ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

METALLIC GLASS CORE UTILIZATION AS THE MAGNETOELASTIC TORQUE SENSOR (p. 4–7)

Jacek Salach, Roman Szewczyk, Michal Nowicki, Igor Korobiichuk

The possibility of metallic glass core utilization as magnetoelastic torque sensors was presented. Design solution of the torque transfer to the ring metallic glass cores was proposed. Magnetoelastic characteristics $B(H)_{T,Ms}$ (take into account the dependence of the magnetic induction B on the magnetic field strength H at a constant torque M_s and temperature T), as well as characteristics B $(M_S)_{H,T}$, which describe the dependence of the magnetic induction B on the torque M_s at constant magnetic field strengths H and temperature T were investigated.

Studies were carried out using metallic glass $Fe_{78}Si_{13}B_9$. The results showed significant magnetic parameters of cores, such as the magnetic induction B, the coercive force H_c and magnetic permeability m_a depending on the given moment M_s. Studies have shown the possibility of metallic glass core utilization to build magnetoelastic torque sensors.

Keywords: torque sensors, amorphous magnetite, metallic glass.

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DEVELOPMENT OF MODEL OF POLYMER MELT MOVEMENT IN EXTRUDER (p. 7–13)

Vitaly Levanichev

The analysis of current approaches to the extrusion process intensification was performed. A model of the polymer melt movement in the metering zone of a single screw extruder, which suggests that the melt moves in the form of a "slug" was developed. The equations for calculating the metering zone, considering the near-wall viscosity (adhesion) of the melt to the surface of the screw and the cylinder, taking into account the total rheological curve of the melt flow were proposed. A comparative analysis with the classical extrusion equation of the Newtonian fluid was carried out. Identity conditions of models (shear and slug) for the slot channel were calculated. The advantages of the model of "slug" flow – a more general nature, the simplicity of perception, consideration of new process parameters were shown.

Increased melt friction on the extruder cylinder walls while reducing the friction on the screw allows to improve the performance of the metering zone of the extruder by 2.2 times.

Keywords: non-Newtonian fluid, extrusion, screw, flow model, melt friction.

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ANALYSIS OF FEATURES OF THE DEFORMATION OF AUXETIC BERYLLIUM (p. 13–17)

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In the framework of the linear elasticity theory using the experimentally obtained elastic stiffness modules, temperature dependences of the elastic compliance modules and tensor components of Poisson's ratios ν_{ij} of beryllium in a wide range of temperatures and directions in the crystal lattice were calculated, and it was shown that with increasing temperature, the value and signs of Poisson's ratios ν_{ij} change differently in various temperature intervals. In the interval 0–300 K, ν_{ij} become negative in the direction [101] (non-axial auxetic). Under the change in temperature from 300 to 400 K, ν_{ij} are positive in all directions in the crystal (not-auxetic state). Increase in the temperature from 400 K leads to negative values of ν_{ij} in the directions [100], [010] and [001] (axial auxetic). Under the temperature above 473 K up to 600 K, ν_{ij} are negative in the entire temperature range (full auxetic). The calculations are visualized by building sections of $\nu_{ij}(T)$ in the space of Euler angles by the plane (001), and by building the indicative surfaces of ν_{ij} in the crystallographic coordinate system at different temperatures. Taking into account the influence of the value and sign of Poisson's ratios on the processes of microplastic deformation in Be, in particular on the movement of dislocations and their interaction with the dislocation atmospheres has allowed to explain the experimentally observed anomaly of amplitude dependences of internal friction in beryllium at a temperature increase in the range from 298 to 523 K.

Keywords: axial, non-axial auxeticity, Peierls energy, edge, screw dislocations, internal friction.

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ANALYSIS OF SPECIFIC AUXETIC PROPERTIES OF FULLERITE C_{60} (p. 18–23)

Mykola Raransky, Vitaliy Balazyuk, Mykhailo Gunko, Andriy Struk

For the first time the negative values of the Poisson ratios μ_{ij} have been calculated and the auxetic directions of fullerite C_{60} have been determined. The values of the Poisson ratios $\mu < 0$ are directed along the crystallographic directions of <110> type, which is indicative of the non-axial auxeticity.

It has been established that with a rise in temperature from 100 K to 170 K, the degree of auxeticity S_a is reduced in proportion to reduction of elastic anisotropy factor$A=2C_{44}/(C_{11}-C_{12})$. The auxeticity of fullerite C_{60} disappears completely in the temperature range 170<T<259 K, the anisotropy remaining practically constant (A=2.2). At $T \geq 259$ the degree of auxeticity again quickly grows in proportion to a rapid growth of anisotropy A. The revealed regularity is typical for crystals of all types of cubic crystal system: increase in the degree of auxeticity close to phase transition points. Such abnormal behaviour of Sa(T) and A(T) has been explained on the basis of analysis of thermodynamic properties of fullerite C_{60}. In the high-temperature region $T>T_c$, due to thermal excitation of the rotational degrees of freedom, the chaotic rotation of molecules C_{60} is increased, providing for the energy efficiency and stability of a closely packed face-centered cubic structure. It has been established that orientation glass-ordered phase transition is caused by a jump-like change in crystal lattice period a(T) of fullerite C_{60} leading to increase in the degree of auxeticity close to T_g.

The mechanisms and regularities of auxeticity formation at points of phase transitions Tg=90 K and Tc=260 K have been revealed. It has been established that the Gruneisen parameter which is a degree of shift of crystal vibration spectrum frequencies ω_i due to a change in the volume is more responsive to crystal lattice deformations.

The method proposed here for determination of abnormal deformations with a change in rotational motion of molecules makes it possible not only to determine the appearance of auxetic properties, but also to get their quantitative value – the Poisson ratio μ_{ij} in certain crystallographic directions ($\mu_{[110]}^{[\bar{1}10]} = -0,003$ at T=170 K).

Keywords: indicating surface of auxeticity, degree of auxeticity, Poisson ratio, Gruneisen parameter, Debye temperature, anharmonicity of thermal vibrations.

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ANALYSIS OF PRESSIOMETRIC RESEARCH OF BASE COMPRESSIBILITY STRENGTHENED WITH THE SOIL-CEMENT USING THE DRILLING-MIXING TECHNOLOGY (p. 24–29)

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The purpose of the paper is to develop a method for compressibility assessment of the soil base on its complete thickness strengthened with the soil-cement using the drilling-mixing technology via pressiometry testing in the boreholes. A stress-strain state (SSS) of the system "soil base – pressiometer probe – hard soil-cement elements" is considered in the process of calculation experiment for resolving the elastoplastic task of soil mechanics using PC PLAXIS 3D Foundation, and based on these data to define the optimum probe parameters ensuring maximum compressible mass versus the technical capabilities of the hydraulic pressiometers.

The lateral soil deformation under the pressure, pressiometer probe sides and dimensions ratio, presence of soil-cement reinforcing elements in the foundation have been determined. Based on these data it was proved, that these dependencies, in general, correspond to the equivalent equations for stamps, and the quantitative difference between them can be adjusted by the scale factor which is established by the results of comparison of the stamp and pressiometry deformation modulus. As a result dependence was created to determine the deformation modulus of the reinforced bases relying on the pressiometry tests. The scientific originality stipulates development of the method allowing adequately assessing the compressibility of a base on the full depth strengthened with the reinforcing soil-cement elements prepared by the drilling-mixing technology.

Keywords: soil base, drilling-mixing method, soil-cement, elasto-plastic task of soil mechanics, calculation experiment, soil compressibility.

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ANALYSIS OF APPROACHES TO MATHEMATICAL DESCRIPTION OF THE CHARACTERISTICS OF MATERIALS WITH HIGH HYDROPHOBICITY (p. 30–41)

Anna Prydatko, Oleksiy Myronyuk, Valentin Svidersky

The increasing interest in the superhydrophobic materials in the scientific world leads to the accumulation of a large amount of theoretical models of such surfaces, and the corresponding experimental data. The ordering of such information is required to create a unified approach to modeling surfaces with controlled hydrophobicity.

The review includes a classification of the main significant characteristics of the hydrophobic properties of materials, namely, wetting, roll-off, and outflow wetting and inflow wetting angles in applying to smooth, as well as rough surfaces. Two fundamental wetting states of textured materials – Cassie-Baxter and Wentzel are described. Next, a set of mathematical models, which allow to calculate the above parameters based on structural and energy properties of the material surface is given. One of the most important characteristics of superhydrophobic materials – wetting state stability is described in the third part of the review, which presents corresponding analytical models, indicating the possible optimal types of the surface structure to achieve the specified state. For example, using irregularities with a reentrant geometry allows to achieve stable values of the wetting angle above 160°. At the same time, it is shown that for large-scale use of superhydrophobic materials, materials with the hierarchical (micro-nano) structure of irregularities are the most suitable.

Keywords: superhydrophobicity, Cassie state, Wentzel state, wetting angle, roll-off angle, wetting hysteresis.

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RESEARCH OF HIGH-STRENGTH CEMENT COMPOSITIONS MODIFIED BY COMPLEX ORGANIC-SILICA ADDITIVES (p. 42–51)

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Forming the optimal structure of the cement stone using various chemical modifiers is one of the most promising areas of technological progress in concrete technology. In most cases, these modifiers are complex additives that may include various plasticizing additives and active mineral substances, such as fly ash, silica fume, metakaolin.

At the same time, the problem of silica fume compatibility with various types of superplasticizers, used in modern binding systems is partially disclosed. This necessitates more research in this area.

In the paper, the physical and mechanical properties of cement compositions, modified by complex organic-silica additives were investigated, and it was shown that the complex additive efficiency reaches 100 % when compared with pure Portland cement and 30 % when compared with the cement systems, modified by superplasticizers only. It was found that the complex organic-silica additive, represented by polycarboxylate superplasticizer and silica fume of different nature, creates conditions for forming the low-basic hydrosilicates, plazolite and hydrogarnets, which provide a high-strength dense structure of cement stone, which were used to obtain high-strength lightweight ceramsite concrete of classes C20/25...C32/40 (B25...B40) with an average density of 1600...1800 kg/m^3, while using unmodified Portland cement allows to obtain ceramsite concrete of classes C10/12,5...C20/25 (B12,5...B25) with the same average density.

Keywords: complex organic-silica additive, silica fume, polycarboxylate superplasticizer, low-basic calcium hydrosilicates, hydrogarnets.

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