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JPRS L/9855

17 July 1981

USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 3/81)



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CONTENTS

COMPOSITE MATERIALS

Interphase Phenomena in Polymers	1
Composite Sintered Antifriction Materials	5

MECHANICAL PROPERTIES

Properties of Construction Materials Versus Working Environment....	9
Strength of Construction Materials, Elements at Sound and Ultrasonic Frequencies	13

MISCELLANEOUS

Metals Requirements in Nation's Production	21
Oxycarbides and Oxynitrides of Metals of Subgroups IVA and VA.....	31
Healing of Defects in Metals	35

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COMPOSITE MATERIALS

INTERPHASE PHENOMENA IN POLYMERS

Kiev MEZHFAZNYYE YAVLENIYA V POLIMERAKH in Russian 1980 (signed to press 31 Oct 80)
pp 5-6, 258-259

[Foreword and table of contents from book "Interphase Phenomena in Polymers", by Yuriy Sergeevich Lipatov, Izdatel'stvo "Naukova dumka", 1700 copies, 260 pages]

[Text] Foreword

Interphase phenomena play a decisive role in the properties of polymer composite materials (filled and reinforced polymers, mixtures of polymers, etc.). The physical chemistry of surface phenomena in heterogeneous polymer systems is thus the theoretical basis for producing materials with the required combination of properties. This area of polymer physics and chemistry began to receive development relatively recently. The first attempt in world literature to generalize the problems of the physical chemistry of filled polymers was our monograph, published in 1967 (Yu.S. Lipatov, "Fiziko-khimiya napolnennykh polimerov" [Physical Chemistry of Filled Polymers], Kiev, Naukova dumka, 1967). Since then studies have appeared which generalize individual aspects of the theory of interphase phenomena in polymer systems, such as the adhesion of polymers (A.A. Berlin and V.Ye. Basin, "Osnovy adgezii polimerov" [Fundamentals of the Adhesion of Polymers], Moscow, Khimiya, 1974; A.D. Zimon, "Adgeziya zhidkosti i smachivaniye" [Adhesion of a Fluid and Wetting], Moscow, Khimiya, 1974; A.D. Zimon, "Adgeziya plenok i pokrytiy" [Adhesion of Films and Coatings], Moscow, Khimiya, 1977), wetting and spreading (B.D. Summ and Yu.V. Goryunov, "Fiziko-khimicheskiye osnovy smachivaniya i rastekaniya" [Physicochemical Fundamentals of Wetting and Spreading], Moscow, Khimiya, 1976), and compatibility and the properties of mixtures of polymers ("Mnogokomponentnyye polimernyye sistemy" [Multicomponent Polymer Systems], edited by R.F. Gold, Moscow, Khimiya, 1974).

The theory of interphase phenomena in polymer systems can be regarded as consisting of three basic parts--the theory of the adsorption and adhesion of polymers on hard surfaces, the structural and thermodynamic theory of the properties of polymers at the interface, and the theory of interphase phenomena in filled polymers and mixtures of polymers. A detailed analysis of the status of the theory of adsorption and of experimental data was given in the monograph by Yu.S. Lipatov and L.M. Sergeeva "Adsorbtsiya polimerov" [Adsorption of Polymers], Kiev, Naukova dumka, 1972. The generalization of data on the structure and physicochemical and relaxation properties of filled polymers and on the reinforcement mechanism was

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given in Yu.S. Lipatov's monograph "Fizicheskaya khimiya napolnennykh polimerov" [Physical Chemistry of Filled Polymers], Moscow, Khimiya, 1977.

The above determined the principle underlying the structure of the present monograph, which represents, as it were, the missing link in the discussion of the general theory of interphase phenomena in polymers begun in the two monographs mentioned. In this book a detailed discussion and a generalization are presented of the results of research in the area of the thermodynamics of interphase phenomena, including the surface and interphase tension of polymers and the thermodynamics of interphase interactions in mixtures of polymers and of studying the structure of boundary layers of polymers in relation to features of the processes of the adsorption of polymers at the interface. On this basis general theoretical ideas are developed regarding ways of controlling the structure and properties of polymer composite materials and regarding the role of interphase phenomena in the origin of various levels of heterogeneity in the systems discussed.

The basis of this monograph is the results of studies published in the literature over the last 6 or 7 years and the results of experimental research carried out in the author's laboratory. In discussing the general state of the problem, which is our basic purpose, at the same time in a number of instances we thought it necessary to elucidate in greater detail individual experimental results which seemed important to us for confirming the concepts developed by the author and his associates.

L.M. Sergeeva (ch 2), A.Ye. Faynerman (ch 5) and A.Ye. Nesterov (ch 6) took direct part in writing some chapters.

CONTENTS	Page
Foreword	5
Chapter 1. Present Status of the Theory of the Adsorption of Polymers on Hard Surfaces	7
1.1. Key traits of the adsorption of polymers from dilute solutions	8
1.2. Theoretical description of the conformational state of adsorbed chain molecules	11
1.2.1. The (Lala-Stepo) theory	12
1.2.2. The (Khuve) theory	17
1.2.3. Other theories	19
1.2.4. Adsorption isotherm of compact macromolecules	23
1.2.5. Use of machine experimentation methods for calculating conformations of adsorbed chains	26
1.3. Experimental estimate of the structure of the adsorbed layer	28
1.3.1. Hydrodynamic thickness of the adsorbed layer	28
1.3.2. Calorimetric methods	30
1.3.3. Spectral methods	32
1.3.4. Colloid chemistry methods	35
1.3.5. Conformations of adsorbed chains in absence of a solvent	36
Bibliography	38
Chapter 2. Adsorption of Polymers from Concentrated Solutions	42
2.1. Dependence on concentration of the solution of conformation of a chain in solutions in good and bad solvents	42

FOR OFFICIAL USE ONLY

2.2.	Formation of colloid-like structures in concentrated solutions of oligomers and polymers; direct measurements of dimensions of aggregates in connection with adsorption	43
2.3.	Features of adsorption from concentrated solutions in connection with structure formation	51
2.3.1.	Dependence of adsorption on the concentration and nature of the solvent and amount of adsorbent in the system	51
2.3.2.	Influence of temperature on adsorption	57
2.3.3.	Influence of molecular weight on adsorption	63
2.4.	Influence of structure formation on properties of adsorbed layers in adsorption from solutions of various concentrations	64
2.4.1.	Thickness of adsorbed layers	64
2.4.2.	Dependence on concentration of the solution of the percentage of adsorbed segments of polymer molecules	67
	Bibliography	71
	Chapter 3. Structure of Boundary Layers of Polymers on a Hard Surface	76
3.1.	Some features of the structure of adsorbed layers in connection with the aggregation mechanism for adsorption	76
3.2.	Structure of adsorbed layers from NMR data	83
3.3.	Conformations and packing of chains as a function of the distance from the surface	86
3.4.	Boundary layers of polymer mixtures	101
3.5.	Gradient of mechanical properties of boundary layers	104
	Bibliography	108
	Chapter 4. Features of Physicochemical Phenomena at a Polymer-Solid Phase Interface	110
4.1.	Features of physicochemical phenomena at a reinforcing filler - polymer phase interface	110
4.2.	Features of processes at the phase interface between high-surface-energy fillers and polymer binders	120
4.3.	Organic fiber - binder interface	123
4.4.	Influence of state of the surface on physicochemical properties of composites	126
	Bibliography	128
	Chapter 5. Surface and Interphase Tension of Polymers	131
5.1.	Definition of concepts	131
5.2.	Thermodynamics and statistics	135
5.3.	Surface tension of liquid polymers	137
5.4.	Surface tension of binary solutions of polymers	140
5.5.	Surface tension of solid polymers	159
5.6.1.	Determination of surface tension of solid polymers from boundary wetting angles	160
5.6.2.	Use of relationships established for fluids in estimating the surface tension of solid polymers	177
	Bibliography	181
	Chapter 6. Thermodynamics of Interaction in Mixtures of Polymers and Phase Separation	186
6.1.	Introduction	186
6.2.	Determination of parameters of χ_2 χ_3 interaction in mixtures of polymers	188
6.3.	Some features of the thermodynamic behavior of mixtures of polymers	193

FOR OFFICIAL USE ONLY

6.4. Thermodynamics of interaction in mixtures of polymer homologs	201
6.5. Thermodynamic theory of the interface between two incompatible polymers	205
Bibliography	209
Chapter 7. Interphase Phenomena in Mixtures of Polymers	211
7.1. Interphase layer in mixtures of polymers	212
7.2. Mechanism for formation of the transition layer [1-3]	214
7.3. Interphase layer in interpenetrating polymer lattices	215
7.4. Statistical theory of (Khelfand's) interphase boundary	219
7.5. Role of colloid chemistry factors in formation of the transition layer	224
7.6. Structure of interphase layers	228
7.7. Structural estimate of thickness of the interphase layer	238
Bibliography	242
Conclusion	245
Role of Interphase Phenomena in Origin of Heterogeneity of Polymer Systems	245
Bibliography	255

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8831

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COMPOSITE SINTERED ANTIFRICTION MATERIALS

Kiev KOMPOZITSIONNYE SPECHENNYE ANTIFRIKTSIONNYE MATERIALY in Russian 1980
(signed to press 30 Oct 80) pp 4-6, 402-403

[Annotation, foreword and table of contents from book "Composite Sintered Antifric-
tion Materials", by Ivan Mikhaylovich Fedorchenko and Liya Ivanovna Pugina,
Izdatel'stvo "Naukova dumka", 1600 copies, 404 pages]

[Text] In this monograph for the first time are generalized data on the properties,
composition and fabrication technology of the most extensive class of materials
for antifricion purposes which are fabricated by the power metallurgy method.
General information is presented on sintered antifricion materials intended for
bearings, packings and other friction parts working under conditions of supplying
a lubricant and without a lubricant, in air and under vacuum, when lubricating with
water, at elevated temperatures, at high speeds and under high pressure, in ag-
gressive and corrosive media. They are classified in terms of working conditions
and a description is given of the fabrication technology and of trends in the de-
velopment of work relating to the creation of materials with better utilization
characteristics.

Intended for scientific and engineering and technical personnel involved in develop-
ing, studying and testing antifricion materials, as well as for VUZ teachers and
students.

Foreword

The production of composite antifricion materials has become an individual branch
of industry in recent times. Their practical value and interest in them are growing
steadily, but extension of their application has been hindered by lack of the
required information on fabrication technology, composition, properties and areas
of application.

A monograph by V. Tsegel'skiy and V. Rutkovskiy titled "Spechennyye podshipniki"
[Sintered Bearings], which is already obsolete and, in addition, is nearly inacces-
sible to Soviet readers, was published in Poland in 1960. Collections including
articles on antifricion and friction materials, but not elucidating the problem as
a whole, appeared in Czechoslovakia in 1964 and in the USA in 1970.

A.D. Moshkov's monograph "Poristyye antifriktsionnyye materialy" [Porous Antifric-
tion Materials] was published in the USSR in 1968. In it are elucidated chiefly

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the utilization properties of some materials working in the presence of a lubricant.

In individual monographs on powder metallurgy (e.g., M.Yu. Bal'shin, "Poroshkovaya metallurgiya" [Powder Metallurgy], 1948; B.A. Borok and I.I. Ol'khov, "Poroshkovaya metallurgiya", 1948; V.D. Dzhons, "Fundamental'nyye osnovy poroshkovoy metallurgii" [Fundamental Principles of Powder Metallurgy], 1960; Ts.G. Gettsel', "Osnovy poroshkovoy metallurgii" [Fundamentals of Powder Metallurgy], 1950; Z. Ministr, "Detali mashin iz metallicheskih poroshkov" [Machine Parts Made from Metallic Powders], 1963) there are sections devoted to bearing materials, but they are limited in scope and do not reflect the most important results of research and development achieved in the last 15 to 20 years. Taking this into account, the authors decided to generalize their own results relating to the creation of composite antifriction materials and the published data. Based on an analysis of the status of the problem of sintered antifriction materials, they also attempted to formulate the key problems in this area and trends in the future development of these materials.

They have discussed the principles of the creation of composite sintered materials on the basis of modern ideas regarding the mechanism of friction and wear and of information obtained on the role of the individual components of antifriction materials and on their influence on physicomachanical and utilization properties. A demonstration is given of the dependence of characteristics on various technological factors and on the composition and working conditions of materials for various purposes. Their structure, properties, the key fabrication conditions and equipment employed, and areas of application are presented.

Materials have been classified by the authors according to a common trait and working conditions--with the presence of a lubricant and without a lubricant; with friction under vacuum and in water and aggressive media; at elevated temperatures and under increased loads, with elevated sliding speeds, and under other conditions.

An indication is given of the basic economic prerequisites for selecting materials with regard to prescribed conditions of utilization and when arranging for their production.

The authors hope that the systematic discussion of questions relating to the theory of the creation of composite antifriction materials, their fabrication technology, properties and areas of application will be of great assistance to the personnel of scientific and planning institutes and to product engineers of enterprises.

For the purpose of preserving the original data relating to a number of studies used in writing this book, units of measurement given in primary sources have been retained.

The authors wish to express their gratitude to V.S. Ageyeva, V.G. Dikiy, I.I. Beloborodov, L.V. Zabolotnyy, V.D. Zozula, A.F. Zhornyyak, L.F. Kolesnichenko, V.N. Paderno, V.V. Polotay, N.Ye. Ponomarenko, V.V. Pushkarev, I.G. Slys', A.I. Yuga, N.I. Katsavell and N.Z. Pozdnyak for assistance in the selection of data, for offering some of the research data, and for technical help in structuring the book.

FOR OFFICIAL USE ONLY

CONTENTS	Page
Foreword	5
Introduction	7
Chapter 1. General Information on Antifriction Materials and Their Working Conditions	
Requirements for materials of friction components	11
Classification of friction components in terms of working conditions and construction of bearings	12
Information on properties of composite antifriction materials and status of their production	17
Modern ideas regarding the mechanism of friction and the wear of materials under friction	26
Key trends in the development of antifriction materials fabricated by methods of powder metallurgy	38
Chapter 2. Key Factors Influencing the Properties of Antifriction Composite Materials	
Role of chemical composition in providing the properties of antifriction materials	42
Influence of grading of original powders on properties of friction materials	47
Influence of parameters of the microstructure and of porosity on the strength and antifriction properties of a material	52
Influence of external factors on the supporting power of antifriction materials	59
Factors influencing the value of the friction coefficient	63
Role of structure and the distribution of stresses in the working layer	66
Influence of technological factors of the fabrication of materials on their properties	68
Influence of the kind of treatment and the state of the surface of bearings on antifriction properties	74
Chapter 3. Selection of the Base Material for Antifriction Materials and of Methods of Influencing Its Physicomechanical Properties	
Classification of metals and alloys by their wear resistance	78
Selection of composition of the base and alloying elements	80
Factors influencing fatigue strength	91
Hardening antifriction materials by means of compaction	94
Strengthening the base material by means of reinforcement	99
Hardening materials by means of heat and chemical-and-heat treatment	102
Chapter 4. Role of Antifriction Additives and Their Interaction with the Material of the Base	
Influence of solid lubricants on supporting power and friction coefficient of composite materials	108
Lubricating capacity of graphite and its interaction with the metal of the base in sintering	119
Properties and behavior of sulfur and sulfides	128
Properties and behavior of selenides and tellurides	142
Fluorides as solid lubricants	145
Lubricating properties of lead and other low-melting metals	150
Properties of boron nitride as a solid lubricant	154
Oxides of metals as solid lubricants	156
Chapter 5. Technology of the Fabrication of Composite Antifriction Materials	

FOR OFFICIAL USE ONLY

Key requirements for the technology, and outlines of technological processes	159
Aspects of preparation of the starting raw material	162
Forming products	170
Sintering	178
Additional heat treatment	188
Chemical-and-heat treatment	191
Hot pressing and extrusion	200
Fabrication of antifriction materials on substrates with a metallic anti-friction layer	201
Antifriction plasma and electrolytic composite coatings	203
Technology for fabrication of metal-polymer composites	206
Mechanical treatment of surfaces	211
Addition of solid and liquid lubricants	225
Chapter 6. Main Types of Composite Antifriction Materials and Their Properties	
Materials based on copper	229
Materials based on iron	238
Materials based on nickel and cobalt	259
Materials based on aluminum and other light metals	265
Materials based on low-melting metals and compounds	269
Metal-graphite materials	274
Metallic two-layer materials utilizing a steel substrate	282
Materials of the matrix-filled type	286
Metal-glass materials	289
Basic types and properties of metal-polymer materials	292
Chapter 7. Special-Purpose Composite Antifriction Materials	
Materials for working in the presence of a fluid lubricant	300
Materials for friction without a lubricant in an air environment, under vacuum and in inert gases	311
Materials for working at elevated temperatures	320
Materials for working with high sliding speeds	328
Materials for working in water and corrosive media	333
Materials for a sliding current collector	339
Materials for end and radial seals	345
Materials for piston rings	354
Selection of bearing materials and economic efficiency of their use	358
Conclusion	365
Bibliography	366

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8831

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MECHANICAL PROPERTIES

PROPERTIES OF CONSTRUCTION MATERIALS VERSUS WORKING ENVIRONMENT

Kiev SVOYSTVA KONSTRUKTSIONNYKH MATERIALOV PRI VOZDEYSTVII RABOCHIKH SRED in Russian 1980 (signed to press 11 Dec 80) pp 2, 327-328

[Annotation and table of contents from book "Properties of Construction Materials Under the Influence of Working Environments", collection of scientific works, Izdatel'stvo "Naukova dumka", 1000 copies, 329 pages]

[Text] In this collection, prepared for the 70th birthday of the founder of a new line of science--the physicochemical mechanics of construction materials, Ukrainian SSR Academy of Sciences Academician G.V. Karpenko, are presented studies relating to research on the deformation and failure of construction materials taking into account real conditions of use, aimed at the development of the elements of the theory of processes of the interaction of working environments with deformable construction materials, at the development of effective methods of determining the stressed-strained state in a construction material with the short-duration and prolonged interaction of loads, elevated and reduced temperature and pressure and of working environments, and at the development of methods of improving the strength and durability of metals and alloys taking into account the influence of working environments.

Intended for scientific and engineering and technical personnel working on problems of the physicommechanical mechanics of materials.

CONTENTS	Page
Foreword	3
Maksimovich, G.G. "Brief Review of the Scientific Work of Ukrainian SSR Academy of Sciences Academician G.V. Karpenko (1910-1977)"	4
Interaction of Working Environments with Deformable Construction Materials	
Panasyuk, V.V. "Development of the Physicochemical Mechanics of Materials in the Works of G.V. Karpenko"	9
Kobzaruk, A.V. and Balatskiy, L.T. "Influence of the Form of the Cycle and the Frequency of Loading on the Short-Time Fatigue of Steel in Sea Water"	16

FOR OFFICIAL USE ONLY

Romaniv, O.N. and Nikiforchin, G.N. "Mechanisms of the Growth of Macrocracks in Steel Under the Influence of Static Loads and Working Environments"	32
Pokhmurskiy, V.I. and Matseyko, M.M. "Basic Mechanisms of the Influence of Stress Concentrators on the Fatigue and Corrosion-Fatigue Strength of Steel"	42
Popovich, V.V. and Dmukhovskaya, I.G. "Influence of Adsorption-Active Media on Mechanical Properties of Metals and Alloys"	47
Katsov, K.B. "Strength and Contact Tolerance of Steel in Adsorption-Active Media"	55
Pokhmurskiy, V.I., Kalakhan, O.S., Prishlyak, A.M., Yaremchenko, N.Ya., Oleksiv, B.Ya. and Frankiv, M.I. "Influence of Environment on Fatigue Strength of Titanium Alloys"	64
Yanchishin, F.P. "Influence of Active Media on Strength of Strained Metals Taking Into Account the Degree of Fineness of the Structure"	69
Preys, G.A. "Influence of Food Processing Technology Media on Failure of Rubbing Surfaces"	78
Prishlyak, A.M., Krizhanovskiy, Ye.I., Tarnavskiy, I.I. and Pelekh, V.G. "Failure of Threaded Connections of Loaded Drill Pipes"	82
Pavlina, V.S. and Astashkin, V.I. "Diffusion Saturation of a Solid in the Case of Commensurability of the Mass of the Solid and Container"	88
Zbozhnaya, O.M., Smiyana, O.D. and Borisov, Ye.V. "Distribution of Nonmetallic Elements of Saturable Metal When Producing Diffusion Coatings in a Medium of Liquid Metal Solutions"	91
Corrosion Cracking and Hydrogen Embrittlement	
Vasilenko, I.I. and Melekhov, R.K. "Polarization Factor in the Process of Corrosion Cracking of Metallic Materials in Solutions of Chlorides"	97
Petrov, L.N. "Physical Chemistry of the Reduction of the Chemical Resistance of a Metal Under Conditions of Corrosion Under Stress"	115
Dikiy, I.I. and Yurkiv, O.I. "Corrosion Cracking of Austenitic Steel in Solutions of Chlorides"	122
Vasil'yev, V.Yu., Isayev, N.I., Yakovlev, V.B. and Shumilov, V.N. "Nature of the Incubation Period of Corrosion Cracking Under Conditions of Local Anodic Activation"	132
Savchenkov, E.A. and Svetlichkin, A.F. "Durability and Hydrogen Embrittlement of Steel in Hydrogen Sulfide Cracking"	142

FOR OFFICIAL USE ONLY

Malyshv, V.N., Stepanov, I.A. and Troshchenko, V.N. "Relationship Between the Hydrogen Permeability and Corrosion-Mechanical Strength of Nickel-Chrome-Molybdenum Steel With Cathodic Polarization"	147
Gol'tsov, V.A. "Phenomenon of Controllable Hydrogen Precipitation Hardening of Metals and Alloys"	151
Nikitin, V.I. "Influence of the Water Heat Transfer Agent on Corrosion-Mechanical Strength of the Material of Steam Generators"	165
Kharitonov, L.N., Samsonovich, Ye.N. and Khaimov, R.M. "Comparative Features of the Fatigue Failure of 20GL and 20GFL Steel"	186
Timonin, V.A. and Baru, R.L. "Relationship of the Processes of Local Dissolution and Hydrogenation in Corrosion Cracking of Steel"	190
Physicochemical Methods of Strengthening Construction Materials	
Karlashov, A.V. "Questions Relating to Improving the Utilization Properties of Materials and Elements of Aircraft Structures and Ways of Implementing Them"	198
Medovar, B.I., Kusiitskiy, A.B. and Stupak, L.M. "Electroslag Refining--an Effective Means of Improving the Corrosion-Mechanical Strength of Metallic Materials"	214
Babey, Yu.I., Gurey, V.M. and Gusti, Ye.Ya. "Influence of Ordinary and Special Mechanical Treatment on the Serviceability of Steel and Cast Iron in Mild Surface-Active Media"	220
Soshko, A.I. "Physicochemical Mechanics of the Treatment of Solids Employing Polymer-Containing Lubricant-Coolants"	232
Shestopalov, V.Ye. "Some Kinetic and Thermodynamic Mechanisms for the Workability of Metals in Polymer-Containing Media"	239
Babey, Yu.I., Maksimishin, M.D. and Lyubitskiy, T.T. "Temperature Fields Originating in the Part-Tool Contact Zone in Friction Hardening Treatment"	247
Shatinskiy, V.F., Kopylov, V.I., Strongin, B.G., Varvus, I.A. and Fedorov, V.V. "Influence of Coatings and Their Dislocation Structure on Mechanical Properties and Internal Friction of Solids"	267
Lyuty, Ye.M. "Disintegration of Solid Solutions Based on Niobium"	276
Shatinskiy, V.F., Goykhman, M.S., Yatsenko, Yu.F. and Rybakov, S.V. "Investigation of the Process of the Formation and of the Air-Tightness of Contact Between Metallic Surfaces in Corrosive Media at Elevated Temperatures"	287
Yatsyuk, A.I. "Dependence of Quality Characteristics of Products on Method of Mechanical Treatment of the Surface"	293

FOR OFFICIAL USE ONLY

- Maksimovich, G.G., Lyutyy, Ye.M., Kudlak, S.M., Baranetskiy, V.S. and Yeliseyeva, O.I. "Apparatus for Testing Materials in Controllable Negative-Pressure Gas Flows at Elevated Temperatures" 307
- Maksimovich, G.G., Pichugun, A.T. and Fedirko, V.N. "Micromachine for High-Temperature Testing of Materials for Fatigue Under Vacuum and in Gas Media" 313
- Rudenko, V.P. "Scale Effect in Short-Time Fatigue of Steel in a Corrosive Environment" 318
- Kissil', A.Ye. and Lyutyy, Ye.M. "Reduction of the High-Temperature Strength of an Nb-Zr-C Alloy During Prolonged High-Temperature Aging Under Vacuum" 322

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8831

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STRENGTH OF CONSTRUCTION MATERIALS, ELEMENTS AT SOUND AND ULTRASONIC FREQUENCIES

Kiev PROCHNOST' MATERIALOV I ELEMENTOV KONSTRUKTSIY PRI ZVUKOVYKH I UL'TRAZVUKOVYKH CHASTOTAKH in Russian 1980 (signed to press 20 Feb 80) pp 2, 486-491

[Annotation and table of contents from book "Strength of Construction Materials and Elements at Sound and Ultrasonic Frequencies", collection of papers, Izdatel'stvo "Naukova dumka", 800 copies, 491 pages]

[Text] This collection contains the papers of the second all-Union seminar titled "Strength of Construction Materials and Elements at Sound and Ultrasonic Loading Frequencies" (Kiev, 1978). A discussion is presented of problems of fatigue strength at high loading frequencies, of the strength of construction materials and elements in strong acoustic fields, of the influence of sound and ultrasonic vibrations on the mechanical properties of materials, of the strength of acoustically active materials, of the development of new techniques for investigating the mechanical behavior of materials under conditions of high-frequency loading, and of the development of methods of calculating the elements of acoustic systems.

Intended for scientific and engineering and technical personnel interested in the influence of strong sound and ultrasonic vibrations on the mechanical properties and strength of construction materials and elements.

	Page
CONTENTS	
Foreword	3
I. Investigation of the Endurance of Materials as a Function of the Frequency of Cyclic Loading	
Kuz'menko, V.A. "Influence of Frequency of Cyclic Loading on Endurance of Construction Materials"	6
Borodachev, N.M. and Malashenkov, S.P. "Influence of Frequency of Cyclic Loading on Durability to the Formation of a Fatigue Macrocrack"	15
Gur'yev, A.V. "Influence of Loading Rate on Inelastic Behavior of a Material"	18

FOR OFFICIAL USE ONLY

Skalozub, S.L. "Use of One Model of the Buildup of Damage for Describing the Dependence of the Endurance of Materials on the Loading Frequency"	27
Vaynshtok, I.I., Yeregin, A.S., Rossel'son, B.S. and Khaskel'berg, G.I. "Forecasting the Endurance of Reinforcing Bar Steel and Welded Joints from the Results of Ultrasonic Tests Under Asymmetric Cyclic Loading"	31
Guslyakova, G.P., Sokolov, L.D. and Shibarov, V.V. "Influence of the Energy of a Stacking Fault on the Process of the Deformation of Some Metals with Various Cyclic Loading Frequencies"	37
Yevseyev, V.V. and Terebilo, G.I. "Thermal Model of the Fatigue Phenomenon"	40
Matokhnyuk, L.Ye. "Influence of Loading Frequency on the Fatigue Strength of Titanium Alloys"	48
Malashenkov, S.P. and Bengus, G.Yu. "On the Problem of Estimating the Fatigue Endurance of Construction Materials When Varying the Cyclic Loading Frequency"	56
Voynalovich, A.V., Matokhnyuk, L.Ye., Tabachnik, V.I. and Shvechikov, M.M. "Investigation of the Influence of Loading Frequency on the Effective Stress Concentration Coefficient in Models Made of Titanium Alloys VT20 and VT22"	62
Grishakov, S.V. and Shevchuk, A.D. "Endurance of Thermostable Steel on Long Cyclic Loading Bases"	67
II. Investigation of the Elasticity, Anelasticity and Fatigue of Materials at Sound and Ultrasonic Loading Frequencies	
Botvina, L.R. and Shabalina, V.N. "Kinetics of the Growth of a Fatigue Crack Under High-Frequency Loading"	73
Golovanev, Yu.M. and Matokhnyuk, L.Ye. "Investigation of the Rate of Propagation of a Fatigue Crack and of Endurance in Models Made of an Aluminum Alloy in a Strong Acoustic Field"	79
Golovin, S.A., Kuz'menko, V.A., Petrushin, G.D. and Pis'menny, N.N. "Investigation of the Anelastic Properties and Fatigue of Cast Iron with Graphite Inclusions of Various Forms"	84
Bozhko, A.Ye., Samokhvalov, V.Yu., Fedorov, A.I. and Shipillo, S.V. "Estimation of the Fatigue Resistance of Sheet Alloy AMg-5M Under Asymmetric Loading with Reference to a Diagram of Limiting Peak Values"	93
Voznyy, T.S. and Troyan, I.A. "Investigation of the Influence of an Asymmetric Cycle on the Endurance of Aluminum Alloys AK8 and AL4 Under High-Frequency Tension-Compression"	98
Vaynshtok, I.S. and Khaskel'berg, G.I. "Investigation of the Dissipation of Energy in Models of the Reinforcement of Ferroconcrete Structures and Its Welded Joints in the Process of Ultrasonic Fatigue Tests"	100

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Voyنالovich, A.V., Matokhnyuk, L.Ye., Minenko, A.M. and Fongae, V.L. "Endurance of 1Kh2M and Kh18N9 Steel Under High-Frequency Tension-Compression"	105
Apinis, R.P. "Investigation of Mechanisms for the Buildup of Fatigue Damage in Glass-Reinforced Plastic at an Acoustical Loading Frequency"	112
Skvortsova, N.V. "Investigation of the Dependence on Temperature of the Elastic and Anelastic Properties of Glass-Reinforced Plastics Based on Thermostable Binders"	118
Vasil'chenko, I.P., Malezhik, M.P. and Tutakov, O.V. "Investigation of the Elastic and Anelastic Properties of a Basalt-Reinforced Plastic"	127
III. Investigation of the Influence of High-Frequency Cyclic Straining on the Structure and Strength of Construction Materials	
Polotskiy, I.G. and Prokopenko, G.I. "Use of Ultrasonic Methods of Treatment for Increasing the Strength of Metals"	133
Goryushin, V.V., Krivko, V.P., Prokopenko, G.I. and Svechikov, V.L. "Influence of Ultrasonic Shock Treatment on the Structure and Properties of the Surface Layers of Iron and Some Steel"	137
Glavatskaya, N.I., Golub, T.V. and Polotskiy, I.G. "Influence of High-Frequency Cyclic Straining on the Structure and Microhardness of Copper-Iron Alloys in the Hardened and Aged State"	141
Polotskiy, I.G., Belostotskiy, V.F. and Nikitova, G.A. "Mechanical Properties and Kinetics of the Ordering of an Ni-Cr Alloy Prestrained at an Ultrasonic Frequency"	146
Bazelyuk, G.Ya., Kovpak, V.I., Matsiyevskaya, S.Ya. and Polotskiy, I.G. "Influence of Preliminary Ultrasonic Irradiation on the Microstructure and High-Temperature Creep of Alloy AK4-1"	150
Beletskiy, V.M., Polotskiy, I.G., Prokopenko, G.I. and Tabachnik, V.I. "Fatigue Characteristics of a Titanium Alloy Subjected to Surface Hardening"	156
Gringauz, F.M. and Dubinin, V.V. "Investigation of the Fatigue Endurance of Models Made of Alloy AK4-1T1 After Preloading in an Acoustic Field"	161
Voznyy, T.S. "Endurance of Construction Materials Under Repeated Static Loading with the Application of Vibrations"	167
Katina, L.V., Kortnev, A.A. and Makarov, V.K. "Critical Velocity of a Cavitation Shock in Failure of a Solid Surface in the Process of Exposure to Ultrasound"	172

FOR OFFICIAL USE ONLY

Bord, V.I. and Dovgyallo, I.G. "Change in the Strength and Ductility Characteristics of Metals and Alloys with Different Straining Rates in an Ultrasonic Field"	176
Trushko, V.P. "Investigation of the Ultimate Strength of Alloy 42NKhTYuA After Drawing with Ultrasonic Vibrations"	184
Kuz'menko, V.A., Tsimbalisty, Ya.I. and Yurchenko, B.I. "Influence of High-Frequency Cyclic Loading on Relaxation of Mean Stresses and Creep in 1Kh2M Steel"	186
IV. Investigation of the Strength of Piezoelectric Ceramics and Other Acoustically Active Materials	
Gavrilyachenko, V.G., Dantsiger, A.Ya., Doroshenko, V.A., Zhitomirskiy, G.A., Pikalev, M.M., Revenko, L.G. and Fesenko, Ye.G. "Problem of Improving the Fatigue Strength of Piezoelectric Ceramic Materials"	194
Klevtsov, A.N., Prokopalo, O.I., Rayevskiy, I.P. and Reznichenko, L.A. "High-Strength Ferropiezoelectric Ceramic Materials Based on Niobates of Alkali Metals"	199
Grineva, L.D., Zatsarinnyy, V.P. and Panich, A.Ye. "Influence of Modifiers on the Mechanical Strength of Multicomponent Piezoelectric Ceramics"	202
Kirillov, V.I. and Pavlov, P.A. "Principles of a Phenomenological Description of Processes of Delayed Fracture of Brittle Materials"	206
Gots, O.M., Kirillov, V.I., Mezhevitinov, Yu.P. and Pakhomova, A.A. "Procedure for Processing Experimental Data on the Longterm Static and Fatigue Strength of Piezoelectric Ceramic Elements"	212
Kirillov, V.I., Potikha, L.Z. and Salomakhin, V.G. "Investigation of the Fatigue Strength of Piezoelectric Ceramic Models"	218
Kuz'menko, V.A. and Pisarenko, G.G. "Endurance of Piezoelectric Ceramics Under Cyclic Tension-Compression at a High Frequency"	223
Gerikhanov, A.K., Golyamina, I.P., Ugryumova, M.A. and Chushko, V.M. "Investigation of the Fatigue Strength of Piezoelectric Ceramics of the TsTsNSN Composition"	234
Gaaza, N.Ye. and Koshchakova, N.P. "Influence of Thermal Parameters of Piezoelectric Elements on Their Fatigue Endurance"	238
Barchukov, V.K., Kochetygov, V.V., Kholopov, V.S. and Shtukarev, Yu.A. "Investigation of the Strength of Cylindrical Piezoelectric Ceramic Elements"	242
Paragova, L.M., Solokhin, N.V. and Tsvetyanskiy, V.L. "Investigation of the Failure Characteristics of Piezoelectric Ceramics Under Cyclic Tension-Compression"	246

FOR OFFICIAL USE ONLY

Solokhin, N.V. and Tsvetyanskiy, V.L. "Relationship Between Internal Friction and Fracture Toughness of Piezoelectric Ceramics"	251
Bondarenko, A.A., Karas', N.I. and Ulitko, A.F. "Piezoelectric Losses in Elements of Structures Made of Piezoelectric Ceramics"	254
Karlash, V.L. "On the Investigation of Dynamic Stresses in Thin Piezoelectric Ceramic Elements Under Strong Electrical Excitation"	257
Gerikhanov, A.K., Golyamina, I.P., Pisarenko, G.G., Khlopotunova, N.A. and Chashina, T.N. "Influence of Glass-Forming Additives on the Fatigue Strength of Magnetostriction Ferrites"	264
Gerikhanov, A.K. and Chushko, V.M. "Experimental Investigation of the Amplitude Dependences of the Dissipation of Energy in Acoustically Active Materials"	268
Ganeva, L.I., Gerikhanov, A.K. and Golyamina, I.P. "Influence of the Method of Making Models and of a Permanent Magnetic Field on the Fatigue Strength of Magnetostriction Materials"	273
V. Investigation of the Strength of Elements of Structures Under the Effect of High-Frequency Cyclic Loads	
Viter, P.A. "Improving the Reliability of Aircraft Long-Life Gas Turbine Engines in Terms of the Fatigue Strength Criterion"	279
Moskalenko, A.I., Serebrennikov, G.Z., Sulima, A.M. and Fedorov, L.A. "Investigation of the Fatigue Strength of Gas Turbine Engine Parts at High Sound Frequencies"	280
Borisova, Ye.A., Voynalovich, A.V., Matokhnyuk, L.Ye., Minenko, A.M. and Shvechikov, M.M. "Fatigue Strength of Welded Elements Made of Alloys VT20 and VT5-1 Under High-Frequency Bending"	285
Chernyak, B.Ya., Isayev, A.I., Khalmurzayev, Kh. and Shevchuk, A.D. "Investigation of the Endurance of Titanium Fasteners at Ultrasonic Frequencies"	289
Belov, I.I., Belova, L.M., Vrachev, A.V., Yevdokimov, B.I., Neronov, A.A. and Rochevov, M.V. "Investigation of the Sonic Endurance of an Airframe in Plant Test Cells"	297
Sidorov, O.T. "Employing Damping of Component Structural Elements for Hastening Estimation of Their Fatigue Endurance"	299
Sidorov, O.T. and Rakshin, A.F. "Investigation of Damping Mechanisms in Elements of Structures with Bolted Connections in the Process of Fatigue Test Runs"	305

FOR OFFICIAL USE ONLY

Gryaznov, B.A., Gorodetskiy, S.S., Rudenko, V.N. and Rovkov, V.A. "Investigation of the Fatigue Strength of Alloy AK-6 Taking into Account the Influence of the Technology for Fabricating Real Parts"	312
Balalayev, Yu.F., Astredinov, M.I., Kholodnyy, V.I. and Meshkov, N.K. "Influence of the Medium and Metallic Coatings on the Strength of Materials Under the Effect of High-Frequency Vibrations"	321
Kuznechik, T.I., Tyavlovskiy, M.D. and Chupilko, V.A. "Investigation of the Endurance of Structural Elements Made of Microwire Under Cyclic Loading"	325
Alefirenko, V.M., Stoler, V.A., Tyavlovskiy, M.D. and Faotovets, Ye.P. "Investigation of the Vibration Strength of Joined Construction Elements"	331
Davydov, G.V. "Strength of Electrode Leads of Semiconductor Devices and Integrated Circuits Under a Strong Acoustic Influence"	336
VI. Development of Methods of Calculating Elements of Acoustic Systems	
Bogomolov, S.I. and Simson, E.A. "Some Problems in Optimizing Waveguides"	341
Kvitka, V.Ye. "Calculation Method for Determining Acoustic Loads in Jet Aircraft"	358
Koshevoy, V.V. and Soroka, S.A. "Acoustic Tests as an Analog of the Holo- graphic Process"	363
Trapezon, A.G. "On Analysis of the Stressed and Strained State of Models for Fatigue Tests Under Simple Bending"	369
Martynenko, M.D. and Dovgyallo, I.G. "Calculation of Longitudinally Vibrat- ing Multistage Rods"	374
Pel'ts, S.P. and Tsvetyanskiy, V.L. "Investigation of the Stressed-Strained State of a Rod-Plate System Under Vibration"	379
Barvinskiy, A.F. and Kalynyak, N.I. "Asymptotic Method of Investigating the Transverse Vibrations of a Beam with a Temperature Field Nonuniform Along Its Axis, Taking into Account the Dissipation of Energy in the Mater- ial"	384
Voytsekhovskiy, N.I. and Grigor'yev, Ye.T. "Estimation of the Fatigue Strength of Models and Elastic Structures Taking into Account the Loading Frequency"	389
Troyan, I.A., Tsimbalisty, Ya.I. and Shevchuk, A.D. "Opportunities for Reducing Thermal Stresses in High-Frequency Straining"	395
Burak, Ya.I., Galapats, B.P. and Kondrat, V.F. "Mechanothermoelectrical Phenomena in Conducting Solids Under Cyclic Loading in an External Magnetic Field"	400

FOR OFFICIAL USE ONLY

FOR OFFICIAL USE ONLY

- Allaverdiyev, A.M. and Kuliyeu, Yu.N. "Calculation of the Stressed State of a Piezoelectric Ceramic Ring and Disk During Alternating Electrical Excitation" 405
- Kovalev, S.P., Pisarenko, G.G. and Chushko, V.M. "Calculation of the Stressed State of Piezoelectric Ceramic Rods Under Vibration" 412
- VII. Development of Methods of Experimental Investigation of the Mechanical Properties of Materials and Elements of Structures Under Conditions of High-Frequency Vibration
- Vasinyuk, I.M. and Kruk, B.Z. "Apparatus for Testing for Fatigue Under Programmed Loading" 420
- Voloshchenko, A.P., Grishko, V.G., Gryaznov, B.A., Zhurbenko, V.V., Konoplyannikov, Ye.G., Onishchenko, A.D., Rovkov, V.A., Troshchenko, V.T., Fedorov, Yu.N. and Fot, N.A. "Automated Bench for Testing Gas Turbine Engine Blades for Endurance" 425
- Skvortsova, N.V. "Procedure for Vibration Testing of Construction Materials Under Rapid Heating to High Temperatures" 430
- Boreymagorskaya, L.A., Navarenko, A.F. and Samoilenko, V.V. "Hydrodynamic Emitting System for Investigating the Strength of Materials Under Conditions of the Effect of Cyclic Loads" 436
- Zhabko, N.I. "Influence on Endurance of Residual Stresses and Strains Caused by Cyclic Elastoplastic Bending" 438
- Lezvinskaya, L.M., Muravin, G.B. and Finkel', V.M. "Investigation by the Method of Acoustic Emission of the Energy Flux Density Field at the Apex of a Normal Fracture Crack" 449
- Tripalin, A.S., Buylo, S.I. and Kholodnyy, V.I. "Problem of the Correlation Between the Formation and Growth of a Fatigue Crack in Models Made of High-Strength Steel and Acoustic Emission Parameters" 456
- Grishakov, S.V., Kuz'menko, V.A. and Pisarenko, G.G. "Employment of Acoustic Emission for Investigating the Fatigue of Piezoelectric Ceramics" 458
- Grishakov, S.V. and Kolmogorov, V.N. "Question of Using the Method of Harmonic Analysis of Ultrasound for Investigating the Fatigue of Materials" 461
- Vyshemirskiy, A.V., Obychev, N.M. and Sofinskiy, B.A. "Experimental Methods of Investigating Vibrations of Elements of Electronic Device Constructions by Employing Lasers" 465
- Drobinskiy, V.S., Radin, N.N. and Shevchuk, A.D. "Instrument for Measuring Amplitude of Vibrations" 470
- Lyashko, F.Ye., Khalmurzayev, Kh. and Chernyak, B.Ya. "System for Recording Amplitude of Vibrations in Testing Metals at Ultrasonic Frequencies" 472

FOR OFFICIAL USE ONLY

Vyboyshchik, M.A., Itkis, Yu.A. and Krishtal, M.A. "Apparatus for Determining the Elastic Modulus and Internal Friction of Models in the Process of Long-Duration Cyclic Loading" 476

Voytenko, A.F. "Method of Investigating the Temperature Dependence of the Elastic Moduli of Metals with the Automatic Recording of Measurement Results" 480

Lysenko, M.V., Pustovalov, G.A. and Sabayev, A.S. "Apparatus for Measuring the Speed and Coefficient of Absorption of Ultrasound in Polymer Materials" 482

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MISCELLANEOUS

METALS REQUIREMENTS IN NATION'S PRODUCTION

Moscow VOPROSY EKONOMIKI in Russian No 3, Mar 81 pp 82-90

[Article by L. Zusman: "Metals Requirements of Societal Production"]

[Text] A materials-conserving type of development is one of the principal directions of technological progress in the material production sectors. A special role in this connection is played by metal, which is a universal object of labor and serves as a material foundation of implements of labor, means of transportation, and structural materials.

The enormous importance of metal enables one to consider the metalloyemkost' [metals requirements, metals-intensiveness] indicator as one of the most important characteristics of technological advance. It characterizes not only a decrease in the weight of counterpart machinery and equipment, structures and transfer devices per unit of their principal technical parameter (output, lifting capacity, accommodation capacity, speed, etc), but also progressive structural changes in utilized structural materials and created fixed assets.

Excessive metal content of transport vehicles and equipment, as well as moving parts in stationary equipment, which amount to not less than one third of the metal by weight contained in all machinery, equipment and transport vehicles, determines additional ongoing outlays during their entire service life. Additional outlays are also due to the necessity of placing bearers and bedplates under stationary machinery and equipment, crane tracks and supporting columns. In addition, it is necessary to use repair parts which weigh more than necessary in minor repairs and major overhauls as a result of increased metal content of fixed assets. Therefore decreasing metal requirements makes it possible to achieve savings not only in metal but also in ongoing expenditures as well.

A study of correlation factors for the period 1961-1962 between growth in this country's metals fund volume and growth in volume of gross societal product indicated that this factor is 0.72, growth of generated national income -- 0.77, and growth in national wealth -- 0.89. Thus the level of metal requirements of societal production, national income and national wealth is reflected fairly faithfully in the relationship with change in the country's metals fund volume.

Resources of ferrous metals hold back growth and development of machine building and to some extent construction as well. Therefore the CPSU Central Committee and USSR Council of Ministers decree of 12 July 1979 states the necessity of drafting

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programs for achieving savings in fuel and metal as one of the priority tasks for the immediate future.

Metal requirements are determined by the pace of growth and development of the metal-consuming branches and sectors, their structure and average level of production metals intensiveness, that is, consumption of metals per unit of output capacity of manufactured machinery and equipment, per cubic meter of erected buildings and structures, per kilometer of rail line, etc. The dynamics of metals intensiveness of fixed assets characterize the direction and intensity of change in this indicator, which is of great importance for future planning of metals requirements in conformity with the targeted growth in fixed assets and structural changes in fixed assets.

Average metals content in the fixed assets of the national economy has been as follows (in tons per million rubles of value of fixed assets, in constant prices): in 1960 -- 1,043.3 (100%); in 1965 -- 1,016.2 (96.8%); in 1970 -- 996.3 (95.0%); in 1975 -- 940.1 (89.6%); in 1978 -- 916.9 (87.4%). Consequently, during the period 1961-1978 the average level of metal content of fixed assets of the national economy declined by 12.6%, which secured a metal savings of 125 million tons for this period. The decrease was achieved as a result of an approximately 8% improvement in the quality and mix of metal products.

The above calculated figures on change in the average level of metal content in the fixed assets of the national economy for 1961-1978 apply to the overall volume of utilized fixed assets. These changes are due chiefly to movement on-stream of new fixed assets, and partially to retirement of fixed assets. Since the volume of fixed assets increased 3.86-fold in the period 1961-1978, the above figures on change in the average level of metal content in respect to new fixed assets coming on-stream should be increased correspondingly by approximately one fourth. Thus the decline in the level of average metal content of fixed assets of the national economy brought on-stream during this period was approximately 15 percent.

In the period 1961-1978 the percentage share of cast iron and steel in consumption of all categories of ferrous metals and castings declined from 22.3 to 17%. Replacement of iron castings with welded structures of sheet steel reduces the weight of structures by 25-30 percent. The principal cause of decrease in the percentage share of iron castings is change in the machinery and equipment product list, and in part machine casting of steel in place of using ingot molds. Therefore the decrease in the metal content of the comparable group of machinery and plumbing fixtures is estimated at 1.0-1.5 million tons, which represents 1.0-1.5 percent of total consumption of all types of ferrous metals and castings.

There occurred in 1961-1978 an intensive process of replacement of steel structures with reinforced concrete structures. Production of precast reinforced concrete structures and components increased from 30.2 million cubic meters in 1961 to 123.2 million cubic meters in 1978, or fourfold. Consumption of metal in reinforced concrete structures in 1978 totaled approximately 15 million tons, as compared with 5 million tons in 1961, while the percentage share of metal in reinforced concrete structures in overall consumption of metal in the construction industry increased from 37 to 52 percent. In 1978 the quantity of metal structures employed in the construction industry was up 96 percent over 1975, while the corresponding increase

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for precast reinforced concrete and concrete structures and components was 130 percent. In the estimate of VNIIZhelezobeton [All-Union Scientific Research Institute of Industrial Technology of Precast Reinforced Concrete Structures and Components], as of the beginning of 1976 reinforced concrete structures and components for the construction industry contained approximately 150 million tons of metal (37-40 percent of the total volume of metal in buildings, other structures, and transfer equipment).

In connection with metal savings achieved by replacing metal structures and components with reinforced concrete (according to the estimate of VNIIZhelezobeton, 28 percent on the average), the decrease in metal content of buildings, structures and transfer equipment in 1978, in comparison with 1961, comprised approximately 3.6 percent of total consumption of metal in the national economy, including approximately 13 percent for buildings, structures, and transfer equipment.

In the period 1961-1975 not more than 1.0 percent of ferrous metals were replaced by plastics in the machine building industry. In the construction industry plastics were used in the manufacture of pipe, plumbing fixtures and accessories. This replacement of ferrous metals by plastics made it possible to save in the period 1961-1978 only 0.4 percent of total metals consumption. Thus the decrease in metal content of fixed assets in connection with change in the structure of structural materials is estimated at approximately 4 percent.

Change in the level of average metal content of fixed assets is influenced by the branch and category reproduction structure of fixed assets, since this indicator varies considerably among individual branches and sectors of the national economy, industry and transportation. An increase in the percentage share of fixed productive assets, with fixed assets of industry the main contributor, with a decrease in the percentage share of nonproduction fixed assets, constitutes an important factor in an increase in the average metal content of the fixed assets of the national economy as a whole. As of 1 January 1972, for example, the amount of metal by weight per million rubles of replacement value of fixed assets was as follows: 1,203 tons in industry; 600 tons in agriculture (including livestock), and 755 tons excluding livestock; 1,492 tons in transportation (including roads, road construction and maintenance); 538 tons in communications; 1,490 tons in the construction industry; 600 tons in municipal and domestic services; 314 tons in housing; 460 tons in other nonproduction assets. Consequently, metal content in fixed assets varies by almost fivefold between the different branches and sectors of the economy. As calculations show, differences in the branch/sector structure of fixed assets in 1978, in comparison with 1960, influenced an increase in their average metal content (by 4.5 percent).

In the period 1961-1978 there occurred significant changes in the percentage shares of individual branches in total industrial output: the percentage share of the chemical and petrochemical industry, machine building, metalworking, and electric power engineering increased, with a decrease in the percentage share of the other branches of industry. These changes resulted in a 3.6 percent increase in the average metal requirements of industrial output in 1978 in comparison with 1960.

Change in the category structure of fixed assets among the branches and sectors of the national economy can substantially affect the average metal content of fixed

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assets in each branch/sector, since the level of metal content varies substantially among the various categories of fixed assets. According to figures as of 1 January 1972, for example, the average metal content of buildings, structures and transfer equipment per million rubles value was 893 tons in industry, 1,265 tons in power machines and equipment, 1,417 tons in working machines and equipment, 2,063 tons in means of transportation, 416 tons in measuring and controlling instruments, devices and laboratory equipment, and 2,100 tons in tools, auxiliary maintenance and production accessories. In the last 20 years there has been a decrease in the percentage share of buildings, structures, and transfer equipment, power machines and equipment, with an increase in the percentage share of working machines and equipment. Modification of the category structure of fixed assets of industry helped increase the average metal content of industrial fixed assets by 0.9 percent.

There has also been a change in the structure of production (freight turnover) and productive fixed assets of mainline transportation: the percentage share of rail hauls in the total volume of all freight hauls declined from 79.8 percent in 1960 to 57.6 percent in 1978; river cargo traffic -- from 5.3 to 4.1 percent; for marine cargo there was an increase from 7.0 to 13.9 percent, motor transport -- from 5.2 to 6.6 percent, oil and refined products pipeline transport -- from 2.7 to 17.6 percent. There was a significant increase in the percentage share of natural gas pipelines transport -- volume of conveyance of merchantable natural gas in 1978 reached 351.1 billion cubic meters, as compared with 112.3 billion in 1965.

At the same time level of metal content (metal quantity by weight in fixed assets per billion ton/kilometers of freight hauled) is as follows: 33,000 tons for rail transport; 14,350 tons for maritime transport; 47,900 tons for river transport; 12,400 tons for common-carrier motor transport; 19,700 tons for oil pipeline transport. These changes in the subbranch structure of transport production (services) in 1978 as compared with 1960 led to a drop in the average level of metal content of production by 4.4 percent.

Thus the following factors influenced change in the level of metal content of the fixed assets of the national economy in the period 1961-1978 (as percentages of 1960):

Improvement in metal products quality and mix	-8.0
Improvement in the structure of structural materials	-4.0
Change in the sector/branch structure of the national economy	+4.5
Change in the branch structure of industry	+3.6
Change in the branch structure of transportation	-4.4
Change in the category structure of fixed productive assets:	
industry	+0.9
agriculture	+50.0
average	+7.0
Increase in the unit output of machinery and equipment	-10.0
Other factors (improvement in designs and performance of machinery and equipment, reduction in weight of construction industry structures, etc)	-4.4
Total decrease in metal content	-15.0

Consequently, in spite of a number of objective factors which influence a 15.1 percent rise in the level of the metals content of fixed assets of the national

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economy, in the final analysis a decrease of approximately 15 percent in the metal content of fixed assets over the period 1961-1978 was achieved.

Corresponding to each period in this country's economic development was a correlation between growth of fixed assets and aggregate volume of metal content in these fixed assets (metals fund), gross societal product, and national income.

In the period 1929-1940 growth of gross societal product and generated national income was averaging twice the rate of increase of fixed productive assets. This was achieved due to an increase in the average annual work force from 11.4 million persons in 1928 to 33.9 million in 1940, including an increase to 25.6 million in the sphere of material production, as well as an increase in labor productivity in all sectors of material production, including a 3.1-fold growth in industry, 1.7-fold in agriculture, 2.7-fold in rail transportation, and 2.5-fold in the construction industry.

A substantial growth in the employed work force during this period was achieved by drawing into societal production new contingents of the able-bodied population and freed labor resources in agriculture. In 1940, in comparison with 1928, the average metal content of fixed productive assets had increased by 58 percent as a result of an increase in the percentage share of industry. In connection with this, the metal content of gross societal product and national income declined by only 16 and 26 percent respectively.

In 1965 gross societal product increased 3.5-fold over 1950, while the increase in generated national income was 3.6-fold, fixed productive assets of all sectors of the economy was 4.0-fold, employed work force -- 1.9-fold, and societal labor productivity -- 3.1-fold. During this period growth in gross societal product and national income began to fall behind the increase in fixed productive assets, and their output-capital ratio increased by 11-14 percent. An industrial output growth of 68 percent was achieved by improved labor productivity in the Fifth Five-Year Plan, 72 percent in the Sixth Five-Year Plan, and 62 percent in the Seventh Five-Year Plan. Nevertheless, in order to ensure the achieved production volume growth in 1965 in comparison with 1950, it was necessary to bring on-stream fixed productive assets exceeding in growth rate the gross societal product and generated national income. However, average metal content of fixed productive assets brought on-stream during this period declined an average of 25 percent in comparison with the extensive employment of high-strength low-alloy steel and reinforced concrete structures and components in place of metal structures, as well as branch structural changes. As a result of this, the metal content of gross societal product and generated national income declined by 15 and 18 percent respectively.

In 1975 gross societal product was up 94 percent over 1965, generated national income was up 91 percent, and fixed productive assets were up 124 percent, that is, there is continuing a growth in the output-capital ratio of gross societal product and national income. In contrast to the preceding period, however, the metal content of fixed productive assets declined by only 9 percent, as a result of which the metal content of gross societal product and generated national income increased by 5-6 percent.

Labor productivity growth in the Eighth Five-Year Plan accounted for 73 percent of total industrial output growth, and 84 percent in the Ninth Five-Year Plan.

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Nevertheless, in order to ensure an increase in output volume in 1975 in comparison with 1965, it was necessary to bring on-stream productive assets exceeding gross societal product and generated national income in rate of growth. This increase was approximately 15-17 percent in the period 1966-1975 as compared with 10-14 percent in 1951-1965. In 1976-1978 gross societal product volume increased by 15 percent in comparison with 1975, with a 15.9 percent increase in national income, while volume of fixed productive assets rose 25 percent, that is, growth of the output-capital ratio of gross societal product and national income continued.

As regards total volume of gross societal product, there is observed a trend toward an increase in the percentage share of industry, transportation and communications, trade, procurements and supply, with a decline in the percentage share of agriculture.

In 1978 1.32 billion rubles of gross societal product in industry was generated per billion rubles of fixed assets value, while in agriculture the figure was 0.89 billion rubles (average for 1976-1978), 0.21 billion in transportation and communications, 2.07 billion rubles in construction, and 1.17 billion rubles in the remaining sectors of material production. It is evident from the above figures that change in the sector distribution of gross societal product fostered an increase in its volume. A lag in growth of gross societal product behind growth in volume of the metals fund in the sectors of material production is due chiefly to an increase in the output-capital ratio in the sectors of material production. For example (in comparable 1973 prices), industrial output volume in 1978 increased by 250 percent over 1975, with a 285 percent growth in fixed productive assets, while during this period gross output volume in agriculture increased by 44 percent, with a 2.7-fold growth in fixed assets, freight turnover volume increased by 2.14 percent, while volume of fixed assets in transportation and communications increased by 151 percent, volume of completed construction and installation work in the construction industry increased by 130 percent, and volume of fixed assets by 300 percent. Thus in 1978, in comparison with 1965, the output-capital ratio was up 14 percent in industry, and had increased 6.1-fold in agriculture, 17 percent in transportation and communications, and by more than 70 percent in the construction industry. We should note that actual growth in the metal content of gross societal product in the period 1966-1978 was considerably less than increase in the output-capital ratio.

Metals fund volume growth in the sectors of material production outstripped increase in generated national income: in 1965 this figure was 9.1 percent above the 1960 figure, 10.7 percent in 1975, and 12.2 percent in 1978. A certain influence on increase in the metal content of generated national income was exerted by changes in its sector structure: the percentage share of industry declined from 51.7 percent in 1965 to 51.2 percent in 1978, in agriculture from 22.5 to 17.4 percent, while in transportation and communications it increased from 5.9 to 6.3 percent, from 9.2 to 10.9 percent in the construction industry, and from 10.7 to 14.4 percent in trade, procurements, supply, etc. At the same time in 1978 generated national income per ruble of value of fixed assets was as follows: 0.451 ruble in industry, 0.349 in agriculture, 0.124 in transportation and communications, 0.950 in the construction industry, and 1.030 rubles in other sectors of material production.

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Change in the sector structure of generated national income in 1978 in comparison with 1965 led to a 3.4 percent decrease in its volume in relation to fixed productive assets and to a corresponding rise in the average level of metal content. In addition there was a substantial increase in the output-capital ratio of generated national income. For industry it rose from 1.87 to 2.13 rubles (by 15.9 percent), for agriculture from 1.77 to 2.86 rubles (by 61.5 percent), for transportation and communications from 7.24 to 7.69 rubles (by 6.2 percent), for the construction industry from 0.67 to 0.904 ruble (by 35.0 percent), while in other sectors of material production it declined from 1 to 0.95 ruble (by 5.0 percent). On the average the output-capital ratio in 1978 was 22.5 percent higher than in 1965.

An increase in the output-capital ratio of generated national income is observed in all sectors of material production and is the most substantial in agriculture and the construction industry in connection with their rapid rate of industrialization and is accompanied by an increase in labor productivity and economic effectiveness of capital investment for the adoption of new equipment.

The increase in metal content of generated national income lags substantially behind the increase in its output-capital ratio. For example, with an increase in the output-capital ratio of national income in 1977 of 22.5 percent over 1965, metal content increased by only 11.4 percent. Thus the level of metal content in fixed productive assets declined on the average.

One observes a trend toward a decrease in specific consumption of raw materials, fuel, electric power and auxiliary materials. Conversion over from steam to electric and diesel motive power on the railroads produced an approximately 30 percent savings in fuel, replacement of metal with reinforced concrete structures promoted savings of metal, and increasing the unit output of turbines with an increase in steam pressure made it possible to reduce fuel consumption at public power generating plants from 645 grams per kilowatt hour in 1940 to 415 in 1965 and 331 in 1978, that is, a reduction almost in half.

These achievements fostered change in sector proportions. With a 66 percent increase in industrial output volume in 1978 over 1970, for example, production volume in the extractive industry increased by only 35 percent (38 percent in mining and 69 percent in processing).

Tougher environmental protection standards, improvement in working conditions, worker health, services and cultural activities, as well as economical utilization of natural resources proceed from the social tasks of the developed socialist society. At the same time this promotes increased productivity of societal labor, decreased corrosion of metal structures of machinery, equipment and buildings, and conservation of water resources. Consequently these measures increase the efficiency of the economy.

Standards established in 1954 were in effect up to the beginning of the 1960's. Facilities were constructed and brought on-stream up to the middle of the 1960's on the basis of these standards, taking into account a certain construction lag in project execution. Standards documents were revised in 1962-1968, and some were modified in 1970-1972. Fixed assets were designed and brought on-stream on the

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basis of these standards from the mid-1960's. Analysis of standards documents specifying working conditions and air pollution standards indicates that in the last 10-15 years requirements have become considerably tougher, resulting in substantial additional capital spending. In the standards adopted in 1971, for example, the number of pollutants for which a maximum allowable concentration was specified increased to 114 as compared with 37 according to the 1953 standards (when maximum allowable concentrations were first established). For 10 substances (of the 37 covered by the 1963 standards) maximum allowable concentrations were cut by 50-67 percent, in particular for harmful gases, fumes and dust in the air of work areas.*

Minimum production space was increased from 4 to 4.5 square meters and space per employee was increased from 13 to 15 square meters, which increased the cost of construction of production buildings by 12.5-15.5 percent. The floor height of administrative buildings increased from 3 to 3.3 meters, and to 4.2 meters in a number of instances.

In ferrous metallurgy expenditures on air and water antipollution measures, improvement of working conditions and other expenditures dictated by application of the new standards, rules and specifications increased specific capital spending in 1966-1970 by approximately 5-6 percent, and in 1971-1975 by 10 percent over the preceding five-year plan.** Thus social measures in the area of capital construction also contributed to an increase in the output-to-capital ratio and consequently the metal content of gross societal product and generated national income.

The level and dynamics of average metal content of the national wealth of the USSR are determined by the ratio of the volume of the nation's metals fund to the volume of national wealth at the end of a given period and are expressed in millions of tons of metal per billion rubles of national wealth. In 1960 this indicator was 765.4 million tons per billion rubles, 663.1 in 1965, 639.5 in 1970, 603.4 in 1975, and 590.7 million tons per billion rubles in 1978, that is, one can observe a steady drop in the average level of metal content in the national wealth of the USSR, due primarily to a steady drop in the level of metal content of fixed assets, which comprise approximately two thirds of its total value. In 1960 there were 3.47 billion rubles of national wealth per billion rubles of national income, and 5.49 billion in 1975, that is, 58 percent more than in 1960, and 5.7 billion rubles in 1978, which attests to the existence of considerable potential for achieving more intensive growth of national income on the basis of reducing the metal content of societal production.

L. I. Brezhnev noted in his Report at the 26th CPSU Congress: "In the new five-year plan large amounts are being allocated for growth and development of the metallurgical industry, both ferrous and nonferrous metals. We of course will be bringing new metallurgical industry facilities on-line. But there also exists

* See "Narodnoye khozyaystvo SSSR v 1978 g." [USSR National Economy in 1978], a statistical yearbook, Izdatel'stvo Statistika, 1979, pp 116-117.

** See P. A. Shirayev and V. A. Shtanskiy: "Effektivnost' kapital'nykh vlozheniy v chernoy metallurgii" [Effectiveness of Capital Spending in Ferrous Metallurgy], Izdatel'stvo Metallurgiya, 1977, pp 200-201.

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another way to overcome the metals shortage -- more intelligent and fuller utilization of what is produced.

"Cutting waste and losses in the metalworking industry merely in half would be equivalent to a 10 percent increase in production of finished rolled ferrous metals. There is a considerable reserve potential in cutting waste in the metallurgical industry proper, as well as metal losses caused by corrosion. And imagine the savings on a national scale to be achieved by reducing the weight of machine tools and equipment, improving the quality of metal and metal products or, for example, expanding the production of metal substitutes. There is plenty in this area for our scientists, designers and efficiency innovators to tackle. Of course all this also requires money, efforts, and a certain amount of time. But in much smaller amounts than for an endless increase in metal production."

As calculations indicate, in the 11th Five-Year Plan, with a targeted growth of capital spending of 12-15 percent over the actual volume of capital spending in the 10th Five-Year Plan and a decrease in the relative magnitude of uncompleted construction in the national economy to the specified level, the volume of fixed assets brought on-stream increases by 17-20 percent; with an increase of 13.6-16.5 percent in production of finished rolled product in 1985 over 1980 and a 17-20 percent increase in fixed assets brought on-stream, the level of their metal content will decline by 3.0-6.0 percent. With an 18-20 percent growth in national income during the 11th Five-Year Plan, almost as large a relative increase in volume of gross societal product is projected, which with a 13.6-16.5 percent increase in production of finished rolled product can generate a 1.5-5.0 percent decrease in the level of metal content in the increased volume. According to our calculations, the increase in national wealth during the 11th Five-Year Plan is projected at 650 billion rubles, that is, a 25 percent increase, with a projected 6-8 percent decrease in the level of the metal content of the volume increase.

Achievement of the targets specified by the "Principal Directions of Economic and Social Development of the USSR in 1981-1985 and in the Period up to 1990" will improve proportions between increase in volume of metal consumption and the principal national economy growth indices, and will ensure a decline in metal content. The most important conditions for this are, first of all, achievement of the targeted proportions between growth in output of rolled ferrous metals and increase in the above-examined national economic indices and, secondly, improvement in the quality and variety of metal products, as well as growth and development of metal-consuming branches -- machine building and construction -- in progressive directions.

Many Soviet-built machines operate at lower speeds, have lower output, are less reliable and less durable than their foreign counterparts, which predetermines their greater specific metal content. This is due to the fact that machines are not updated over an extended period of time, and many models become obsolete. In spite of the fact that approximately 1,500 units of machinery, equipment and instruments of obsolete design have been retired each year in recent years, the rate of replacement of machine building products cannot be considered adequate.

As a rule machinery and equipment become obsolete 8-10 years after first going into production. Therefore accelerated updating of machine building products is essential. There should be intensification of work in the area of revising the

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machinery product mix, especially series-produced machinery, on the basis of more modern designs and utilization of advanced technology and new materials. The structure of machine building production will be improved in 1981-1985, with products boasting greater output and smaller metals requirements.

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OXYCARBIDES AND OXYNITRIDES OF METALS OF SUBGROUPS IVA AND VA

Moscow OKSIKARBIDY I OKSINITRIDY METALLOV IVA I VA PODGRUPP in Russian 1981
(signed to press 3 Dec 80) pp 2-4, 143-144

[Annotation, foreword and table of contents from book "Oxycarbides and Oxynitrides of Metals of Subgroups IVA and VA", by Stanislav Ivanovich Alyamovskiy, Yuriy Galiulovich Zaynulin and Cennadiy Petrovich Shveykin, Izdatel'stvo "Nauka", 1000 copies, 144 pages]

[Text] In this monograph are given the results of investigations of oxycarbides and oxynitrides of metals of subgroups IVA and VA: data on the conditions for their formation, regions of homogeneity, concentration dependences of lattice constants and of the extent of occupation of the lattice, coefficients of thermal expansion, IR absorption spectra, methods of identifying these compounds and the influence of high pressure and temperatures on the properties of high-melting compounds.

This monograph is intended for scientific and engineering and technical personnel involved in physicochemical investigations of high-melting compounds and problems of solid state physical chemistry.

Foreword

Compounds of transition metals of subgroups IVA and VA belonging to interstitial phases occupy an especially important place in research relating to the development of new materials. This is explained by the fact that many interstitial phases are distinguished by refractoriness, heat resistance, high hardness, and also specific electrical and magnetic characteristics, they possess the properties both of metals and of covalent crystals, and the majority of them have broad regions of homogeneity. This makes it possible to alter their characteristics over a rather considerable range while preserving the same, often relatively simple (of the NaCl cubic type), structure. Therefore interstitial phases are exceptionally convenient subjects for theoretical research.

Whereas primarily binary compounds of metals of subgroups IVA and VA were the subject of study previously, at the present time increasingly greater attention is being paid to three-component phases. Of course, oxycarbides, oxynitrides and carbonitrides (MC_xO_y , MN_zO_v , MC_xN_z) can be formed both in the carbothermal production of the respective metals and in the production of their carbides, nitrides and lower oxides. Therefore, for more deliberate control of processes making it

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possible to produce specific products of the required purity and composition, it is necessary to accumulate data on oxycarbides, oxynitrides and carbonitrides. Besides, the synthesis of three-component phases is usually carried out under less rigid conditions than that of two-component. In connection with this the question arises of the advisability in a number of instances of replacing carbides, nitrides and oxides with oxycarbides, oxynitrides and carbonitrides.

Three-component interstitial phases are interesting in the scientific respect. On the one hand this is due to the development of the theory of phases of variable composition in connection with the presence in the unit cell of many three-component compounds of structural vacancies in both sublattices. On the other hand, the study of oxycarbides and oxynitrides of metals of subgroups IVA and VA (especially with a relatively simple crystal structure) is necessary in order to explain the mechanisms for alteration of the chemical bond in them on account of introduction of the second component and the nature of its influence on the energy spectrum of the electrons of the original carbides, nitrides and oxides. Especially as sufficiently reliable data on these binary compounds have been obtained in the last decade.

In the book "Soyedineniya peremennogo sostava" [Compounds of Variable Composition], edited by B.F. Ormont and published in 1968, in chapter six are generalized data on oxycarbides and carbonitrides of metals of subgroups IVA and VA obtained chiefly from 1940-1960. In the present publication are presented the results mainly of research performed at the USSR Academy of Sciences Ural Science Center Institute of Chemistry beginning in the 1970's and concerning primarily oxygen-containing compounds--oxycarbides and oxynitrides of Ti, Zr, Hf, V, Nb and Ta.

In the first two chapters data are presented on formation conditions, regions of homogeneity and key structural and certain other physicochemical characteristics of oxycarbides and oxynitrides of metals of subgroups IVA and VA, primarily with a cubic (of the NaCl type) structure. In the third chapter certain general mechanisms are discussed which are characteristic of the phases of the system $M^{IV}, V-C-N-O$. This relates, in particular, to the concentration regions of their existence, dependences of lattice constants on composition, features caused by the defect structure of interstitial phases, etc. Generalized data are presented on the coefficients of thermal expansion of three-component interstitial phases and features of their IR spectra. The fourth chapter is devoted to the influence of high pressure and temperatures on the characteristics of high-melting compounds and to their discussion from the viewpoint of the theory of virtual compounds.

CONTENTS	Page
Foreword	3
Chapter 1. Oxycarbides	5
Oxycarbides of Titanium	7
Region of homogeneity of an oxycarbide of titanium at 1500 °C	8
Concentration dependences of lattice constants of an oxycarbide of titanium	9
Degree of occupation of the unit cell of an oxycarbide of titanium with a cubic (of the NaCl type) structure	13
Oxycarbides of Zirconium	17
Possibility of the existence and stabilization of zirconium monoxide	17
Solid solutions of carbon and oxygen in alpha-zirconium	21

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Region of homogeneity of an oxycarbide of zirconium with a cubic (NaCl type) structure at 1700 °C	24
Influence of pressure of the gas phase on region of homogeneity of an oxycarbide of zirconium	27
Concentration dependences of lattice constants of an oxycarbide of zirconium with a cubic (NaCl type) structure and of the degree of its occupation	29
Oxycarbides of Hafnium	32
Region of homogeneity of an oxycarbide of hafnium with a cubic (NaCl type) structure at 1900 °C	32
Concentration dependences of lattice constants of an oxycarbide of hafnium and of the degree of its completeness	34
Oxycarbides of Vanadium	35
Concentration regions of the stability of an oxycarbide of vanadium with a cubic (NaCl type) structure	35
Concentration dependences of lattice constants of an oxycarbide of vanadium	38
Degree of completeness of the crystal lattice of an oxycarbide of vanadium	40
Oxycarbides of Niobium	43
Conditions for the formation of oxycarbides of niobium with a cubic and hexagonal structure	43
Identification of oxycarbides of niobium	48
Concentration regions of the single-phasesness of oxycarbides of niobium	49
Oxycarbides of Tantalum	50
Some characteristics of an oxycarbide of tantalum with a hexagonal structure	50
Possibility of forming an oxycarbide of tantalum with a cubic (NaCl type) structure	53
Chapter 2. Oxynitrides	58
Oxynitrides of Titanium	58
Regions of homogeneity and dependence of lattice constants of an oxynitride of titanium with a cubic structure on composition	58
Degree of occupation of the unit cell of an oxynitride of titanium with a cubic (NaCl type) structure	63
Possibility of forming an oxynitride of titanium based on Ti_2O_3	64
Oxynitrides of Zirconium	64
Region of homogeneity of an oxynitride of zirconium with a cubic (NaCl type) structure at 1500 °C	65
Dependence of lattice constant of an oxynitride of zirconium and degree of its occupation on composition	67
Study of redistribution of charges in certain interstitial phases with a cubic (NaCl type) structure based on zirconium, by the x-ray electronic method	68
Oxynitrides of Hafnium and Vanadium	70
Region of homogeneity of an oxynitride of hafnium with a cubic (NaCl type) structure at 1500 °C	70
Degree of completeness of the lattice of an oxynitride of hafnium and the concentration dependence of its constant	72
Concentration region of stability, constants and degree of completeness of the lattice of an oxynitride of vanadium with a cubic (NaCl type) structure	72
Oxynitrides of Niobium and Tantalum	75

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Chapter 3. Some Features of the Phase Components of $M^{IV}, V-C-N-O$ Systems	77
Conditions for formation of oxycarbides, oxynitrides and carbonitrides of metals of subgroups IVA and VA	77
Concentration dependences of lattice constants of interstitial phases with a cubic (NaCl type) structure based on metals of subgroups IVA and VA	81
Structural features of binary and three-component interstitial phases of $M^{IV}, V-C-N-O$ systems	87
Structural mechanism for introduction of oxygen into the crystal lattice of titanium carbide	92
Possibility of realizing a structurally nonuniform structure in phases of $M^{IV}, V-C-N-O$ systems	96
Coefficients of thermal expansion of oxycarbides, oxynitrides and carbonitrides of metals of subgroups IVA and VA	99
IR absorption spectra of some binary and ternary phases of $M^{IV}, V-C-N-O$ systems	105
Chapter 4. Transformations in High-Melting Compounds Caused by High Pressure and Temperatures	111
Carbides	111
Nitrides	117
Monoxides	118
Oxycarbides and oxynitrides	123
Regarding the actuality of the existence of virtual compounds	124
Conclusion	129
Bibliography	131

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8831

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HEALING OF DEFECTS IN METALS

Kiev ZALECHIVANIYE DEFEKTOV V METALLAKH in Russian 1980 (signed to press 20 Oct 80)
pp 4-6, 278-279

[Annotation, table of Contents and preface from book "Healing Defects in Metals",
by Leonid Nikandrovich Larikov, Izdatel'stvo 'Naukova dumka', 1,700 copies, 280 pages]

[Text] This monograph discusses the present status of the problem of healing micro- and macrodefects in metals. The author examines the principal types of defects of crystalline structure and various classifications of the processes of their healing. Modern theoretical concepts on the mechanism and kinetics of these processes are presented, and the author discusses the nature of the influence of type of crystal lattice, energy of packing defects, impurities, pressure and other factors on the kinetics of healing, and describes basic experimental results obtained from an investigation of the processes of healing of defects occurring as a result of deformation, irradiation, quenching, phase transformations, and diffusion saturation. The author discusses application of controlled healing of defects as a method of obtaining a desired structure and properties of metal products.

This monograph is intended for scientific workers, graduate students, engineers, and upper-division undergraduates specializing in the field of physics of metals.

	Contents	Page
Preface		5
Chapter 1. Description of Processes of Healing of Defects		7
1. Defects of Metals		7
2. Classification of the Processes of Healing of Defects		19
3. Methods of Identifying Defects and the Processes of Their Healing		24
Chapter 2. Mechanism and Kinetics of Healing of Defects		64
1. Recovery		64
2. Polygonization		76
3. Recovery With Rotation		82
4. Recrystallization		91
5. Healing of Body Defects		119

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Chapter 3. Influence of Various Factors on Healing of Defects	133
1. Type of Crystal Lattice and Energy of Packing Defects	133
2. Impurities	137
3. External Conditions	142
Chapter 4. Healing of Defects in Deformed Metals	152
1. Dynamic Healing of Defects During Deformation	152
2. Healing of Defects Following Deformation	158
3. Secondary Deformation During Relaxation of Internal Stresses	186
Chapter 5. Change in Defect Structure of Metals Strain Hardened by Different Methods	188
1. Irradiation	188
2. Surface Alloying	200
3. Quenching From High Temperatures	207
4. Phase Transformations	211
Chapter 6. Controlled Healing of Defects as a Method of Obtaining Desired Structure and Properties	217
1. Growing Single Crystals and Their Preservation During Working	217
2. Obtaining Fine-Grained Structure of Polycrystals	223
3. Obtaining Isotropic and Anisotropic Materials	226
4. Increasing Productivity of Machinery Pressure Shaping Metals	232
5. Welding of Metals in Solid Phase	236
6. Increasing Heat Resistance	246
7. Increasing Structural Strength of Metal Products	252
Bibliography	260

Preface

Natural metals and alloys contain various defects -- disarrangement of the regular crystalline structure -- which substantially influence their properties. The healing of defects which takes place during working of metals or in the process of their utilization at elevated temperatures is of considerable practical significance.

The physical essence of such processes has been the object of intensive investigation since the establishment of physics of metals as a scientific discipline. Early publications, including the literature of the 1950's, were synthesized in surveys [1-4]. In the 1960's the volume of publications on various aspects of healing of defects in metals increased sharply. The increased interest in these processes is also attested to by the holding of specialized scientific conferences in the USSR [5, 6], the United States [7, 8], France [9], Austria [10], and the GDR [11]. Monographs were published dealing with the metallographic and technical aspects of the processes of recovery and recrystallization [12-16]. Processes of healing were also examined to some extent at conferences dealing with defects in crystalline structure [17-29].

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Synthesis of the large volume of publications which have appeared in the last decade is made difficult not only by the quite substantial volume of factual material but also a lack of unanimity of views on many key questions.

This monograph examines the mechanism and kinetics of the physical processes of healing of micro- and macrodefects in metals and alloys. The question of the influence of type of crystal lattice on the contribution of various physical processes toward formation of the aggregate of properties of metals and alloys is restated.

The first chapter examines the principal types of defects in crystalline structure of metals and various classifications of the processes of their healing. A brief description of the physical principles on which methods of identifying defects are based is presented.

Chapter 2 presents modern theoretical concepts on the mechanism and kinetics of the processes of healing of point, linear, surface and body defects in metal crystals.

Chapter 3 discusses the physical nature of the influence of type of crystal lattice, energy of packing defects, impurities, pressure and other factors on the processes of healing of defects in metals.

Healing of defects in deformed metals is examined in Chapter 4. Particular attention is devoted to dynamic recovery and recrystallization in the course of plastic deformation.

Chapter 5 discusses data obtained in an experimental study of the healing of defects occurring as a result of irradiation, quenching, phase transformations, and diffusion saturation.

Chapter 6 deals with applied aspects of the problem. Controlled healing of defects is viewed as a method of obtaining the desired structure and properties of metals in working them.

The range of questions examined in the monograph is not exhaustive. In particular, healing of macrodefects during sintering of powders is not discussed. The author did not consider this advisable in view of the availability of a large number of publications on this subject.

The contents of this monograph are based to a substantial degree on theoretical and experimental research conducted at the Ukrainian SSR Academy of Sciences Institute of Physics of Metals. The author would like to express his thanks to the persons who took part in this research, especially candidates of physics and mathematical sciences S. T. Borimskaya and N. V. Dubovitskaya, who in addition were extremely helpful in preparing the manuscript for this volume.

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