ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

DOI: 10.15587/1729-4061.2019.184294

DEVELOPMENT OF A NEW METHOD FOR AUTOMATED SELECTION OF ROBOTIC MECHANIC-ASSEMBLY TECHNOLOGIES BASED ON THE TECHNICAL AND ECONOMIC CRITERIA (p. 6–18)

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A new method for the automated selection of robotic mechanic-assembly technologies according to technical and economic criteria was proposed. The choice is made on the known set of robotized mechanic assembly technologies, components of the system of technical and economic criteria, analyzed methods for depreciation expense of residual value of industrial robots and other organizational and technological input data. The content of the latter is: the period of operation of industrial robots in flexible production cells, period and volume of production, quantity and volume of product batches for launch in manufacturing.

The process of selecting robotic mechanic-assembly technologies is performed at the minimum value of one of the user-selected technical and economic criteria from their pre-developed system. Each of the criteria with different degree of detailing reproduces the content of the «robotic» component of the cost of production of a product unit and is determined by using only industrial robots.

The performed formalization of the selection process made it possible to develop algorithmic support, which underlies functioning of the developed computer program in the software environment MS Excel. The performance of a computer program was tested on the examples that on the set of the synthesized robotic mechanic-assembly selection technologies differ only by varying data on the organizational and technological features of using industrial robots in mechanic-assembly flexible production cells.

The analysis of the obtained results showed that the selection criterion, determined by the use of the straight-line method of depreciation expense of industrial robots, regardless of the number of their useful years, is the smallest criterion for the examined examples under equal conditions.

The mathematical generalizations were formed and the recommendations on using the methods of depreciation expense of the cost of industrial robot, which determine their residual cost when calculating selection criteria, were given.

The method for the selection of robotic mechanic-assembly technologies is invariant in the context of the possibility of its use in different countries with different regulatory base concerning the existing methods of depreciation expense for determining residual value of industrial robots.

Keywords: industrial robot, robotic mechanic-assembly technology, technical-economic criterion, depreciation.

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DOI: 10.15587/1729-4061.2019.183663

MODELING AND IMPROVEMENT OF SADDLING A STEPPED HOLLOW WORKPIECE WITH A PROFILED TOOL (p. 19–25)

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A new technological process of forging massive stepped hollow rings has been investigated based on modeling. This process implies the saddling of a hollow blank with a stepped deforming tool. We have devised a procedure of experimental modelling based on the law of geometrical similarity. The procedure makes it possible to establish regularities of change in the shape of a hollow workpiece and in the formation of surface defects while deforming with a stepped tool. The varied parameter was a relative height of the ledge (diameter ratio) of the original workpiece. Based on the research results, we determined the taper of rings, which forms during forging in line with a new technique. The study involved blanks made of lead and steel.

Modeling allowed us to determine that the deformation with a stepped tool could lead to the emergence of taper on a ring. These results can be explained by the fact that the process of deformation of the ledge of a hollow workpiece is accompanied by a more intense deformation of the ring in a tangential direction than in the ledge, due to the difference in thicknesses of the stepped hollow workpiece. An increase in the degree of ledge deformation leads to an increase in its diameter. Macrostructural investigation of the wall of a stepped ring has allowed us to establish that the process of forging a stepped hollow workpiece with a ledge die leads to the formation of a fibrous structure that coincides with the profile of the stepped part. Such a location of fiber rules out the possibility of its cutting in the process of machining. Based on the results from experimental modeling, it was determined that it becomes possible to forge stepped hollow rings, which extends the technical possibilities of saddling massive parts for responsible purposes.

Keywords: ring forging, saddling operation, large forgings, stepped ring, die, stepped tool, taper.

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DOI: 10.15587/1729-4061.2019.183541
IMPROVING THE TECHNOLOGY OF PART MACHINING BY SURFACE PLASTIC DEFORMATION (p. 26–32)

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The purpose of this work is to study the technological process of strengthening hollow cylindrical parts of tractor engines using surface plastic deformation.

Experimental studies in a wide range of changes in various factors have been preliminary performed on models. The data obtained were recalculated from the model to specific parts – piston fingers and bushings of the top heads of connecting rods in automotive tractor engines. The study was aimed at determining the efforts, stresses, changes in shape, the properties and structure of a parts' material. In the course of our study, the law of similarity was maintained, whereby the sample models were geometrically similar and physically identical to parts. The rational shape of machining tools was experimentally established – conical; as well as its optimum dimensions: angle of inclination, 10°30'; magnitude of the calibration belt, 6–7 mm, which provide for the magnitude of strengthening and surface quality of the machined material. We have experimentally established the effect of angle of inclination of the machining tool on the amount of a metal sticking to its working surface. The dependence of the amount of a sticking metal on its hardness and the elasticity module has been established. We have determined the impact of height of the calibration part of a machining tool on the roughness of a part's machined surface.

The empirical dependence of machining allowance with a residual deformation along the outer diameter of a piston finger has been derived based on the laboratory data obtained. It has been found that the most dangerous are the tangential stresses along the outer surface of piston fingers, which were determined in the process of deformation by a strain gauge method. We have experimentally established the value of machining allowance over a single run of the working tool at vibration deformation of piston fingers, which ensures a reduction in tensile residual stresses. Our study into the static strength of piston fingers has found that the magnitude of wear depends on the following basic factors: a machining method, the material and time of operation.

The research into the weight wear of piston fingers and bushings of the top heads of connecting rods has established that at vibration deformation the amount of wear is less compared to regular expansion. The magnitude of wear of the piston fingers restored by a vibration method is 1.13 times less than that in those restored by regular expansion.

Keywords: plastic deformation, process modelling, vibration treatment, residual stresses, surface roughness, strengthening.

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DOI: 10.15587/1729-4061.2019.183269
A SEARCH FOR TECHNOLOGIES IMPLEMENTING A HIGH FIGHTING EFFICIENCY OF THE MULTILAYERED ELEMENTS OF MILITARY EQUIPMENT (p. 33–40)

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Technologies for the production of multilayered spherical bottoms and cylindrical shells of quasi-layered material and compaction of the multilayered wall of military equipment elements are developed. The need for these studies is associated with increasing survivability and eliminating fragmentation effects of multilayered structures on manpower and equipment that use pressure vessels (submarines, flamethrower vessels, elements of armored vehicles).

Operating conditions for the most efficient use of structures made of layered structural materials are presented. Their advantages in operation and production are described. The highest efficiency is achieved with firm adhesion of structural layers or with the use of quasi-layered materials. The solution to this problem is possible using the energy of high explosives. It is experimentally found that explosive loading leads to an increase in toughness and ballistic resistance of treated materials. Analysis of various methods of multilayered wall compaction is carried out and the most effective technologies are proposed.

As a result of the research, process parameters, requirements for process equipment are established.

The importance of the presented studies is associated with increasing the fighting efficiency, survivability of military equipment and personnel.

Keywords: explosion welding, multilayered wall compaction, composite materials, quasi-layered materials, armored vehicles.

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DOI: 10.15587/1729-4061.2019.183882
DETERMINING THE CONDITIONS FOR DECREASING CUTTING FORCE AND TEMPERATURE DURING MACHINING (p. 41–50)

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The theoretical approach to calculating and controlling the force and temperature parameters of edge cutting and abrasive machining processes taking into account the provision of the minimum possible power consumption of the cutting process is given. The conditions for reducing cutting force and temperature and improving the quality and rate of grinding and edge cutting machining are theoretically determined. They consist mainly in reducing the relative shear angle of the machined material and, accordingly, power consumption by increasing the cutting capacity of the tool. It is analytically found that in grinding, cutting force and temperature are greater than in edge cutting machining due to the intense friction of the grinding wheel bond with the machined material and the presence of negative rake angles of cutting grains. It is shown that cutting temperature during grinding can be reduced using the multipass grinding pattern, as well as patterns of high-velocity creep-feed wheel-face and double-disc grinding. On this basis, the approach to creating technologies of effective high-velocity defect-free edge cutting and abrasive machining of machine parts and carbide cutting tools is developed.

The developed technology of form grinding on the modern HOFLER RAPID 1250 gear grinding machine using a special highly porous form abrasive wheel tapered on both sides received practical application. This wheel has a high cutting capacity in conditions of high-velocity creep-feed grinding. Compared to the conventional method of gear grinding by the generating process, carried out under conditions of multipass grinding, this allowed increasing machining rate up to 5 times. The technology of high-velocity creep-feed external grinding of multipoint carbide cutting tools (milling cutters, reamers) with high-strength metal-bonded diamond wheels using the electrical discharge dressing method is developed. This made it possible to increase the rate by 2–3 times and provide high-quality defect-free machining of carbide tools.

Keywords: machining quality and rate control, machining, cutting force and temperature.

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DOI: 10.15587/1729-4061.2019.183844
SUBSTANTIATION OF THE METHOD OF INTEGRATED GROUP UNIFICATION OF MACHINE AND APPLIANCE DESIGNS (p. 51–59)

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The study object: group unification of designs of process machines and appliances. Unification is one of important means of improving efficiency of production and operation of assemblies (parts) which reduces cost of their manufacture and repair. Unification is also a standardization subsystem which significantly increases the interest in its study and implementation.

One of the problems in development of group unification of designs consists in the lack of sufficient theoretical base and the studies towards unification are often reduced to simplification. This causes worsening of production efficiency because of slowdown of the process of creation and implementation of unified designs at a steady rate of growth of nomenclature of assemblies (parts), equipment and tools.

An approach was proposed based on a hypothesis of possibility of finding criteria (formulas) that will allow designers to a priori assess conformity of the design structure to the established levels of unification, define laws and specify methods for optimizing the design structures by adapting to the technological equipment. This approach was implemented through the use of the axiomatic theory, laws of composition, theory of groups and symbolic logic.

As a result of the study, definition of the primary element was obtained and a procedure of its construction was presented, formulas of unified parts were derived and the theorem of unification of assembly (part) design structure was formulated. Features of integrated unification of groups of parts and the equipment for their manufacture were considered.

The study results will allow designers to improve the intellectual design process and promote widespread use of the systems of automatic design of process equipment. The study results are of interest for:

– designers of enterprises when creating closed databases of unified parts (assemblies) which will significantly reduce time of development and introduction in manufacture of new products and increase their efficiency;

– software users in creation of accessible open databases of unified parts (assemblies) aimed at concealed advertising and promotion of sales of unified products.

Keywords: primary element, theory of groups, theorem of unification, integrated group unification.

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DOI: 10.15587/1729-4061.2019.184546

EXPERIMENTAL STUDY OF THE ACCURACY OF BALANCING AN AXIAL FAN BY ADJUSTING THE MASSES AND BY PASSIVE AUTO-BALANCERS (p. 60–69)

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The paper reports determining and comparison of the quality of dynamic balancing of rotating parts in the assembly (impeller) by correction mass and applying passive auto-balancers using the axial fan VO 06-300-4 as an example. The impeller is balanced in two planes of correction – from the side of a fairing and from the side of an electric motor's shank.

It was established that prior to balancing the magnitudes of root-mean-square values (RMS) of vibration speed at the casing of the fan correspond with a margin to the balance quality grade: 1x vibration components (1x) – G2.5; total – G6.3. The main source of vibrations is the dynamic residual imbalance of the impeller. The basic component of vibration speeds is the 1x one (at a frequency of 25 Hz), that is, it can be reduced by balancing. The non-1x vibration components occur at subharmonic frequencies, 25/2 and 25/3 Hz, and are smaller by the order of magnitude.

When the impeller is balanced by correction mass, the initial imbalances from the side of a fairing and a shank are, respectively, 81.4 and 115.2 g·mm, and the residual ones are 7.4 and 7.2 g·mm. The magnitudes of RMS of vibration speed can be reduced at the fan's casing to the magnitudes corresponding to the balance quality grade (with a margin): 1x – G0.4; total – G2.5. The main contribution to the residual vibrations is made by the non-1x vibration components occurring at subharmonic frequencies.

At dynamic balancing of the impeller by two ball auto-balancers, in the presence of any imbalances (in two planes of correction) that can balance the auto-balancers, the RMS of vibration speed at the fan's casing correspond to the balance quality grade: 1x – G1; total – G2.5. Ball auto-balancers react to imbalances constituting not less than 3 % of their balancing capacity. The residual imbalances are not stable, but are not larger from the side of a fairing and a shank than, respectively, 22.2 g·mm and 21.6 g·mm.

Research results are applicable for low-pressure axial fans, specifically VO 06-300/VO-12-300; VOG/VO-15-320; VO 2,3-130/VO 46-130. They make it possible to decide on the expediency of balancing fans by passive auto-balancers.

Keywords: low-pressure axial fan, balancing, ball auto-balancer, automatic balancing, balancing by mass correction, vibration speed.

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DOI: 10.15587/1729-4061.2019.184939

DEVELOPMENT OF A RESOURCE-SAVING, SMALL-SIZED DOWNHOLE HYDRAULIC MACHINE FOR WELL DRILLING (p. 70–76)

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Our analysis of the structural features and technological capabilities of serial downhole hydraulic motors (hydraulic machines), designed for drilling wells, has revealed their shortcomings. These include the limited resources due to the complexity of their design, the consumption of a working fluid, significant dimensions in length, mass, low rotation frequencies of the shaft, which do not correspond to the technological modes of wells diamond drilling. Based on the analysis of structural schemes of downhole hydraulic motors it has been concluded that the greatest opportunities for maximum use of the potential energy of a working fluid are demonstrated by rotary-type hydraulic machines.

We have proposed, as the object of the study, a structural scheme of the hydraulic machine, which applies the physical principles of converting the weight (energy) of the column of a working fluid at the time of stator rotation around the non-rotating rotor. The principles of separation in the direction of movement of the incoming flow from the reverse spreading have been taken into consideration, as well as the exclusion of a stagnant zone and the creation of a multilevel momentum of reactive forces by the flow of a fluid.

Based on the devised procedure, we have performed theoretical calculations of energy characteristics of a two-chamber deep hydraulic machine, defined technical specifications; the calculation scheme of force interaction between a working liquid and the elements of a hydraulic machine is given.

Based on the results from theoretical calculations, the structural-technological documentation for a downhole hydraulic machine has been developed; a prototype was made and experiments were conducted to determine operability of the scheme, as well as the boundary values of its operation. The quantitative values for its energy characteristics were determined based on the readings from control-measurement instrumentation.

We have conducted a comparative analysis of the technical and energy characteristics of a rotary-type downhole hydraulic machine with industrially produced hydraulic engines, the turbodrill TG-124, and the screw engine D1-124, of the same diameter.

Conditions for the utilization of a downhole hydraulic machine have been proposed, as well promising directions for the further research and development to improve it and expand the scope of its application.

Keywords: stator, rotor, working fluid, rotation momentum, well drilling.

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DOI: 10.15587/1729-4061.2019.182507

GRAPH-ANALYTICAL OPTIMIZATION OF THE TRANSVERSE VERTICAL CROSS-SECTION OF A CONTACT ZONE BETWEEN SOIL AND AN ELASTIC WHEELED MOVER (p. 77–84)

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The intensification of agricultural production under modern conditions implies the use of super-powerful mobile technical means, which leads to an increase in the levels of technogenic impact on soil and, consequently, deteriorates its fertility. Therefore, the most acute issue related to current agricultural production is aimed at resolving the task on improving the operational indicators of wheeled running systems of mobile technical means. This necessitates an analytical study into the processes of soil deformation under the elastic motors of mobile wheeled agricultural machinery.

We have proposed a procedure of the graph-analytical step-by-step modeling of the process of soil deformation under pneumatic tires of mobile agricultural equipment taking into consideration the changing shape of an elastic tire sheath. Using appropriate graphic models makes it possible to explore, in stages, the process of soil compaction inside the profile of the track it formed. It has been found that in the contact area «deformed soil – the surface of an elastic wheeled mover of the mobile vehicle» the highest level of compaction is observed in the soil layer, which is directly in contact with the elastic mover. The depth of the recompacted soil layer on the «track bottom» depends on the dimensions of a tire of the wheeled mover and does not exceed the value of 0.075 width of the tire. The highest soil compaction level is observed in the area directly adjacent to the gauge. It has been established that the most dangerous design of a pneumatic tire, in terms of soil overcompaction in the track, is the shape of an elastic tire sheath that is described by the curve of the Cassini oval with four points of inflection. We have outlined distinctive features of recommendations to determine the operational values of tire working pressure depending on specific physical-mechanical and agro-technological properties of soil and the character of performed technological operations.

Keywords: soil compaction, elastic deformer, field of pressure forces, nonlinearity of soil deformation.

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