EVALUATION OF ONE OF THE HEAT LOSS IN DETERMINING THE THERMOPHYSICAL PROPERTIES OF SUBSTANCES

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Abstract: *when determining the thermophysical properties of various substances by calorimetric methods, it is necessary to take into account the outflow of heat from the installation, which is associated with the design features of the installation. During the experiments, a temperature difference is created in the calorimeter and the change in this difference with time is measured, which requires a heater and a thermocouple inside the measuring cell. The heater and thermocouple is placed inside the tube, passing along the central axis of the calorimeter core. This creates additional difficulties, because possible outflow of heat through this tube. In this paper, an estimate of this heat loss is made.*
Keywords: *thermophysical properties, calorimeter, autoclave, error due to heat leakage, heat flow, temperature field.*

ОЦЕНКА ПОТЕРИ ТЕПЛА ПРИ ОПРЕДЕЛЕНИИ ТЕПЛОФИЗИЧЕСКИХ СВОЙСТВ ВЕЩЕСТВ

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Аннотация: *при определении теплофизических свойств различных веществ калориметрическими методами необходимо учитывать отток тепла из установки, что связано с конструктивными особенностями установки. В ходе экспериментов в калориметре создается разность температур и измеряется изменение этой разности со временем, что требует наличия нагревателя и термопары внутри измерительной ячейки. Нагреватель и термопара располагается внутри трубки, проходящей вдоль центральной оси ядра калориметра. Это создает дополнительные сложности, т.к. возможен отток тепла по данной трубке. В данной работе производится оценка данной потери тепла.*
Ключевые слова: *теплофизические свойства, калориметр, автоклав, погрешность вследствие утечки тепла, тепловой поток, температурное поле.*

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To determine the thermophysical properties of liquids can be used both stationary and non-stationary methods of investigation. Non-stationary methods include monotonous heating methods and bicalorimeter methods.

When calculating the thermal conductivity and isobaric heat capacity by these methods, it is necessary to take into account the heat loss through the tube that penetrates the measuring cell. There are a heater and thermocouples in such high-pressure tubes. Heat also leaves the ends, in the absence of compensation cylinders. The latter leads to a violation of the temperature field along the length of the cylinders. The calorimeter scheme is given in picture 1. Core 1 (the ampoule in the case of determining the isobaric heat capacity) is inside autoclave 2. The gap between them is filled with the investigated liquid 3. Tube 4 with an electric heater with a power of W_0 runs along the core axis.

After establishing equilibrium in the cell, the electric heater is turned on. The core temperature, and hence the temperature

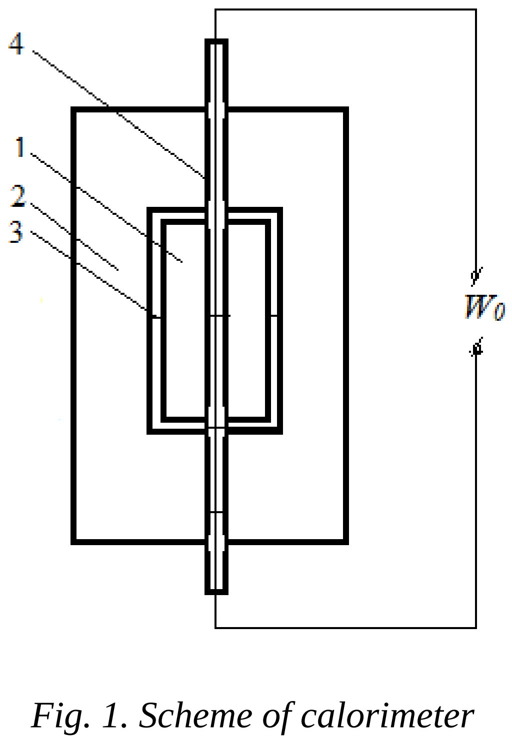
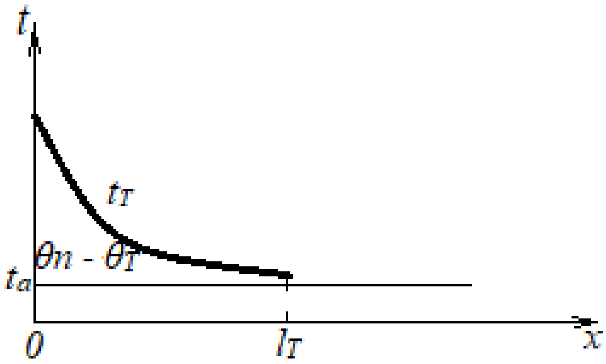


Fig. 1. Scheme of calorimeter

difference between the core and the autoclave, increases. To determine the coefficients of thermal conductivity and heat capacity, it is necessary to measure the temperature difference between the core and autoclave θ with time at a certain value of W_0. In the case of stationary mode, this difference is constant. Let us determine the heat leaving through the tube to the environment (autoclave) with a constant temperature t_0. The temperature field along the tube from the core is shown in picture 2. As is known, the heat balance equation

$$\frac{d^2\theta}{dx^2} - m_b^2\theta = 0 \quad . \tag{1}$$



Here $m_b^2 = \frac{2\pi\lambda}{\lambda_b S_b ln K_b}$, λ_b- is the coefficient of thermal conductivity of the material of the tube, S_b- is the sectional area of the tube, $K_b = \frac{r_2}{r_1}$ is the ratio of the radii of the cylindrical gap.

When solving this problem, we consider the ideal thermal contact between the tube and the core, heat is lost only through the wall of the tube and the tube is located strictly concentrically in the hole of the autoclave.

The solution to equation (1) is

$$\theta = Ce^{-mx} \quad . \tag{2}$$

Considering the boundary conditions $x=0$, $\theta=\theta_n$, we obtain

$$\theta = \theta_n e^{-mx} \, . \tag{3}$$

Heat flow from core to tube

Pic. 2. Temperature field along the tube core

$$q_0 = -\lambda_b S_b \left(\frac{d\theta}{dx}\right)_0 = \lambda_b S_b \theta_n m_b = \theta_n \sqrt{\frac{2\pi S_b \lambda\lambda_b}{lnK_b}} \quad . \tag{4}$$

Loss from both ends of the tube will be

$$q_1 = 4\pi\theta_n \sqrt{\frac{(r_1^2 - r_0^2)\lambda\lambda_b}{2lnK_b}} \quad , \tag{5}$$

where θ_n- is the temperature difference between the tube and the autoclave, r0 is the inner radius of the tube.

Heat flow from the core through the measuring layer

$$q_2 = \frac{\lambda\theta_n}{\delta} S = 2\pi\frac{\lambda\theta_n}{\delta} K_1(l_0 + R_1) \ , \tag{6}$$

Here S is the area of the working surface of the core, δ is the thickness of the measuring layer of the liquid, l_0, R_1- is the length and radius of the core. If we take the annular and end gaps equal, and δ has a very small value, then $ln\frac{R_2}{R_1} \approx \frac{\delta}{R_1}$.

Then from expressions (5) and (6) for the correction for heat loss through the tube

$$\Delta = \frac{q_1}{q_2} = \frac{2\delta}{R_1(l_0 + R_1)}\sqrt{\frac{(r_1^2 - r_0^2)\lambda_b}{2\lambda ln K_b}}$$

For example, this correction for liquid hydrocarbons (λ = 0.1 W / (m · K) is palpable Δ = 0.02, i.e. 2%, if we take $l_0 = 10\ cm, R_1 = 1\ cm, \delta = 0{,}05\ cm$, for a steel tube $\lambda_b = 16$ W / (m · K).

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