MEASUREMENTS OF THERMAL CONDUCTIVITY OF CARBON WOOL "CARBOTEXTIM-B" AT HIGH TEMPERATURE

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When the hot neutron source (HNS) of the reactor PIK [1]was decided to create it was decided to use carbon wool "Carbotextim-B" as a high temperature insulation. This carbon wool was produced by a process of grafitation of the viscose rayon "mtilon" [2]. It is the fibrous haotic structure material.

There is a need know thermal conductivity of carbon wool λ lon large scale of temperatures T.

The investigations of the dependence λ on T were made by the method of an infinite-dimensional cylinder [3,4,5,6].

The experimental plant was created. It allowed to measure the effective thermal conductivity in a temperature range up to 1800 K both in vacuum (at vacuum-pressure $10^{-2} - 10^{-3}$ millimeters of mercury) and in helium and in nitrogen atmospheres (at pressure 1.0—1.2 *atm*).

The temperature measurement error does not exceed 2 per cent The heat flux measurement error was about 5 per cent.

From the heat conditions equation for an infinite-dimensional cylinder

$$q_l = -2\pi R\lambda(T)\, dT/dR$$

by means of separation variables and integration equation was made as

$$q_l \ln(R_2/R_1)/2\pi = \int_{T_2}^{T_1} \lambda(T)\, dT, \tag{1}$$

where R_1 and R_2 are radiuses of hot and cold surfaces of the sample accordingly, T_1 and T_2 are temperatures of hot and cold surfaces of the sample accordingly, q_l is heat flux per unit of length which crossed through the sample of the material under investigation.

If the dependence λ on T approximated as

$$\text{a)}\quad \lambda = a_1 + b_1 T + c_1 T^2$$

or

$$\text{b)}\quad \lambda = a_2 + b_2 T^3 + c_2/T$$

equation (1) can be written as

$$\text{a)}\quad q_l \ln(R_2/R_1)/2\pi(T_1 - T_2) = a_1 + b_1(T_1 + T_2)/2 + c_1(T_1^2 + T_1T_2 + T_2^2)/3$$

or

$$\text{b)}\quad q_l \ln(R_2/R_1)/2\pi(T_1 - T_2) = a_2 + b_2(T_1^4 - T_2^4)/(T_1 - T_2) + c_2 \ln(T_1/T_2)/(T_1 - T_2)$$

Both these equations may be presents as

$$z = a_i + b_i x + c_i y \tag{2}$$

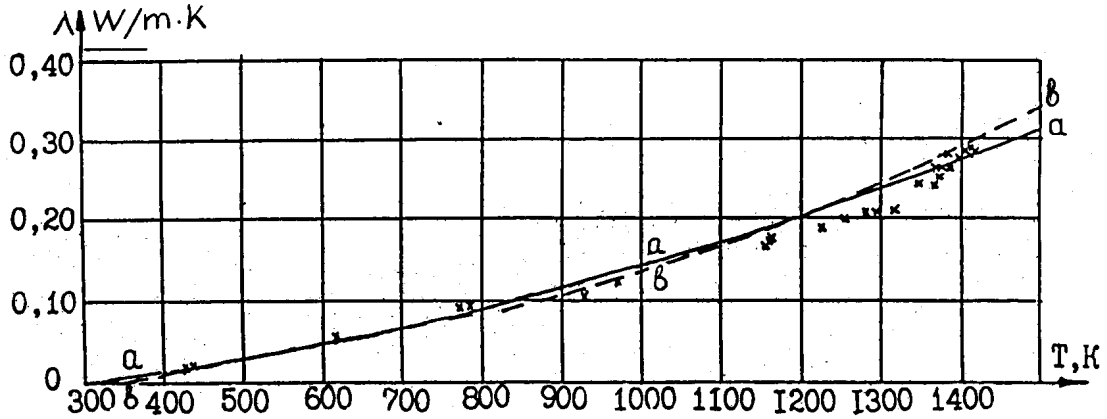

Fig.1. Dependence of thermal conductivity λ of the carbon wool "Carbotextim-B" on temperature T in vacuum

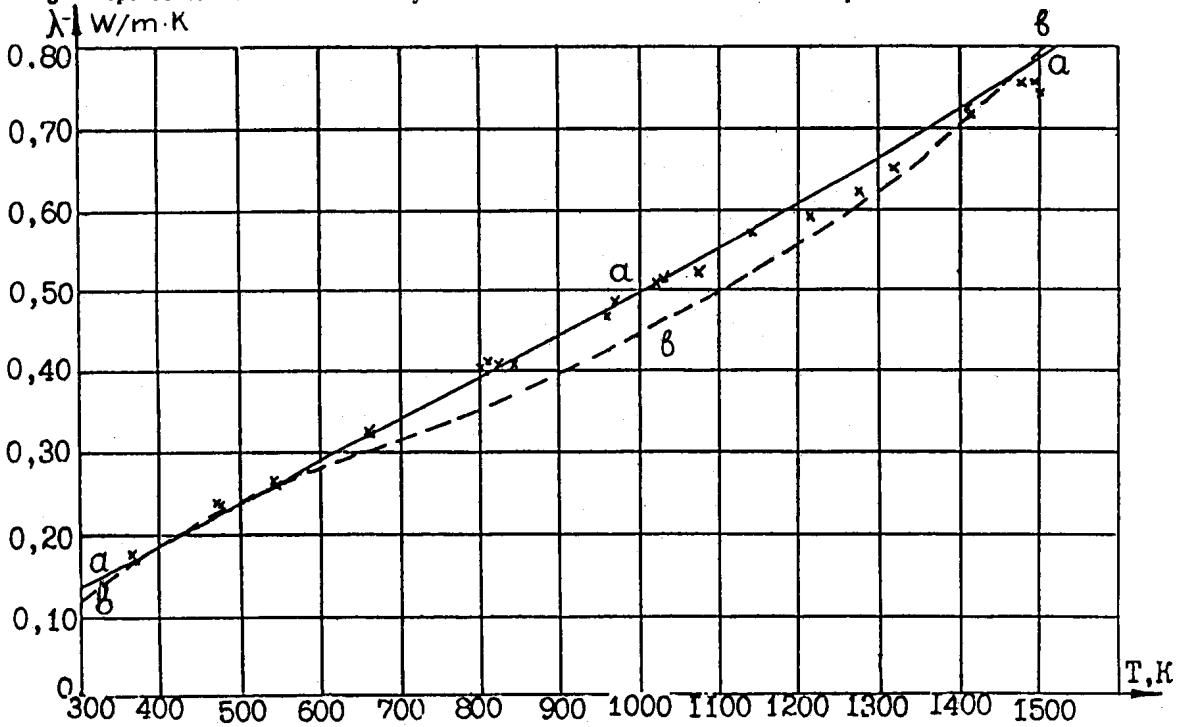

Fig.2. Dependence of thermal conductivity λ of the carbon wool "Carbotextim-B" on temperature in helium atmosphere

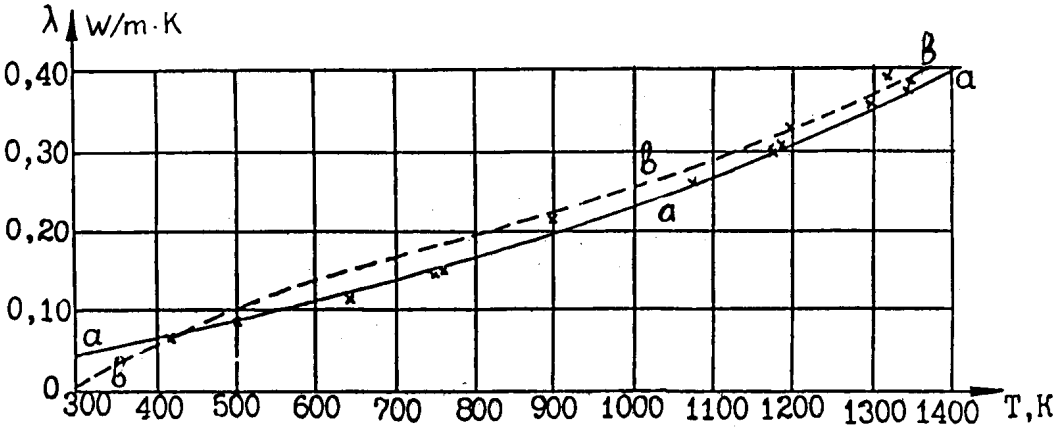

Fig.3. Dependence of thermal conductivity λ of the carbon wool "Carbotextim-B" on temperature in nitrogen atmosphere

For each assemblage of measuring experimental values $T_1 > T_2$ andq_l equation (2) may be written. Values z,x,y are known from the experiments, but a_i, b_i, c_i are the unknown values. For each three measurements the set of equations can be written

$$\left\{\begin{array}{l} z_1 = a_i + b_i x_1 + c_i y_1 \\ z_2 = a_i + b_i x_2 + c_i y_2 \\ z_3 = a_i + b_i x_3 + c_i y_3 \end{array}\right\}$$

For carbon wool "Carbotextim-B" the following dependence λ on T were obtahed.

Vacuum

$\lambda_a = -0.018 + 3.3 \cdot 10^{-5} T + 1.25 \cdot 10^{-7} T^2$ (3) for $500\,K < T < 1100\,K$

$\lambda_b = 0.069 - 24/T + 8.70 \cdot 10^{-11}\, T^3$ (4) for $900\,K < T < 1500\,K$

Helium

$\lambda_a = -0.005 + 4.5 \cdot 10^{-4}\, T + 5.00 \cdot 10^{-8}\, T^2$ (5) for $400\,K < T < 1100\,K$

$\lambda_b = 0.39 - 84/T + 1.35 \cdot 10^{-10}\, T^3$ (6) for $900\,K < T < 1500\,K$

Nitrogen

$\lambda_a = 0.01 + 7.5 \cdot 10^{-5}\, T + 1.45 \cdot 10^{-7}\, T^2$ (7) for $500\,K < T < 1100\,K$

$\lambda_b = 0.26 - 84/T + 7.90 \cdot 10^{-11}\, T^3$ (8) for $900\,K < T < 1400\,K$

The random error in dependencies (3)-(8) was defined at the designed temperature range in comparison

$$\Lambda_T = \int_{T2}^{T1} \lambda\,(T)\, dT$$

with

$$\Lambda_{T=}\, q_1 \ln (R_2/R_1)/2\pi$$

and does not exceed 5 per cent.

Dependencies of thermal conductivity λ of carbon wool "Carboxtim-B" on temperature allow to calculate geometric parameters and temperatures conditions of the HNS of the reactor PIK.

References

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