ABSTRACT AND REFERENCES
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MODELING OF MELTING PROCESS IN A SINGLE SCREW EXTRUDER FOR POLYMER PROCESSING (p. 4-11)

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We developed a mathematical model of the melting zone of a single screw extruder for processing of polymers. The model takes into account a heat transfer of a polymer with a screw and a cylinder of an extruder (parameters of a heat transfer agent in the screw, as well as parameters of a heat carrier or electric heaters on the outer surface of the cylinder), as well as the real boundary conditions (the screw rotates, the cylinder is fixed).

The classical and most commonly spread plane-parallel model of the melting process, in contrast to the developed model, considers a fixed screw and a rotating cylinder extended on the plane. Therefore, processes that actually occur near the surface of a rotating screw are conditionally transferred to the side of a fixed cylinder and vice versa. It distorts fields of speed and temperature of a polymer in the screw channel, as well as the viscosity value of a polymer along the channel height.

We investigated a temperature field of a polymer in the screw channel, as well as a relative width of a polymeric solid bed along the length of the melting zone of the extruder (the ratio of a width of the polymer solid bed to a width of the screw channel). We compared results of the calculation with the experiment. We showed that the proposed model describes the process of melting of a polymer better than the classical inverse plane-parallel model. We also proposed the approach to modeling of an extruder in general as sequences of its interconnected functional zones.

The difference between calculated and measured values of the dimensionless width of the polymeric "solid bed" from the dimensionless coordinate along the axis of the screw does not exceed 15 %. This is less than at using the traditional approach to modeling of the melting process.

The developed technique was successfully implemented for the modes of processing of various polymeric materials at extruders with screws of diameter 32, 45, 63, 90, and 125 mm.

The use of the developed mathematical model will make it possible to better forecast effective modes of the screw extruder, especially if it is necessary to account for heat transfer between surfaces of a screw and a cylinder, as well as processing of materials characterized by low thermal resistance.

Keywords: single-screw extruder, polymer, granule, melting zone, boundary conditions, polymer solid bed, temperature field.

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DEVELOPMENT OF A TECHNOLOGY FOR ABSORBING SCREENING OF COMMAND POSTS WITH ELECTRONIC EQUIPMENT (p. 12-19)

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The problem of creation of a technology for effective protection of rooms of control points with electronic equipment against powerful intentional and industrial interferences was studied. Development of ray weapons is a new challenge to electronic equipment safety by the use of modern powerful electromagnetic weaponry. Absence of theoretical recommendations in the conditions of growing practical needs causes the relevance of this problem solution.

As a result of theoretical and experimental studies, rational ways for solution of the problem related to the necessity of absorption of the field energy in a wide frequency range at the level of 40...50 dB were substantiated while the level of absorption known from publications is 10...20 dB.

The basis for solving this problem is a significant improvement of the technology for preparation of a filler with necessary electromagnetic properties. This is an electrically conductive ferrite-ferrite compound with a structure of spinel of inverse type which has the commensurate levels of relative dielectric and magnetic permeability and electrical conductivity of (103...104) S/m. These properties of the filler will contribute to the satisfaction of generally contradictory requirements. Such are the requirements for reducing the field energy reflection from the surface of the radiation absorbing coating of the room and the requirements for increasing linear energy absorption by coating (12...15 dB/mm). Therefore, the proposed 4 mm thick absorbing Sorel cement tiles with the proposed filler provide absorption of field energy in a wide frequency band at a level of 40...50 dB due to their polymerization filling.

The choice of the aforementioned binder base for the filler is justified because significant levels of thermal stability of the base are required. In principle, it is also necessary to improve the technology of highly concentrated filling of the solid, heat-resistant polymer base for the radiation absorbing coating, which effectively protects hardware of the command post from contemporary ray weapons.

Existing organic polymer bases for the required coating have a limited ecological purity and working temperature not exceeding 250...300 °C.

Therefore, it is expedient to use an environmentally friendly inorganic polymer in a form of Sorel cement with significantly higher thermal stability. That is why the technology of screening rooms by covering their inner surface with absorbing Sorel cement tiles was proposed. Once the filler is prepared, pre-filling of the aqueous solution of cement ingredients with dispersed filler as a field energy converter is made. After solidification of the Sorel cement tiles and covering the surface of the room, energy of interfering electromagnetic fields falling on the coating converts into heat energy.

The necessary hardware screening at a level of 40...50 dB is provided by the following technology stages. First, thermochemical synthesis of conductive ferrite oxide of transition metals with a structure of spinel of inverse type is carried out at a temperature above 600 °C. Secondly, vibrational polymerization concentrated filling of the base mixture of the magnesium oxide and saturated aqueous solution of magnesium chloride is realized without the loss of strength of the tiles after their solidification. The tiles are solidified at room temperature for 15 to 17 hours.

Keywords: electromagnetic screening of rooms, ferrite radiation absorbing materials, Sorel cement, polymerization filling.

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WEAKENING OF ROCK STRENGTH UNDER THE ACTION OF CYCLIC DYNAMIC LOADS (p. 20-25)

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We report results of experiment on the estimation of decreasing strength of natural stone exposed to repeated dynamic loading. The study was conducted in order to assess the feasibility of using natural stone for the accompanying extraction of stone blocks under conditions of gravel quarries. We examined samples from 13 Ukrainian deposits of natural stone. The stresses were created by a weight dropped on the tiles made of natural stone. The damage was evaluated using the ultrasonic device UK-14MP. The established resistance of rock to repeated impact actions showed that at a low specific energy of the impact (1.47–2.7 kJ/m^3) there are the granites (Zhezhelivski, Tokivski, Koretski deposits) that are almost not destroyed. These very deposits are suitable for the accompanying extraction of blocks of natural stone under conditions of gravel quarries. Building structures from these fields can be used in facilities and buildings that are exposed to vibration. Depending on the energy capacity of destruction, we conditionally divided natural stone into three groups. By applying a nondestructive control, we found that granites lose their strength prior to destruction from 11.6 to 41.5 % because of anthropogenic microcracking. The fatigue strength of granites is affected by the content of quartz; an increase in quartz results in increasing strength. It is demonstrated that the texture of granite exerts not a less impact on the strength of the stone; an increase in grain size in granite leads, despite a considerable content of quartz, to a decrease in the stone fatigue strength. Increasing accessorial minerals in granites leads to a decrease in fatigue strength.

Keywords: natural stone, energy capacity of destruction, resistance to impact actions, dynamic loads, propagation of ultrasonic wave.

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ANALYSIS OF ENERGY OF INTERNAL WAVES IN A THREE-LAYER SEMI-INFINITE HYDRODYNAMIC SYSTEM (p. 26-33)

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Energy characteristics of waves propagation along the contact surfaces in a hydrodynamics system "liquid half-space – layer –layer with a rigid lid" are explored. Based on the solutions of first approximation to a weakly non-linear model, the integral relations for wave motion energy in each layer and for the total energy of the system were obtained. An analysis of energy of wave processes revealed that an increase in wave number causes a decrease in energy of wave motion of the upper layers, and energy of wave motion of the lower half-space at some values of wave number reaches extreme values. In this case, total energy of the system is descending in nature and rather quickly approaches its limit value.

The numerical values of energy for three different cases of propagation of progressive waves were obtained: only along the upper contact surface, only along the lower contact surface, along both surfaces simultaneously. Comparison of the obtained values of energy revealed that in the case of waves propagation along both contact surfaces simultaneously, the total energy of the system is close to the sum of energies of the system at waves propagation along one of the surfaces.

Keywords: weakly non-linear model, three-layer hydrodynamic system, internal waves, wave motion energy.

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STUDY OF THE METHOD FOR ASSESSING ATMOSPHERIC TURBULENCE BY THE ENVELOPE OF SODAR SIGNALS (p. 33-40)

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The method for measuring the intensity of atmospheric turbulence based on assessment of statistical characteristics of the sodar signal envelope was investigated. This method requires no changes to the sodar hardware, but rather gives the possibility to make fuller use of echo-signals in order to obtain meteorological information.

Through theoretical analysis, it was shown that the echo-signal envelope is distributed by the Rice law. The parameter of the law of envelope distribution is unambiguously associated with intensity of atmospheric turbulence.

Assuming standard stratification of the atmosphere, the values of the parameter of the law of envelope distribution for four classes of atmospheric turbulence according to the ICAO classification were calculated: weak, moderate, strong and storm.

Convergence of the experimental law of distribution of the envelope of acoustic echo-signals to the theoretical law at different measurement time was studied. It was experimentally determined that the theoretical and experimental laws of distribution of the sodar signal envelope mismatch with probability of less than 5 % at measurement time from 10 to 30 minutes. The results of measurement using this method converge to a stationary value at measurement time of more than 10 min.

The use of the examined method for assessment of atmospheric turbulence in addition to already used methods will make it possible to increase accuracy and time resolution of sodars.

Keywords: acoustic sounding, sodar, turbulence, echo-signal, envelope, aviation meteorology, wind power industry.

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EXAMINING THE CURRENT OF DRILLING MUD IN A POWER SECTION OF THE SCREW DOWNHOLE MOTOR (p. 41-47)

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By using the module Flow Simulation from the programming environment SolidWorks, we obtained parametric fields of turbulent flow of drilling mud in the subject of research – a power section of the screw down-hole motor (SDM). The subject of research is the characteristics of turbulence of the drilling mud flow. An analysis of the obtained model parametric fields of turbulent flow of drilling mud in the power section of SDM shows two distinctive regions that differ by the characteristics of turbulence in the drilling mud current. These sections are localized in the neighborhood of contact points "rotor-stator", and along the distance between these points. In the first section, the developed flow turbulence almost disappears; the dissipation of flow energy significantly decreases. In the second section, there is a developed turbulence of drilling mud, which causes increased dissipation of flow energy and a possible damage to the stator by a solid phase of drilling mud. Vorticity of drilling mud in this region reaches the maximum values of 1,875.7 s^{-1}. Turbulent time scale in the second region reaches the minimum values of 0.001 s, and the metrical scale of pulsations is comparatively small – from 0.011 to 5.666 m, indicating the presence of small-scale turbulent vortices and the elevated dissipation of flow energy. Thus, the second section is the most vulnerable to a damage to the stator by a solid phase of drilling mud.

An endoscopic examination of the surface of the SDM stator, which we conducted, revealed damage to its working surface, specifically deep scratches, guide scratches, cavities. Localization of damage is from the middle and to the tail part of the power section at a distance of 2.53–4.78 m from the beginning of the power section of SDM.

The models obtained are recommended for using in hydraulic calculations of SDM, for choosing a rational mode of its operation.

Keywords: screw down-hole motor, pair "rotor-stator", drilling mud, modelling, parametric fields.

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DEVELOPMENT OF PRINCIPLES AND METHODS FOR CALCULATION OF DIRECT CURRENT HYBRID CONTACTORS (p. 48-56)

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The study showed that we can implement the principle of current control of the main circuit of a hybrid DC contactor by introduction of a small-size transformer of current into it. It has two primary windings, the first of which is connected to the first pole in succession with the main contact, the second one – in series with a semiconductor switch, which shunts this contact in opposition to the first, and one secondary power supply.

The study determined peculiarities of the processes of current flowing from the circuit of the main contacts, the commutation of a current transformer, the charging of a commutation condenser for locking of a semiconductor switch. The study showed that a magnetic wire conductor of a transformer is saturated and a control circuit is deenergized in a switched-on state. When a contactor is switched off, the charge of a commutation condenser capacitor goes due to a direct current under an action of EMF, which occurs on the secondary winding of a transformer during its re-magnetization in the opposite direction by current flowing in a shunting circuit. At the same time, at the given values of a cross section of a magnetic conductor and capacity of a condenser, a voltage level to which it is charged, does not depend on the number of turns of the secondary winding, but it is proportional to a square root of commutated current. The time of its charge under the same conditions is proportional to the number of turns of the secondary winding. This makes it possible to approach reasonably definition of parameters of elements that provide reliable locking of semiconductor switchers.

The study showed that the proposed hybrid contactors, due to introduction of circuit current control, have properties that enhance their competitiveness compared to the existing ones. Specifically, they increased reliability, they do not need a power supply from an additional power source, they exclude standard drivers, they show minimized energy consumption. Thus, the application aspect of a use of the obtained scientific result is the possibility of creation of competitive reliable hybrid DC contactors for voltage up to 1,000 V and currents of 100–630 A.

Keywords: hybrid contactor, main contacts, semiconductor switch, current transformer, current control.

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