ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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PRINCIPLE OF MODERNIZATION OF THE AIRCRAFT AN-148, AN-158, AND AN-178 FOR IMPROVING THEIR FUEL EFFICIENCY AND INCREASING COMPETITIVENESS (p. 6–16)

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In order to create new competitive advantages for the medium-haul aircraft An-148 and An-158, the application of the D-436-148FM engine for these aircraft has been considered. This would expand the operational range of aircraft flights, reduce noise on the ground, and harmful emissions from the engine.

A distinctive feature is the achieved thrust of the engine D-436-148FM undera maximum emergency mode, 19.4 % higher than the thrust of the engine D-436-148D. That was made possible by optimizing the fan, improving the combustion chamber, and turbine cascade.

The required amount of bench and flight tests has been performed. The engine certification is currently being completed. Specialists at the Antonov State Enterprise and Ivchenko-Progress State Enterprise studied the issue of installing the D-436-148FM engine on the An-148 and An-158 aircraft family. No changes to the design of the engine and aircraft are required. The engine is mounted on the same pylons without changes to the nacelle and engine bonnets.

Energy-dependent systems associated with the engine have been investigated. There is no need for the fundamental changes in related systems for the engine's operational modes according to the Aircraft Flight Manual.

An engineering analysis of the comparison of flight-technical and flight-landing characteristics of the An-158 aircraft equipped with the engines D-436-148D and D-436-148FM has been performed. The data were obtained from the flight tests of the An-158 certified aircraft, taking into consideration the wind tunnel studies, flight tests of the An-178 aircraft, data from the An-158 Flight Manual, and the altitude and speed performance of the D-436-148D and D-436-148FM engines. The altitude and speed characteristics of the D-436-148FM engine, which have been calculated, were confirmed by the flight tests of the An-178 aircraft.

A feasibility study of engine replacement has been carried out, based on the comparison of the technical and economic characteristics of the An-158 aircraft equipped with the D-436-148D engine and D-436-148FM operated in various atmospheric conditions.

The principle of creating a family of aircraft of transport category of different configurations and purposes, based on a single engine, has been proposed.

Keywords: aircraft family, aircraft engine, aerodynamic performance, altitude and speed characteristics, operating costs.

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MODELING THE PROCESS OF RADIAL-DIRECT EXTRUSION WITH EXPANSION USING A TRIANGULAR KINEMATIC MODULE (p. 17–22)

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It has been proposed to use the developed triangular kinematic module 2a with a curvilinear sloping boundary as an axial one, making it possible to describe the character of metal flow in the reversal zone to radial extrusion. Based on the energy method, we have derived the magnitudes of deformation force power inside the built kinematic module 2a, the power of friction forces at the border of the contact between a blank and a tool, and the power of cut forces with adjacent kinematic modules. The result is the obtained analytical expression of the reduced pressure for the deformation of the axial triangular kinematic module 2a with a sloping boundary, whose shape depends on the parameter α. We have analyzed the possibilities of optimizing the reduced deformation pressure for the parameter α under different ratios of geometric parameters of the module and friction conditions. Taking into consideration the shape of the adjacent kinematic module 3a, it has been proposed to use the resulting reduced pressure dependences to calculate the power modes of the combined sequential radial-longitudinal extrusion processes with the developed radial component of metal flow.

A comparative analysis has been performed of the estimation schemes EM-2a with the developed axial triangular kinematic module 2a and EM-2 with the use of the axial rectangular kinematic module 2 and experimental data from modeling the process of combined radial-direct extrusion with expansion. The data on a deformation effort derived from the EM-2a scheme (with the developed triangular module with a curvilinear boundary 2a) and EM-2 exceed those experimentally obtained by 12–15 % and 15–20 %, respectively. This confirms the rationality of using the developed axial kinematic module 2a with a curvilinear boundary instead of an axial rectangular kinematic module when modeling processes of the sequential radial-direct extrusion with the developed radial component of metal flow.

The resulting dependences of the reduced pressure of the module 2a deformation can be built into other estimation schemes of successive radial-longitudinal extrusion processes. As a result, the decrease in the obtained power parameters of the process could amount to 7–10 % relative to the schemes involving the axial rectangular kinematic module 2.

Keywords: simulation of combined extrusion processes, kinematic module, energy method, deformation process.

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DEVELOPMENT OF A MODEL OF TOOL SURFACE DRESSING WHEN GRINDING WITH CROSSED WHEEL AND CYLINDRICAL PART AXES (p. 23–29)

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Three-dimensional geometric modeling of the forming process of cylindrical parts during grinding with crossed axes of it and the wheel has been carried out. Grinding of shafts, which are widely used in the automotive industry, machine tool industry, and rolls of strip rolling mills has been carried out at one location with a wide abrasive wheel oriented relative to the workpiece. Based on the obtained spatial model of

shaping and removal of the allowance, the distribution of the allowance along the cutting area of the tool during grinding with an oriented tool has been studied. It has been shown that on the peripheral cutting section of the grinding wheel, roughing, finishing and calibration are combined.

A modular three-dimensional model of dressing the grinding wheel peripheral section with a single-chip diamond tool during grinding with crossed axes of the tool and part using standardized modules of the dressing tool, orientation and shaping has been developed. Based on the presented model, the geometric accuracy of the tool peripheral section shaping after its dressing has been studied. Based on the presented model, the geometric accuracy of the tool peripheral section shaping after its dressing has been studied. In order to obtain the necessary microgeometry and cutting properties of abrasive wheels, in accordance with the features of processing the rolls of strip rolling mills with an oriented tool, dressing with a reduced feed rate of the dressing tool to the calibration section is proposed. The feed rate of the dressing single-chip tool depends on the value of allowance. Different feed rates of the dressing tool provide different development of the tool cutting peripheral section. This, in turn, increases the intervals between dressing processes of the grinding wheel, which operates in the blunt mode. Therefore, the resistance is increased, and the cost of processing is reduced. Implementation of the proposed method of wheel dressing during single-pass grinding with crossed axes of the tool and cylindrical part will provide high accuracy, quality of the machined surfaces, and also significantly increase the efficiency and productivity of processing. The developed dressing method can be applied for round grinding processes with crossed axes of the workpiece and abrasive wheels.

Keywords: two-side face grinding, crossed axes, wheel dressing, wheel surface development, cylindrical parts.

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REVEALING PATTERNS IN THE WEAR OF PROFILE DIAMOND WHEELS (p. 30–37)

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The electro-erosive wheel dressing exerts a significant impact on the machining accuracy of an article and the efficiency of the profile grinding process.

To effectively control machining accuracy, the most important is the error due to the wear of a diamond wheel.

The wheel should be dressed when wear approaches to the border but does not go beyond the tolerance field. This would reduce the number of defects at machining and bring down the utilization of diamonds. In addition, this reduces the dressing time and, therefore, improves the efficiency of profile diamond grinding.

The paper reports the methodology and results of an experimental study into the wear of profiled diamond wheels. The specific utilization of diamonds was examined on the grinding wheels of the direct profile. The amount of a wheel linear wear was measured by a contactless method applying a special device based on the use of eddy current sensors. This was followed by determining the integrated amount of the worn volume of a diamond layer; after that, the weight of the used diamonds was measured. The mass of the sanded material was determined by weighing it before and after machining.

A mathematical method of planning and analysis of experiments was used to establish the functional dependence of the specific utilization of diamonds on the technological machining modes and the diamond layer parameters. The result of regression analysis is the derived functional dependence of diamond specific utilization on the following factors: the concentration of diamonds in a wheel, the grit of the tool, the grinding wheel velocity, the depth of grinding, and the speed of an article.

To determine the patterns of wear of the shaped diamond wheel, we received an imprint of its profile on a control plate made from a solid alloy and measured the coordinates of the points of the working part of the profile relative to the non-utilized areas. Determining the difference of coordinates before and after the experiment has helped find the amount of radial wear of the grinding wheel at the appropriate profile point.

Keywords: profile grinding, specific diamond utilization, technological machining modes, wheel characteristics.

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EFFECT OF SLIME AND DUST EMISSION ON MICRO-CUTTING WHEN PROCESSING CARBON-CARBON COMPOSITES (p. 38–51)

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Results of theoretical and experimental studies aimed at establishing features of micro-cutting with abrasive grains characterized by active emission of slime and dust particles were presented. The slime particles are just partially withdrawn from the interaction zone and partially change surfaces of the tool and the workpiece of a carbon composite material, in particular, of carbon-carbon and carbon-polymer groups.

The above materials possessing a complex of unique physical and mechanical properties are used in high-tech production though composites remain difficult to process materials. The problems manifest themselves to their utmost in making various apertures, shoulders, cutting of holes, processing edges.

The study has shown that the phenomenon of dust and slime emission in abrasive processing of carbon-based non-dense composites and plastics results from sliding fracture and cyclic weakening of the surface non-dense layer which exhibits quasi-brittle properties under the action of fast-moving micro-indenters. Conditionality of the average slime particle sizes by normal stresses in the cutting zone and the magnitude of protrusion of diamond grains above the cutting surface of the tool was revealed.

Since it was found that the particles formed during cutting are only partially withdrawn outside the cutting zone and the degree of removal decreases with an increase in the processing time, a conclusion on the cause of change in the state of the tool surface was drawn. The remaining slime and dirt change topography of the surface which results in the cutting zone temperature rise to critical values.

It was shown that the use of tools with cyclic advance makes it possible to partially improve the condition of material processing which is relevant for the implementation of the processes of ring diamond drilling, processing with diamond saw blades. It was proved that the intermittent application of areas of the diamond-bearing layer reduces the phenomenon of dirt particle sticking to the surface of the working tool. Thus, the tool stays free of dirt for longer and the machining process is more efficient.

Keywords: abrasive cutting, drilling, oscillation frequency, diamond grain, carbon-based composite material, slime, dust.

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DETERMINING THE INFLUENCE OF THE THICKNESS OF AN ADHESIVE LAYER ON A CHANGE IN THE ANGLES OF CONTACT AND TANGENT ANGLES (p. 52–67)

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A method has been proposed for establishing experimentally the optimum ratio of the thickness of a W-shaped adhesive layer of the spine part of a book block sewn with threads to the necessary and sufficient efforts that are applied for its bending in the block opening process.

The dependence of the effort applied to the opening of a block in a page or stochastic sequence, as well as a place of bending the spine's adhesive plate, influences the duration of the book's use until the beginning of irreversible destructive processes.

It has been shown that increasing the thickness of the adhesive layer leads to an increase in efforts aimed at overcoming the elastic properties of the polymer plates, obtained after the polymerization of the applied adhesive, from the side of the curved outer surface of the block spine, as well as increases the surface tension of the concave surface of the adhesive layer, which is in direct contact with the sewing threads implanted in the structure of the adhesive and the paper of the spine folds of the book sections.

An increase in the surface tension leads to a decrease in the indicators of the relative lengthening of the adhesive layer, which negatively influences the formation of the natural opening angles of the book blocks and requires additional efforts for the operational use of the book.

It has been revealed that the location of the points at which efforts are applied for bending a spine's adhesive plate, in the zones that are limited by the angles of contact, and in the deltoid sections within the intra-section space, influences the magnitude of the applied effort.

This paper describes the elastic-plastic state of the SH-shaped spine part of a book block in the form of the constructed algorithm showing stages in the influence of the adhesive layer thickness on the deformation of the spine part.

The dependences of change in the angles of contact and tangent angles of an adhesive layer, at the stages of a discrete change in its thickness, are represented in the form of the inter-dependent graphic curves in a general coordinate system.

The results derived from the established ratio of the thickness of a W-shaped adhesive layer to changes in the angles of contact and tangent angles have contributed to the elaboration of the new norms for quantitative adhesive use.

Keywords: angles of contact, tangent angles, profile application of the adhesive composition, W-shaped spine.

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THE INTENSITY OF WATER REMOVAL FROM SHALLOW DRAINAGE SYSTEMS CONSIDERING THE PROPERTIES OF FILLER MATERIALS (p. 68–75)

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To date, there are virtually no experimental studies of drainage structures. The object of the presented study is a road structure with transverse shallow drainage arranged

in wet sections of roads. In order to determine the drainage intensity of the drainage structure, an experiment was performed on a special installation for modeling the road structure depending on the properties of filler materials.

Parameters of the installation make it possible to arrange a structure that corresponds to real conditions, that is, the parameters of a road of category III and study the processes of formation of the filtration flow in the drainage trench which is impossible with real objects.

The laboratory installation was used to study operating conditions of drainage structures: a layer of crushed stone of 20–40 mm fraction and two types of transverse shallow drains with different filler materials in the trench. In the process of a series of experimental studies, the volume of water drained from the trench and drainage time was measured. According to the study results, based on the methods of mathematical statistics, unified equations of the correlation-regression model concerning the mode of operation of the drainage structure were constructed depending on initial soil moisture in the roadbed.

According to the results of experimental studies, one of the main indicators of work of shallow drainage structures which depends on the properties of materials of trenches fillers, that is, the drainage intensity was determined. It was found that in contrast to the structure with a PVC pipe filled with coarse sand, the drainage structure with a crushed stone core in the trench worked in one mode of the formed flow. The work of the structure with the pipe is divided into short-term and long-term modes depending on the drainage intensity. The obtained regression dependences enable forecasting of the amount of water drained by the proposed drainage structures in a certain period for field conditions.

Keywords: road construction, drainage layer, shallow drainage, polyvinyl chloride pipe, crushed stone core.

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SUBSTANTIATING THE CHOICE AND OPTIMIZING THE PARAMETERS FOR THE TECHNOLOGY OF HOT RECYCLING OF ASPHALT CONCRETE ROAD COATING (p. 76–84)

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The method of expert assessments has been used to substantiate that the most significant factors that significantly influence the mechanism and kinetics of technological processes of the regenerated mixture preparation are the temperature of its preparation and the content of the regenerating additive. We have investigated their influence on

the physical-mechanical parameters of regenerated asphalt concrete, obtained using the technology of hot recycling of asphalt concrete pavement applying the «in place» method. The experimental research has established the dependences of the physical and mechanical parameters (water saturation, compressive strength at 0 °C and 50 °C) of regenerated asphalt concrete on the content of an additive and stirring temperature. The mathematical models have been constructed in the form of second-degree polynomials that describe the dependence of water saturation and strength at the compression of regenerated asphalt concrete on the temperature of preparation and the content of a regenerating additive. It has been established that increasing the stirring temperature increases compressive strength at 0 °C; at the same time, compressive strength at 50 °C and the measure of water saturation decreases. The increase in the regenerating additive reduces all the examined physical and mechanical indicators. Based on an analysis of the results obtained, we have determined the regions of rational values of the stirring temperature of loose asphalt-concrete crumbs (125–135) °C, as well as the content of an additive (0.26–0.28) %, when preparing hot asphalt concrete mixture. In terms of physical-technical indicators, the resulting mixture meets the requirements set by DSTU B V.2.7-119:2011 «Asphalt concrete mixes and road and airfield asphalt concrete. Technical specifications» for hot fine-grained asphalt mixtures. The reported results could prove useful when devising a technology of hot recycling of asphalt concrete pavement by the «in place» method and for studies related to its improvement.

Keywords: hot recycling, asphalt concrete, experimental and statistical modeling, stirring temperature, regenerating additive.

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ESTABLISHING A PATTERN IN THE INFLUENCE OF TWO-LAYER GREASING ON THE WEAR RESISTANCE OF RAILS (p. 85–91)

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This paper reports the results of an experimental study into the influence of two-layer greasing, formed from the graphite powder and base molecules of industrial oil, on the durability of the side surface of a rail head. Thus, increasing the concentration of graphite powder in oil from 0 to 3 % under a load of 363–646 N decreases a wear rate by 42–29.7 %, respectively.

The study procedure implied modeling the process of rolling friction at slippage using rollers at the SMC-2 friction machine. This particular type of friction occurs in the tribosystem wheel flange the side surface of a rail head in the curved track sections. The supply of oil applying an aerosol technique was also implied. Two independent factors were varied: the concentration of graphite powder in the industrial oil I-12A and an external load. The constant factors were the roller rotation frequency, which enabled stable slippage at the level of 20 %, and oil temperature, and the duration of each test.

The results of the experiment have made it possible to derive a regression equation, which describes the wear pattern of a roller in the friction pair «roller – roller» depending on the selected factors.

At the final stage of this work, we calculated a rail resource in the curved track section. The results of calculating a railroad rail resource under conditions of increasing the concentration of graphite powder from 0 to 3 % at external loads from 363 to 646 N have demonstrated an increase in the rail resource from 40 to 61 %. The calculation was based on the obtained experimental data, which characterize the friction process between the side surface of a rail head and the wheel flange in a curved track section under the conditions of two-layer greasing at various loads. The two-layer greasing was formed through the aerosol application of oil onto the friction surface with a different concentration of graphite.

The data obtained make it possible to predict the service life of rails in the curved track sections under conditions of two-layer greasing.

Keywords: graphite powder, two-layer greasing, wheel-rail, tribological system, wear resistance, aerosol.

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