ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

MODELLING OF CRYSTALLIZATION PROCESS OF POLYMERIC COMPOSITION IN SPACE AND TIME (p. 4-10)

Vitaly S. Borovik, Vitaly V. Borovik

In order to increase the efficiency of the analysis of the process of crystallization, by the example of a polymer composition the attempt of a multidimensional visualization was made, which allows creation of program systems to visually solve a wide range of tasks of the formation of crystals. The authors, based on the main provisions of the special theory of relativity, attached the physical sense to the concept of time, using the basic provisions of the concept of time and space that allows establishing a link between the various points of space. With the help of the quasi Lorentz transformation in the Minkowski universe, the modelling of the process of formation of crystals of polymer compositions was carried out in a four-dimensional space, combining physical three-dimensional space of factors affecting their formation, and time. The modeling of the process of crystallization in a 4D space has an important role not only as a great informative and probative force, but also as a means of promoting a better understanding of the processes of crystallization, in evaluating and searching for the optimal management of this process. The research results are likely to have a wide range of applications in the analysis of scientific, technical, technological and other processes, evolving in space and time.

Keywords: formation of crystals, multidimensional space, the quasi Lorentz transformation; Minkowski universe.

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DEVELOPMENT OF A MATHEMATICAL MODEL OF MICROWAVE FILTER BASED ON THE PARTIALLY FILLED CROSS-SHAPED WAVEGUIDE-DIELECTRIC RESONATORS (p. 11-17)

Dovlet Mamedov, Alexander Yushchenko

A mathematical model of microwave filter based on the WDR, partially filled by height, set in the cut-off cross-shaped waveguide

was developed. The solution to the problem of the H_{10} wave scattering along the WDR chain was carried out by applying the GSM and partial regions methods. The obtained model makes it possible to consider an arbitrary number of waves not only in the regular, but also in the cut-off waveguide. Numerical algorithm was programmatically implemented and the convergence of calculations was studied, as a result of which we established that in order to ensure the error in the calculation less than 0.2 %, it was sufficient to consider 5–7 modes in the cut-off cross-shaped waveguide. A mathematical calculation of the one-tier filters designs and their comparison to the experimental prototypes was performed to establish the reliability of the developed model. An experimental study showed that the divergence between the calculated and measured frequencies did not exceed one percent that is the confirmation of the adequacy of the calculations, fulfilled on the basis of the developed model.

This model was implemented in the original method of intellectual synthesis and optimization of designs of multitier microwave filters, whose key idea consists in the logical analysis of the frequency response and the subsequent decision making about an evolutionary change in the design, which ensures its assigned form. The results of the study are planned to apply in designing a new model of microwave filter with resonators of different classes.

Keywords: microwave filter, waveguide dielectric resonators, cross-shaped waveguide, generalized scattering matrix.

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EFFECT OF THE STATE OF SURFACE LAYER ON 40X STEEL FATIGUE CHARACTERISTICS (p. 18-24)

Karyna Vakulenko, Iryna Kazak, Volodymyr Matsevityi

Cyclic testing of 40X structural steel with the implementation of the intermediate surface plastic deformation of the samples by the proposed special technique using the striker-ball tool is described. Changing the level of degradation of the material was determined by the coercive force method. The tests were carried out with the purpose to ascertain the possibility of increasing the durability of the material as the result of the surface treatment by reducing the concentration of accumulated fatigue defects.

The test results showed an increase of durability of steel from 3–5 up to 10 times or more (with larger amplitudes), accompanied by a decrease in the values of the coercive force, and the increase in the samples endurance limit by 20-40 MPa. The authors attributed this effect to healing of the material defects occurred as a result of surface treatment, and refinement of the surface layer structure and improving the level of compressive macrostrains on it which was established with the help of the X-ray method. The obtained results indicate the possibility of using this kind of surface treatment to heal defects in products which were in operation and the need to reduce the level of degradation of the metal in order to prolong their life.

Keywords: cyclic loading, surface plastic deformation, healing of defects, fine structure changes.

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DEVELOPMENT OF A STOCHASTIC MODEL OF FAILURE OF STRUCTURAL MATERIALS IN CREEP AT HARDENING STAGE (p. 25-31)

Ivan Doyar, Volodymyr Poshyvalov

The results of research of patterns of long-term failure of metals and alloys in isothermal creep considering all its stages are presented.

The approach to prediction of long-term strength characteristics of structural materials in isothermal creep under uniaxial steady load is proposed. This approach is original in the probabilistic interpretation of kinetic equations describing the creep, as well as a variety of failure criteria and their relative characteristics.

Using the experimental creep curves, the adequate stochastic model was constructed and the method of identification of unknown constants of the model was developed.

The calculations of basic probability characteristics of the time to failure on the example of experimental data for PA6 aluminum alloy specimens at various stress and temperatures levels were carried out.

According to the research, it is enough to use the quadratic dependencies as dependencies of distribution parameters of random variables a and b, as well as the parameters c and g on the stress and temperature. The choice of the type of dependencies of higher degrees has little impact on calculation results.

The proposed model can be used for prediction of the time to failure of various structural materials, as well as the development of methods, standards and guidelines in the field of reliability and durability assessment of structural materials.

Keywords: failure, isothermal creep, material damage, time to failure, probability distribution.

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RESEARCH OF STRUCTURE AND FORMATION OF NODULAR GRAPHITE INCLUSIONS IN DUCTILE CAST IRON (p. 31-36)

Valerii Ivanov, Valentina Pirozhkova, Valentin Lunev

A set of research of nodular graphite inclusions in ductile cast iron was carried out, including micrographic, X-ray and petrographic methods. Petrographic method has more possibilities and allows conducting research not only in the reflected but also in the transmitted light, to determine the structure and composition of graphite inclusions in the cases where other, even the most accurate methods, cannot apply.

Based on the metallographic, petrographic and X-ray research, we introduced a new mechanism of formation of nodular shaped graphite in ductile cast iron. It is due to the simultaneous formation of a gas bubble, supply channel and its base – the mouth – graphite with a cavity inside that form a single system. We identified three morphological varieties of graphite, formed during different periods of changes in the physical-chemical conditions of liquid cast iron: in the moment of interaction of magnesium with carbon monoxide – clear-cut hexagonal; during the period of disproportionation of carbon monoxide in the volume of the gas bubble – aggregates of crystals of various shapes; during the "tempering" of carbon monoxide – film (cryptocrystalline).

It was found that a full filling-up of the total volume of a gas bubble by graphite is carried out in three stages: the first two stages – by primary graphite, which deposits on the inner shell of the bubble, starting from the periphery to the centre, then it forms a nodular shape of graphite and the third and final – by secondary film graphite, distributed from the centre to the periphery.

The obtained results will make it possible to take into account the peculiarities of the formation of nodular shaped graphite inclusions when designing technological processes of obtaining castings for various purposes, to determine the values of modifying additives, and, ultimately, to control the morphology of graphite phase in ductile cast irons.

Keywords: nodular graphite, gas bubble, magnesium oxide, metallography, petrography, X-ray microanalysis.

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A STUDY OF SYNTHESIS AND PROPERTIES OF MANGANESE-CONTAINING OXIDE COATINGS ON ALLOY VT1-0 (p. 37-43)

Nikolay Sakhnenko, Maryna Ved, Ann Karakurkchi, Alexander Galak

The study has substantiated the choice of components of manganese-containing electrolytes and their rational concentrations as well as determined the current density range for one-step plasma electrolytic oxidation of the VT1-0 alloy. Oxidation with mixed oxides produced coatings of different compositions and surface morphology. It has been shown that control over the chemical and phase compositions of coatings, the surface topography, and the grain size as well as incorporation of manganese oxides into a coating can be achieved by varying the concentration of the electrolyte and the oxidation parameters.

Adding manganese sulfate to a pyrophosphate electrolyte has proved to be valuable for enhancing the content of the alloying component in the oxide layer and for reducing the concentrations of potassium and impurities. An increase in the current density of plasma electrolytic oxidation has been found to promote the formation of the oxide layer with a more developed surface area that is characterized by alternating torus-like inclusions and nanoporous sections.

By studying the distribution of the content elements throughout the thickness of the oxide coating, it has been determined that manganese is uniformly distributed in the surface layer, but phosphorus is mainly located at the oxide-solution interface.

It has been found that the synthesized mixed oxide coatings of manganese and titanium are highly resistant to abrasion. Incorporation of manganese has proved to reduce the grain size and improve the surface development, which facilitates catalytic activities in the oxidation reactions of carbon monoxide. The resulting materials can be used in process systems of catalytic purification.

Keywords: the VT1-0 alloy, plasma electrolytic oxidation, oxide coatings, manganese, catalytic activity.

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THE CHOICE OF THE OPTIMAL TEMPERATURE AND TIME PARAMETERS OF GAS NITRIDING OF STEEL (p. 44-50)

Dhafer Wadee Al-Rekaby, Viktoriia Kostyk, Kateryna Kostyk, Alexandr Glotka, Mykola Chechel

Mathematical modeling of the gas nitriding process allows solving the problems of control of process parameters, prediction of outcomes and development of various treatment conditions, which is quite an urgent issue today. The research was aimed at selecting the optimum temperature and time parameters of gas nitriding of 38Cr2MoAl steel. Optical and electron microscopy showed that the diffusion layer after gas nitriding in the ammonia environment is the nitrided case and the region of internal nitriding. The experimental data showed that the diffusion layer depth varies from 40 to 650 μm in the range of gas nitriding temperatures of 500 – 560 °C and time of 20–80 hours, while the surface hardness varies within 6.5–10 GPa. The mathematical models in the form of quadratic polynomials, describing the dependence of the depth of the nitrided case and the surface hardness on the temperature and time of gas nitriding were obtained. The mathematical description of the changes in the depth of the nitrided case and surface hardness depending on the changes in the treatment temperature and time, which allows determining the specific conditions of the gas nitriding (temperature and time) based on the desired depth of the diffusion layer or the surface hardness of 38Cr_2MoAl steel was constructed.

Keywords: thermochemical treatment, gas nitriding, diffusion layer depth, surface hardness.

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DEVELOPMENT OF THE ZINC COATING PIPE CONNECTION TECHNOLOGY WITH ARC SOLDERING METHOD USING (p. 50-54)

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The application of the arc brazing method for zinc-coated pipes joining with using the copper-based additives is suggested in this publication. This method is an alternative of the arc welding with minimal destruction of coating at the adjacent to the weld area, and it application has been analyzed and substantiated.

The microstructure and microhardness research of the zinc-coated low-carbon steel pipes with the diameter of 150 mm and wall thickness of 3.2 mm was made and research results are presented. The research results have shown that joint formation takes place due to a diffusive layer at the alloy line, and the connection strength depends on its sizes. It is revealed that magnification of the intermetallic phases volume concentration in the weld metal increases its strength.

It is found that the strength of the arc-welded pipe joints is affected by bevel edges. The connection with bevel edges has a greater strength with straight edges, as well as the contact area is increased with the base metal weld.

The arc brazing method can be recommended for zinc-coated pipes joining with using the CuAl8 wire and the bevel edge has to be made before arc brazing via research results. This method will provide the sufficient joints strength without the considerable zinc cover damage.

Keywords: joint, arc brazing, zinc coating, microstructure, microhardness, diffusion, weld joint, heat affected zone, strength.

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