2)$. The temperature was determined from the formula

$$\overline{T} = \frac{2.75 \cdot 10^4}{4.19 - \ln \frac{I_1}{I_2}}. \quad (1)$$

No special experiments were made to test the absence of reabsorption; however, the absence of self-absorption of the lines has been revealed in experiments in which equipment of the same type and operating under the same conditions was employed. The distribution laws of temperatures measured along a row of chords in a cross section were determined from the $\ln(I_1/I_2)$ oscillograms obtained (Fig. 1), which were manually processed. To this end, a $\ln(I_1/I_2)$ oscillogram which represented a continuous random process was discretized on the basis of Kotel'nikov's theorem. The obtained values of $\ln(I_1/I_2)$ were used together with relation (1) to find the discrete temperature values, which were then used to determine the temperature distribution law (Fig. 2a).

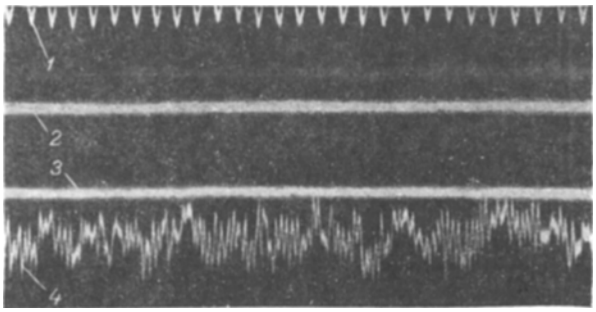

Fig. 1. Oscillogram of the logarithm of the intensities ratio of two spectral lines: 1) time-marker signal (f = 500 Hz); 2) $\ln(I_1/I_2)$ = +1; 3) $\ln(I_1/I_2)$ = 0; 4) $\ln(I_1/I_2)$ in the jet.

The radial distribution of the temperature fluctuations was determined from the temperature fluctuations measured along a row of chords in the jet cross section, which constitute a stationary random process, as has been shown in [1]. To this end, we used a successive approximation technique [3] to construct a family of radial temperature distributions from the value of the temperatures measured along the row of chords in the jet cross section, with like values of the distribution function $F(\overline{T})$. The family of distributions obtained (Fig. 2b) can be used to determine the temperature distribution law at various points of the jet radius. This can be readily demonstrated by introducing for the radial temperature distribution a function $F[T(r)]$ which

Institute of Heat and Mass Transfer, Academy of Sciences of the Belorussian SSR, Minsk. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 16, No. 1, pp. 145-147, January, 1969. Original article submitted March 27, 1968.

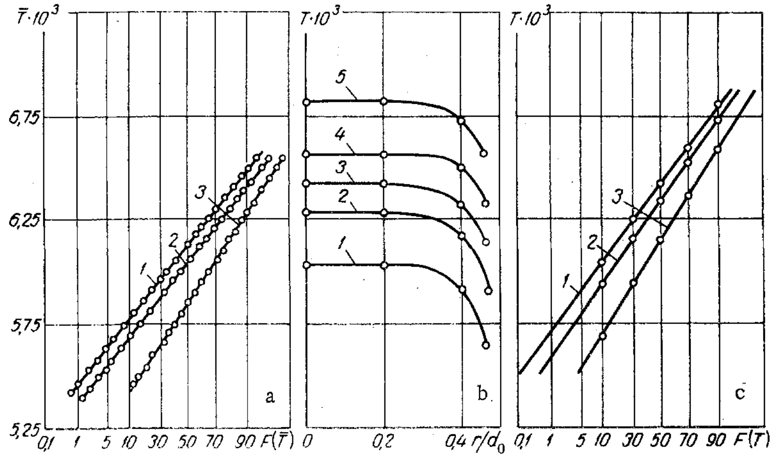

Fig. 2. Temperature distribution (in °K) over the cross section of the plasma jet: a) distribution curves of temperatures measured along the row of chords (1) $l/d_0 = 0, 0.2$; 2) $l/d_0 = 0.4$; 3) $l/d_0 = 0.46$; b) radial temperature distribution for several values of the cumulative probability [1) $F[T(r)] = 10$; 2) 30; 3) 50; 4) 70; 5) 90%]; c) distribution curves of temperatures along the jet radius [1) $r/d_0 = 0, 0.2$; 2) 0.4; 3) 0.46] F(T) in %.

describes the probability of the radial temperature distribution not being situated above a certain curve $T_1(r)$. Mathematically, this can be expressed as follows:

$$F[T(r)] = P[T(r) \leqslant T_1(r)].$$

Then, for the radial temperature distribution $T_1(r)$ constructed from the temperatures measured along the row of chords in the jet cross section with like values of the distribution function $F(\bar{T}_1)$, we obtain $F[T_1(r)] = F(\bar{T}_1)$. Thus, having a family of curves $T_1(r), T_2(r), \ldots, T_i(r)$ with known values of $F[T_1(r)], F[T_2(r)], \ldots, F[T_i(r)]$, it is not difficult to determine the temperature distribution law at different points of the jet radius. It may be seen from Fig. 2c that the mean value of the temperature decreases and the rms deviation increases from the core to the periphery of the jet. Furthermore, it can be seen from Fig. 2a and 2c that the distribution laws of the temperatures measured along the row of chords are similar to the distribution laws of the temperatures, at the corresponding distances, along the jet radius.

NOTATION

I_1, I_2 are the spectral intensities;
T is the temperature measured along a chord;
l is the distance of a chord from the center of the jet cross section;
d_0 is the jet diameter;
T_1 is the temperature along the jet radius;
r is the instantaneous value of the radius;
P is the probability.

LITERATURE CITED

1. B. E. Moshkin, Teplofizika Vysokikh Temperatur, 5, No. 1 (1967).
2. V. N. Kolesnikov and V. V. Bogdanov, Opt. i Spektr., 1 (1956).
3. O. N. Dubrovskaya, in: Measurement of Flame Temperatures [in Russian], Oborongiz (1954).