ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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DETERMINATION OF THE INFLUENCE OF DEFLECTIONS IN THE THICKNESS OF A COMPOSITE MATERIAL ON ITS PHYSICAL AND MECHANICAL PROPERTIES WITH A LOCAL DAMAGE TO ITS WHOLENESS (p. 6–13)

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In the period of technological preparation and initial stages of development in the mass production of composite products, there is a fairly large number and variety of technological defects. The rate of these defects often exceeds the permissible requirements of design documentation and therefore results in faulty products. The most characteristic technological defect for composite structures reinforced with continuous fibres or fabric materials is the deviation of the thickness of the moulded composite from its projective value. Another type of common defects is local violations of integrity in discrete volumes of polymer composite materials in the forms of pores and voids that appear when making their packages in technological forming equipment. The analysis and substantiation of the tolerance fields for these types of technological defects have been carried out. The tolerances on deflection of the thickness of the product being formed from the design value are established. It is shown that the input control determines the deviation of the thickness from the nominal value for a single-layered semifinished product. The deviation in the thickness of the package from the nominal includes the components that arise during its formation. These components are related to the integral deviations of the technological mode of formation (pressure, temperature, and time change) from those that are regulated by the relevant documentation. The analytical dependences are obtained for the reasonably defined assignment of tolerance fields for the physicomechanical properties of a polymeric composite material having a deviation in the thickness in the presence of local violations of continuity in the form of voids. In contrast to the existing models, the obtained dependencies have helped estimate the quality of technological processes of the formation of semifinished products and products made of polymer composite materials by the rate of defects of the considered class. An analysis of the influence of defects of this class on the physical and mechanical properties of the polymeric composite material has been carried out. It is shown that when using some reinforcing material with a passport field of tolerance, the value of the volumetric fibre content is always in its range. At the same time, the rejection of the bulk content of the binder may go beyond its passport field of tolerance.

Keywords: composite, formation, thickness variation, integrity violation, tolerance field, physical and mechanical properties.

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INVESTIGATING THE STRENGTH AND DEFORMABILITY OF THE NODE THAT CONNECTS PRECAST SLABS AND MONOLITHIC JOISTS IN A FLAT PRECAST-MONOLITHIC FLOORING SLAB (p. 14–25)

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The paper reports a study into the strength and deformability of the node that connects precast slabs and monolithic flooring joists in a flat precast monolithic floor based on the work of dowel pins. Current regulations for the design of reinforced concrete structures do not take into consideration the calculation of nodes that connect precast-monolithic structures in flat floors using dowel pins.

We have devised a procedure of experimental research that accounts for the specificity in the operation of a precast slab that forms a floor's part. It was established that a change in the type of supports changes parameters for the stressed-strained state of samples of a precast monolithic floor slab: relative deformations of concrete, deformations of samples, as well as strength.

Testing the samples of a precast monolithic floor slab has demonstrated reliable operation of both the junction and the normal cross-section of the slab. It was determined that the node that connects precast multi-hollow slabs and a monolithic flooring joist using dowel pins has a 1.42-fold strength margin.

The paper reports results from field testing a fragment of the frame of a building for the influence of vertical loads. It is shown that the development of deformations in the main bearing elements of a floor slab occurred almost in line with a linear dependence; they amounted to 18.55 mm (for the central precast slab of a floor slab's center) and 14.64 mm (for the bearing flooring joist). These deformations are more than 2 times less than the permissible value for vertical deformations (deflection) for these elements, which is equal to 40 mm.

The results from field testing have led to a conclusion on that the precast and monolithic elements in the floor slab's disk operate as a solid structure. The tests did not detect any mutual displacements of the side ends of precast slabs relative to the load-bearing flooring joists.

The procedure for calculating the strength of the connecting node has been improved. A change in the strength of samples of a flat precast monolithic floor slab is accounted for by the introduction of an appropriate coefficient for the operation conditions of transverse reinforcement, which is equal to 0.8.

Keywords: precast monolithic floor slab, flat flooring slab, keyed joint, structural strength of flooring slab.

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DEFINING THE PARAMETERS FOR A BRUSH WITH POLYPROPYLENE BRISTLE WHEN UNCOVERING THE ROOT SYSTEM OF MATERNAL PLANTS (p. 26–32)

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The paper addresses the operation of a cylindrical brush with elastic rods of bristles at the disclosure of the root system of maternal plants. It has been established that the basic components of the resistance force in the operation of a given brush is the sum of resistances caused by the soil viscosity force, the static resistance of loose particles of soil and the resistance force at removing soil particles. Based on the minimization of costs of energy, the optimal kinematical parameters have been defined for the brush with a vertical rotation axis. The value for the total resistance force is largely affected by the angular speed of the brush. In addition to the resistance force, the rods of the brush bristles are exposed to the normal reaction from the soil base. By deriving the resultant of these two forces using a method of the Legendre elliptic integrals, we have established the optimal dimensional parameters for the rods of bristles made of polypropylene. A given method has made it possible to take into consideration their significant, compared with the rods' length, deformations as a result of their bending. The rods' length has been determined to be the maximally possible one to ensure the conditions for the removal of soil from a swath that covers the root system of maternal plants of clonal rootstock. In addition, the influence of the friction force during brush operation has been investigated. This implies friction among soil particles and against the surface of the bristle rods. It was determined that the forces of friction, as well as the normal reaction of soil, have little effect on the operation of a cylindrical brush while

opening the root system of maternal plants. This is due to the lack of a solid foundation when a bristle rod is at work, which in turn makes it possible to arrange the bristle rods one by one at the surface of the brush. The absence of necessity in the considerable relative stiffness makes it possible for the bristle rods to remove soil from the swath while minimizing damage to the plants. By using the Legendre elliptic integrals of second kind, we have explored the deflection of bristle rods in a cylindrical brush while opening the root system of maternal plants. The magnitude of the rod deflection during operation affects the degree of it removing the soil particles. An increase in deflection changes the angle between a working facet of the bristle rod and the soil surface. This leads to a decrease in the removal of particles and to an increase in their compaction in a swath. Therefore, we have calculated the length of bristle rods that could ensure the required operating parameters under a predefined load.

Keywords: root system, maternal plants, clonal rootstock, soil cutting, bending deformation.

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IMPROVING THE EFFICIENCY OF A SOWING TECHNOLOGY BASED ON THE IMPROVED STRUCTURAL PARAMETERS FOR COLTERS (p. 33–45)

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The paper reports results from research into improving the efficiency of the technological process of sowing agricultural crops based on the theoretical and experimental studies of functional dependences of operations in the course of the technological process on parameters for colters. Their variants have been substantiated, which, in the subsequent synthesis in various combinations, has made it possible to construct, depending on the requirements, a family of versatile, combined, and specialized colters.

Based on the comparison of analysis and experimental research into the widely applied designs of colters, as well as the parameters for their operation, we have discovered flaws in operation and established their impact on reducing the yield of grain crops. In addition, we have theoretically substantiated the influence of the type and structure of colters on the interaction with soil and seeds during sowing under different conditions. That has made it possible to establish a correlation between the parameters for colters and operations within the technological process.

The data obtained have become the basis for designing new structural elements and types of colters (a family of them) that meet the requirements of the agronomic science and consumers. They improve the technological processes of interaction between their structural parameters (frontal surface, tip, side cheeks) and soil. This improves the formation of furrow for seeds, arranging them evenly for area and depth of covering with moist soil. That improves the germination, development of cultural plants, and increases yields by up to 10 %.

These working bodies are capable of row, narrow-row, scattered, anti-erosion planting, as well as sowing sparse shoots; they improve productivity and protect soil from erosion.

Thus, the result of the current work is the created and improved family of colters for grain seeders:

– with universal tips: a tip colter, an anchor colter, a tip colter with a combined tip, a colter with a combined tip, a colter with a combined tip with cutouts in cheeks and a soil compactor-separator, a tip colter with a guider and adjustable seed reflector;

– for narrow rows: a tip colter;

– combined: a combined tip colter with a right angle of soil penetration with a guider and a seed reflector;

– anti-erosion: a tip colter, an anchor-disk colter with an attachment mechanism, a paw colter.

Keywords: differentiation of seed layer, tipped colter, frontal surface, combined tip, colter's cutout side cheeks.

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DEVELOPMENT OF A TECHNIQUE TO CONTROL AND ENSURE THE PREDEFINED POROSITY OF A GRAIN LAYER IN THE PNEUMO-SEPARATING CHANNEL AT A GRAIN HEAP CLEANER (p. 46–53)

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To operatively control the state of a layer of the separated grain heap, while cleaning it from impurities in a pneumo-separating channel, it has been suggested to use ultrasonic waves with a frequency of 40 kHz.

We have established the relationship between supplying air and a material on the difference from the average values for the lengths of ultrasonic waves paths, acquired from ultrasonic range finders, which are installed at the beginning, in the middle, and at the end of a pneumo-separating channel.

Based on this pattern, we have designed a means to control and ensure the predefined porosity of the grain layer in a pneumo-separating channel of the grain layer cleaner. The technique is based on the principle of continuous calculation of the difference between the average values for the lengths of ultrasonic waves paths, acquired from range finders, located inside a pneumo-separating channel. The obtained values are transmitted to the control unit in order to process them by comparing the obtained values with the specified ones. Should a deviation in the obtained values from those specified occur, one has to adjust the supply of a material and/or air to the pneumo-separating channel.

The developed means of operative control over the state of a separated layer makes it possible, during cleaning, to maintain grains in a suspended condition at the assigned level of fluidization.

This ensures the best conditions for the removal of waste impurities throughout the entire volume of a grain layer, the high quality of grain cleaning at high efficiency of the cleaner.

Keywords: ultrasound, grain cleaning, pneumo-separating channel, grain porosity control, supply of material, air flow rate.

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CORRELATION OF SURFACE ROUGHNESS, TOOL WEAR, AND CHIP SLENDERNESS RATIO IN THE LATHE PROCESS OF ALUMINUM ALLOY – 6061 (p. 54–60)

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The research on the lathe process has described that the tool nose radius parameter is one of the factors that has an influence on

surface roughness in the form of product quality. Chip slenderness ratio is an important parameter in the lathe process that can be applied theoretically or empirically. The lathe process was carried out on the Aluminum Alloy – 6061 material, the effects of the selected responses, namely surface roughness (*SR*), surface area of tool wear (*Vb*), and chip slenderness ratio (δ) were investigated. The selection of the main cutting tool nose radius (*ns*), spindle speed (*n*), feeding speed (*vf*), and depth of cut (*a*) can affect surface roughness which were conditioned to be constant, can influence chip shape and chip slenderness ratio and surface area of tool flank wear. The chip shape in the lathe process has a correlation with the product surface roughness, the chip slenderness ratio, and the tool flank wear.

In this study, the experimental investigation and statistical analysis used the Taguchi experimental design method of *L*9 (3^4) orthogonal array, and the parameters used in the lathe cutting process of Aluminum Alloy – 6061 were tool angle, spindle speed, depth of cut and feed rate that affected the response results ((*SR*), (δ), and *Vb*).

The contribution of each factor to the output is determined by variance analysis. Using ANOVA, the multiregression model is obtained by the relationship between the factors (*ns*, *n*, *vf*, and *a*) on the response (*SR*, δ, and *Vb*), expressed by the following equation: $SR=0.955556+0.074444ns+0.006667n+0.005556vf-0.001111a$, $\delta=7.18889-1.17556ns-0.59222n-0.60222vf-0.09111a$, and $Vb=0.320370-0.073704ns-0.021481n-0.041481vf-0.032593a$.

Correlation results found that: (a) tool nose radius of 0.4 mm, feeding speed 56 mm/min, and cutting depth of 0.25 mm had an influence on $SR=1.11$ μm, (b) tool nose radius of 1.2 mm, feeding speed 58 mm/min and the depth of cut of 0.25 mm have an influence on $\delta=7.07$, (c) tool nose radius of 0.4 mm, feeding speed of 60 mm/min, and cutting depth of 0.50 mm have an influence on $Vb=0.34$ mm^2. The conclusion is that the effect on the correlation of the *R*2 value is very strong against $SR=97.89$ %, $\delta=94.45$ % and $Vb=67.30$ %.

Keywords: nose radius, chip slenderness ratio, surface roughness, flank wear, Taguchi Method, ANOVA.

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EFFICIENCY ANALYSIS OF THE TECHNOLOGY OF ROLLER FORMATION OF FINELY-GRAINED CONCRETE PRODUCTS (p. 60–68)

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Efficiency of using the roller forming technology with forced rotation of the working body (roller or sector) was disclosed. The results of development of an advanced technology of roller formation were presented. This technology features absence of slippage and jamming of the working body relative to the surface of the concrete mixture being formed. Slippage and jamming arise because of growth of inertial forces of freely rotating rollers.

Advantages of this technology over the vibrational technology were indicated, namely:

– the possibility of combining in one unit the processes of spreading, compacting and smoothing the concrete mixture to enable, first of all, development of highly mechanized and automated technological lines, and increase their productivity;

– the possibility of efficient compaction of very hard fine concrete mixtures which in turn creates prerequisites for obtaining durable products, reduced cycles of heat treatment and smaller specific quantity of metal in production;

– the possibility of using fine concrete mixtures with scarce cement slurry that do not exceed normative values for a concrete with a coarse aggregate;

– the possibility of effective improvement of sanitary conditions for the personnel due to absence of vibration and significant noise reduction;

– refuse expensive and in some cases scarce coarse aggregates which ensures significant savings.

These dependences characterize and demonstrate increase in the level of pressure of working bodies on the surface of the formed product. As a result, the coefficient of mixture compaction increases from 0.983 for free rotation of rollers to 0.998 for forced rotation.

Keywords: fine concrete mixture, stabilizing beam, fiber reinforced concrete, steel-fiber reinforced concrete, steel fibers, fiber orientation, forced sector turning

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DEVELOPMENT OF PRINCIPLES TO CONTROL THE PROCESSES OF CONTINUOUS CASTING OF ALLOYS USING MAGNETODYNAMIC EQUIPMENT (p. 69–75)

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A new principle to control the temperature and mass flow rate of metal melt at its continuous casting has been proposed. It has been established that such control can be executed based on continuous monitoring of the mass of a liquid alloy in casting and metallurgical assemblies and at appropriate adjustment by the equipment systems. Using electromagnetic fields and magnetohydrodynamic (MHD) factors to influence a liquid-metal environment is an effective means to ensure the required technological and technical-economic indicators for the process of continuous casting. We have proposed an appropriate principal structural-functional circuit for the automated control system (ACS) over the process of continuous casting of alloys, based on the application of a magnetodynamic tundish (MD-T) and a magneto-weighting system. Their basic design features and functional capabilities have been defined that are related to the processes of continuous casting, compared both with existing equipment and systems for similar purposes. It has been proposed to implement MD-T in the form of a two-chamber assembly, which separates the functions of receiving the melt from a steel-casting ladle, heating the liquid metal, releasing it into the crystallizer of a continuous casting machine (CCM). Stabilization of the flow rate mode of casting, including low-head, is achieved by permanently controlling the mass of melt in the system and by tracking its level in the release chamber of MD-T and in the crystallizer of CCM.

The devised technique and created assemblies, the system, as well as auxiliary devices, would make it possible to significantly improve modern technologies of continuous casting.

Keywords: continuous casting, magnetodynamic tundish, mass flow rate, automated control system.

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