МАТЕРИАЛОВЕДЕНИЕ

За літературними даними вивчено, проаналізовано методами кореляційного та регресійного аналізу і обґрунтовані залежності коефіцієнта теплоємності, теплопровідності, лінійного коефіцієнта теплового розширення та зміни ентальпії від температури, порядкового номера та радіусу атома металів. Вивчено експериментальні дослідження теплофізичних властивостей композиційних полімерних матеріалів на основі політетрафторетилену, ароматичного поліаміду, поліміду та наповнювачів

Ключові слова: метали, полімери, теплофізичні властивості, температура, кореляційний аналіз, регресійний аналіз

По литературным данным изучено, проанализировано методами корреляционного и регрессионного анализа и обоснованные зависимости коэффициента теплоемкости, теплопроводности, линейного коэффициента теплового расширения и изменения энтальпии от температуры, порядкового номера и радиуса атома металлов. Изучены экспериментальные исследования теплофизических свойств композиционных полимерных материалов на основе политетрафторэтилена, ароматического полиамида, полиимида и наполнителей

Ключевые слова: металлы, полимеры, теплофизические свойства, температура, корреляционный анализ, регрессионный анализ

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THERMOPHYSICAL PROPERTIES OF METALS AND POLYMER COMPOSITIONS

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1. Introduction

It's known [1 – 8], that the enthalpy (H), thermal conductivity (λ), the coefficient of thermal capacity at constant pressure p = const (c_p) or specific volume υ = const (c_V), linear thermal expansion coefficient (α), depends on the temperature (T), but there are missing: a thorough analysis of this relationship for metals, not given approximation functions that describe these dependencies and not found correlation between thermal conductivity and temperature, serial number and the radius of the periodic table metals atom.

One of the most important characteristics of polymeric materials is their thermophysical properties, such as thermal conductivity and thermal capacity. The knowledge of these characteristics allows to choose the application and optimal temperature ranges of products usage from polymeric and metallic materials.

The aim of research work was to establish the dependence of changes in enthalpy, thermal conductivity, thermal capacity at the constant pressure and the linear coefficient of thermal expansion on temperature, radius and serial number of metal atoms of I B group of the periodic table of elements and search for correlations and approximating mathematical models between these characteristics, and also the study of thermal properties of composite materials based on polytetrafluoroethylene (PTFE), aromatic polyamide (PA) and polyimmide (PI) depending on the temperature and concentration of fillers.

2. Work objective

The metals of I B group of the Periodic system elements were an object of research : copper, silver and gold, as well as composite materials based on aromatic polyamide (fenilon C-2), polyimide (PM-69) and polytetrafluoroethylene (PTFE 4) filled with high-strength graphite, carbon fiber from tape VMN-4, basalt fiber and colloidal graphite C-1. The properties of these materials are given in [9 – 14], where the classification of carbon fibers is defined in [15, 16]: HM – highly modular ; PAN – with polyacrylonitrile fabric, ribbons or fibers; ρ = 1800 kg/m^3 – specific density of the fiber; γ = 1.0 % – specific elongation at break, d_f = 6.0 microns – the average diameter of the fibers; σ_f = 2.0–2.5 GPa – tensile strength of the fiber, E_v = 240–300 GPa – modulus fiber tensile, T_k = 2673 ± 20 K – final temperature thermal treatment of fibrous materials.

Basalt fibers obtained from deposits of minerals Berestoveckij and had the following characteristics : ρ = 2700 kg/m^3; γ = 1–4%; d_f = 11 microns ; σ_f = 1.8–2.2 GPa, E_v = 93–114 GPa.

Colloidal graphite C-1 was obtained by thermal anthracite graphitization at 2773 ± 100 K, followed by grinding in a colloid mills. Graphite C-1 had the following characteristics: ash content of 1.5 %, moisture content 0.5 %, fineness of grinding: the particle size of 1–80 microns particle size of the main fraction 1–8 microns (75 %) the residue on the sieve with holes 63 microns – less than 0.5 %.

The compositions based on polytetrafluoroethylene, aromatic polyamide and polyimmide fibers and dispersions, powders of graphite or carbon fibers were obtained by CMA-technology [17]. Shredding source of carbon fibrous materials was carried out in the hammer mill KDU "Ukrainian" at 3000 rev./min. working groups, and then type knife grinders MRP-1 at 7000 rev./min. (frequency of rotation 117 s^{-1}, the maximum speed of 78 m/s) 10 min. for carbon fibers and 20 min. for basalt fiber to obtain fibers with bulk density ρ = 30–50 kg/m^3. Aromatic polyamide powders and fillers were mixed in Mills MRP-1 at 7000 rev./Min. 5 min. This mixing process was accompanied, however, with an additional decomposition of the polymer powders, graphite and fibers. Fibers before and after mixing were volume (mass) gamma-distribution and Weibull distribution for lengths in the range of 20 – 1200 microns [18]. Preparations were made by the technology of processing of aromatic polyamides compression [19]. The fibers were arranged randomly in layers that are perpendicular to the force pressing in the direction of deformation and heat flow in the study of thermal conductivity on temperature.

3. Experimental part

3.1. The tabular data was used for analysis [1]. Correlation and regression analysis were performed in [20 – 22]. Selective correlation coefficient of the relationship between y and x r_p was calculated by the formula [20, 21]. Zero hypothesis of equality to zero of general correlation coefficient was advanced.

$$H_0: \uparrow \begin{matrix} \rho = 0 \\ r_p \neq 0 \end{matrix}, \quad (1)$$

and also alternative hypothesis

$$H_1: \uparrow \begin{matrix} \rho \neq 0 \\ r_p \neq 0 \end{matrix}, \quad (2)$$

where the selective correlation coefficient was a statistically estimate of the general correlation coefficient:

$$r_p \to \rho . \quad (3)$$

The test H_0 was performed for a significance level α = 0,05 and α = 0,01 and degrees of freedom f:

1. For a critical value of the correlation coefficient $r_{кр.}$ [22];
2. In terms of Student's t_T [21];
3. According to the Fisher transformation [21] and the product $(z_T \cdot \sigma_Z)$.

3.2. The thermal conductivity of the investigating polymer materials was measured by the apparatus ITλ-400 in the monotonous mode of heating on cylindrical samples. Flat surfaces of samples were being grinded by fray powder on the control plate to surface roughness R_Z = 0.63. The measurements were performed according to standard techniques. While commissioning the measure ITλ-400, calibration was provided. The measurements were performed in the temperature range 323 – 473 K over 25 K.

4. Results and discussion

The dependence of enthalpy change from temperature, serial number and radius of atom of metals has been analyzed and proved by correlation and regression analysis. Fig. 1 represents the dependence enthalpy (ΔH) of copper, silver and gold from the temperature (T). It is shown that enthalpy is growing from ΔH = 39.5 kJ/kg to ΔH = 463 kJ/kg (for copper), from ΔH = 23.8 kJ/kg to ΔH = 245 kJ/kg (for silver) and from ΔH = 13.3 kJ/kg to ΔH = 147 kJ/kg (for gold) with the growth of temperature from T = 400 K to T = 1357 K. With the growth of the serial number of metal enthalpy decreases (Fig. 1).

The dependence of coefficient of thermal conductivity from temperature, serial number and radius of atom of metals has been analyzed and proved by correlation and regression analysis [23]. It is shown that with increasing temperature for most metals thermal conductivity decreases. In Fig. 2 shows the dependence of thermal conductivity (λ) of copper, silver and gold from the temperature (T) in the temperature range 0–50 K (Fig. 2, a) and in the range 100–1300 K (Fig. 2, b). As can be seen from Fig. 2, a for gold (curve 3) observed a slight increase in the coefficient of thermal conductivity of $\lambda \approx 200$ and λ = 800 W/m·K with increasing temperature from ~ 0 K to T_{max} = 20 K. With further increase in temperature from T_{max} = 20 K to 50 K coefficient of thermal conductivity slightly decreases from λ = 800 to λ=439 W/m·K. For silver and copper (Fig. 2, a curve 1 and 2, respectively) observed a significant increase in the coefficient of thermal conductivity from λ = 4800 to λ = 10600 W/m·K (for silver) and from $\lambda \approx 500$ to λ = 5000 W/m·K (for copper) with increasing temperature from ~ 0 K to the temperature of the peak maximum of its value (T_{max} = 8 K for silver and T_{max} = 15K for copper). With further increase in temperature from T_{max} to 50 K coefficient of thermal conductivity decreases sharply from λ = 10600 to λ = 700 W/m·K (for silver) and from $\lambda \approx 5000$ to λ = 1500 W/m·K (for copper). As shown in Fig. 2, b, the coefficient of thermal conductivity of metals: copper (curve 1), silver (curve 2), gold (curve 3) with increasing temperature from T = 100 to T = 1300 K decreases linearly from λ = 500 to λ = 320 W/m·K (for copper), from λ = 431 to λ = 381 W/m·K (for silver) and from λ = 343 to λ = 247 W/m·K (for gold) and is independent of the atomic number of elements the metal.

Established that growth between coefficient of thermal conductivity and the radius of metal atoms no linear connection between a metals of periodic elements at temperatures 100, 200, 273, 300 and 900 K is close linear relationship [24, 25].

The dependence of coefficient of thermal capacity from temperature, serial number and radius of atom of metals has been analyzed. It is shown that with increasing temperature for most metals thermal capacity increases. Established that growth between coefficient of thermal capacity and the radius of metal atoms no linear connection between a metals of periodic elements at temperatures 100, 200, 273, 298 and 700 K is close linear relationship [26, 27].

In Fig. 3 shows the dependence of coefficient of thermal capacity (c_p) metal-subgroup of group Periodic system – copper, silver and gold – from the temperature (T) in the temperature range 0–200 K (Fig. 1, a) and in the range

200–1200 K (Fig. 1, b). As shown in Fig. 1, a, for gold (curve 3), an increase in the coefficient of thermal capacity from $c_p = 6 \cdot 10^{-6}$ to $c_p = 0.123$ kJ/kg·K, for silver (curve 2) a significant increase from $c_p = 7.2 \cdot 10^{-6}$ to $c_p = 0.225$ kJ/kg·K, for copper (99.99 %) (curve 1) increases sharply from $c_p = 14 \cdot 10^{-6}$ to $c_p = 0.356$ kJ/kg·K with increasing temperature from ~ 0 K to T = 200 K. The coefficient of thermal capacity with increasing atomic number of elements decreases. As shown in Fig. 1, b, the coefficient of thermal capacity of metals: copper (curve 1), silver (curve 2), gold (curve 3) with increasing temperature from T = 200 to T = 1200 K increases linearly from $c_p = 0.356$ to $c_p = 0.502$ kJ/kg·K (for copper), from $c_p = 0.225$ to $c_p = 0.267$ kJ/kg·K (for silver) and from $c_p = 0.123$ to $c_p = 0.142$ kJ/kg·K (for gold), depending on the serial number of elements the metal.

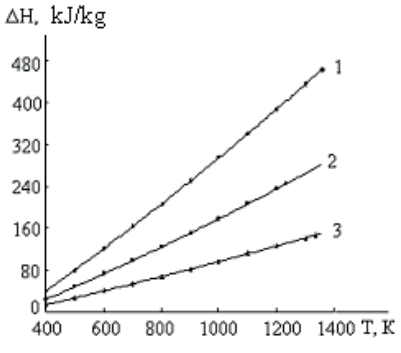

Fig. 1. Dependence of enthalpy change (ΔH) from temperature (T) for: 1 – copper (Z = 29), 2 – silver (Z = 47), 3 – gold (Z = 79)

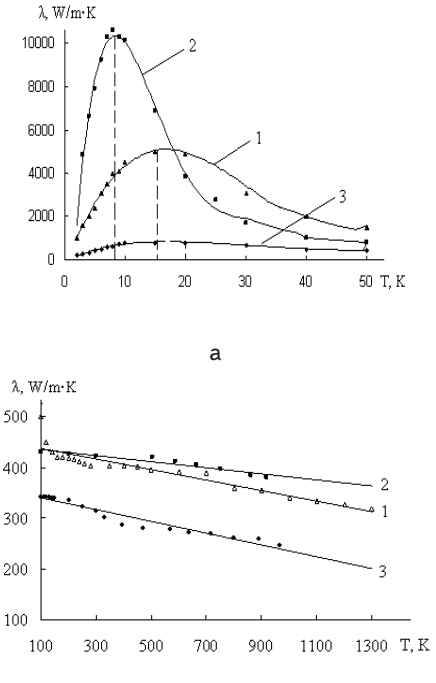

Fig. 2. Dependence of the thermal conductivity (λ) from temperature (T) for: 1 – copper (Z = 29), 2 – silver (Z = 47), 3 – gold (Z = 79): a - in the temperature range 0-50 K; b - in the temperature range 100-1300 K

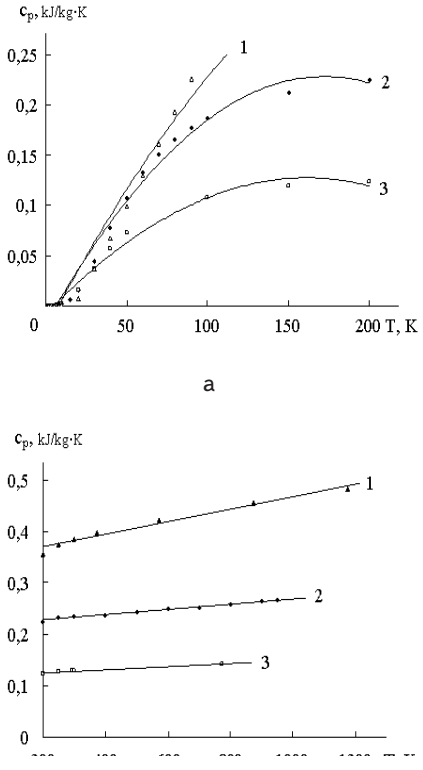

Fig. 3. Dependence of the thermal capacity (c_p) from temperature (T) for: 1 – copper (Z = 29), 2 – silver (Z = 47), 3 – gold (Z = 79): a - in the temperature range 0-200 K; b - in the temperature range 200-1300 K

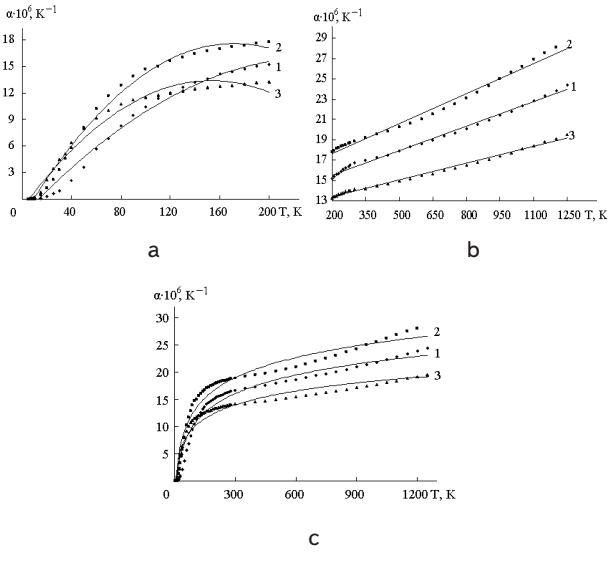

Fig. 4. Dependence of the linear coefficient of thermal expansion (α) of the metal from the temperature (T): 1 – copper (Z = 29), 2 – silver (Z = 47), 3 – gold (Z = 79)

The dependence of linear coefficient of thermal expansion from temperature, serial number and radius of atom of metals has been analyzed and proved by correlation and regression analysis. It is shown that with increasing temperature for most metals linear coefficient of thermal expansion increases.

Fig. 4 represents the dependence of the linear coefficient of thermal expansion (α) of the metals subgroup of the periodic system elements – copper, silver and gold – from the temperature (T) in the temperature range 0-200 K (Fig. 4, a) in the temperature range 200-1250 K (Fig. 4, b) and in the range from 0 to 1250 K (Fig. 4, c). As shown in Fig. 4, a, linear coefficient of thermal expansion of metals with increasing temperature from ~ 0 K to T = 100 K rapidly increases from $\alpha = 0{,}008 \cdot 10^{-6}$ to $\alpha = 10{,}45 \cdot 10^{-6}$ (for copper), from $\alpha = 0, 02 \cdot 10^{-6}$ to $\alpha = 14{,}7 \cdot 10^{-6}$ (for silver), from $\alpha = 0{,}026 \cdot 10^{-6}$ to $\alpha = 11{,}5 \cdot 10^{-6}$ (for gold). Further increase in temperature from 100 K to 200 K leads to a slight increase of the linear coefficient of thermal expansion. As the Fig. 2, b in all three cases, linear coefficient of thermal expansion increases linearly, from $\alpha = 11{,}5 \cdot 10^{-6}$ to $\alpha = 19{,}5 \cdot 10^{-6}$ for gold (curve 3), $\alpha = 10{,}45 \cdot 10^{-6}$ to $\alpha = 24{,}4 \cdot 10^{-6}$ for copper (curve 1) and from $\alpha = 14{,}7 \cdot 10^{-6}$ to $\alpha = 28{,}1 \cdot 10^{-6}$ for silver (curve 2) with increasing temperature from T = 100 K to T = 1250 K. As shown Fig. 2, c with increasing temperature from ~ 0 K to 100 K linear coefficient of thermal expansion for Cu, Ag and Au intensively growing. In the range of high temperatures there is a slight increase in the linear coefficient of thermal expansion with increasing temperature in all three cases. Dependence $\alpha = f(T)$ is described by logarithmic equation with linear expansion coefficient does not depend from the serial number of elements.

Established that growth between linear coefficient of thermal expansion and the radius of metal atoms is linear connection between a metals of periodic elements at temperatures 100, 200 and 300 K, at temperature 800 K – no linear connection . Established that growth between linear coefficient of thermal expansion and the serial number of the metal atoms is linear connection at temperatures 100, 200 and 800 K, at temperature 300 K– no linear connection [28].

Explain the properties can be found as follows. During the solidification of metals (such as in the cooling melt) while the huge number of small crystals, which interfere with each other to grow and acquire the correct form. Therefore, any metal product has polycrystalline structure consisting of a large number of small crystals - the so-called crystallites, or grains, which, unlike the well-polished single crystals of other inorganic substances have irregular shape and different spatial orientation. For this reason, in the crystal structure of metals occurring defects that significantly affect the physical properties of metals.

Experimental investigation of thermophysical properties of composite polymeric materials based on polytetrafluoroethylene, aromatic polyamide and polyimide and fillers are explored. Thermophysical behavior of polyimide composites filled with graphite and carbon fibers have been studied in a wide temperature range. Fig. 5 represents the influence of the concentration of fiber (carbon fiber fabric with THN-2m) filler on the thermal properties of antifriction materials based on polyimide PM-69. Found that when injected in the composition of the carbon fiber fabric THN-2m in amounts up to 40 wt. % of the observed linear increase in thermal conductivity of the material temperature. In Fig. 5 clearly shows that the thermal conductivity increases linearly with increasing concentration of graphite fibers. This dependence increases with temperature tests. Two characteristic ranges have been revealed on concentration dependence: $\varphi < 20$ % vol. and $\varphi > 40$ % vol. Composite behavior has been found differ essentially beyond the limits indicated [29].

A significant increase in thermal conductivity of composites is observed with the introduction of metal powders (Fig. 6). This is due to the fact that the filler content 20 vol. % or more, the role of surface phenomena at the interface of phases, as most of the substance enters the state boundary surface layers. Interaction of metal particles with macromolecules of the polymer prevents globule formation and shifts the mobility of interstitial segments in the boundary layer. This process involves the formation of aggregates of macromolecules of the polymer, which in turn is a consequence of the formation of donor-acceptor bonds between the metal particles and macromolecules of the polymer at the interface phases. This facilitated energy exchange processes and thus increases the thermal conductivity of the composite. Note that for materials with low conduction matrix and high conductive filler metal powder at concentrations 25-28 vol. % thermal conductivity of the composite decreases with increasing temperature. This phenomenon is due to the dominant role of the metal particles in highly filled polymer systems, for which the behavior of the composite in thermal repeats dependence of thermal conductivity of metal temperature.

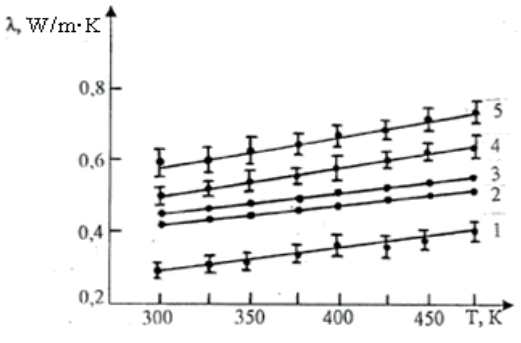

Fig. 5. The dependence of the thermal conductivity (λ) from temperature (T) of composite materials based on aromatic polyimide PM-69 and graphite carbon fiber (THN-2m): 1 – 0 % carbon fiber; 2 – 10 %; 3 – 20 %, 4 – 30 %, 5 – 40 %

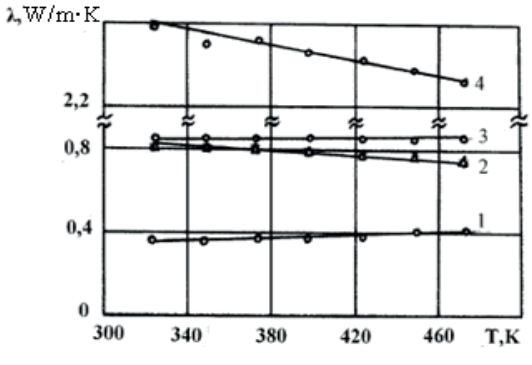

Fig. 6. The dependence of thermal conductivity (λ) from temperature (T) for composites based PTFE-4 with fillers: 1 – 25.4 % vol. carbon fiber, 2 – 28 vol. % nickel powder + + 2.6 vol % powdered molybdenum disulfide, 3 – 20 % vol. ARV graphite powder; 4 – 28vol. % copper powder + 2.6 % vol. powdered molybdenum disulfide

The regularities thermal conductivity of composite materials on the basis of polytetrafluoroethylene, based on dependency upon temperature and concentration of ingredients of the filler were discovered. When checking the ade-

quacy of the models revealed that the dependence of thermal conductivity λ from temperature T for the composite materials PTFE +5 % PI +15 % UTM-8, PTFE + 8 % PI + 8 % UTM-8, PTFE +10 % PI + 15 % UTM-8, PTFE + 15 % PI + + 5 % UTM-8 not only corresponds the model $\lambda = a + b \cdot T$, but also an adequate model $\lambda = a \cdot T^2 + b \cdot T + c$ (for the range of temperatures 323 – 473 K) [30].

Dependence between size of components filler, its form and distribution for sizes, concentration, degree of the grafitation, thermal conductivity of components of the filler and thermal conductivity of composite material based on polytetrafluoroethylene and aromatic polyamide are explored. Theoretical analyze of results calculations of thermal conductivity of composite materials with different fillers using Maxwell-Aiken, Odelevskyi, Dulnev and Nielsen's formulas are made [31, 32]. Analysis of the results of calculations of thermal conductivity of composites with different fillers Maxwell-Aiken, Odelevskyi, Nielsen and Dulnev formulas leads to the conclusion that the slightest deviation from the calculated thermal conductivity is observed for the experimental formula Nielsen (Table 1). But the greater thermal conductivity of composite fillers, the greater the deviation of empirical data from experimental. Steels Nielsen equation taking into account the ratio of thermal conductivity fillers and polymer shape of the filler particles, Poisson's ratio of the polymer matrix. However, the dependence of the thermal conductivity of the composite on the temperature of heat treatment of carbon fibers and the distribution parameters of particles and fibers in size equation Nielsen ignores.

Dependence between thermal conductivity and temperature of composite materials based on aromatic polyamide with different fillers is explored (Fig. 7, 8).

Fig. 7 represents dependence of thermal conductivity from temperature for compositions based on aromatic polyamide: with minimal graphite content (2.31 mass fraction) (curve 5), with a maximum content of carbon fiber (34.99 mass fraction), graphite (22.99 mass fraction) and basalt fiber (49.61 mass fraction) (curve 7); containing 28.59 mass fraction carbon fiber, 18.8 mass fraction graphite, 13.2 mass fraction basalt fiber (curve 11); containing 28.59 mass fraction carbon fiber, 6.5 mass fraction graphite, 39.88 mass fraction basalt fiber (curve 12); containing 28.59 mass fraction carbon fiber, 6.5 mass fraction graphite, 13.2 mass fraction basalt fiber (curve 13); containing 9.81 mass fraction carbon fiber, 18.8 mass fraction graphite, 39.88 mass fraction basalt fiber (curve 14); containing 9.81 mass fraction carbon fiber, 18.8 mass fraction graphite, 13.2 mass fraction basalt fiber (curve 15); containing 9.81 mass fraction carbon fiber, 6,5 mass fraction graphite, 39.88 mass fraction basalt fiber (curve 16).

In Fig. 8 shows dependence of thermal conductivity from temperature for compositions based on aromatic polyamide: with a maximum content of basalt fiber (49.61 mass fraction) (curve 8); with minimal basalt fiber (4.00 mass fraction) (curve 9); with minimal carbon fibers (3.4 mass fraction), graphite (2.3 mass fraction) and basalt fiber (4.00 mass fraction) (curve 10); in the absence of fillers (curve 17).

The largest thermal conductivity are compositions containing the maximum amount of graphite, the lowest thermal conductivity are compositions containing a minimal amount of graphite. The effect of temperature is most noticeable in the compositions of the maximum and minimum content of carbon fiber, graphite and basalt fibers (Fig. 7, curve 7, Fig. 8, curve 10).

Table 1

The thermal conductivity of composites based on PTFE-4 for temperature 298 K

Filler	Volumetric filler content, %	Calculated thermal conductivity (W/m·K) by the formulas				Experimental thermal conductivity (W/m·K)
		Maxwell-Aiken	Odelevskyi	Nielsen	Dulnev	
Graphite C–1	20.0	0.42	0.41	0.83	0.46	0.82
Titanium carbide /d = =1–2 мкм/	23.0	0.45	0.45	0.44	0.49	0.40
Carbon fibers (GC; LM; E_B = 37 ГПа; σ_B = 0,54 ГПа; T_K = 1120 K)	26.7	0.49	0.49	0.45	0.49	0.39
Coke + Carbon fibers (GC; LM; E_B = 37 ГПа, σ_B = 0,54 ГПа T_K = 1120 K)	15.0+7.0	0.35	0.35	0.37	0.35	0.47
Coke + +Carbon fibers (GC; LM; E_B = 36 ГПа, σ_B = 0,49 ГПа; T_K = 2670 K)	15.0+7.0	0.37	0.38	0.37	0.38	0.69
Coke + Carbon fibers (PAN; HM; E_B = 270 ГПа, σ_B = 2,2 ГПа T_K = 2670 K)	15.0+7.0	0.63	0.29	0.36	0.39	0.49
Powder copper + +molybdenum disulphide	28.0+2.6	0.52	0.52	0.64	0.56	2.6
Powder nickel + +molybdenum disulphide	28.0+2.6	0,52	0.52	0.63	0.56	0.82

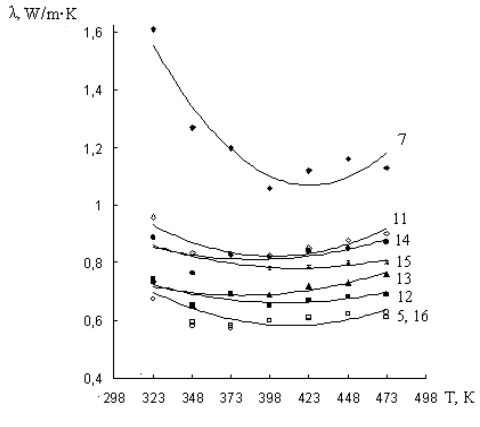

Fig. 7. Dependence of thermal conductivity (λ) from temperature (T) for compositions based on aromatic polyamide

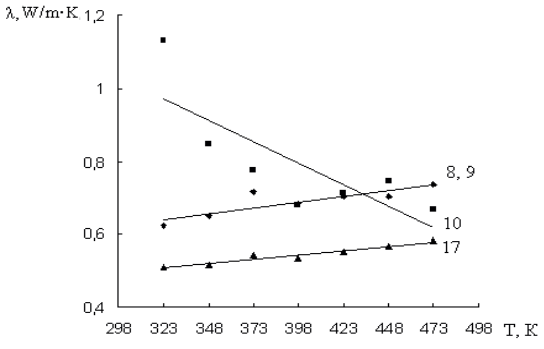

Fig. 8. Dependence of thermal conductivity (λ) from temperature (T) for compositions based on aromatic polyamide

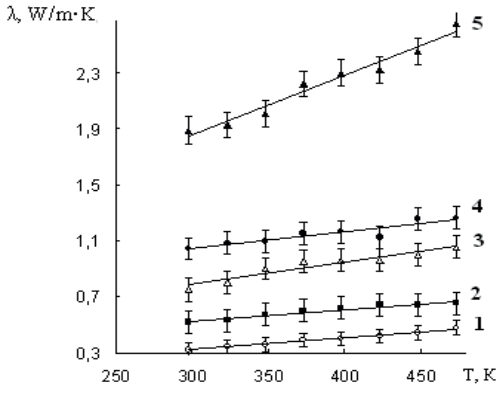

Fig. 9. Dependence of the thermal conductivity (λ) and confidence intervals for composite materials based on aromatic polyimide PM-69 and graphite C-1 the temperature (T) at a concentration of graphite (% by mass): 1 - 0, 2 - 10 3 - 20 4 - 30, 5 — 40

In Fig. 8 shows a linear relationship between the thermal conductivity and temperature with a minimum content of carbon fiber, graphite and basalt fibers (Fig. 8, curve 10), and with increasing temperature the thermal conductivity decreases. For minimum and maximum content of basalt fibers (Fig. 8, curves 8, 9) and in the absence of combined filler (Fig. 8, curve 17) observed a linear increase in the coefficient of thermal conductivity on temperature. For most components of the combined ratio filler composite thermal conductivity decreases with temperature, passing through a minimum [33].

Influence of nature of dispersion fillers (graphitise) on thermophysical properties of aromatic polyimide in dependency upon temperature are explored. Using Maxwell-Aiken, Odelevskyi, Dulnev and Nielsen's formulas theoretical analyze of results calculations of thermal conductivity of composite material with dispersion graphite filler are made [34].

The effect of high concentrations (graphite C-1) filler on the thermal properties of antifriction materials based on polyimide PM-69 (Fig. 9). Found that when injected into the composition structure of graphite C-1, the thermal conductivity initially increases linearly with increasing filler content (up to 30 % by mass), and then when the content of graphite C-1 more than 30 % by mass, this figure increases dramatically, which can be explain the formation of conductive channels at a given concentration of graphite. Accordingly, it has returned linear approximation equation (Fig. 9):

$$\lambda = 0{,}0009T + 0{,}0615 \text{ for curve 1 (a = 0 \%);} \quad (4)$$

$$\lambda = 0{,}0008T + 0{,}286 \text{ for curve 2 (a = 10 \%);} \quad (5)$$

$$\lambda = 0{,}0016T + 0{,}3173 \text{ for curve 3 (a = 20 \%);} \quad (6)$$

$$\lambda = 0{,}0012T + 0{,}6867 \text{ for curve 4 (a = 30 \%);} \quad (7)$$

$$\lambda = 0{,}0043T + 0{,}582 \text{ for curve 5 (a = 40 \%).} \quad (8)$$

The total error ranged from 1.5 – 6.99 % when the temperature T = 298 – 473 K and the concentration of graphite C-1 C = 0 – 40 %.

6. Conclusions

1. The temperature dependence of thermal conductivity and thermal capacity, enthalpy changes and linear coefficient of thermal expansion of the metals: copper, silver and gold were studied, their approximation dependences were received.

2. After the results of correlation analysis, we set the relation between the coefficient of thermal conductivity, coefficient of thermal capacity, enthalpy change, the linear coefficient of thermal expansion and the radius of atoms and atomic number of metals under certain temperatures. Value of linearity and nonlinearity was given; the dependence between the coefficient of thermal conductivity, coefficient of thermal capacity, enthalpy change, the linear coefficient of thermal expansion and the radius of atoms and atomic number of metals under certain temperatures was generalized.

3. New correlations of dependence of thermal conductivity from temperature and concentration for composite materials were received on the basis of polytetrafluoroethylene, aromatic polyamide and polyimide and fillers.

4. The fact was set, that the coefficient of thermal conductivity of the studied polymers increases with increasing temperature.

5. The influence of the nature of particulate and fibrous fillers on the thermal properties of antifriction materials was researched. Ushering graphite powder with different dispersion and ash or carbon fibers with different structures and the degree of carbonization and graphitization in compositions, based on aromatic polyimide, one can develop antifriction materials with desired coefficient of thermal conductivity.

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