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USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 5/81)

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USSR REPORT

MATERIALS SCIENCE AND METALLURGY

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Leningrad VYSOKOTEMPERATURNAYA ZASHCHITA MATERIALOV in Russian 1981 (signed to press 8 Apr 81) pp 2, 299-303

[Annotation and table of contents from book "High-Temperature Protection of Materials", edited by Academician M. M. Shul'ts, Doctor of Technical Sciences A. I. Borisenko, Candidates of Technical Sciences Ye. A. Antonova and A. Ya. Sitnikova, Doctors of Technical Sciences S. S. Solntsev and N. P. Kharitonov, USSR Academy of Sciences Institute of Silicate Chemistry imeni I. V. Grebenshchikov, Izdatel'stvo "Nauka", 1900 copies, 304 pages]

[Text] This volume is based on scholarly papers presented at the Ninth All-Union Conference on Heat-Resistant Coatings. These papers contain the results of the latest research conducted in the area of obtaining protective coatings for structural materials. They present the physicochemical principles of obtaining and investigating the properties of temperature-stable protective and other special coatings in metallic and nonmetallic structural materials. Various types of coatings are examined: diffusion, plasma, detonation, dross-firing, low-temperature hardening, etc. Considerable attention is devoted to a description of methods of bonding and testing coatings in various corrosive media.

This volume is intended for scientists, engineers and technicians working in the area of development of highly efficient means of protecting structural materials in various operating conditions.

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UDC: 678.675

POLYMERS AND POLYMER-BASED COMPOSITE MATERIALS IN INDUSTRY

Kiev POLIMERY I KOMPOZITSIONNYYE MATERIALY NA IKH OSNOVE V TEKHNIKE in Russian 1981 (signed to press 2 Feb 81) pp 2-4, 179-180

[Annotation, foreword and table of contents from book "Polymers and Composite Materials Based on Them in Technology", by Dmitriy Moyseyevich Karpinos and Valentina Ivanovna Oleynik, UkSSR Academy of Sciences Institute of Problems of Materials Science, Izdatel'stvo "Naukova dumka", 1500 copies, 180 pages]

[Text] This monograph synthesizes advances in the development and investigation of polymeric materials in the last 15-20 years in the USSR and abroad.

Alongside growth in production and expansion of areas of application of traditional polymeric materials (polyethylene, polypropylene, polystyrene, phenolformaldehyde, epoxy, polyester and other resins), an industry of new polymeric materials is beginning to develop in all countries (polyimides, polyphenylene sulfide, polyester sulphones, polyphenylene oxide, ABS-plastics, polyurethanes, etc); in addition to glass fiber as a reinforcing element for polymer-base composite materials, the manufacture of which is steadily increasing, new reinforcing fibers are appearing in the industry of various countries -- carbon, silicon carbide, boron, organic (polyamide hydrazide, polyoxyquinoline, polyphenylene, etc).

The authors examine polymers and reinforcing components manufactured and used in industry, their properties, types of products manufactured, output volume, cost, area of application, modern methods of reinforcement and modern concepts on the mechanism of failure of polymer-base composite materials under various load conditions.

This volume is intended for a broad group of specialists working in the area of materials science.

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FOREWORD

The last two decades have noted remarkable advances in the materials science of polymeric materials. A number of polymers have been synthesized, the heat resistance and thermal stability of which up to 100°C exceeds the corresponding values of traditional polymers. This qualitative leap forward has been achieved due to advances in planned synthesis. The materials obtained on the basis of these polymers can operate at a temperature of 260-300°C for several thousand hours without deterioration of properties; they include the polyimides, for example. A number of thermoplastic polymers have been synthesized, characterized by the ability to operate for an extended period of time at a temperature of 200-260°C, by radiation resistance, dimensional stability, creep resistance, chemical stability, and other properties essential in industry which make it possible to replace metals with these materials (phenylone, polyphenylene sulfide, polyester sulphones, etc). New reinforcing components for composite materials have been developed -- carbon, boron, silicon carbide filaments, filaments of aluminum oxide, organic fibers (polyparaphenylene, polyoxaline, polyamide hydrazide, etc), which expand possibilities of developing composite materials with a large range of properties. New kinds of reinforcement are being employed, such as hybrid reinforcement combining different types of reinforcement, which leads to the development of composite materials with a felicitous combination of properties. Success has been achieved in investigation of the mechanism of failure of composite polymeric materials, which also makes it possible to develop materials with improved properties.

At the present time there is no single source which discusses sufficiently fully questions pertaining to new polymeric materials in commercial manufacture. A book by N. A. Adrova, M. I. Bessonov et al, entitled "Poliimidy -- novyy klass termostoykikh polimerov" [Polyimides -- a New Class of Thermostable Polymers] synthesizes data on polyimides obtained up to 1968. In subsequent years a number of new types of polyimides were developed in the USSR and abroad, information on which is contained in various articles. "Spravochnik po plasticheskim massam" [Guide to Plastics], in two volumes, published in 1975 under the editorship of V. M. Katayev et al, contains information on new thermostable polymers -- polyethylene terephthalate, polycarbonates, polyarylates, and phenylone, manufactured by Soviet industry, but many other new polymeric materials are also utilized in the world plastics industry.

The purpose of this volume is to present a synthesis of world experience in the development of new polymers and polymer-base composite materials in the last 15-20 years. This volume examines materials which have found practical application, are manufactured by industry, or are on the way toward commercial manufacture.

An analysis presented in Chapter 1 on the state of and development trends in the polymeric materials industry, conducted on the example of industrially developed (USSR, United States, the Scandinavian countries, Austria) and some developing countries indicates that this industry is a rapidly growing, promising branch of production. In addition to the manufacture of traditional polymeric materials (polyethylene, polypropylene, polystyrene, polyester, epoxy, phenoloformaldehyde resins, etc), new polymeric materials have been developed and produced by industry in the last 10-15 years (polyimides, polybenzimidazoles, pyrrones, polyphenylenes, ABS-plastics, polyrurethanes, polycarbonates, aromatic polyamides, polysulphones, polyphenylene sulfide, etc). New types of reinforcing elements for composite polymeric materials have been developed and are being manufactured.

Chapter 2 describes new thermostable plastics (polyimides). The chapter describes the history of development, level of industrial production, growth prospects, and types of products being manufactured and developed in the USSR and abroad (the following resins: Skybond, pyraline, Qx-13, P13N, P105A, NR-150, polyimide 2080, SP-6, SP-12, SP-95, kainol, PM-67, PM-69, and others). Methods of processing, hardening operations and the properties of end products are described, with examples of application in the aircraft industry, machine building and other branches of industry.

Chapter 3 examines new thermoplastics and composite materials based on them, discusses principal products, properties, methods of processing, and areas of application. Polyurethanes, ABS-plastics, polyphenylene sulfides and polysulphones are described in detail.

Chapter 4 contains research results on new reinforcing filaments for polymer-base composite materials. The discussion includes the principal methods of obtaining filaments and the types of filaments employed for reinforcing polymers. Carbon filaments are described: history of development, production methods, types of products manufactured abroad (tornell, modmor, grafil, etc), production volume, cost, development prospects, properties, areas of application, as well as new organic filaments manufactured by foreign industry (nomex, kevlar, X-500). Their chemical structure is given, as well as production process, properties, production volume, cost, and examples of application. Various components of fixed-wing and rotary-wing aircraft in the manufacture of which carbon-containing plastics are employed are analyzed.

Chapter 5 describes modern methods of reinforcing polymer-base composite materials, and modern concepts on the mechanism of failure of reinforced and filled polymeric materials under various loading conditions, as well as in conditions of environmental influence.

Chapter 6 describes the principal modern methods of processing polymeric materials into finished products, the specific features of processing new polymeric materials, and development trends in manufacturing methods.

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NEW BOOK ON COMPOSITE MATERIALS

Moscow KOMPOZITSIONNYYE MATERIALY in Russian 1981 (signed to press 7 Apr 81) pp 2-4, 288-292

[Annotation, foreword by Academician N. M. Zhavoronkov and table of contents from the book "Composite Materials", chief editor, USSR Academy of Sciences corresponding member A. I. Manokhin, Izdatel'stvo "Nauka", 2,350 copies, 294 pages]

[Text] Annotation. This collection presents results of theoretical and experimental work on basic directions in the problem of composite materials. It is drawn from materials of the 4th All-Union Composite Materials Conference and examines the physicochemical properties of coated and uncoated reinforcing materials, the thermodynamics and kinetics of the interaction between reinforcing and matrix, the structure, properties and technological features of manufacturing and testing both structural and special-property composite materials with filament, laminate and dispersion reinforcing based on metal, ceramic, carbon and polymer matrices, methods of joining composite materials, and some areas of application. Research results are presented on the mechanics of composite materials, strength under short-term and long-term load, types of failure and corrosion behavior of composite materials, and problems in planning and designing items with complex shapes. The work is intended for a broad range of scientists and engineers, designers, metallurgists, technologists and materials specialists working on the development, production and application of structural materials in new equipment.

Foreword. The development of new composite materials with filament, laminate and thin-dispersion reinforcing, better physicomechanical and special physicochemical properties, will lead to a qualitative leap in scientific and technical progress, not only in aviation, space and ship-building technology, but also in machine building, power engineering, electronics, electrical engineering, radio engineering, transport, construction and other branches of the national economy.

Over the past five years, we have achieved some success in developing the theory and technology of obtaining composite materials and reinforcing media, the theory of nonhomogeneous media and optimum reinforcing, the physics and mechanics of strain hardening and strength in composite materials with a broad spectrum of structures, properties and areas of application.

Whereas super-strength, rigid, lightweight, filament-reinforced composite materials were called the materials of the future in the early 1970's, they are already the materials of today.

A number of questions of the physicochemical theory of the contact interaction of matrix and reinforcing materials, principles of choosing plasticizing, barrier and technological coatings for reinforcing materials and technological methods of applying them, and efficient new processes for obtaining composite materials have been worked out. Much research has been done on the mechanisms of strain hardening, deformation and failure of filament composite materials under various load conditions.

A number of filament composite materials with polymer, metal, carbon and ceramic matrices reinforced with boron, carbon and metal filaments, laminate and dispersion-hardened materials have been developed. Threadlike crystals combined with continuous filaments have found application in composite materials with polymer matrices. Industrial production of boron and various carbon and organic filaments, threads and strips, tungsten, molybdenum and other filaments has been set up, as have the production of several threadlike crystals, the experimental production of silicon carbide filaments and high-strength metal filaments and the pilot-industrial production of plasma-sprayed intermediate composite materials and others.

Industrial technology has been developed for producing sheets and certain other types of intermediate dispersion-hardened composite materials, filament (aluminum-boron filament) and polymer composite materials, as has pilot-industrial technology for obtaining thin deformation-alloy foils by rolling in a superplastic state. Intensive work is being done on obtaining and studying the properties of composite materials with directional eutectic structures. Research, development and production of a number of new composite materials with special physicochemical properties, as well as of refractory and heat-resistant ceramics and other materials, have been developed substantially.

Glass-, boron- and carbon-plastics, materials of the carbon-carbon type, dispersion-hardened metal-ceramic materials and others are already being used widely.

In recent years, we have set up the production of intermediate composite materials on a metal base, of the aluminum alloy - boron or borsik filament type, in the form of plasma monofilaments which are then used to manufacture pipe and cylindrical housings by hot pressing and sheets by pack rolling. Using such production as a base, we are currently doing the technological-design development needed to expand the production of intermediate products and filaments for reinforcing them.

The USSR Academy of Sciences has paid a great deal of attention to setting up and coordinating fundamental and applied research on composite materials here. The materials published in this collection, from the 4th All-Union Conference organized by the USSR Academy of Sciences' Scientific Council on Structural Materials for New Equipment, Scientific Council on Synthetic Materials, Metallurgy Institute imeni A. A. Baykov and the All-Union Order of Lenin Scientific Research Institute of Aviation Materials, sum up work on the problem as of 1978 and outline ways of further developing it.

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MECHANICAL PROPERTIES

UDC: 620.1.05:620.171.3

STRESS-STRAIN TESTING OF MATERIALS AT HIGH TEMPERATURES

Kiev MEKHANICHESKIYE ISPYTANIYA MATERIALOV PRI VYSOKIKH TEMPERATURAKH in Russian 1980 (signed to press 16 Dec 80) pp 2-4, 206-208

[Annotation, foreword and table of contents from book "Mechanical Testing of Materials at High Temperatures", by Mikhail Mironovich Aleksyuk, Valentin Alekseyevich Borisenko and Valeriy Petrovich Krashchenko, UkSSR Academy of Sciences Institute of Problems of Strength, Izdatel'stvo "Naukova dumka", 1750 copies, 208 pages]

[Text] This monograph examines methods and equipment for testing materials employed in new equipment under conditions simulating actual operating conditions. The authors describe new methodological solutions and corresponding unique equipment and devices for investigating refractory and composite materials across a broad temperature range (from 20 to 3000°C) and range of rates of deformation.

The authors examine problems of experimental investigation of hardness, characteristics of elasticity, short-term and long-time tensile, compressive, and bending strength. The authors describe systems of providing force and temperature loading conditions and present examples of their calculations. Particular attention is focused on ensuring accuracy of measurement of temperatures, loads and deformations in determining the stress-strain characteristics of materials in conditions of a vacuum, inert and oxidizing media.

This volume is intended for scientists, engineers and technicians working in the area of investigation of the mechanical properties of materials of various classes.

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FOREWORD

Development of the modern machine building industry and especially power, aeronautical and rocket engineering is connected with the development of new heat-resistant structural and protective materials capable of operating under conditions of high temperatures and mechanical loading close to maximum. In connection with this, scientific research aimed at determining the patterns of behavior of structural materials employed for components operating at high temperatures has become considerably more important. Performance of such research is distinguished by a high degree of complexity and requires elaboration of new methodological devices in conducting experiments and building appropriate testing equipment.

The conditions of stress-strain tests have become extended in recent years. Problems of stability or variability of the physical structure of a material in the process of deformation are acquiring primary significance.

The complexity and diversity of the physicomechanical processes taking place in a deformable solid lead to ambiguous end results, which are manifested in the form of unexpected failure or unwarrantedly high mechanical resistance. A correct explanation of the behavior of a material under load and, what is more important, prediction of this behavior are possible only after determining the physical essence of the processes which take place. In connection with this, such widely known operating factors as degree of complexity of stressed state, rate of deformation, broad range of temperatures, degree of physicochemical activeness of the environment, etc, should be examined from the standpoint of their influence on the structural foundation of the material and through it on the observable mechanical properties.

Modern materials science is offering technology a large number of materials of the most diversified function. Many of these materials are employed for the manufacture of critical machine parts, some are utilized as reinforcing elements in the form of wires, filaments, foils, coatings, and laminations, which in turn can be components of complex macro- and microheterogeneous materials, forming the heterogeneous structure of the majority of alloys or matrices and hardeners in composite materials.

Investigation of materials in normal conditions is performed with traditional methods on standard equipment. Development of new methods, however, has also required new design solutions.

Methods of investigation of hardness, microhardness, and tensile testing of small specimens are promising and sometimes the only possible methods for determination and study of the mechanical properties of materials in small volumes. These tests can be conditionally assigned to the category of micromechanical methods of investigation of the properties of materials [121, 128, 166, 205]. Development of methods of studying the strength of refractory metals at temperatures which are double to triple the temperature reached in testing equipment (up to 1300°K) was a highly complex problem, the solution of which required overcoming major engineering and methodological difficulties. A group of new special high-temperature high-accuracy testing machines was developed, equipment which eliminates the influence of harmful extraneous phenomena on the specimens being tested: evaporation and oxidation of materials, friction in the guides and seals of the micromachines, heating of force measuring devices, vibration of equipment components and the building, as well as many other factors.

In connection with the necessity of perfoming structural tests simultaneously with force loading, high-temperature testing mechines are equipped with metallographic observation devices. The majority of newly designed and built testing machines and their assemblies are original inventions.

Designs of testing equipment and devices have been developed for investigating the strength characteristics of structural materials, as well as certain types of filamentary compositions, loaded across a broad range of temperatures and rates of deformation.

This monograph presents a survey of stress-strain testing methods and descriptions of corresponding equipment, with analysis of their design and methodological features.

3024
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NONFERROUS METALLURGY

UDC: 669.295.721.008

PRESENT, FUTURE OF USSR TITANIUM-MAGNESIUM INDUSTRY

Moscow TSVETNYYE METALLY in Russian No 7, Jul 81 pp 55-60

[Article by A. N. Petrun'ko: "Along the Path of Technological Advance"]

[Text] Synthesis of the scientific and production experience of establishment, development and improvement of the titanium-magnesium industry in the USSR, the successes of which are universally acknowledged, is extremely important for innovative utilization during achievement of the plan targets specified for 1981-1985.

Considerable ground has been covered. The lessons of the past have been useful and instructive, and this offers a foundation for recalling several stages in the work of the All-Union Titanium Scientific Research and Design Institute.

In August 1956 a GSPI [State Special Design Institute] branch was established in Zaporozh'ye, based at the Dnieper Titanium-Magnesium Plant. The task of this branch was to provide engineering design documentation for the pioneer of the Soviet titanium industry -- the Dnieper Titanium-Magnesium Plant.

Over a period of two years the institute's designers and engineers built experimental models of equipment for the plant's second unit, developed experimental models of apparatus and equipment, and designed basic and auxiliary production facilities.

In 1958 the branch was transformed into the Ukrgiprotsvetmet Ukrainian Design Institute of Nonferrous Metallurgy. Performing basic work in the area of development of titanium production in the city of Zaporozh'ye, the institute was also involved in performing general design activities for other nonferrous metallurgical facilities in the Ukraine. A scientific research component was established as an element of the institute.

The team of designers and researchers was established by the beginning of 1960, and the institute's facilities were improved.

The institute's first director was I. S. Zagorskiy, while in the subsequent period considerable work in the area of institute organization and development was performed by director V. P. Denisov, USSR State Prize recipient, and his deputy for scientific affairs, E. Ye. Lukashenko.

In the laboratories research was conducted in the area of improving production of aluminum, titanium, and silicone compounds; new methods of analysis and physicochemical investigations were developed.

Research was supervised by candidates of technical sciences L. N. Antipin, S. F. Vazhenin, I. P. Sorokin, I. A. Grikit, V. V. Rodyakin, S. I. Denisov, and N. A. Akimova.

Lacking its own experimental facilities, the institute initially conducted research directly on industrial equipment, in laboratories and shops of titanium-magnesium, aluminum, and electrode plants. Enterprise specialists took active part in this work. The subject matter focus was basically in conformity with current production needs, and practical adoption of research results was accelerated. The main thing was the fact that the work force developed a striving toward close cooperation between scientists and production people, which was and continues to be of great importance in their work.

The work effectiveness of the institute during this period was also promoted by considerable attention toward the institute's needs and activities, and constant assistance by the directors of DTMZ [Dnieper Titanium-Magnesium Plant], DAM [Dnieper Aluminum Plant] and DEZ [Dnieper Electrode Plant] -- P. I. Miroshnikov, I. K. Strel'chenko and S. M. Goncharenko.

As the institute grew and the qualifications of the staff improved, scientific research and design activities in the area of titanium production expanded. In the period 1960-1965 a number of large-scale design projects were carried out for the Zaporozh'ye Titanium-Magnesium Combine. There occurred extensive development of scientific research work in the area of development of enclosed-type ore roasting furnaces and a process of melting titanium slags in these furnaces, high-output chlorinators, efficient condensation systems, high cyclic output reduction and separation equipment for obtaining sponge titanium, as well as a number of research projects aimed at improving the quality of sponge titanium.

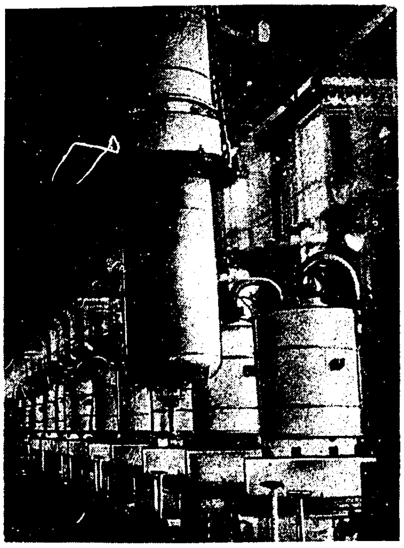
The USSR titanium-magnesium industry was built in a short period of time. Growing metals requirements dictated a rapid pace of development. This evoked the necessity of extensive enlistment of talented manpower. An enormous volume of work pertaining to designing enterprises and equipment for scientific research as well as bringing equipment and processes on-stream was performed during the construction of titanium-magnesium plants: by VAMI [All-Union Institute of Aluminum and Magnesium] in construction of the Bereznikovskiy plant; by Giredmet in construction of the Ust'-Kamenogorsk plant, and by the Titanium Institute in construction of the Zaporozh'ye plant. A mutual exchange of information and know-how and the established productive cooperation among the staffs of these institutes promoted movement on-stream of the original design capacity of these enterprises largely in the Eighth Five-Year Plan.

In 1965 the Titanium Institute was designated the lead branch institute for the titanium-magnesium industry and was renamed the All-Union Titanium Scientific Research and Design Institute.

In subsequent years all scientific research topics pertaining to titanium were transferred over to the institute from VAMI, as were the functions of lead institute in the production of magnesium. Radical structural changes have taken place in conformity with the institute's specialization, and its facilities have improved. A significant contribution toward the organization of scientific research and design projects as well as determination of the main areas of institute activity during this period was made by its director, P. V. Inashvili, its subsequent director, R. K. Ognev, deputy directors for scientific affairs V. I. Borodin and N. V. Galitskiy, and chief engineer M. T. Krivoshey.

In 1976 the Bereznikovskiy branch, which is also celebrating its 25th anniversary this year, was made a component of the Titanium Institute.

Today the Titanium Institute is a lead branch institute, with its own experimental production facilities, performing scientific research, experimental design, design engineering and technical-economic work, which are defining the future development prospects of the titanium-magnesium subbranch.



High-Output Unit for Producing Sponge Titanium

The institute contains an EDP center, equipped with third-generation YeS-1020 computers and Nairi units, with the aid of which results are processed, engineering design calculations are performed, and automated scientific and technical information systems are being created. Greatly utilized in design activities are the simulation-model method, copyless production of drawings, standard solutions and applications.

Organizational development of the Titanium Institute was accompanied by continuous improvement in its scientific and practical activities as well as improvement in personnel qualifications.

The productive activities of institute personnel have increased. In the last five years 287 certificates of invention have been granted, and 69 inventions have been incorporated into production, with overall savings of 6.7 million rubles. The institute's project results are being registered under foreign patents.

Institute staff personnel have published 57 books and pamphlets, and more than 1,300 articles in scientific journals. A total of 18 volumes of collected scientific papers and specific-topic volumes have been published, dealing with problems of improving existing and development of new industrial processes in the production of titanium and magnesium.

A total of three doctoral and 45 candidate dissertations have been defended based on projects carried out at the Titanium Institute.

The institute staff is continuing to expand and deepen a tradition which was established in the initial period -- productive cooperation with enterprises and institutes in a partnership arrangement pertaining to seeking and adopting major, important improvements in the equipment and technology of titanium-magnesium production facilities. This has helped transform the titanium-magnesium subbranch into a large-scale modern industry employing high-output and high-efficiency process equipment which makes it possible to achieve guaranteed high product quality.

A substantial increase in titanium and magnesium production in the last decade, 1971-1980, has been obtained exclusively by means of renovation of enterprises and modernization of equipment, for the most part without building new facilities, with utilization of the results of scientific and technical projects conducted by the staff of the Titanium Institute in cooperation with enterprises and other institutes of this branch.

In the area of titanium slag processing, projects pertaining to designing and building high-output enclosed ore roasting furnaces and process development were headed by S. I. Denisov. V. G. Raspopin, V. G. Bryndin, G. M. Shekhovtsev, M. Sh. Reyngach, and V. V. Asaf'yev participated actively on the working team.

The renovation of ore roasting furnaces conducted in 1980, with their capacity being increased, is completed. Renovation boosted furnace output at BTMK [Bereznikovskiy Titanium-Magnesium Combine], for example, by 51 percent, while reducing specific consumption of electricity by 14.4 percent; recovery in this process was increased by 3.3 percent, and the relative number of workers was reduced by 35.

A large aggregate of scientific-technical and design projects was performed on the process of chloridizing roasting of titanium slags and titanium tetrachloride treatment. As a result of adoption of project results, the design output capacity of shaft and salt chlorinators has increased by 34 and 56 percent respectively. During the 10th Five-Year Plan alone shop output capacity increased by 7.8 percent as a result of renovation of chlorinators at BTMK, without increasing the number of personnel. N. V. Galitskiy, A. B. Bezukladnikov, and D. P. Baybakov made a substantial contribution toward solving these problems.

Under the direction of N. V. Galitskiy, V. I. Starshenkov, and V. I. Drozhzhev, the institute worked on improvement and development of new methods of deep treatment of titanium tetrachloride and study of the composition of the impurities of complex substances contained in it and methods of removing them. Adoption of research results made it possible at all enterprises sharply to improve quality of the product of this process and to boost equipment output. In 1970-1975 enterprises adopted copperless cleaning of titanium tetrachloride with lower chlorides of titanium, with employment of a new, more available and cheaper reagent, which generated more than 1 million rubles in savings. In 1979-1980 there occurred extensive investigation of rectification conditions in large-diameter towers. Adoption into industry of the new towers made it possible to increase output by 50 percent in this process and to boost to 95 percent output of the top grades of titanium tetrachloride.

Improvement and modernization of basic industrial equipment in the process of obtaining sponge titanium were accomplished, beginning in 1966, under the direction of A. Ye. Andreyev, V. M. Mal'shin, and V. M. Skrypnyuk. In a short period of time, through the unified efforts of scientific personnel, design engineers and production people, working with specialists from the Giredmet Institute and other organizations, high-output, high-efficiency units were developed, and total renovation of this process was accomplished at all enterprises.

Alongside improvement of equipment, a great deal of work is being done to improve the quality of sponge titanium. At the present time the quality of sponge titanium produced by Soviet enterprises is at the level of the finest foreign product, while the highest-grade sponge, TG-90, has no equal abroad.

A special place in the institute's activities is occupied by the search for areas of efficient application of titanium and titanium alloys in civilian branches of industry. Resolution of this problem was assigned to the institute in 1969. Under the direction of S. F. Vazhenin and V. V. Volynskiy, research was conducted on the employment of titanium at more than 200 enterprises of various branches, and an extensive campaign was organized to publicize the properties and advantages of this remarkable metal. As a result, by 1976 consumption of titanium in nonferrous metallurgy, chemical and petroleum machine building and the chemical industry had increased more than fivefold. Annual savings from accelerated adoption of titanium amounted to approximately 3 million rubles.

V. V. Volynskiy, G. A. Kolobov, and Yu. V. Dobrunov were awarded the Ukrainian SSR State Prize for their work in the area of application of titanium in the chemical industry.

One of the most important and promising problem areas in which the institute has been working since 1965 is the development of titanium powder metallurgy technology. By 1970 the theoretical principles of obtaining powders by the electrolysis method had been elaborated, under the direction of L. N. Antipin, and experimental-commercial scale electrolytic cells had been designed and built. Subsequently these projects in the area of titanium powder metallurgy were headed by Yu. G. Olesov, V. V. Nerubashchenko, N. N. Koygushskiy, V. A. Drozdenko, and R. K. Ognev. Through the efforts of the research teams under their direction, working in cooperation with the Ukrainian SSR Academy of Sciences Institute of Problems of Materials Science and the Zaporozh'ye Machine Building Institute, by 1977 a process and equipment had been developed for producing powders and products of powders, generating savings ranging from 3 to 15 thousand rubles per ton of product. Employment of titanium filtering elements in the chemical industry and in nonferrous metallurgy is particularly effective. Savings amount to 100,000 rubles per ton of filters.

Highly effective, radical improvements have been accomplished in the area of magnesium production. Working jointly with VAMI, development of equipment has been completed, as has the total renovation of magnesium electrolysis shops at all enterprises of the subbranch, with installation of new, high-output electrolytic cells without cathode box. This has made it possible to increase their output by up to 20 percent, to boost output volume without increasing work force, to reduce specific consumption of electricity by 1400-2000 kilowatt hours, to increase chlorine yield by 50 kg/t, to achieve significantly healthier working conditions, to eliminate laborious cathode replacement operations, and to mechanize sludge recovery. Research is continuing, under the direction of V. N. Devyatkin, Yu. M. Ryabukhin and G. N. Svalov, on further improving the magnesium electrolysis process, on reducing magnesium and chlorine losses, and on developing methods of protecting structural components against oxidation and the aggressive action of the melt.

In recent years the institute staff has done a great deal of work on improving existing and developing new techniques of treating stack gases, effluents, on neutralization and utilization of production process chloride waste, which has made it possible substantially to reduce discharge of harmful material in the environment.

Stable production of merchantable hypochlorite pulps has been achieved by improving the process of treating chlorine-containing magnesium production gases. Research has been conducted on utilization of chloride waste in deep well drilling; sludge trap sediments and calcium chloride solutions are utilized in the production of cements and concrete.

The work accomplished by the Titanium Institute since its establishment has attained a very large scale. At the present time the average annual volume of scientific research work runs in the vicinity of 4 million rubles, while the total volume of design and development work runs at approximately 2.0 million rubles. Each year the institute presents design-estimate documentation representing a sum in excess of 20 million rubles. Savings achieved from adoption of completed research in the last 10 years has almost doubled, amounting to 9,190,000 rubles in 1980. Correspondingly, return on each ruble spent is now 3.95 rubles, in comparison with 2.49 rubles in 1970.

The institute's scientific and technical activities in the last 10 years have been directed toward boosting the technical level of the titanium-magnesium subbranch and improving the technical-economic indices of enterprises. All production volume growth, both in titanium and magnesium, was obtained in the 10th Five-Year Plan solely as a result of reequipping enterprises. Basic technical-economic performance indices have improved substantially during that same period.

Output of sponge titanium bearing the state Seal of Quality increased to 86 percent in 1980, while the figure for magnesium and magnesium alloys rose to 84 percent. Percentage of complete utilization of raw materials improved: it has reached 84 percent in titanium production, and 88 percent in magnesium production.

Further development of this subbranch and improvement in its technical-economic indices in the 11th Five-Year Plan will be achieved both by elaboration and adoption of new technical solutions and improvement of existing industrial processes, and as a result of reducing the materials-intensiveness of production, achieving savings in metal and energy resources, and mechanization of manual labor on the basis of comprehensive specific programs worked out by the enterprises and the institute.

Subbranch technical development plans for the 11th Five-Year Plan call for further modernization of basic industrial equipment in all processes, adoption of new industrial processes, continuous-flow mechanized lines, and creation of the prerequisites for total mechanization and automation of production.

A slag granulation process will be adopted in titanium slag melt processing, alongside further increase in the output of basic process equipment, which will make it possible to eliminate a number of laborious operations and boost titanium recovery by 1.5-2.0 percent.

An increase in the output of chlorinators and adoption at all enterprises of the process of deeper treatment of titanium tetrachloride in high-output screen rectifying towers will be accomplished in the chloridizing roasting process and treatment of titanium tetrachloride.

In the reduction and vacuum separation process, efforts are to be concentrated on bringing on-stream high-output units, deepening reducer treatment, and optimization of conditions with the employment of automated control systems.

In the 11th Five-Year Plan particular attention is to be focused on commercial-scale adoption of continuous-flow magnesium production. Adoption of this technology will make it possible substantially (by 20-30 percent) to boost labor productivity of basic production personnel and to create the prerequisites for total production mechanization and automation.

Plans call for a substantial change in solving problems of production waste recovery in all basic processes.

Institute efforts will also be focused on creating the scientific-technical foundations of new processes and equipment, including a continuous titanium production method, the plasmochemical and electrolytic techniques of titanium production, plus a number of others.

Further acceleration of technological advances in titanium-magnesium production will be promoted by a more thorough study of advanced know-how in achieving high indices, and mutual exchange of experience among enterprises and institutes in the area of adoption of advanced equipment and processes.

The necessity of directing these efforts is a most important task of the Titanium Institute in the 11th Five-Year Plan.

The tasks facing the work forces of the Titanium Institute and titanium-magnesium enterprises are large and complex, and the principal task is that of maximum satisfaction of the needs of the economy in high-quality metals -- titanium and magnesium. The high level of personnel skills and qualifications, substantial experience and know-how in organizing joint projects amassed by the institute and enterprises of this subbranch, and close cooperation between institute scientists and production specialists in solving concrete problems constitute a guarantee of accomplishment of these tasks.

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POWDER METALLURGY

UDC: 669.295:621.762

TITANIUM POWDER METALLURGY

Moscow POROSHKOVAYA METALLURGIYA TITANA in Russian (signed to press 6 Apr 81) pp 2-4, 247

[Annotation, foreword and table of contents from book "Powder Metallurgy of Titanium", by Valentin Semenovich Ustinov, Yuriy Georgiyevich Olesov, Viktor Antonovich Drozdenko, and Lev Nikolayevich Antipin, Izdatel'stvo "Metallurgiya", 2000 copies, 248 pages]

[Text] The first edition of this book came out in 1973. In the second edition the authors examine the present state and development prospects of titanium powder metallurgy. They discuss the technology of the basic processes of obtaining titanium powders; attention is devoted to the properties of powders and sintered products made from titanium powders in relation to the method of production, additional treatment, alloying and precipitation hardening. The authors discuss industrial safety in the manufacture and application of titanium powders and sintered products made of such powders. The authors show the technical-economic effectiveness of powder metallurgy methods in the manufacture of sintered products of powders in place of cast titanium, as well as from employment of such products (porous and structural) in the nation's economy.

This volume is intended for engineers and technicians working in the field of titanium powder metallurgy, and can also be useful to graduate students and higher educational institution upper-division undergraduates of the corresponding fields of specialization. Fifty-two illustrations, 75 tables, 269 bibliographic items.

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FOREWORD

The first investigations in the area of titanium powder metallurgy were conducted at the end of the 1930's, but research in this field did not reach a sufficient degree of intensity until commercial production of metallothermic titanium was developed.

Powder metallurgy methods are employed to produce items with properties comparable with the properties of melted metal, as well as new materials which are difficult to produce from molten metal (gas absorber filtering elements, metal-polymer coatings, antifriction products, etc).

Development of the manufacture of high-quality (electrolytic) titanium powders made it possible to employ commercial-scale processes for producing a number of sintered items -- structural components of the engine and instrument engineering industries, filters, dispersing agents, etc (1). Since publication of the first edition of this book, the technical-economic characteristics of titanium powder metallurgy have been defined, requirements on powders have been detailed, and the principal parameters of the processes of molding, sintering and additional processing of sintered products have been elaborated. It was determined that sintered titanium products can be produced with utilization of equipment employed in ferrous powder metallurgy and that of other metals (mixers, grinding and compression molding equipment, sintering furnaces).

An optimal combination of physical-mechanical, physicochemical and process properties of titanium and titanium-base alloys is attracting the attention of representatives of practically all areas of new technology -- from aerospace to medicine. The problems which are arising thereby (shortage of titanium, high cost of products, etc) can be resolved with utilization of powder metallurgy methods.

The development of new processes of obtaining titanium (plasma metallurgy, continuous metallothermic process, electrolysis) will lead to producing part or all titanium in powder form, and if so, powder metallurgy will not only supplement the existing method of mass production of titanium products but will replace it to one degree or another.

The authors have analyzed Soviet and foreign experience in the development and adoption of industrial processes and equipment for obtaining titanium powders and products from such powders. Since the first edition of this book was published (1973), a considerable number of scientific research results have been published in periodicals, especially dealing with new trends in titanium powder metallurgy. A number of theses presented in the first edition on the basis of analysis of data in the literature and laboratory investigations, have undergone experimental-industrial testing and verification at that time. Fundamentally new areas of application of titanium powders have been determined, such as obtaining refractory titanium compounds by the method of self-propagating high-temperature synthesis (SVS-process). Products and materials obtained from titanium powders have been tested in industrial conditions. All this has dictated the necessity of thorough revision of this book during preparation for publishing a new edition.

The authors hope that the materials contained in this volume will prove useful both for engineers and technicians working in the area of producing and processing powders and for the users of products of titanium and titanium alloys.

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MISCELLANEOUS

UDC: 629.7.036.5.-536.3.001.2(082)

KINETICS OF HIGH-TEMPERATURE FAILURE OF MATERIALS

Kiev KINETIKA VYSOKOTEMPERATURNOGO RAZRUSHENIYA MATERIALOV in Russian 1981 (signed to press 30 Dec 80) pp 2-4, 151-152

[Annotation, foreword and table of contents from book "Kinetics of High-Temperature Failure of Materials", by Vasiliy Semenovich Dvernyakov, UkSSR Academy of Sciences, Izdatel'stvo "Naukova dumka", 1100 copies, 152 pages]

[Text] In this monograph the author describes methods of studying the process of high-temperature failure of, for the most part, heat-protective materials, under conditions of radiant, convective, and combined heating. The author presents a conjugate problem variant for the case of combined heating and conditions on the moving boundary of physicochemical transformations within a material in the process of failure (Stefan condition). The author briefly describes external and internal regions of interaction of materials in various environments and extensively presents an experimental base created on the principle of utilization of radiant energy of the sun (special solar units) and other sources. The author presents results of investigations of the process of interaction and shows the fundamental possibility of estimating experimentally the kinetics of high-temperature failure of materials.

This volume is intended for scientists, engineers and technicians conducting research in the area of materials science and design of flying vehicles and engines; it may also be useful for specialists in related fields of technology, graduate students and undergraduates at higher technical schools.

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FOREWORD

The contemporary stage of study of the problem of spacecraft entry into dense layers of atmosphere involves thorough study of the problems of physics, hydrodynamics, and chemistry of the phenomena which accompany the process of interaction of a heat-shield material (TZM) with the surrounding medium. Comparisons of theoretical calculations and experimental data have made it possible to achieve significant progress in understanding the structure of the flow field as well as physicochemical transformations which occur. There has been a substantial improvement in the accuracy of calculations connected with analysis of spacecraft reentry into the atmosphere, such as calculations of convective and radiant heat flows, mass removal and heating of the heat-protective coating, radar cross section of the trail, etc. In spite of the fact that one can with a fair degree of certainty extend calculation methods to conditions which substantially differ from those for which there is a substantial quantity of experimental data, elaboration of methods of determining the dynamic interrelationship of the properties of media and materials with the rate of failure and heating remains an extremely important stage in selecting an optimal heat shield.

It has now become necessary to seek ways and methods of synthesizing information on effective, thermophysical, optical and other properties of materials in the process of their disintegration in media with various composition and thermodynamic parameters. The available large quantity of factual material requires appropriate classification and convenient forms of compact presentation of experimental and calculated data.

This book is a result of work performed by the author together with various experts: industrial engineers who design heat shield materials, the design engineers who utilize these materials, and testing personnel, who accomplish feedback from experiment results to the formula and process of manufacture of the materials.

The author's task was greatly facilitated by the following published monographs: Yu. V. Polezhayev and F. Yu. Yurevich, "Teplovaya zashchita" [Heat Shielding] (Moscow, Energiya, 1976); B. M. Pankratov, Yu. V. Polezhayev, and A. K. Rud'ko, "Vzaimodeystviye materialov s gazovymi potokami" [Interaction of Materials With Gas Flows] (Moscow, Mashinostroyeniye, 1976). Thanks to these studies, it was no longer necessary to make a detailed examination of the problems of heat and mass transfer in high enthalpy flows and solids, the mechanism of absorption of heat and the physicochemical processes which take place within heat-protective materials. For this reason the author presents only basic information on the external and internal regions of the process of interaction of materials in various media, essential for presentation of the bulk of this volume -- elucidation of the dynamic interrelation of external and internal parameters and evaluation of the possibility of directed influence on the process by formula and manufacturing process techniques during the manufacture of the materials.

This monograph is divided into five chapters, unified by the common idea of compact presentation of the process of high-temperature failure of heat-shield materials by a mathematical model which reflects the interrelationship of external and internal parameters with the rate of movement of the boundary of physicochemical transformations in the material.

Chapter 1 deals with analysis of the process of heat exchange with a non-destructing surface and ablating surface of a material (external region of interaction). A concise picture is presented on the interaction of materials in various media, taking into account the influence of the radiant component of overall heat flow. A brief survey of experimental methods of investigation and equipment is presented; an examination is made of the influence of external factors on the effectiveness of materials; experimental equipment which utilizes the radiant energy of the sun (special solar units) is presented.

Chapter 2 examines the moving boundaries of physicochemical transformations within TZM (internal region of interaction), presents the properties of typical TZM by zones, presents a classification of well-known materials and examines the properties of individual components of TZM and their influence on heat-shielding effectiveness.

Chapters 3, 4, and 5 are devoted to substantiation, derivation and analysis of the solution of an equation which reflect the kinetics of high-temperature failure as a particular case of conjugate problems for conditions of convective and radiant heating. They also contain analytic expressions of the most typical interactions of materials in the conditions of various experimental equipment, with comparison of certain experimental data and solution results. These investigations are a part of the problem of designing engines, heat-stressed equipment and flying vehicles as a whole.

The author would like to express his profound thanks to UkSSR Academy of Sciences Academician I. N. Frantsevich for his daily attention and discussion of the manuscript, and to V. V. Pasichnyy, V. S. Tsyganenko, and G. F. Gornostayev for assistance in preparing individual sections. The author expresses thanks to his colleagues, young specialists and graduate students for their participation and critical comments. The author would like to express particular thanks to O. A. Teplyakova for her assistance in readying the manuscript for publication.

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