NOISE THERMOMETRY FOR VERY HIGH PRESSURE USE

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ABSTRACT

The present paper describes a new method of balancing the Johnson noise of a sensing resistor with that of a reference resistor in the noise thermometry. In place of the conventional technique which measures the mean square voltage of the thermal noise, the present method is substantially to count the number of pulses exceeding an established constant gate voltage for a unit duration of time.

When an appropriate constant value was chosen as the gate voltage, an improved sensitivity in balancing both the noise voltages was obtained. The accuracy of this thermometry is such that 0.1 % at room temperature and 0.3 % at 900 K both at an atmospheric pressure.

The new method was applied to correct the output of the thermocouple imbedded in a girdle-type high pressure cell.

RÉSUMÉ

Nous décrivons ici une méthode thermométrique nouvelle consistant à équilibrer le bruit de Johnson d'une résistance détectrice à celui d'une résistance de référence. Au lieu de mesurer suivant les techniques conventionnelles le carré moyen de la tension du bruit thermique, la méthode que nous proposons revient à compter le nombre d'impulsions qui dépassent un seuil déterminé, au cours de l'unité de temps.

Après avoir choisi une valeur convenable du seuil, la sensibilité a été améliorée en équilibrant les deux bruits de fond. La précision de cette technique de thermométrie est voisine de 0,1 % à la température ambiante, 0,3 % à 900 K, sous la pression normale. Nous avons utilisé ce procédé pour corriger le signal du thermocouple introduit dans la cellule haute pression frettée.

1. Introduction

It is well known that the output of a noise thermometer is independent of pressure and free from any contamination of a sensing resistor within a high pressure and high temperature environment. Several authors have made experimental investigations of the noise thermometer [1-4].

The present paper describes a new method of balancing the Johnson noise of a sensing resistor with that of a reference resistor. The balancing point of the Johnson noises in the sensing and the reference resistors was detected by counting the rate of pulses surpassing a constant gate voltage. By means of this method, pressure correction was made to the outputs of thermocouples embedded in a girdle type high pressure cell.

2. Experiment

The absolute temperature T_s of a sensing resistor (the real part of an impedance : $\mathrm{Re}\,(Z_s)$) is determined by means of equalizing a mean square voltage $\overline{v_s^2}$ of the sensing resistor with that $\overline{v_r^2}$ of a reference resistor $\mathrm{Re}\,(Z_r)$. The sensing resistor is expressed in a parallel combination of resistance R_s and capacitance C_s.

According to Nyquist's law, $\overline{v_s^2}$ is given by

$$\overline{v_s^2} = \int_{f_1}^{f_2} 4kT_sR_s/(1 + (2\pi f C_s R_s)^2)\,df\,, \qquad (1)$$