ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

DOI: 10.15587/1729-4061.2017.109239

DEVELOPMENT OF WRAPPING PAPER WITH IMPROVED OPACITY, STRENGTH, AND WHITENESS (p. 4–10)

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The study presents results of the design of a paper wrapping material, which simultaneously possesses high functional (strength and opacity), aesthetic (whiteness), and technological properties (color acceptance and print sharpness). The latter is a particularly important element in the marketing strategy of food manufacturers because it enables creation of the packaging that is attractive to consumer and thus may increase sales.

According to results of the conducted study, it was found that the set of proposed activities could increase discontinuous paper length to over than 5000 m and opacity to 92 %, while the linear deformation is reduced by 2–2.5 times in comparison with the analogue. The introduction of titanium dioxide as a filler to the paper pulp provides a whiteness level of 88 %. The use of polyvinyl alcohol fiber enhances color acceptance and print stability. This is due to the creation of resistance to the plucking of fibers and particles of the filler by paint during printing and friction. The results are confirmed by the uniform mass indicators per 1 m^2 and humidity in 8 points.

It is advisable to use results of the study performed in the production of wrapping paper, as well as when selecting packing material for one or another food product, which is especially important at present – in the context of European integration and production of goods that meet international standards.

Keywords: wrapping, food products, product properties, polyvinyl alcohol, titanium dioxide, cellulose fibers, paper formation, kaolin, print sharpness.

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DOI: 10.15587/1729-4061.2017.109588

EXPERIMENTAL CONFIRMATION OF THE THEORY OF IMPLEMENTATION OF THE COUPLED DESIGN OF CENTER GIRDER OF THE HOPPER WAGONS FOR IRON ORE PELLETS (p. 11–18)

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We present results and special features of the conducted experimental studies into proposed theory of implementation of the coupled design of a center girder of hopper wagons for iron ore pellets. The importance and relevance of the set scientific and practical task is predetermined by economic expediency. In particular, by the attained possibility of bringing down the cost of manufacturing such wagons by 10 %. In addition, such approach could be used for the modernization (including scheduled repairs of different types) of wagons under study, which would make it possible to significantly reduce the cost of their operation.

The research found that the coupled design of the center girder of hopper wagons for iron ore pellets would guarantee to ensure the required indicators for operational reliability over the rated service life of wagon of 15 years. We can highlight as the scientific results of the work conducted the developed and experimentally-confirmed comprehensive technique for the implementation of coupled designs of wagon beams. The practical importance of research results is demonstrated by the proposed and patented solutions of technical realization of the chosen direction, implemented at a number of Ukrainian wagon building companies. The new and valuable results of present work include a created adequate spatial finite-element computer model of the improved design of hopper wagons for iron ore pellets.

The proposed methodical complex for reducing the manufacturing cost of hopper wagons for iron ore pellets by the conjugated design of their carrying beams is expedient for application in other types of freight wagons, as well as other means of transport engineering.

Keywords: transport mechanics, freight wagons, load bearing systems, resource-saving, stressed-strained state, tests.

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DOI: 110.15587/1729-4061.2017.111216

EQUATIONS OF MOTION OF VIBRATION MACHINES WITH A TRANSLATIONAL MOTION OF PLATFORMS AND A VIBRATION EXCITER IN THE FORM OF A PASSIVE AUTO-BALANCER (p. 19–25)

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Generalized models have been built of one-, two-, and three-mass vibration machines with a rectilinear translational motion of platforms and a vibration exciter in the form of a ball, a roller, or a pendulum auto-balancer.

In the generalized model of a single-mass vibration machine, the platform relies on an elastic-viscous support with the guides enabling the platform's rectilinear translational motion. A passive auto-balancer is installed on the platform.

In the generalized models of two- and three-mass vibration machines, each platform relies on a fixed external elastic-viscous support with the platforms coupled in pairs by elastic-viscous inner supports. The guides allow the platforms to move rectilinearly translationally. A passive auto-balancer is installed on one of the platforms.

We have derived differential equations of the motion of vibration machines. The equations are reduced to the form that is independent of the type of an auto-balancer.

The models of particular one-, two- and three-mass vibration machines can be obtained from the generalized models by selecting a specific type of the auto-balancer.

The models of particular two-mass vibration machines can also be obtained from the corresponding generalized model by rejecting one of the external elastic-viscous supports.

The models of particular three-mass vibration machines can also be derived from the corresponding generalized model by rejecting:

– one or two external elastic-viscous supports;

– one of the three inner elastic-viscous supports;

– one or two external elastic-viscous supports and one of the three inner elastic-viscous supports.

The constructed models are applicable both for analytical studies into dynamics of the relevant vibration machines and for performing computational experiments.

When employed in analytical studies, the models are designed to search for the established modes of a vibration machine motion, to determine conditions for their existence and stability.

Keywords: inertial vibration exciter, two-frequency vibrations, resonant vibration machine, auto-balancer, single-mass vibration machine, multi-mass vibration machine.

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DOI: 10.15587/1729-4061.2017.110962

STUDY OF CUTTING PRESSES IN DESIGNING A WOMEN'S COSTUME FOR HOSPITALITY INDUSTRY (p. 26–36)

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The authors conducted analytical studies to identify materials used to produce women's footwear based on an analysis of the costumes of the leading capitals (Paris, Milan, London, and New York) over ten years.

The experimental measuring stand for researching characteristics of cutting presses was designed. To conduct the research, we developed the program for obtaining the main technical indicators of electrohydraulic pressing equipment in LabVIEW environment that makes it possible to control the process of cutting and to process and store data, obtained from the analog-to-digital converter. A number of structural changes were made for research based on the press PVG-8-2-0.

It was found that due to proposed improvements, power consumption of the equipment decreased by 35 % compared with that of the press PVG-8-2-0 and by 14 % compared with that of the press C06.01 Compart, taking into account coefficient of correspondence of maximum working forces that occur during cutting. Within one cycle, the proposed design of the press provides significant energy saving, which is 5.12 kW compared with the press PVG-8-2-0 and

11.72 kW compared with the press C06.01 Compart. Coefficient of set power consumption of the electric engine is the highest among all the examined presses and is 0.85, which indicates high power efficiency. Efficiency of the improved electrohydraulic pressing equipment was determined, equal to 33 %, which is 11 % higher compared to that of the press PVG-8-2-0.

Keywords: electrohydraulic cutting press, parts of women's shoewear, design, hospitality industry.

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DOI: 10.15587/1729-4061.2017.109611

STUDY OF THE STRESS-STRAIN STATE IN DEFECTIVE RAILWAY REINFORCED-CONCRETE PIPES RESTORED WITH CORRUGATED METAL STRUCTURES (p. 37–44)

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Promising technologies for repair of defective reinforced-concrete pipes with the use of corrugated metal structures have been developed. As a result, it was established that the use of corrugated metal pipes in the major repair of reinforced-concrete pipes will eliminate need of stopping movement of railroad and motor transport. This will enable recovery works in a short time with practically no changes in conditions of operation of transport facilities.

Vertical and horizontal pressure forces on the reinforced-concrete pipes strengthened with a corrugated metal pipe under the influence of static and dynamic loads from the railway rolling stock were calculated. It was established that the value of both vertical and horizontal pressures on a reinforced-concrete pipe arising from the action of rolling stock decreases with an increase in the filling height because of energy dissipation in the depth of soil. For the filling height above the pipe 1 m, the value of vertical pressure from the load C14 was 7.568 kPa and horizontal pressure was 2.523 kPa. The respective figures for vertical and horizontal pressures were 5.957 kPa and 1.986 kPa for the filling height 2 m and 4.912 kPa and 1.637 kPa for the filling height 3 m.

According to the results obtained for static and dynamic pressure forces, the stress-strain state of the pipe in interaction with the soil filling was calculated by the finite element method. The results of calculation of the stress-strain state of the composite pipe showed that the maximum stresses occurring in the vault of the repaired pipe did not exceed maximum permissible values. The magnitude of the stresses in the pipe vault was 0.024 MPa and strains measured $9.3 \cdot 10^{-4}$ mm.

Keywords: reinforced-concrete pipe, corrugated metal structure, defect, promising technologies, equivalent forces, static load, dynamic load, stresses, strains.

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DOI: 10.15587/1729-4061.2017.109629

DEVELOPMENT OF THE ANALYTICAL METHOD FOR DETERMINING THE ARMOR WEAR OF THE DRUM BALL MILL (p. 45–50)

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The object of the research to develop an analytical method for determining the armor wear rate of the drum ball mill was the boiler TP-100 (TP-100A) of the 200 MW power unit of Burshtyn TPP (Ukraine), equipped with two individual dust-preparation systems with drum ball mills KBM 370/850 (Sh-50A).

An effective analytical method for determining one of the main performance indicators of a drum ball mill – the wear rate of the drum armor, grinding balls and the relationship between them in case of «G» grade coal combustion for TP-100 boilers is proposed. Its essence is to reduce human labor costs, more accurately determine the wear rate of the drum armor and grinding balls. This method is characterized by the fact that the main estimation indicator is the drum armor wear rate depending on the manufacture quality of armored plates (manufacturer).

According to experimental studies, the ratio of the armor wear rate of the drum, equipped with a sleeper armor, to the wear rate of grinding balls is a constant value of 0.07. The statistics of the interrepair time of Burshtyn TPP mills, depending on the armor grade, are summarized in the table. The experimental and estimated parameters of the drum armor wear of Burshtyn TPP KBM are given.

The influence of the armor grade, provided the maximum allowable drum armor wear (b_δ=0.5) on the estimated maximum drum ball charge and the mill operation duration is investigated.

The dependency of over-expenditure of balls on the mill operation duration and the place of armor manufacture is given. The equations describing the curves of this dependency are derived. According to the dependency $N_m=f(G_b)$, the mill electric motor loading in case of the actual ball weight of 70 t in the drum is determined.

The recommendations for diagnosing the operation of drum ball mills using different fuels, with the corresponding calculations and equipment, are given.

Keywords: analytical method, steam boiler, drum ball mill, coal, drum armor wear rate, ball wear rate, mill operation duration, ball charge.

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DOI: 10.15587/1729-4061.2017.109638

CALCULATION-EXPERIMENTAL MODELING OF WEAR OF CYLINDRICAL SLIDING BEARINGS (p. 51–59)

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The problem of developing a calculation-experimental method for calculating wear of a sliding bearing based on a two-factor wear model (contact pressure - sliding velocity) with identification of wear resistance parameters was considered. Analysis of known studies has shown that existing approaches required solution of complex systems of integral-differential equations or cumbersome numerical methods that are unacceptable in the engineering practice. As a result, a model of the sliding bearing wear in conditions of boundary friction was obtained in a form of dependence of the wear rate on the dimensionless complexes of contact pressure and sliding velocity. On the basis of the proposed wear model, the wear-contact problem for a cylindrical sliding bearing was solved. The equation of equilibrium for medium pressures and the approximating function of linear wear from the arc of contact between the shaft and the bushing were used as the determining equations. The solution was obtained in a closed form as a dependence of wear degree on the friction path. To identify parameters of wear resistance in the wear model, a calculation-experimental method for determining calculated dependences of wear resistance parameters was developed on the basis of the wear test by the «cone – three balls» scheme. The results of wear tests of bronze conical specimens with a variable wear spot and two values of sliding velocity were taken as a base. An example of implementation of the calculation-experimental method for calculating wear of a cylindrical bearing was given. It has shown that the calculated wear values were consistent with the operational data on wear of sliding bearings. Influence of determining factors of sliding velocity and load on bearing wear was studied. The obtained results were recommended for predicting wear of sliding bearings at the design stage and optimizing their design and operational parameters.

Keywords: sliding bearing, wear-contact problem, wear model, wear testing, wear resistance parameters.

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DOI: 10.15587/1729-4061.2017.110444

MODELING A FLOW PATTERN OF THE GRANULAR FILL IN THE CROSS SECTION OF A ROTATING CHAMBER (p. 59–69)

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The efficiency of working processes of machines of the drum type is determined by the mode of flow of the fill in a rotating chamber. But the numerical and experimental results obtained over a recent period approach the actual behavior of the examined medium only in terms of qualitative characteristics.

A mathematical model is built for a three-phase flow mode of granular fill in the cross section of a cylindrical chamber that rotates around the horizontal axis. The analytical-experimental research method is applied. A calculation algorithm is derived that approximately establishes position of the flow regions and the distribution of velocities in the cross sections normal to the flow direction, depending on the kinematic, geometrical, inertial, and rheological parameters of the system.

Based on the performed modeling, the effect of rotation velocity of the chamber on the characteristics of a three-phase flow mode of the fill was determined. We established conditions when mass fractions of the active sliding layer and the region of a non-free fall reach maximal values, while mass fraction of the passive quasi-solid-body region acquires a minimum value. The conditions are determined when thickness and mean velocity of the sliding layer reach a maximum.

We revealed a predominant reduction in thickness, in the average velocity and the shear rate gradient in the normal cross section along the length of the layer. A decrease in the thickness and an increase in the average velocity and the gradient of shear rate of the sliding layer were registered with a decrease in the relative size of the chamber granular fill's element.

Visualization of flow patterns confirmed a convergence of the calculation results and experimental data within a range of 11–13 %.

Keywords: granular fill, rotating chamber, three-phase flow mode, flow pattern, visualization.

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DOI: 10.15587/1729-4061.2017.110820

MODELING A PROCESS OF FILLING THE MOLD DURING INJECTION MOLDING OF POLYMERIC PARTS (p. 70–77)

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We investigated the process of filling the molds used in injection molding with the molten polymer, particularly, the formation of lines of seals in the presence of several intake openings in the mold or when the melt flows round the obstacles. As a result of analysis of the designs of molds we established main causes of the low quality of molded products. It is shown that the presence of seals significantly reduces quality of the polymeric goods. Accordingly, it is recommended to design the molds so that it is possible to avoid formation of seals in the products. Alternatively, if this is not possible, it is necessary to ensure that the seals are absent in places that accept maximal loads.

In the present work, we developed a mathematical model of the dynamics of motion of a viscous fluid with free surface in the mold cavity. The model includes the Navier-Stokes equations, the equation of continuity and the Laplace equations. By solving the specified system of equations, we determined rate components of a two-dimensional flow and pressure of the melt in the process of filling a mold. Based on the application of the method of markers and cells, we carried out analytical studies into formation of the line of seals in the polymeric products made by injection molding. It is proven that the position of seals in the finished product depends on the geometry of the mold cavity and the location of intake openings and do not practically depend on the temperature parameters of the process. It was established that dependences of rate of the melt flow front on the height and width of the mold are non-linear in nature, which must be considered when estimating duration of technological cycle of injection molding.

The use of the results of present research makes it possible to reduce the cost of designing molds for producing polymeric products with improved operational properties.

In order to confirm adequacy of the mathematical model to actual processes, we conducted experimental research. A maximal deviation of experimental data from analytical data does not exceed 12 %.

Keywords: mold, melt of polymer, velocity field, pressure field, estimated grid, seals.

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