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THERMAL DIFFUSIVITY OF CARBON DIOXIDE IN THE CRITICAL REGION

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An analysis and comparison of CO_2 thermal diffusivity measurements in the critical region performed in [1] and [2] is presented.

In [1] the present authors presented results of measurement of thermal diffusivity of CO_2 in the critical region. The measurements were performed with a polarization shift interferometer.

The results obtained in [2] with the aid of a holographic interferometer were presented in the form of tables and graphs in the coordinates $a-\rho$ and compared to our data. In constructing the graph $a = f(\rho)$ in [1] density values taken from [3] were used, these agreeing satisfactorily with the data used in [2].

Becker and Grigull graphed our results in the coordinates $a-\rho$, using density values obtained from the equation of state of Meyer-Pittroff et al. [4], obtaining a distorted graph with intersecting isotherms (Fig. 1). This was the basis for the conclusion that the data of [1] were evidently distorted by the effect of convection. In support of this conclusion it was noted that a polarization shift interferometer is less sensitive than the holographic one used in [2], so that in the process of measuring thermal diffusivity the authors of [1] had created temperature differentials between the foil and CO_2 under study an order of magnitude, or in some cases, two orders of magnitude, larger than in the experiments of [2].

The latter is in fact true. In [1] $\Delta T \approx 0.03°K$, while in [2] ΔT varied from approximately 0.3°K far from the critical point to 0.0001°K near the point. Nevertheless, it can be said with assurance that our results were not distorted by convection effects. Firstly, in the thermal diffusivity measurements visual monitoring of the interference pattern was carried out continually. Second, the method used for processing the interferograms permitted error-free detection of the commencement of convection. With molecular heat transfer the graph $(2x)^2 = f(\tau)$ which was constructed by decoding the interferograms is linear in character, beginning to curve when convection develops.

The distortion of the graph obtained by Becker and Grigull in processing our results can be explained in the following manner.

The Meyer-Pittroff equation does not describe the state of a material in the critical region sufficiently well. This statmeent is supported by the fact that in [2] isotherms in the coordinates $\lambda-\rho$ using density values obtained with this equation have a double "hump" at densities close to critical, not corresponding to the real character of the change in λ with ρ.

Naturally, use of an undoubtedly inaccurate equation of state cannot serve as a criterion for evaluating the correctness of experimental data. A direct comparison of the results of [1] and [2] would be of interest. Figure 2 shows isotherms $a = f(\rho)$ for the data of [2] (dashed lines) and [1] (solid lines). Density values obtained by Zenger [5, 6] were used for both sets of graphs. There is good qualitative agreement on all isotherms. On the descending portions of the isotherms over a wide pressure range and on the critical isochor the results also agree well quantitatively. On the lower portion of the descending branch and the rising branches there is some layering. However, in the critical region, where measurement becomes more complex, and the measurement uncertainty increases significantly, such divergence of the rsults can be regarded as completely acceptable.

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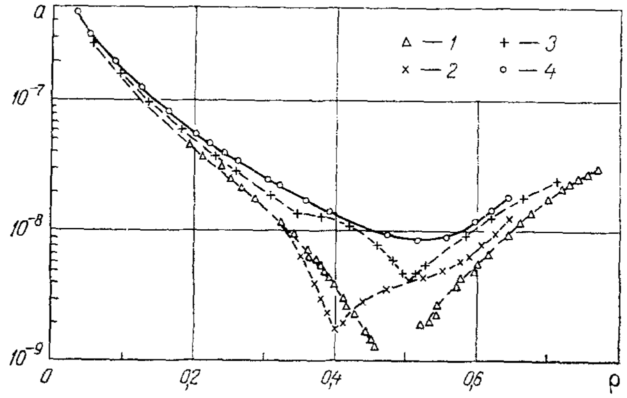

Fig. 1. Thermal diffusivity of CO_2 according to data of [1]. Graph taken from [2]. Isotherms: 1) 31.2°C; 2) 32.3; 3) 34.7; 4) 40.

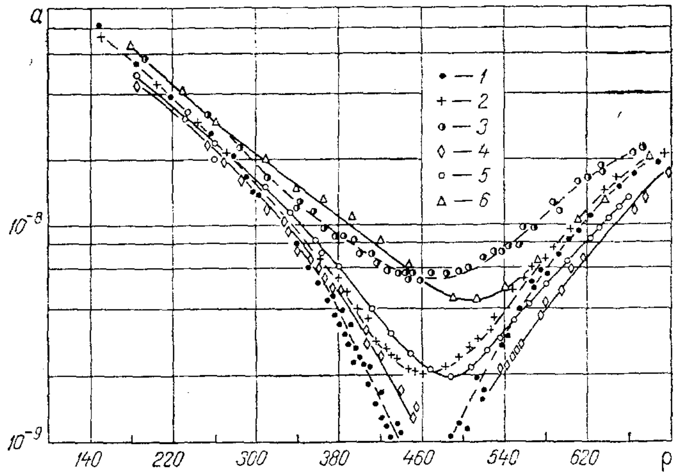

Fig. 2. Thermal diffusivity of CO_2 according to data of [2] (curves 1-3) and [1] (curves 4-6). Isotherms: 1) 31.2°C; 2) 32.1; 3) 34.8; 4) 31.18; 5) 32.3; 6) 34.72.

NOTATION

a, thermal diffusivity, m^2/sec; ρ, density, kg/m^3; ΔT, temperature differential between heater and test material, °K; 2x, distance between symmetric interference bands at moment of photography, m; τ, time corresponding to position of interference bands at moment of photography, sec; λ, thermal conductivity coefficient, W/(m·K); T, absolute temperature, °K.

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