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UNIFICATION OF FILLING STATION EQUIPMENT INTENTED FOR FILLING OF SPACECRAFT, UPPER STAGES AND LOW-THRUST PROPULSION SYSTEMS OF SPACE LAUNCH SYSTEMS

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The object of research is filling stations, projected for filling the upper stage, low-thrust propulsion system of spacecraft. The disadvantage of existing designs of filling stations is the use of filling equipment of the outside organization for spacecraft filling. It is proposed to standardize the equipment of filling stations for filling of spacecraft, upper stages, and low-thrust propulsion systems, which makes it possible to extend the service of filling stations and provide a cheaper version of spacecraft filling for launching customer without additional outside organization. Comparative analysis of factors is used to study the possibility of full unification of filling stations. These factors determine the filling characteristics of rocket propellant components for spacecraft and upper stages.

These factors are:

– design features of the propellant systems of spacecraft and upper stages;

– nomenclature of propellant components and compressed gases used for spacecraft filling;

– filling technology;

– filling equipment.

The obtained results confirmed the almost complete identity of technological operations of spacecraft filling and upper stages and the equipment used to spacecraft filling, which is the basis for the design of standardized and, thus, cheaper filling stations.

Keywords: filling station, propellant component, spacecraft, upper stage, unification, propellant tank.

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MODELS AND METHODS FOR ANALYSIS OF TEMPERATURE AND THERMOMECHANICAL FIELDS IN THE BODIES OF COMPLEX SHAPE IN SPECIALIZED INTELLIGENT SYSTEM

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The design of axisymmetric bodies of complex form, taking into account temperature and thermomechanical fields, is the object of research. To model these fields need to solve boundary value problems for differential equations with partial derivatives. Structural and regional structural methods are used to solve the boundary value problems of thermal conductivity and thermoelasticity.

CAD, meeting modern requirements, should include systems based on knowledge. Also, improving the efficiency of CAD is achieved thanks to the development of methods of solution of thermal conductivity and thermoelasticity tasks in the bodies of complex form. Using created structures, we receive more stable and accurate solution of the problem of analysis of thermal and thermomechanical fields in the considered objects.

The specialized intelligent system is created. It contains a database of knowledge: a database of geometric forms of designed objects and methods of solving of relevant problems; a database of rules which allow to automate the choice of method and structure of solutions, equations of boundary of its areas; other information, required to increase the degree of automation of computer modelling. Created system creates the program on RL language for some programming system (PS), which solves the problem. Created system is production system.

The pictures of temperature and thermomechanical fields are studied with the help of created system in axisymmetric bodies of complex form – pistons of internal combustion engine (ICE), homogeneous and consisting of composite materials. The impact of insert material, form and location on the picture of the temperature and thermomechanical fields in these ICE pistons is researched. These researches help to design these objects in order to reduce the temperature in the critical points of the object. This improves the thermal regimes in these objects, increase their strength, reliability and durability.

Keywords: design, modeling, boundary value problems, intelligent system.

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INVESTIGATION OF NATURAL OSCILLATIONS OF INHOMOGENEOUS ORTHOTROPIC CIRCULAR PLATE LYING ON INHOMOGENEOUS VISCOELASTIC FOUNDATION

page 16–19

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In the building of large engineering complexes, bridges and overpasses for various purposes and in many other areas the plates of widely different configurations are used. These plates are made of natural and artificial orthotropic materials. Among them, rectangular and circular plates are the most common. According to the above mentioned natural oscillations, engineer-designer and calculator need to properly assess real property of construction element and the influence of the environment, which is in contact during the operation. Therefore, the object of this study is inhomogeneous circular plate lying on inhomogeneous viscoelastic foundations.

It is assumed that the moduli of elasticity and the plate density are continuous functions of the current radius. In this case, unlike homogeneous plates, the motion equation is complex differential equation with variable coefficients. In this regard, there is need to build an approximate analytical solution method.

In the course of the study we used methods of separation of variables and Bubnov-Galerkin orthogonalization method, which gives effective results with homogeneous boundary conditions.

An axisymmetric form of natural oscillations of orthotropic circular plate with inhomogeneous radius lying on inhomogeneous viscoelastic foundation is considered. The case, when the plate is rigidly clamped around the contour, is studied in detail. Numerical analysis for concrete values of the characteristic parameters is carried out.

The motion equation is obtained taking into account inhomogeneity of the plate and the foundation, as well as partial variable coefficients of the fourth order.

Keywords: plate, continuity, orthotropicity, density, foundation, frequency, elastic moduli, motion equation.

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DEVELOPMENT OF THE COMBINED HARDENING TECHNOLOGY OF OBTAINING SOLID COATING ON THE SURFACE OF STEEL PRODUCTS

page 20–23

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It is found that grinding of the grain structure of the surface layers of steel 38Cr2MoAl takes place after the laser treatment. In this case, the thickness of the hardened layer ranges from 0,2 to 0,41 mm depending on the change of the laser beam velocity (between 1,5 and 0,5 m/min, respectively).

Subsequent boriding it possible to obtain a higher boride layer with a thickness of 0,140 mm and microhardness up to 22,5 GPa, compared with boriding without preliminary laser treatment providing a hardness of 20 GPa and depth of the layer up to 0,073.

The technology of boriding intensification is proposed. Its feature is the use of preliminary laser treatment of the surface of steel products and the fine boron powder as a saturating medium for chemical and heat treatment.

It is shown that the use of fine boron powder as a saturating medium for chemical and heat treatment.

The offered application of boriding technology of steel products will allow to combine chemical and heat treatment with a heat treatment operation, which will increase the service life of equipment parts operating properties of the diffusion layers of tools, stamping and pressing equipment.

Keywords: laser treatment, intensification of boriding process, depth of hardened layer, microhardness.

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METALLURGICAL TECHNOLOGY

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STRENGTH ANALYSIS OF LAMELLAR GRAPHITE CAST IRON IN THE «CARBON (C) – CARBON EQUIVALENT (C_{EQ})» FACTOR SPACE IN THE RANGE OF C = (3,425–3,563) % AND C_{EQ} = (4,214–4,372) %

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The object of research is the structural lamellar graphite cast iron, where the carbon equivalent (C_{eq}) is in the range of (4,214–4,372) % and the carbon content (C) is in the range of (3,425–3,563) %.

The aim of research is to describe the distribution of values of tensile strength of cast iron series in the factor space C–C_{eq} at a fixed level of Cr–Ni–Cu–Ti alloyed complex in narrow ranges.

To achieve this aim, there are the next objectives.

1. Build a workable analytical description of the impact of the selected input variables on the tensile strength of cast iron.

2. Study the response surface and identify the most informative point of the factor space for further detailed investigation of the microstructure in these points.

It is shown that polynomial regression equation provides forecast accuracy, exceeding the accuracy using a linear regression equation in 1,23 times. An existence of a saddle point is revealed on the basis of the canonical transformation of response surface. It is an informative indicator, which suggests that the respective values of the input variables C = 3,492 %, C_{eq} = 4,28 % when the content of alloying elements Cr ± 0,032 %, Cu ± 0,026 % form a microstructure that guarantees the value of cast iron tensile strength *TS* = 203 MPa. In view of the resulting confidence interval, this value with a probability of 95 % is in the range of *TS* = (193–213) MPa. Metallographic microstructure description in the saddle point is important and can be obtained by the development of modeling results.

It is noted that there is a fundamental opportunity to improve accuracy and obtaining more precise description of the response surface – due to numerical building of D-optimal plan or artificial orthogonalization of full factorial experiment, inside the considered in this work

Keywords: lamellar graphite cast iron, induction crucible furnace, regression equation, canonical transformation of the response surface.

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DEVELOPMENT OF A NEW IRON-BASED SHAPE MEMORY ALLOY

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The object of research is the technology for producing iron-based shape memory alloy. One of the most problematic moments in this process is the need to increase the degree of shape recovery while maintaining high mechanical characteristics.

It is found that the developed iron-based shape memory alloy has sufficient mechanical properties.

The results show that the surface oxidation isn't observed for heating of the samples in temperature range 600–1000 °C.

During the experiment it is found that alloy is corrosion resistant and doesn't change a mass in 10 % solution of sulfuric acid.

It is found form recovery degree of the proposed alloy is 73–95 % while maintaining such important properties as strength, viscosity, corrosion and oxidation resistance.

Keywords: iron-based alloy, shape memory effect, oxidation resistance, corrosion resistance.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

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DEVELOPMENT OF A DEVICE PROVIDING RESOURCE-SAVING START-UP OF INDUCTION MOTORS UNDER REDUCED VOLTAGE

page 37–44

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Electromechanical and thermal transients at start-up of squirrel-cage induction motors in reduced voltage conditions are the object of research. One of the most troubled places in these processes is sufficient difficulty diagnosing of resource consumption of induction motors with heavy start-up in reduced voltage conditions and timely facilitation of such regimes with a view to resource saving.

To determine the diagnostic parameters of starting modes for induction motors at reduce of supply voltage it is necessary to identify the dependence of start-up duration depending on the parameters of the «motor – working machine» system and their impact on the thermal insulation wear in motor during period after start-up. Therefore, the main way to increase the operational reliability of induction motors is to develop technical device for diagnostics of additional thermal insulation wear in induction motor.

We use such methods as: analysis method and mathematical modeling method. It is grounded that pulse of squared starting current can take as diagnostic parameter of additional thermal insulation wear of induction motor. Investigation of thermal insulation wear shows that the thermal transient at the start-up is adiabatic. Main thermal insulation wear is during period after start-up. The dependence of additional thermal insulation wear on the pulse of squared electric current of induction motor allows to select pulse set point of squared starting current of proposed device, which will facilitate the starting mode of the motor. A structural diagram of the device for diagnostics of additional thermal insulation wear in squirrel-cage induction motor during period after start-up is proposed.

Keywords: induction motor, electromechanical and thermal transient, reduced voltage, starting mode.

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STUDY OF SURGE ARRESTER MODEL UNDER INFLUENCE OF VARIOUS CURRENT PULSES

page 44–48

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The model of surge arrester, which consists of two nonlinear resistors, connected with each other via two inductive and a resistive element is studied. To determine the model parameters are only required by the data given in the catalogs of surge arresters manufacturers. Until now, in the simulation of surge arresters insufficiently investigated the effect of currents typical for lightning surges.

It is shown that the model of surge arrester can be investigated by comparing the results of computer simulation with the data given in the catalogs of surge arresters. The study will use the following data, specific both switching and lightning surges: the residual voltage at switching impulse current, the residual voltage at lightning impulse current, as well as the residual voltage at steep current pulse.

Residual voltages corresponding to the 250–2000 A standard switching current pulses, 1.5–20.0 kA standard lightning current pulses and 10.0 kA steep current pulses were defined using Micro-Cap model of surge arrester. Residual voltages obtained in the simulation were compared with the corresponding values given in catalogs of surge arresters. It is shown that the smallest error takes place under the influence of lightning current pulses on the model of surge arrester.

The model of surge arrester in Micro-Cap program allows high accuracy determination of the residual voltage on the surge arrester during the flow of discharge pulses, which are typical for lightning surges. The model also allows to calculate the transients during the flow of the lightning currents, which are composed with several successive pulses, which can pose a significant danger to the surge arresters. The results of the research can specify the parameters of substation protection against different overvoltages and, thus, reduce economic losses due to possible faults.

Keywords: circuit simulation, surge arrester, residual voltage.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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ANALYSIS OF EFFICIENCY AND RELIABILITY OF BLAST-FURNACE PROCESS WASTE HEAT RECOVERY SYSTEMS

page 49–54

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The object of research is a hot blast generating system, which consists of three hot blast stoves with sequential mode of operation. One of the factors that reduce the hot blast stove block efficiency is the existence of losses with the waste gases, the heat of which can be recovered and used for combustion air preheating.

In order to improve the efficiency of a hot blast generating system the possibility of using of recuperative heat exchanger for waste heat recovery is observed. The process of initial parameters determining (the required level of combustion air preheating, waste gases temperature and flow rate at the inlet of the heat exchanger) is described. Software based on using of an original mathematical model and used for calculating of the parameters of the waste heat recovery heat exchanger was created. These data provide tools for refined calculation of heat recovery systems based on recuperative heat exchangers.

It is shown that the combustion air preheating results in a reduction of the coke oven gas flow rate. The calculations results in building of temperature distribution diagrams that allow to define the areas of corrosion. Such areas in the observed recuperative heat exchanger model appear at temperatures below 26 °C.

Thus, the set approaches can be used to refine the calculation of heat-transfer equipment of waste heat recovery systems to improve their reliability, long life, analyze their technical and economic parameters. This will improve the energy efficiency of the hot blast stoves block and reduce the cost of iron production.

Keywords: hot blast stove, heat recovery, recuperative heat exchanger, efficiency.

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