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USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 3/81)

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CONTENTS

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 Sergeyevich 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. Sergeyeva "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 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. Sergeyeva (ch 2), A.Ye. Faynerman (ch 5) and A.Ye. Nesterov (ch 6) took direct part in writing some chapters.

CONTENTS

8831
CSO: 1842/115

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COMPOSITE SINTERED ANTIFRICTION MATERIALS

Kiev KOMPOZITSIONNYYE SPECHENNYYE ANTIFRIKTSIONNYYE 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 Antifriction 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 antifriction purposes which are fabricated by the power metallurgy method. General information is presented on sintered antifriction 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 aggressive 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 development of work relating to the creation of materials with better utilization characteristics.

Intended for scientific and engineering and technical personnel involved in developing, studying and testing antifriction materials, as well as for VUZ teachers and students.

Foreword

The production of composite antifriction 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 inaccessible to Soviet readers, was published in Poland in 1960. Collections including articles on antifriction 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 Antifriction Materials] was published in the USSR in 1968. In it are elucidated chiefly 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 metallicheskikh 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 physicomechanical 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. Zhornyak, L.F. Kolesnichenko, V.N. Paderno, V.V. Polotay, N.Ye. Ponomarenko, V.V. Pushkarev, I.G. Slys', A.I. Yuga, N.I. Katsaveli 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.

CONTENTS

8831
CSO: 1842/117

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 physicomechanical mechanics of materials.

CONTENTS

8831
CSO: 1842/116

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.

CONTENTS

8831
CSO: 1842/118

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 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 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 the 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 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 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.

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 contruction 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.

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 13.9 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 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

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* 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. Shiryayev 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.

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 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.

3024
CSO: 1842/90

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 Gennadiy 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_y, 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 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

8831
CSO: 1842/119

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

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].

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.

3024
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