MECHANICS

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RESEARCH OF INFLUENCE BALLISTIC CHARACTERISTICS OF WEAPONS ON THE SHOOTING EFFICIENCY TAKING INTO ACCOUNT THE SAFETY OF THE SMALL ARM USE

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The object of research is the process of performing a fire mission by employees of the security forces in the presence of unauthorized persons in the direction of fire. The paper investigates the influence of the ballistic characteristics of weapons on the effectiveness of performing fire missions by security forces, taking into account the security of the use of weapons. The purpose of the use of weapons by security forces is usually the cessation of the offender or its detention. In this case, the deaths or injuries of a hostage or an unauthorized person as a result of the use of weapons should qualify as failure to fulfill the assigned fire mission. An analysis of the tactics of actions and features of the use of weapons by security forces indicates that the main reason for the danger of the use of small arms for unauthorized persons is the excessive distance of the bullet's flight, at which it maintains lethal action. At the same time, with this the distance of the lethal action of a bullet is one of the factors that can be corrected. It depends on a combination of the ballistic characteristics of the weapon, namely the muzzle speed and the ballistic coefficient of the bullet. The analysis of known studies shows that the existing scientific and methodological apparatus for determining the effectiveness of firing does not allow to determine the effectiveness of the execution of the fire mission, taking into account the safety of the use of small arms due to the imperfection of the corresponding models. The model of the process of performing the fire mission has been improved by taking into account the influence of the ballistic characteristics of the weapon on the probability of hitting unauthorized persons, which makes it possible to assess the safety of the use of weapons. As a result of the study of the influence of ballistic characteristics of weapons on firing efficiency, taking into account the safety of the use of weapons, it was found that there is a need to minimize the difference between the aiming range of the weapon and the range at which the bullet maintains lethal action. Excessive energy of a bullet increases the likelihood of hitting an outsider due to an increase in the area of the danger zone of its destruction as a result of through penetration of the target. The probability of performing a fire mission with a limitation on the safety of using weapons is positively affected by increasing the stability of the muzzle speed of a bullet.

Keywords: firing efficiency, ballistic characteristics, small arms, fire tasks, security forces.

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IMPROVEMENT OF THE EFFICIENCY OF NOISE PROTECTIVE SCREENS DUE TO SOUND ABSORPTION

page 11–15

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The object of research is the sound field from linear sound sources around noise screens. The decrease in sound levels with the screen is primarily due to the geometric dimensions of the screen and the relative position of the screen and the sound source. The influence of these factors has been given a large number of scientific publications. However, the problematic point of such studies is that screens were considered either completely acoustically rigid or sound-absorbing.

In this paper, the situation of the impedance screen is considered, quite often applied in practice. The calculation of the field around such a screen is carried out by computer simulation, which makes it easy to change the value of the acoustic impedance of the screen surface.

To calculate the sound field around the screen, the finite element method is chosen. Sound-absorbing properties of the screen were determined by changing the acoustic impedance of the front side of the screen. At the same time, the screen remained acoustically opaque. Thus, an analysis is made of the influence of the sound absorption coefficient on the sound field around the screen from different heights of the screen and the distance of sound sources to the screen. This makes it possible to obtain results of sound pressure levels around screens encountered in engineering activities. Studies have shown that the use of sound-absorbing cladding for noise screens can increase their effectiveness. It is revealed that the closer the screen is located to the sound source, the greater the influence of its sound-absorbing properties. It is shown that for low frequencies the increase in screen efficiency due to sound absorption can reach 5 dB.

The obtained results during the study can be used in the design of noise protective shields to reduce noise levels from traffic flows. The results obtained will be especially useful when designing screens with heights of more than 4 m.

Keywords: noise protective shield, sound diffraction, sound level reduction, impedance properties, sound-absorbing screen.

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RESEARCH OF THE MILLING PROCESS OF A CYLINDRICAL SURFACE BY AN ORIENTED INSTRUMENT

page 16–18

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The object of research is the milling process with the crossed axes of the cylindrical surface and the tool. During the research, general modular three-dimensional models of the tool surface, the processes of removing the allowance and the shaping of the cylindrical surface are used on the basis of three unified modules: tool, shaping and orientation. Computer simulation is also used to build a three-dimensional model of the milling process of a cylindrical surface with an oriented tool. A graphic scheme of milling a cylindrical surface with an oriented tool has been created. The developed cylindrical module for shaping the tool surface, which is described by the product of the displacement matrices along the corresponding axes and the surface of the machined part, is represented by the product of the radius of the tool vector and its orientation module in the shaft coordinate system. The resulting graph of the distribution of the specific productivity of the milling process along the tooth profile of the tool during processing with crossed axes of the cutter and part. An analysis of this graph shows that the milling method with an oriented tool makes it possible to increase the accuracy of the shaping process due to uniform wear of the tool. The intersection angle of the cylindrical surface and the tool is also determined, the value of which is taken from the condition of ensuring the maximum removal of the material layer with uniform loading of the end part of the cutter. For this, a three-dimensional model of the process of milling a cylindrical surface with crossed axes of the tool and the part is developed, in which rough milling is carried out by the end part of the tool, and the finish – by the peripheral. In the course of the research, it is found that when finishing milling, the value of the rotation angle of the cutter is taken from the condition that the peripheral part of the cutter is fully loaded. Improving the processing efficiency is achieved by crossing the axes of the tool and the part, which allows to program the intersection point, and uniform wear of the cutter, which improves the quality of the machined surface. It is also possible to use high-speed milling to provide increased processing productivity.

Keywords: cross axis milling, oriented cutter, modular three-dimensional modeling, cross angle, cylindrical part.

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ANALYSIS OF THE INFLUENCE OF AERODYNAMIC QUALITIES OF THE COMPONENTS OF MIXTURES ON SEPARATION IN POWER-SAVING VORTEX VEHICLES

page 19–22

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The object of research is gas-dynamic vortex processes in heterogeneous polydisperse flows. One of the most problematic issues is the determination of the aerodynamic characteristics of the components of a heterogeneous polydisperse medium, which are necessary to create a mathematical model of the separation process. The study used methods of mathematical modeling based on the theory of similarity. A technique has been developed for assessing the aerodynamic parameters of mixture components, on the basis of which a number of aerodynamic similarities have been compiled. The coefficients of lift, aerodynamic drag, lateral force, longitudinal, transverse and rotational moments of the components of the grain mixture are obtained. This is necessary for theoretical studies of gas-dynamic processes in vortex separators in unsteady three-dimensional flow with variable flow density, concentration and flow rate of the separated mixture components and the carried fractions. The Reynolds vibration criterion is obtained, based on which the trajectories and energy of the vortex motion of individual components and the separation degree of heterogeneous mixtures are determined. This allows to improve the mathematical model of the distribution process of heterogeneous polydisperse mixtures in the proposed energy-saving vortex separators. The obtained results provide the basis for improving the general theory of heterogeneous vortex flows by introducing an external disturbance criterion that takes into account the drag of the vortex force field and the amplitude-frequency energy level. Thanks to this, it is possible to evaluate the influence of any argument in the desired function. The research results make it possible to automate the analysis of process characteristics and compare them by parameters with experimental data. And also to evaluate the correspondence of dynamic, kinematic and gas-dynamic functions calculated from the given geometric parameters of the vortex devices with the functions obtained from the averaged values. These data makes it possible to work out a range of variations in the parameters of the geometric design of vortex apparatuses by zones, parameters at the inlet, outlet, and degrees of separation, minimize the number of manufactured laboratory and semi-industrial vortex apparatuses, and unify a number of units. Compared with similar known separators, vortex apparatuses are proposed that reduce the cost of preparing raw materials in the grain mill area by a factor of tens due to the elimination of moving working parts, assemblies and screens.

Keywords: aerodynamic parameters, vortex separator, heterogeneous mixture, redistribution speed, drag coefficient.

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SUBSTANTIATION OF CONDITIONS OF MAINTAINING STABILITY OF HAULAGE DRIFTS DURING DEVELOPMENT OF STEEP SEAMS

page 23–26

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The object of research is the processes of ensuring the stability of lateral rocks in haulage drifts during the development of steep coal seams. With an increase in the depth of mining, the applied methods of protecting local preparatory excavations should ensure their operational condition in the excavated areas and correspond to changing mining and geological conditions within the mine field. Investigations of the manifestations of rock pressure in haulage drifts along the length of the excavation section are performed under field conditions. At specially equipped metering stations, the displacement of the lateral rocks on the preparatory excavation circuit is determined. The haulage drift is protected by rolling bonfires made of wooden sleepers or coal pillars. In the course of research, the influence of the stiffness of protection structures on the stability of lateral rocks in the haulage drift is established. A linear relationship is recorded between the displacements of the roof rocks and the load on the lining in the excavation along the length of the excavation section while protecting the haulage drift by the coal pillars. At the same time, with a decrease in the stiffness of the pillars by 80 %, the section of the haulage drift decreases by 50 % from the initial one. It is noted that the use of wooden structures for protection structures allows to limit the displacement of rocks on the contour of the haulage drift. As a result of the interaction of lateral rocks with wooden protection structures, with a decrease in their stiffness by 80 %, the section of the haulage drift decreases by 30–35 % from the initial one. Studies have shown that the reduction in the stiffness of wooden structures occurs due to their compression, and the coal pillars – as a result of destruction. It is noted that the most difficult conditions for maintaining haulage drifts are formed when using coal pillars. It is recommended, to ensure the stability of local preparatory workings, the use of compliant protection structures or the laying of excavated space. The obtained research results can be used when choosing a method for protecting haulage drifts on steep coal seams.

Keywords: rock pressure, haulage drift, protection methods, treatment works, rolling bonfires, coal pillars.

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RESEARCH OF CHANGES OF STRENGTH INDICATORS OF SEMI-RIGID COVERS GLUED BY MODIFIED ADHESIVE COMPOSITIONS

page 27–31

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The object of research is the processes for producing modified adhesive compositions based on PVA (polyvinyl acetate) dispersions for use in technological processes for the manufacture of semi-rigid book and magazine covers. The conducted experimental studies are based on the application of a comparative method for determining the tensile strength of glued, without bias, samples of binding materials using modified adhesive compositions and identical compositions without modification. The main assumption of the study is that the use of polymer thickeners and emulsifiers compatible with latex PVA, which are actively used in the technological processes of the paper and printing industries, contribute to the formation of additional strength of semi-rigid covers. This can be achieved without analysis and the selection of possible components, taking into account the mechanical properties that arise after the use of such modifiers that substantially depend on the adhesive strength between the material of the outer part of the cover and the adhesive binder. It is proposed for an experimental study of the use of substances with high adhesive properties to thick coated papers and thin binding boards, from which semi-rigid book and magazine covers are made. The structural features of adhesive films obtained from polyvinyl acetate latex were determined, which have improved flexibility, elasticity, high adhesion and water resistance when water-soluble modifiers are added to them. An experimental determination was made of the possibilities of increasing the structural strength of semi-rigid book and magazine covers after gluing with modified binding adhesives, which did not significantly increase the thickness of the adhesive layer and did not change the contour geometry of the manufactured covers. It was proved that the adhesive mixtures used to modify the PVA dispersion did not affect the structural homogeneity of the glued spatial structure of the semi-rigid covers, and did not affect the appearance of external defects in the form of plane inhomogeneity, or point thickenings of the surface of the covers. The results of studies on the gluing of structural parts of reamers of semi-rigid covers with modified adhesive compositions create additional opportunities in planning the use of consumables in the manufacture of covers for strength indicators, predefined dimensional conditions for the use of modifier substances. Experimental studies have shown discreteness – growth, decrease in dimensional indicators of the strength of semi-rigid covers glued with modified adhesive compositions, contributes to the practical application of the results, both in the planning of technological processes and in the calculation of the cost of book production.

Keywords: PVA (polyvinyl acetate) dispersions, semi-rigid covers, adhesive compositions, strength indicators.

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RESEARCH OF STABILITY OF GEOMETRIC PARAMETERS OF WOOD UNDER THE MOISTURE ACTION

page 32–35

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The object of research is a promising structural material – modified wood. Extending the use of wood while maintaining structural characteristics is a promising area of research. Modification of wood in accordance with structural requirements, taking into account sanitary and other requirements, is an important task. The most common modification technologies are impregnation. Pressure autoclaving wood requires sophisticated equipment to create unprofitable pressure. Impregnation by the condensation method or the method of «cold and hot baths» significantly reduces the cost of obtaining modified wood. The study of the stability of the geometric dimensions of modified wood under the moisture influence makes it possible to evaluate the effectiveness of the modification (impregnation) process and, as a result, evaluate the service life. Samples from pine timber (DSTU ISO 738:2018) with a size of 300–70–15 mm are used. For research, three groups of samples are selected with radial (*R*), tangential (*T*) and mixed (*M*) direction of wood fibers. For impregnation modification, linseed oil and drying oil were used at a concentration of 25 g/l. In accordance with the modification technology, the samples are soaked in an aqueous solution with a desiccant, then immersed in linseed oil heated to 130±10 °C, and then immersed in linseed oil at a temperature of 20 °C. The obtained samples are dried under atmospheric conditions and soaked in water for 24 hours to study the stability of geometric dimensions. As a result of studies, it is found that the optimal temperature for heating the samples is the range 120–140 °C. It is also found that the most resistant to changes in geometric dimensions are samples with a mixed direction of the fibers (*M*), in which size changes are 0.5 % compared to dry samples. Regardless of the direction of the fibers, the moisture absorption of the modified samples is 0.07 vol. %, which is of great practical interest.

Keywords: wood impregnation, condensation method, linseed oil, aqueous solution with desiccant, wood modification, geometric dimensions.

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OPTIMIZATION OF AMPLITUDE-FREQUENCY CHARACTERISTIC OF BROADBAND VOLTAGE DIVIDER INTENDED FOR MEASUREMENT OF POWER QUALITY PARAMETERS

page 35–39

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The object of research is the circuit diagram of a broadband capacitive-resistive voltage divider with a series-parallel connection of its resistive and capacitive components. For many years, the use of voltage dividers was limited to measuring various voltages in high-voltage laboratories. However, voltage dividers, compared to voltage transformers, are characterized by a wider bandwidth, therefore they began to be considered as one of the main means of measuring voltages in high-voltage electric networks. One of the catalysts for the implementation of this solution may be the intensive development of the Smart Grid concept, which requires new, more advanced means of monitoring the quality of electric power. Therefore, experimental and theoretical studies aimed at reducing the error of broadband voltage dividers are important.

The task of optimally adjusting the low voltage arm of the voltage divider is solved by using linear programming elements to study the systematic error function.

This article presents the results of the study of adjusting the amplitude-frequency characteristics of the voltage divider, which are aimed at reducing its error. For this purpose, a parameter for optimizing the capacitance value of low-voltage arm at which the absolute value of the positive and negative maximum of the systematic error of the capacitive-resistive voltage divider will be the same was found. The calculations are performed for different values of the division ratio of the voltage divider. The resulting data sets are generalized in the form of three-dimensional graphs.

The work contributes to the further development of the theory of high-voltage voltage dividers. As a result of the studies, the possibility of optimizing the amplitude-frequency characteristics of a broadband capacitive-resistive voltage divider by varying the capacitance value of its low-voltage arm is shown. The studies are relevant due to the fact that this category of high-voltage scale transducers has the potential to become mandatory for determining the quality of electric energy directly in high-voltage networks.

Keywords: voltage divider, amplitude-frequency characteristic, electric power quality, high-voltage scale transducer.

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SIMULATION OF THE DISTRIBUTION OF AIR FLOWS AND FUEL COMBUSTION PRODUCTS IN A CHANNEL OF A TUNNEL KILN

page 40–43

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A characteristic problem of the operation of tunnel kilns with high overlap is the output of products with low quality and a decrease in the energy efficiency of the burning process as a whole. Therefore, the object of research is the process of the flow of kiln gases through the channel of the tunnel kiln, the change in velocity of which was studied depending on the geometric parameters of the tunnel.

In the course of studies of the dependence of the velocity distribution of the flow of kiln gases along the channel of the kiln on its geometric characteristics, a numerical simulation method in a simplified 2D formulation using the OpenFoam open code using the k–ω shear stress turbulence model is used. The velocity fields of kiln gases are obtained for three options for the height of the channel: the base with a vault height of 2 m, with a reduced vault height along the entire length of the tunnel and with a reduced tunnel height only in the burning zone. Analysis of changes in flow rates shows that the most effective would be to reduce the height along the entire kiln length, while changing the arch height in the burning zone will hardly affect the uniformity of velocities in the heating zone. Reducing the arch height also minimizes the likelihood of a return air flow in the cooling zone in the area from burning to the place of air extraction for drying. A lower overlap in the cooling section will increase the intensity of heat removal and, accordingly, reduce its loss with the product in order to use it for drying products.

The presented simulation results make it possible to note that a change in the height of the overlap will lead to an increase in aerodynamic drag and, consequently, a pressure drop. This will require additional energy costs for driving draft engines and the possibility of increasing temperatures in the space under the cars.

Keywords: tunnel kiln, kiln gases, channel height, velocity distribution simulation, velocity field.

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