

NATIONAL ACADEMY OF SCIENCES OF UKRAINE

H. V. KARPENKO PHYSICO-MECHANICAL INSTITUTE

# PHYSICOCHEMICAL MECHANICS OF MATERIALS

International Scientific-Technical Journal

Founded in January 1965

Published bimonthly

**VOLUME 42, № 5, 2006**

September – October

---

---

## CONTENTS

*Pokhmurskyi V. I., Kviatkovski L., Zin' I. M., Laion S. M., Bilyi L. M., and Ratushna M. B.* Corrosion protection of aluminium alloys by inhibiting pigments .....7

*SUMMARY.* Aluminum alloy corrosion inhibition by strontium chromate and phosphates of zinc and calcium with the use of electrochemical impedance spectroscopy and DC polarization was studied. It was established, that calcium hydrogen phosphate is perspective inhibiting pigment for organic protective coatings on aluminum/copper alloy. The alloy specimens have charge transfer resistance in the extract of  $\text{CaHPO}_4$  comparable with that of specimens in the extract of strontium chromate. The extract of calcium hydrogen phosphate simulates the behaviour of strontium chromate inhibitor, slowing down cathodic and anodic reactions on the aluminium alloy surface.

*Tkalenko D. A., Byk M. V., Harbuz V. M., and Vyshnevskaya Yu. P.* The influence of anion electrolyte composition on anodic ionization rate of non-passivated metals .....12

*SUMMARY.* It is shown that in relatively dilute acid solutions a maximum current of a diffusive nature is observed on the polarization curves of iron and its analogues. The value of such maximum current does not depend directly on pH of solution, but is related to the concentration of anions. The last circumstance formed the basis of the hypothesis that the maximum current is determined by the rate of delivery of anions, which take part in neutralization of metal cations positive charge to the electrode surface. The proposed hypothesis foresees the formation of such labile particles, as ionic pair or cation-anion complexes under anode dissolutions of iron.

When solving the problem about the order of metal ionization reaction by hydroxide ions in acid electrolytes it is necessary first of all to take into account, the fact that during investigation of electrode processes in such environments we deal with the corrosive system. It is necessary to take into account in the study of ionization process kinetic the fact that the measured anode current densities represent the rate of metal ionization not quite accurate, as they are in fact the sum of rates of two coupled reactions.

*Bairachnyi B. I., Smirnova O. L., and Tovkes V. V.* Anodic behaviour of stainless steel in sulfamate chloride electrolytes .....17

*SUMMARY.* The anodic behavior of 08X18H9T stainless steel in electrolyte solutions is investigated. It is established that the steel passive state, caused by the presence of the dense oxide film on its surface is violated in a solution containing sulfamate acid and chloride ions. Kinetics of the anodic process is investigated and the reactions, which take place in the process of stainless steel dissolution under anodic polarization, are described.

*Slobodian Z. V., Mahlatiuk L. A., and Nykyforchyn H. M.* Synergism realization in corrosion inhibitors 1, 2, 3 benzotriazol trimolybdate, tungstanate and chromate .....21

*SUMMARY.* Inhibition action of new compounds of 1, 2, 3 BTA trimolybdate, tungstanate and chromate is caused by intramolecular synergism, as a result the inhibition coefficient of corrosion rate of steel in water essentially exceeds a total inhibition coefficient of corrosion rate by compositions based on BTA and corresponding oxoanions. Compounds of 1, 2, 3 BTA trimolybdate, tungstanate and chromate are the inhibitors of mixed action, inhibiting both electrode reactions, moving the compromise potential to the less negative values. Impedance investigations and calculation of the

degree of surface packing by those compounds allows to assume, that their inhibiting effect is caused by chemisorption, described by the Frumkin–Tiomkin isotherm.

*Prytula A. O., Pohreliuk I. M., and Fedirko V. M.* Interaction of amorphous boron with titanium alloys in gas oxygen-containing environment .....30

*SUMMARY.* The influence of partial pressure of oxygen during diffusion saturation of titanium with boride phases (TiB, TiB<sub>2</sub>) formation at 900°C was investigated. The dependence of activity of saturating medium that includes powder-like amorphous boron and vacuum on partial oxygen pressure is found. Some physical characteristics of formed boride coatings are presented.

*Stashchuk M. H. and Malyk O. M.* Calculation of electron potential at a weld in NaCl solutions .....35

*SUMMARY.* The influence of residual stresses, caused by a weld, on the electrode potential in the welded construction element is evaluated. For semi-planes welded by a base weld such distribution was set by a correlation according to the Nikolaiev and Trochoun approach. It is shown that in the given scheme 12X1MΦ steel will be an anode, and a weld and X18H10T steel – a cathode.

*Shapovalov O. V., Shapovalova O. M., and Ivchenko T. I.* Corrosion and mechanical properties of titanium, alloyed with aluminium, iron and molybdenum .....41

*SUMMARY.* The influence of Fe, Al, Mo on corrosion and mechanical properties of titanium is established. It is shown that the iron reduces corrosion resistance of titanium in 3.5 times with the increase of iron concentration from 0.1 up to 5%. Microalloying with molybdenum of Ti–Al–Fe–Mo alloys hampers the process of corrosion. The low-alloyed structural and corrosion-resistant titanium Ti–Al–Fe–Mo alloys were developed. Their novelty is confirmed by the patents of Ukraine.

*Khoriev A. I.* Working out of titanium alloys by a complex alloying method .....45

*SUMMARY.* The influence of alloying on the mechanical properties of welded joints and base metal of Ti–Al–Mo–V–Cr–Fe titanium alloys has been investigated; theoretical aspects and principles of complex alloying of titanium alloys as well as the theory of adding materials alloying for welding of α-, (α+β)- and β-alloys have been formulated. It has been shown that structural (α+β)- (BT23) and β- (BT19) titanium alloys formed on the basis of the proposed theory provide high weight efficiency of modern aircraft vehicles constructions.

*Herasymchuk A. I., Mazurenko Ye. A., Vrochynskiy S. L., Medvediev O. M., and Moliar O. H.* Formation of technological protective coatings by chemical precipitation from a gaseous phase.....51

*SUMMARY.* The theoretical preconditions of a choice of thermal treatment modifiers, allowing the formation on metals nanometric and thin-film technological protective coatings (nanolayers) which give new properties to the products surface are proposed. Such a technological approach has just started to be applied, it is very perspective and does not need the significant changes in the existing technological schemes.

*Saldan I. V., Dubov Yu. H., Riabov O. B., and Zavalii I. Yu.* The influence of modification of the Ti<sub>2</sub>Ni alloy-based metal hydride electrodes on their discharging characteristics .....56

*SUMMARY.* A new computerized PGStat-8 device, which is assigned for testing in galvanostatic and potentiostatic conditions and also for study of the charge–discharge characteristics of MH electrodes based on Ti<sub>2</sub>Ni-type alloys has been developed. The influence of partial substitution of Ti→Zr,V and Ni→Co,Cu; oxygen modification; homogenizing annealing; polymer addition and metallic bonding on discharge capacity and cyclic stability of prepared MH electrodes has been shown.

*Bulyk I. I. and Trostianchyn A. M.* Structure of SmCo<sub>5</sub>-based alloy after disproportionation–recombination .....65

*SUMMARY.* Solid-HDDR in the KC37 alloy that contains SmCo<sub>5</sub> and SmCo<sub>3</sub> phases was studied at  $P_{H_2} \approx 4$  MPa and 1158 K by means of X-ray phase analysis, scanning electron microscopy and electron probe microanalysis. The alloy disproportionates in hydrogen into a mixture of samarium hydride and cobalt with a grains size of  $\leq 1$   $\mu$ m. The recombination results in the renewal of the initial phases with the formation of fine-grained structure of SmCo<sub>3</sub> phase and reduction of its amount. The alloy holding during recombination for 55 min leads to the formation of elongated grains of the structure.

*Nazarchuk Z. T., Teterko A. Ya., and Hutnyk V. I.* The analysis of the electromagnetic field disturbed by a subsurface crack in a semi-space .....69

*SUMMARY.* The electromagnetic field of the longitudinal crack in an electric conducting half-space has been investigated using the vigorous integral equation technique. The results of calculation of disturbed electric and magnetic disturbed field components have been presented for different locations of the crack.

*Filshynskiy L. A., and Abido A.* Harmonic oscillations of a layer excited by concentrated sources ....75

*SUMMARY.* Wave fields of displacements and stresses in the layer under its harmonic excitation by sources concentrated along a line have been determined. Components of field values have been represented in the form of series, which coefficients are expressed in the closed form in terms of the Hankel functions.

*Horechko N. O., and Kushnir R. M.* Calculation of nonstationary thermoelastic state of a tribosystem during breaking.....81

*SUMMARY.* An approach to determination of temperature fields and displacements in tribo-contact thermoelasticity problem has been proposed. It has been assumed that compressive load and translation velocity are time-varying, friction coefficient depends on temperature, non-ideal thermomechanical contact is observed at the interface.

## FROM THE HISTORY OF FRACTURE MECHANICS DEVELOPMENT

*Toth L. and Yarema S. Ya.* Formation of the science about metal fatigue. Part 1. 1825–1870 .....87

*SUMMARY.* Formation of the first stage (1830–1870) of the science on cyclic fatigue of metals, tightly connected with failures in railway transport, is presented. In the 30ies Franch engineers (J. B. Poncelet, A. Morin, et al.) described fatigue. However scientific researches started in the 40ies in England (W. J. Rankin, H. James, W. Fairbairn, J. E. Mac Connel et al.). Still the fundamental investigations were carried out in Germany by A. Wöhler. He developed a methodology and means (machines, equipment) for fatigue tests of railway carriage axles and specimens. He also introduced the fatigue limit and number of cycles before failure as the basic characteristics of metal resistance to fatigue. As a result of systematic investigations he obtained an extensive information about fatigue behaviour of metals and the influence of loading mode (bending, twisting, tension), stress ratio, notches, etc. on the specimens.

## SCIENCE FOR PRODUCTION

*Kuntyi O. I.* Silvering of magnesium by contact deposition in aqueous solutions and environment of dimethyl formamide (DMFA).....95

*SUMMARY.* The deposition of thin silver films on magnesium surface in solutions of silver complexes in water and organic aprotic solvents was investigated. It is shown, that the compact silver films with good adhesion are precipitated in aqueous solutions of cyanocomplexes  $[Ag(CN)_2]^-$  under hydrodynamic conditions. In the solutions of less stable complexes (thiocyanate  $[Ag(CNS)_4]^{3-}$ , thiocarbamide  $[Ag(thio)_4]^+$ ) there is a contact deposition of dispersed silver. In dimethylformamide solutions of complexes  $[Ag(CNS)_4]^{3-}$  a thin silver film with good adhesion to a magnesium surface is formed. The special features of the morphology of silver sediments, which are formed on the magnesium surface are observed.

<i>Neprila M. V., Gnyp I. P., and Lychkovskiy E. I.</i> Electrode for measuring ohmic and impedance characteristics of pipeline protective coatings.....	98
--	----

*SUMMARY.* A mobile electrode of original design for measuring ohmic and impedance characteristics of protective coatings on the pipes of diameter 27...1420 mm in laboratory, route and field conditions has been proposed. The electrode was calibrated on plane specimens with respect to measurement of the transient ohmic resistance by the method of “hollow cylinders”. The data of measurements of the transient ohmic resistance of identical coatings on plane specimens and pipes of different diameters, relative error values have been proposed. A good correlation between the investigation results has been shown. Owing to the original design of the working chamber and magnetospring hold-down device, the electrode can be used for investigation of inclined, wall and ceiling surfaces of steel structures. A conclusion was done about the expediency of the electrode introduction into the State Standard.

<i>Baseleva N. A.</i> The influence of oxalic acid on BT1-0 titanium corrosion in aqueous-ethylene glycol heat carrier .....	103
--	-----

*SUMMARY.* Regression-analytical and regression models are proposed. These models allow to calculate corrosion losses of BT1-0 titanium with time and also acceleration coefficients of corrosion in dependence on concentration of oxalic acid and temperature. It has been established that in 66% ethylene glycol solution the oxalic acid intensifies corrosion of BT1-0 titanium at concentrations higher than 0.1%, due to the process of formation of oxidation products of titanium with oxalate – ions, especially at high temperatures.

<i>Rabinovych O. V., Vakhrusheva V. S., Derhach T. O., Severina L. S., Puchykov A. V., Trehubenko H. N., Khoma M. S., Krutsan H. M., and Uzlov O. V.</i> Corrosion properties of rolled products made of new low-alloyed high-strength steels .....	108
---	-----

*SUMMARY.* All-round corrosion and corrosion-and-mechanical investigation of a new low-alloyed high-strength steels with carbonitride strengthening of  $\Gamma 2C$  and XC types has been carried out for the first time. It has been shown that in the tests for atmospheric corrosion, corrosion cracking, corrosion fatigue and in testing in alkaline and in a number of salt solutions the high-strength rolled products had corrosion resistance at the same or even higher level than the 09Г2Д steel rolled products commercially used in rail-way car building. Prospective use of the high-strength rolled products of the steel with carbonitride hardening in building of rail-road cars of a new generation to extend a car operation period with no repairs has been shown.

## SHORT REPORTS

<i>Kliakhina N. A., Terpii D. M., and Hru B. A.</i> Chemical resistance of tantalum boride films in sulphuric acid solution.....	113
--	-----

<i>Kuziukov A. N. and Levchenko V. A.</i> Local corrosion of titanium in organic synthesis environments .....	115
---	-----

## IN SCIENTIFIC CIRCLES

<i>Nazarchuk Z. T. and Nykyforchyn H. M.</i> Corrosion modeling to enable corrosion informed selection to life prediction.....	117
--	-----

<i>Chervinska N. R.</i> Problems of corrosion and corrosion protection of materials.....	120
--	-----

<i>Dmytrakh I. M. and Student O. Z.</i> The Sixteenth European Conference on Fracture, ECF-16 .....	122
---	-----

<i>Balytskyi O. I. and Marushchak N. O.</i> New ideas in studies on mechanical fatigue of metals? .....	127
---	-----

## JUBILEES

<b>Victor Fedirko</b> (to the 60 <sup>th</sup> birthday) .....	129
--	-----

OUR LOSSES

<b>Miller Keith</b> (an obituary notice) .....	130
<b>Mossakovsky Volodymyr</b> (an obituary notice) .....	131