THERMAL CONDUCTIVITY OF MERCURY VAPOR

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Tables of the thermal conductivity of mercury vapor for temperatures from 500 to 1200°K and pressures from 0 to 20 MPa are calculated from experimental data.

Several papers [1-5] have been published on the thermal conductivity of mercury vapor. The measurements in [1, 2] were performed by the steady-state hot-wire method. Vargaftik and Yakush [2] estimated that the accuracy of their data is 2.8% for temperatures from 500 to 1200°K and pressures of 100-300 mm Hg. The results in [1] were obtained for a narrow temperature range near 470°K, and agree with [2] within the limits of error of both experiments. The experiments in [3, 4] were performed by the periodic heating method, and the authors estimate the errors of the results are 6 and 5.1% respectively. At 700°K the agreement of the data in [2-4] is very good, but at temperatures below 700°K there are substantial differences. Thus, at 476°K the difference between [1] and [3] is ∿30%, which is far outside the limits of error estimated by the authors. It was shown in [5] that the values in [3] at low pressures are too low because of the way the temperature jump in periodic heating was taken into account. The correction for the temperature jump in [3] was made by using formulas which are generally applicable for steady-state temperature distributions. After the introduction of a correction by the formulas derived in [5] for an unsteady temperature distribution, the agreement of [1] and [3] is considerably improved, and the experimental points of [1-3] fall on a single curve for the thermal conductivity with a spread of 1.5%. This is curve 1 of Fig. 1. The thermal conductivity of mercury vapor was measured in [4] near the saturation line for temperatures of 527-1265°K. In the range of temperatures and pressures where the dimerization of mercury atoms and the imperfect nature of the vapor do not have a significant effect on the thermal conductivity, the data of [4] agree with [3]. However, after the introduction of a correction for the temperature jump according to the formulas of [5], the difference between the results in [4] and [2] at temperatures below 800°K is decreased to 3%, which is within the limits of accuracy of both measurements. The error of experiments performed in [6] in the range 600-2300°K by a modified hot-wire method was estimated by the authors to be 3% (curve 3 of Fig. 1). At low temperatures the agreement between data of [6] and [1-4] is somewhat better; the differences reach 14% at 1200°K.

Data on the thermal conductivity of mercury vapor can also be obtained from experimental papers on viscosity at temperatures up to 1200°K [8-11], but not [12], which has systematic errors. We approximated the experimental points from [8-11] by a third degree polynomial by the least-squares method. The equation obtained has the form

$$\eta\cdot 10^5 = 1.5656 - 1.1150\cdot 10^{-4}T + 1.6317\cdot 10^{-5}T^2 - 7.2762\cdot 10^{-9}T^3. \quad (1)$$

The average deviation of the experimental values of η from (1) is 1.92%. The well-known relation

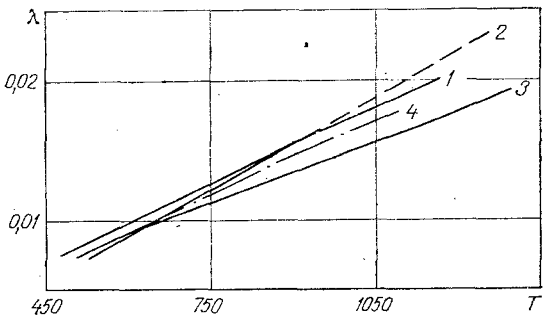

Fig. 1. Thermal conductivity of mercury vapor. λ, W/m·°K; T, °K.

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TABLE 1. Thermal Conductivity of Mercury Vapor

T, K	$\lambda \cdot 10^3$, W/m·°K							λ_s
	P=0,1 MPa	P=1 MPa	P=2 MPa	P=4 MPa	P=6 MPa	P=8 MPa	P=10 MPa	
500	7,96*							7,96
550	8,83*							8,83
600	9,74*							9,75
650	10,67							10,69
700	11,61							11,64
750	12,56							12,60
800	13,51	13,58						13,58
850	14,46	14,52						14,58
900	15,40	15,46	15,52					15,59
950	16,33	16,38	16,45	16,58				16,61
1000	17,23	17,28	17,34	17,46	17,60			17,64
1050	18,11	18,16	18,22	18,33	18,46	18,61		18,70
1100	18,95	19,00	19,05	19,16	19,28	19,42	19,57	19,79
1150	19,75	19,79	19,85	19,95	20,06	20,19	20,33	20,89
1200	20,50	20,54	20,59	20,69	20,79	20,91	21,05	21,99
1250	21,20	21,24	21,29	21,38	21,47	21,58	21,72	23,11

*For $P < 0.1$ MPa.

$$\lambda = 2.5\eta c_v, \tag{2}$$

was used to calculate the average values of the thermal conductivity (curve 4 of Fig. 1). It is clear from the figure that the values of λ calculated from the viscosity are in better agreement with experiments [1-4] (the deviation is 5-6%) than with [6].

The experiments in [4] were performed close to the saturation line. Curve 2 of Fig. 1 corresponds to values of the thermal conductivity of saturated mercury vapor obtained in [4]. With an increase in temperature as a consequence of the increase in pressure, the polymerization of mercury atoms and the imperfect nature of the vapor have a greater and greater effect on the thermal conductivity (open part of curve 2). With a decrease in temperature the effect of these factors is diminished, and at 750-800°K, where according to [7] the compressibility of saturated mercury vapor $z = 0.99$, the thermal conductivity of saturated and superheated vapor should be nearly the same. At this and lower temperatures the data of [1-4] agree within 3%. On the basis of experiments [1-5] we recommend the following expression for the temperature dependence of monatomic mercury vapor in the temperature range 450-1200°K:

$$\lambda \cdot 10^3 = 2.097 + 4.139 \cdot 10^{-3} T + 19.329 \cdot 10^{-6} T^2 - 8.333 \cdot 10^{-9} T^3. \tag{3}$$

Attributing the polymerization of mercury atoms to the imperfect nature of the vapor, we obtain the dependence of the excess thermal conductivity $\Delta\lambda = \lambda_s - \lambda$ on the density ρ from the values of λ_s [4]. The values of the density of mercury vapor were taken from [7]. At temperatures above 1073°K the tabulated values of ρ were extrapolated, taking account of data in [13]. The dependence of $\Delta\lambda$ on ρ is well described by the second degree polynomial

$$\Delta\lambda \cdot 10^3 = 2.077 \cdot 10^{-3} \rho + 2.37 \cdot 10^{-6} \rho^2. \tag{4}$$

Equations (3) and (4) were used to calculate the values of the thermal conductivity of mercury vapor at various temperatures and pressures listed in Table 1.

NOTATION

λ, thermal conductivity; λ_s, thermal conductivity of saturated vapor; $\Delta\lambda$, excess thermal conductivity; η, viscosity; ρ, density; T, temperature.

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EFFECT OF VARIABLE ELECTRIC FIELDS ON THE THERMAL CONDUCTIVITY OF DIELECTRIC LIQUIDS

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We give a description of the apparatus, procedure, and experimental results of an investigation of the effects of variable electric fields on the thermal conductivity of dielectric liquids.

The results of many investigations indicate an intensifying effect of constant and variable electric fields of low and high frequencies on heat exchange in dielectric liquids [1-4]. However, the nature of the phenomenon and the mechanism of the processes taking place when the heat exchange in dielectric liquids is affected by an electric field have not been sufficiently clarified. Up to now, therefore, there is no general method for calculating the heat exchange in an electric field.

The authors of studies devoted to this problem attribute the intensification of the heat exchange to the occurrence of electroconvection, i.e., the macroscopic motion of the liquid under the action of electric-field forces. They usually disregard the question of the thermophysical properties of the medium in the field, assuming that they cannot change or that they are negligibly small.

Attempts at the experimental investigation of the effect of electrical fields on the thermal conductivity of liquids have been carried out in [5-7]. The results of these studies did not confirm the assumptions concerning the effect of constant and variable low-frequency (∿50 Hz) fields on the thermal conductivity of liquids. There are no data at all on the effect of high-frequency electric fields on the thermal conductivity of liquids.

The purpose of the present study is to investigate experimentally the effect of electric fields with frequencies of $3 \cdot 10^5$ to $6 \cdot 10^5$ Hz on the thermal conductivity of dielectric liquids. The thermal conductivities were measured by a relative method using a plane layer in combination with an interference method for determining the temperature difference in a

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