ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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IMPROVING THE DESIGN ELEMENTS OF SPRAYERS TO IMPROVE TECHNOLOGIES IN THE PROTECTION OF BLACK CURRANT AGAINST PESTS (p. 4–10)

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The harmful organisms that prevent obtaining constant harvests of black currant are, first of all, the complex of sucking pests. The application of insecticides for the protection of black currant plantings against these phytophages depends primarily on the timely qualitative and effective treatment using the developed specialized rolling stock. In order to gain the desired effect, present study reports design features, which ensure the optimality of spraying zones due to the symmetrical double-sided arrangement of original arc-shaped brackets with nozzles relative to the axis of motion of the unit.

Improving effectiveness in spraying the bushes of black currants is provided by the spatial geometric location of nozzles in the layout diagram of the specialized rolling stock with the modernized sprayer OP-2000. For this purpose, we calculated the arc lengths of original brackets L=1250 and the inclination angles of nozzles α=33.3°.

As the present study revealed, the modernized sprayer OP-2000 (Ukraine) makes it possible to provide a reduction in the population density of plants with sucking pests by 5.8 times, which increases the harvest yield of berries by 0.8 t/ha. In this case, net profit increases by UAH 24573 per hectare at profitability of 386 %

Keywords: black currant, phytophages, modernized sprayer, insecticides, specialized rolling stock, sucking pests.

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DEVELOPMENT OF A NEW METHOD FOR OBTAINING CLAYDITE WITH A MINIMAL THERMAL CONDUCTIVITY COEFFICIENT (p. 11–16)

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The object of study is the technology of creation of claydite with a minimal coefficient of thermal conductivity. Most problematic is the lack of methods for determining the optimal technological parameters of thermal treatment of raw materials to obtain claydite with a low coefficient of thermal conductivity. The reason for this is that the existing methods are aimed at creating mullite during roasting of the alumina raw materials, as a substance of sufficient strength. Although, when claydite is used as a thermal insulation filling or as an additive to a concrete mixture, a reduction in the coefficient of thermal conductivity in the formation of the structure of claydite is more significant than the strength value. In the course of research, we created a number of experimental samples of claydite at different initial factors. Fire resistance was determined by comparing the behavior of the examined and standard samples when heated. Bulk thermal conductivity was determined by the thermal conductivity meter ITP-MG4 made by SKB Stroypribor, Russia. Strength of the material was determined by the Rockwell method.

To determine the optimal technological parameters for the production of claydite from the specified alumina mixture, we used the method of experiment planning and the optimization of the resulting equation employing the Lagrange method with the Kuhn-Tucker conditions. Based on data received, the technology of obtaining claydite with improved thermal-physical properties is as follows. Clay mixture is dried to humidity of 38 % and the granules are formed (by pressing a grid with a cell of 6×20 mm). Next, the pallet with granules is put into a heating furnace for 15 minutes at 270 °C. After the heating furnace, the granules are discharged into a drum furnace, where they are roasted at temperature 1250 °C for 1.5 hours.

The results obtained make it possible to reduce the coefficient of thermal conductivity of claydite by 2.25 times. The applied technique could be used for future studies of samples with different additives, including industrial waste. This in turn will allow a more effective use of available raw materials as well as reduction in the cost of product.

Keywords: claydite, alumina, component of concrete mixtures, optimal thermal conductivity, pore formation, thermal treatment.

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DEVELOPMENT OF THE MODEL OF PETROLEUM WELL BOREABILITY WITH PDC BORE BITS FOR UZEN OILFIELD (THE REPUBLIC OF KAZAKHSTAN) (p. 16–22)

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A mathematical boreability model has been developed for PDC bits which are distinguished by exceptionally high durability in soft and medium hardness non-abrasive rocks. It is in these rocks that oil wells are drilled at the large Uzen deposit (Republic of Kazakhstan).

To date, numerous boreability models have been developed for boring wells with roller bits, which realize the impact-rotational method of borehole bottom destruction with rock chipping elements. This method requires application of a high axial static load to the borehole bottom in combination with the impact momentum from the rotating roller bit.

Existing models do not take into account features of the boring process with PDC bits, which realize destruction of the borehole bottom by microcutting and the diamond-carbide elements operation in a self-sharpening mode.

A large array of data on boring performance with PDC bits has been processed using mathematical statistics. As a result, a mathematical model has been created which takes into account greater durability of the bits and wear depending on the drop in productivity at the measured interval of the well. The model includes three parameters: identification of initial boring velocity, rate of velocity drop and an exponent to which the boring time is raised.

The obtained model was confirmed by the practice of field boring with PDC bits. A comparative evaluation of performance of the PDC bits and the previously used roller bits in boring wells in the Uzen field has shown that the durability of the PDC bits is 7 times higher than that of the rollerbits and the productivity is 1.6–1.8 times higher.

The developed model is recommended for testing at other deposits where PDC bits are used. The model enables prediction of performance of these bits depending on the degree of wear and further optimization of the boring process to drill wells at the lowest costs.

Keywords: borehole, boreability model, PDC bit, wear, comparative evaluation, roller bits.

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EXPERIMENTAL RESEARCH OF RECTILINEAR TRANSLATIONAL VIBRATIONS OF A SCREEN BOX EXCITED BY A BALL BALANCER (p. 23–29)

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The vibrations of the screen box excited by the ball balancer are experimentally investigated. The stand of the screen and two-frequency vibration exciter in the form of the ball balancer has been created for this purpose. The elastic supports of the box allow it to perform three principal vibrational motions corresponding to three resonant speeds of the shaft rotation: vertical rectilinear, angular oscillatory around one of two transverse central axes of the box.

During the adjustment of the stand, it has been defined that the ball balancer excites almost ideal two-frequency vibrations of the screen box. The slow frequency corresponds to the rotational speed of the balls centers around the longitudinal axle of the shaft, and the fast one corresponds to the rotational speed of the shaft with the unbalanced mass attached to it. The two-frequency mode arises in a broad range of parameters and its general characteristics can be changed by changing: the mass of the balls and unbalanced mass; angular velocity of the shaft rotation.

It is experimentally defined that the balls get stuck at the lowest resonance frequency, thus exciting the first form of the box vibrations. As a result, the box makes almost pure translational rectilinear vibrations and there are no angular components. In this regard, there is no need to impose additional kinematic constraints on the box motions.

On the assumption that the box makes two-frequency vibrations, in the software package for statistical analysis Statistica, the coefficients in the relevant law have been picked up. At the same time, it has been defined that:

– the process of determination of the coefficients values is stable (robust), the coefficients practically do not vary with the time interval of measurement of the law of the box motion;

– the amplitude of the slow vibrations is directly proportional to the total mass of the balls;

– the amplitude of the fast vibrations is directly proportional to the unbalanced mass.

The discrepancy between the laws of motion obtained experimentally and with the statistical analysis methods is less than 1 %.

Keywords: inertial vibration exciter, two-frequency vibrations, resonant vibration machine, auto-balancer, inertial screen.

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ANALYTICAL RESEARCH INTO THE MOTION OF ORGANIC MIXTURE COMPONENTS DURING FORMATION OF COMPOST CLAMPS (p. 30–35)

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Effective way of improving the level of plant production is composting. Therefore, it is a relevant task to create energy-saving equipment and related technologies for the production of composts while providing effective fermentation under conditions of agricultural enterprises. However, at present, there are no machines and equipment in Ukraine for composting the organic raw materials. In addition, dependences of relationship between design and kinematic parameters of working bodies of the appropriate machinery and parameters of clamps have not been explored properly.

In order to conduct analytical studies into the process of work of a clamp turner, we applied the method of analytical modeling of its operation process. To form the clamps of compost and their aeration, we proposed working bodies in the form of a drum with a radial arrangement of blades.

An analytical model of drum with a radial arrangement of blades is proposed. The model makes it possible to establish the character of motion of compost particles depending on geometrical parameters of the drum and the kinematic indicators of performance. We found the absolute flight velocity, initial throwing angle of compost particles and the time of compost particles motion before leaving a blade. Developed analytical model makes it possible to set the parameters for loading and unloading the drum blades within a wide range of values of design and technological parameters. Based on the analysis of the model proposed, it can be argued that in order to control a clamp height, it is necessary to change the kinematic indicators of drum performance.

Results of the research reported here theoretically confirmed working ability of the designed equipment; however, it needs to be tested under industrial conditions.

Further studies should be conducted in the direction of examining the influence of equipment parameters on the reduction in energy costs in the production of composts.

Keywords: compost clamps, blade drum, motion of a particle along the blade, motion trajectories.

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ESTIMATION OF FAILURE-FREE OPERATION OF METAL WATER PIPES (p. 35–41)

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Calculation of reliability of water supply facilities cannot be performed if data on the reliability of separate elements are missing. One of the ways to obtain data on the reliability of elements is an analysis of statistical data on failures. In order to establish quantitative indicators of reliability of water supply networks, we analyzed statistical data on damage to water pipes in the city of Kremenchuk, Poltava region (Ukraine). The time coverage of data analyzed on the failures of the cast-iron and steel pipes with diameter of 50...300 mm was 7 years. We found the main causes of failures: for the cast-iron pipes – cement outlet from bell joints (68 %); for the steel pipes – transverse fistulas (71 %). The mean value of specific failure rate parameter and its interval estimates are calculated. The weighted average value of specific failure rate parameter, regardless of the diameter is: $\omega_0^{mid} = 2{,}98$ 1/year·km (cast iron pipes) and $\omega_0^{mid} = 2{,}06$ 1/year·km (steel pipes). Based on analysis of the received results, we built dependence graphs of specific failure rate parameter on the diameter of a pipeline. They demonstrated that with an increase in the diameter, specific failure rate parameter decreases. The obtained dependences allow us to calculate reliability indicators for other assortments of diameters of pipes. The data recieved might be useful for calculating the failure free operation of water supply systems, which determine reliability of water supply to consumers.

Keywords: water supply, water supply networks, metal pipes, reliability, failure free operation, causes of failure of pipes.

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ANALYSIS OF THE CURRENT STATE OF ADDITIVE WELDING TECHNOLOGIES FOR MANUFACTURING VOLUME METALLIC PRODUCTS (REVIEW) (p. 42–52)

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The current state of 3D technologies for manufacturing of volumetric metal products is analyzed. It is shown that the main advantages of additive welding technologies for obtaining three-dimensional metal structures of complex shape in comparison with SLM-technologies are:

– increase of the process productivity by 1–2 orders with the same power consumption; 3–10 times reduction in the cost of equipment;

– the possibility of increasing the overall dimensions of the created parts by a factor of 10 or more;

– expansion of the range of used consumables (powders, wires, composite materials);

– increase in the utilization factor of consumables by 20–50 %.

The main drawbacks of additive welding technologies for the production of three-dimensional metal structures are quite large dimensions of the heat-affected zone and the build-up layer. This leads to the emergence of undesirable temperature gradients, the accumulation of residual stresses and, as a result, a decrease in performance. One of the methods for eliminating these drawbacks is to increase the thermal locality of the energy source. For example, the use of non-transferred arc plasma.

The analysis of additive plasma-arc welding technologies and own research has shown that their advantages are:

– high (5...50 kg/h and more) performance;

– the possibility of obtaining sufficiently thin (1.5...5.0 mm) walls with a relatively small overheating;

– about 5-fold saving of materials in combination with the increase in the quality (for example, strength and density) of the resulting metal parts, in comparison with the traditional methods of mechanical manufacture.

Keywords: 3D printing, additive manufacturing, welding technologies, three-dimensional metal products

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SIMULATION OF DYNAMIC FRACTURE OF THE BOREHOLE BOTTOM TAKING INTO CONSIDERATION STRESS CONCENTRATOR (p. 53–62)

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In the problems of high-speed impact, penetration, explosion, aerohydroelasticity and other non-stationary processes accompanied by high strain rates, program complexes using an explicit method for solving equations of continuum mechanics are widely used. At present, the most promising method for modeling and calculating such problems is the finite element method.

Explosive or mechanical creation of initial cracks in the bottom part of the borehole makes it possible to reduce significantly amount of the load necessary for fracture contributing to a more effective development of the shoulder foot. This leads to a reduction in subdrilling. Presence of the subdrilling increases drilling costs by 20...30 %, worsens crushing of the upper part of the rock body and increases fracturing of the upper part of the next shoulder. However, this method requires additional costs and complicates the process of charging wells. One of the possible ways to simplify this method is to form the borehole bottom with a minimum rounding radius of the zone of interface between the borehole bottom and the wall.

It was established that the value of the relative radius of rounding between the bottom and the walls of the borehole significantly affects the character of the crack formation in the lower layers. It is possible to overcome the problem of obtaining $r_{cr} \rightarrow 0$ by creating borehole structures with a shock wave concentrator at the borehole bottom. The conical surface of these devices will ensure making the angle between the borehole bottom and the wall less than 90°.

Keywords: borehole, subdrilling, stress concentrator, drilling and blasting operations, finite element method, AUTODYN.

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FORMATION OF FIBROUS MACROSTRUCTURE IN A BEARING RING AT STAMPING AND ROLLING (p. 63–69)

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The numerical modeling of the technological process of stamping and unrolling of a bearing ring is carried out. By using the method of finite elements, we obtained a numerical solution of the problem on thermal conductivity and the contact problem on thermo-viscous-plasticity for determining the shape-changing of the billet of a bearing ring in the process of stamping and unrolling. When modeling, at each subsequent step of the solution of a boundary problem, we assign as the initial state a distribution of the temperature field of the billet of a bearing ring, which was established at the end of each technological operation. An analysis of distribution of the Lagrange lines revealed changes in the distribution of fibrous structure of the billet material of a bearing ring at sequential technological operations of die forging and unrolling. It is proposed to use double-pass molding and, additionally, unrolling for displacing the exit of fibers from the raceway to the surface of board and forming the rational fibrous macrostructure of the bearing ring billet. Results of numerical simulation with an accuracy of 4.7 % coincided with the distribution of fibrous macrostructure of material during metallographic analysis of the experimental sample of a bearing ring billet.

Keywords: bearing ring, fibrous structure, viscous plasticity, stamping, unrolling, method of finite elements.

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