JPRS L/10274

22 January 1982

USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 1/82)

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APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500020043-7

JPRS L/10274

22 January 1982

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(FOUO 1/82)

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COMPOSITE MATERIALS

UDC 669.71

COMPOSITE MATERIALS

Moscow KOMPOZITSIONNYYE MATERIALY in Russian 1981 (signed to press 7 Apr 81) pp 3-4, 288-292

[Foreword and table of contents from book "Composite Materials", edited by A. I. Manokhin, editor-in-chief, corresponding member, USSR Academy of Sciences, Izdatel'stvo "Nauka", 2350 copies, 305 pages]

[Text] Foreword

The creation of new composite materials with fibrous, laminated, and thinly-dispersed hardening which have increased physico-mechanical and special physico-chemical properties must lead to a qualitative jump in scientific and technical progress not only in the aviation, space and shipbuilding sectors of technology but also in machine building, power, the electronic, electrical engineering, and radio engineering industries, transportation, construction, and other sectors of the national economy.

During the past five years definite success has been achieved in our country in the area of developing the theory and technology for obtaining composite materials and reinforcing agents, the theory of heterogeneous media and optimum reinforcement, the physics and mechanics of strain hardening and composite material strength with the broad spectrum of structure, properties, and areas of use.

If at the beginning of the 1970's super-strong, sturdy and light composite materials strengthened with fibers were called the materials of the future, then they are now already today's materials.

A number of questions have been worked up concerning the physico-chemical theory of the contact interaction of matrix and reinforcing materials, principles for the selection of plasticizing, barrier and technological coatings on reinforcing materials and the technological methods of applying them, and new efficient processes for obtaining composite materials. A large amount of work has been carried out on studying the mechanisms of cold hardening and deformation, and the destruction of fibrous composite materials under various load conditions.

A number of fibrous composite materials have been developed with polymer, metallic, carbon, and ceramic matrices, strengthened with boron, carbon and metallic fibers, laminated and dispersion-strengthened materials. Thread-like crystals coupled with continuous fibers have been used in composite materials with a polymer matrix. They have organized the industrial production of boron and various carbon and organic fibers, fabrics and tapes, tungsten, molybdenum and other fibers, the production of several items of thread-like crystals, the experimental industrial production of silicon carbide fibers, high-strength metallic fibers, the experimental industrial production of semi-finished composite material products by the plasma spraying method, etc.

The industrial technology has been worked out for the production of sheets and some other semi-finished products of dispersion-strengthened composite materials, fibrous (aluminum-boron fiber) and polymer composite materials, the experimental industrial technology of obtaining thin foils from deformed alloys by rolling under super-plasticity conditions. Intensive work is going on to obtain and study the properties of composite materials with directed eutectic structures. Research and the development and production of a number of new composite materials with special physico-chemical properties, and also refractories, heat-resistant ceramics, etc., have been significantly developed.

Glass, boron and carbon plastics, carbon-carbon type materials, dispersion-strengthened metal ceramic materials, etc., are already in wide use today.

Production has recently been organized of composite material semifinished products on a metallic base of the aluminum alloy-boron and borsik fiber type, in the form of plasma uni-strips which are then used to manufacture pipes and cylindrical casings by hot moulding and sheets by pack rolling. Technological design efforts necessary to widen the production of semifinished products and fibers for their reinforcement are presently being carried out based on this production.

The USSR Academy of Sciences is paying great attention to the organization and coordination of fundamental and applied research on the problem of composite materials in the country. The materials of the 4th All-Union Conference organized by the Scientific Council of the USSR Academy of Sciences on Construction Materials for New Technology, the Scientific Council of the USSR Academy of Sciences on Synthetic Materials, the Institute of Metallurgy imeni A. A. Baykov of the USSR Academy of Sciences, and the All-Union Order of Lenin Scientific Research Institute of Aviation Materials, published in this collection, sum up the work on this question up to 1978 and outline the paths for its further development.
(Academician N. M. Zhavoronkov)

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8524
CSO: 1842/6

POWDER METALLURGY

UDC: 621.762

RESEARCH IN TECHNOLOGY OF METAL POWDERS AND SINTERED MATERIALS

Sverdlovsk ISSLEDOVANIYA TEKHNOLOGII METALLICHESKIKH POROSHKOV I SPECHENNYKH MATERIALOV in Russian 1980 (signed to press 22 Oct 80) pp 2-8, 135-136

[Annotation, table of contents and editor's introduction from book "Research in Technology of Metal Powders and Sintered Materials", edited by V. Ya. Bulanov, V. F. Ukhov, and Ye. S. Michkova, USSR Academy of Sciences Urals Scientific Center, UNTs AN SSSR, 700 copies, 144 pages]

[Text] This volume contains articles dealing with current scientific-technical and economic aspects of powder metallurgy. It presents the results of study and theoretical substantiation of industrial processes of producing metal powders and sintered structural materials based on iron and other elements. This volume presents the results of investigations to study the properties of sintered materials, heat treatment and combined heat treatment and mechanical working on the basis of research conducted at organizations in the Urals region.

This volume will be of interest to scientists and practical specialists working in the field of powder metallurgy.

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EDITOR'S INTRODUCTION

Modern industry is imposing increasingly more extensive and rigid demands on various materials. Development and improvement of such areas of science and technology as physics, chemistry, electronics, and all areas of machinery engineering have placed on the agenda the question of developing and utilizing materials with special properties, which has required the development of powder metallurgy on a higher scientific and technological level. In the last 100 years numerous organizations and industrial plants have been established in such countries as the USSR, the United States, the FRG, Czechoslovakia, Japan and a number of others, which work with development of sintered materials, and experimental data have been amassed. Intensive utilization of advances in the natural sciences for synthesizing practical results and formulating a general theory of processes of obtaining materials with preselected properties began in the 1950's and 1960's. From the above we can formulate the following problems of physical powder metallurgy.

The problem of obtaining powders with prescribed properties and dimensions. Development of powder metallurgy at the contemporary level involves solving a number of technical problems, one of which is obtaining metal and nonmetallic powders of a specified structure, properties, and composition. The term "powder" should be defined more broadly, with the term including composition, structure, and properties of powder particles. The single concept of powder as a particle visible to the naked eye within a specific range of sizes (from several microns to fractions of a millimeter) does not tie in theoretically with the theses of modern powder metallurgy. At the present time we can obtain such particles ranging from several angstroms to several millimeters in size. On the basis of these particles we can produce materials with predetermined properties, structure and composition, both ultradense and ultraporous. At the present time it is possible to obtain powders with unlimited dispersion of particles (from microparticles to filaments) by physicochemical methods, on the basis of application of the laws of physical chemistry and chemical physics.

The properties of materials produced by the powder metallurgy method depend basically on the composition and physicochemical properties of the initial powders. The best way to alter the compositions of these materials is to use natural dispersoids, each of which will be single- or complex-alloyed, and uniformly (homogeneously). It is possible to produce such homogeneous-alloy dispersoids only by chemicometallurgical methods which, on the one hand, make it possible to obtain a predetermined and selective degree of refining and, on the other hand, to leave in each dispersoid the requisite number of needed alloying elements or any phases. At the present time such tasks are accomplished in two phases -- initially pure powders and pure alloying elements or their alloys are produced, and subsequently the latter are artifically charged into the base. This method of producing multiconstituent materials is unwieldy and does not enable one to create a continuous series of homogeneous materials. It essentially repeats the traditional methods of obtaining cast alloys of discrete composition, approximately 600 of which exist at the present time, and all of which were created over several decades, taking account of various intuitive experiments by means of selective sampling.

But it is essential to bear in mind that there cannot exist in nature ready combinations of various elements in one and the same raw material. Therefore in order to create materials with a predetermined composition and properties it is necessary to employ a combined method -- chemical control of the initial composition of dispersoids with supplementary artificial charge addition prior to chemical processing of the raw material, so that the alloying elements and phases organically enter the compounds being reduced or oxidized, that is, performing controlled physicochemical synthesis (UFKhS).

The problem of physicochemical investigation and prediction of the properties of sintered materials. After producing powders of any specified degree of dispersion, one can proceed to the next stage in developing new materials -- elaboration of the physical and physicochemical fundamentals of shaping and sintering, their interaction and combining, or elimination of one of them, which would make it possible to create any predetermined properties of materials. In this area it is necessary to investigate the processes of interaction and reaction of the particles of powders of any degree of dispersion in relation to the properties, composition and structure throughout the entire diversity of various combinations of given properties and atomic-molecular bond between the dispersoids proper and their phase constituents. One should take into consideration the submicrostructure of point, linear and plane defects, the most important of which are dislocations in all their diversity.

Correct elaboration of the above-listed problems determines the possibility of eliminating additional operations following molding and sintering (machining, heat treatment, etc) or improving and reducing them to a minimum, with the aim of obtaining the final shaped part.

The properties of microobjects of dispersoids of any size are determined by many interrelated factors.

The functional relationship between optimized parameters and numerous factors cannot be determined with the aid of the well-known traditional divisions of higher mathematics. Recently developed cybernetic methods ("black box" methods) enable one to solve various problems of powder metallurgy without going into the essence of the complex physicochemical processes taking place during the forming of a sintered body. The mathematical method of extremum experiment planning enables one to link practically all the major factors by a regression equation and to determine the parameters of the initial dispersoids and the conditions of formation of a sintered body from them or any processes taking place with the employment of dispersoids -- metallurgical, welding, machining.

New possibilities for predicting and producing multiple-constituent materials or processes are offered by graphic-analytical forecasting, where all properties, conditions and compositions of a material of any complexity are represented in the form of a three-dimensional cluster of symbolic points (OFT). With the aid of uncomplicated graphic operations, expanding all system components onto a plane, one can solve the problem of determining optimal system properties in relation to the physical characteristics of the initial dispersoids.

As improvements are made in the equipment and methods of physicochemical analysis of metals and alloys at the micro- and submicrolevels and a sharp increase in labor productivity in computer interpreting research results, it is possible to determine the functional dependences of optimized parameters on numerous physicochemical factors and their relationship by means of mathematical processing of graphic-analytic relations. This will make it possible in materials science to depart from the traditional methods of seeking new materials. With the aid of precise mathematical calculation, one can predict properties in relation to the characteristics of the initial building blocks (dispersoids) and the conditions of their forming and sintering, in the process of which various physicochemical processes are also taking place at the atomic-molecular, submicro-, micro- and macrolevels.

Further improvement of experimental method and method of determining the properties, composition and structure of dispersoids and materials based on them is essential, particularly since they are assuming an increasingly more complex composite character. The accuracy and sensitivity of methods of analysis and their objectivity determine the possibility of reproducibility of obtaining the specified materials at different points in a single specimen.

Exclusively physical methods must also be employed for phase analysis -- X-ray diffraction analysis, photographic analysis, and analysis with ionizing recording, with discrimination of individual radiations, and electron-diffraction analysis in conditions of diffraction, microdiffraction, local analysis with X-ray microanalyzers, etc.

In connection with the possibility of producing dispersoids at the level of atoms and molecules, nuclear and electron magnetic and paramagnetic resonance units should be employed for analysis.

For direct and indirect observation of microstructure, it is necessary to employ new equipment -- microscopes with remote screens (scanning), with automatic computer devices, and high-resolution electron microscopes. All this would make it possible to determine not only dislocation tracks but also to make kinetic observations of processes taking place in zones commensurate with interatomic distances and the size of individual molecules and atoms. These devices should be combined in operation with the most advanced automatic recording devices for interpreting the obtained information -- microphotometers, oscilloscopes, and electronic computers.

We should note that obtaining separate, fragmentary information cannot provide any exhaustive information for predicting and discovering new laws. It is essential to obtain not discrete but continuous information on a given process, on both a dynamic and kinetic basis, with its numerous variations in composition and at the micro- and submicrolevels. Only after detailed processing of this information is it possible to obtain functional patterns for predicting the properties of sintered multiconstituent materials.

The problem of improving existing technologies and problems of turning out finished products. It has been established that the strength of the individual particles -- dispersoids -- differs from one surface zone to another, ranging from 20 to 400 kg/mm^2, while the theoretical strength of these dispersoids, taking into account their phase composition and the physicochemical properties of the structural components, can amount to 700 kg/mm^2 or more for iron powders, for example. Thus two discontinuities exist between the strength of produced sintered materials and the individual dispersoids of which they are formed. The first lies between the calculated theoretical strength of ideal dispersoids of complex structure and the strength of the actually produced material of actual dispersoids. This gap constitutes a strategic reserve of powder metallurgy, and the maximum strength obtained by calculation is that cherished, fairly realistic goal toward which every investigator should strive. The second gap (somewhat smaller) lies between the strength of certain zones of each dispersoid and the strength of the material obtained on the basis of that dispersoid. There is a realistic possibility of achieving the experimental strength characteristics of individual zones within the next few years. Up to the present time iron-base materials have been obtained with a strength of 80-100 kg/mm^2, and achieving a strength of 200-400 kg/mm^2 is not far off.

Improvement of existing processes of forming and sintering, chiefly determination of optimal conditions (time, temperature, environment), development and employment of heat treatment, combination chemical and heat treatment methods as well as other means of influencing the structure of materials in order to change their properties in the desired direction constitute one of the important tasks of powder metallurgy. Employing dynamic methods, high and ultrahigh pressures for forming and shaping, as well as preheating and heating materials while applying pressure to them, one obtains compact and ultracompact materials with both already known and new, unique properties. This requires development of totally new processes of forming and shaping by the direct effect on the powder of electrical impulses, electromagnetic waves, ultrasound, high-frequency currents and other physical factors, as well as activation of the processes of forming and sintering by affecting dispersoids with chemical, physical or combined methods.

The following materials can be obtained as a result of research on the manufacture of sintered products and materials:

a) structural materials, with any desired properties, with final geometric dimensions and configurations, which require little or no machining, unlimited in weight and size, commensurate with machine parts manufactured by other methods (casting, forging, stamping, etc);

b) antifriction materials (machine parts) for any desired operating conditions, within a broad range of conditions -- temperature, environment, pressure, load;

c) friction materials (machine parts) operating in various conditions and environments;

d) porous materials (filters) operating in any environments;

e) materials for the manufacture of electrical contacts, materials with high electrical resistance and, the reverse, superconductors. This problem can be solved with a radical change in the process of manufacture of stators and rotors of electric motors, generators and transformer cores, by employing magnetodielectrics in place of the traditional packages of plates with their complex treatment and processing and their uncontrolled characteristics.

The following dispersoids can be employed to produce materials for machining metals and other complex alloys and materials and for achieving further increase in labor productivity in metalworking, particularly in finishing operations, as well as for reinforcing impact-stamping tools, including molds for powder metallurgy:

of a specified composition and size for controlling crystallization processes in general metallurgy -- ingot, casting, etc (with further improvement in labor productivity, quality of the metal produced, reduction in production-line rejects and, finally, control of the processes of producing metal with specified macro-, micro- and submicroproperties);

of various composition and structure for welding production and for producing welded seams and surfacings with specified properties, as well as for employing electrodes of predetermined composition for all kinds of welding, including electro-slag remelting.

With the aid of dispersoids, obsolete methods of producing semifinished products by means of blast furnace, open-hearth and other metallurgical processes will gradually be eliminated, with a transition to new physicochemical-metallurgical processes -- direct production of powders of a specified composition and structure from ores, with subsequent production of rolled stock of any size and sectional shape with controlled properties and with a substantial reduction of energy expenditures and total, no-waste utilization of raw materials.

Employment of dispersoids will make it possible to develop advanced research methods and to create a general theory of materials on the basis of new laws of materials science.

3024
CSO: 1842/23

REFRACTORY MATERIALS

UDC: 666.76.002.3

REFRACTORIES INDUSTRY GROWTH IN 11TH FIVE-YEAR PLAN

Moscow OGNEUPORY in Russian No 9, Sep 81 pp 1-8

[Article by G. Ye. Zaychenko (Soyuzogneupor All-Union Production Association): "Raw Materials Base of the Refractories Industry in the 11th Five-Year Plan"]

[Text] Implementing the historic resolutions of the 25th CPSU Congress and extensively employing various forms of socialist competition, the work forces of mining enterprises of the refractories industry successfully accomplished plan targets pertaining to production of refractory raw materials for the 10th Five-Year Plan (see table).

Table 1.

Raw Materials	Production Plan Percentage of Fulfillment		
	For Soyuzogneupor All-Union Production Association	For Ukrogneupornerud Republic Production Association	For USSR Minchermet
Refractory clay	103.4	101.9	102.8
Kaolin	-	101.4	101.4
Magnesite	102.7	-	102.7
Quartzite	109.3	102.0	104.8
Dolomite	92.8	104.7	103.8

Successful completion of the 10th Five-Year Plan was promoted by intensification of minerals production at existing enterprises, bringing new surface and underground mining facilities on-stream, replacement of obsolete and worn-out mining transfer and auxiliary equipment, increasing labor productivity, adopting new forms of organization of labor, dissemination of the advanced work methods of production innovators, as well as further improvement of mining technology.

In the 10th Five-Year Plan the Kuleshovskiy and Vostochno-Bezovskiy refractory clay production sections were brought on-stream in the Suvorovskoye Mining Administration, more than 7 kilometers of hard-surface road were built, an asphalt plant, a new administration and services building, and a gas scrubbing department in the fireclay shop; in 1981 construction will be completed and a garage for heavy-payload dump trucks will go into operation.

In the mines of the Borovichskiy Refractories Combine, the ChPU, MBLD, and KMSh continuous miners experienced further adoption in excavation, preparation, cutting and stoping operations, which made it possible to boost the level of mechanization of these operations from 35 to 84 percent. Hoisting equipment of obsolete design at Mine No 2 imeni Artem were replaced by new, more sophisticated equipment; rotary bucket excavators for extracting refractory clays were renovated at the Ust'ye-Brynkino pit.

The work force at the Semiluki Refractories Plant, working with the Donets affiliate of the Scientific Research Institute of Mining, developed the ER-315/630 rotary bucket excavator, which at the present time is the most sophisticated and high-output equipment for selective working of refractory clays and kaolin deposits.*

A considerable volume of excavation and preparation work was performed in constructing the Belyy Kolodets and Strelitsa Blizhnyaya pits. As a result, designed output was reached ahead of schedule at the Belyy Kolodets pit, and refractory clay production began at the Strelitsa Blizhnyaya pit.

At the Tarasovskoye Mining Administration low-output excavators and drilling machines were replaced with higher-output EKG-4.6 excavators and 2SBSh-200 drilling machines; considerable work to remove dust from the air at work stations was performed at the crushing and grading mill.

At the Chelyabinsk Mining Administration, the Bugor pit was constructed and brought into production, and has already been brought up to designed output; the production and stripping rotary bucket excavators, with self-propelled belt spoil dumpers, have been upgraded and modernized; an administration-services combine, boiler house and other facilities were completed and brought into operation.

The work force at the Bogdanovich Refractories Plant further expanded mining operations at the Kul'durskiy brucite mine, as a result of which on-line production capacity was exceeded. A crushing and grading unit was built at the mine, as well as standard-gauge tracks linking the industrial site with MPS [Ministry of Railways] tracks, which makes it possible to load crushed brucite into MPS cars directly at the mine.

Considerable work has been accomplished at the pit mines of the Magnezit Combine in further replacement of obsolete mine transport equipment by more sophisticated and higher-output equipment, narrow-gauge rail transport with trucks, and on boosting production at the Karagayskiy and Stepnoy mines. A pit to exploit the Nikol'skiy section of the magnesite deposit went into production, renovation of DOF [Crushing and Concentration Mill] No 1 was performed, and designed output was reached in the magnesite concentration in heavy suspensions department at DOF No 2 (Figure 1) [photo omitted]. Construction was completed on an experimental commercial-scale department for concentrating magnesite by chemical means; preliminary tests produced encouraging results. A truck-hauled overburden dump 96 meters in height was successfully put into operation (Figure 2) [photo omitted]. The mine railroad shop

* G. Ye. Zaychenko, Yu. I. Berezhnoy, P. M. Kut'kov, et al, OGNEUPORY, No 2, 1981, pp 29-32.

completed track switching control automation and centralization, repair of dumpcars and electric mine locomotives.

Improvement of excavator, drilling and blasting operations continued at the quartzite mine of the Pervoural'sk Dinas Refractory Brick Plant; equipment was modernized at the plant's crushing and grading mill.

The miners at the Chasov-Yar Refractories Combine put into operation a pit mine in the Redkodub section, second units of the Vostochnyy and Yuzhnyy mines, and improved mining operations in complex geologic conditions.

The work force at the Druzhkovka Mine Administration accomplished a considerable amount of work on constructing a second pit unit for working the Novorayskoye refractory clay deposit and on improving mining production operations with the employment of high-output mine transport equipment -- ESh-15/90, ESh-10/70, and EKG-4.6 excavators in combination with BelAZ-540 heavy-load dump trucks.

The Kirovograd Mine Administration constructed and put into operation a pit in the left-bank part of the deposit. Complex geologic conditions and unconfirmed geologic data on commercial mineral reserves required great efforts on the part of the work force for development of mining operations and for achieving refractory clay production plan targets.

The work force of the Priazovskoye Mine Administration began production in a new section of the deposit with complex geologic conditions.

The miner work forces at the Vatutinskiy and Velikoanadol'skiy combines improved mining operations in conditions of increased kaolin bed flooding and a heavier layer of overburden (Figure 3) [photo omitted].

Thanks to the adoption of higher-output mining and drilling equipment, the work force of the Ovruchskoye Mine Administration, in spite of increased pit depth, successfully met the production target in the 10th Five-Year Plan.

The work forces of refractories industry enterprises devoted constant attention to reclaiming and utilizing land disturbed by mining operations. Figure 4 [photo omitted] shows reforestation of a reclaimed mined-out area of the Zapadnyy Mine at the Chasov Yar Refractories Combine.

Considerable credit for meeting the refractory raw materials production targets of the 10th Five-Year Plan must go to highly skilled, conscientious workers -- production leaders and innovators, who successfully mastered the new mine transport equipment and mining operation processes and who have an innovative attitude toward their job.

The new five-year plan (1981-1985) assigned even more complex and responsible tasks to the miners of the refractories industry.

Production increases in the 11th Five-Year Plan over the 10th Five-Year Plan are targeted as follows: refractory clay -- by 13.2 percent; magnesite -- by 6.8 percent; kaolin -- by 6.8 percent; quartzite -- by 3.6 percent. Geologic conditions for working refractory raw materials deposits will be more complex in the new five-year plan. Production growth in refractory raw materials should occur primarily through intensification of production processes, improvement in mining process operations, replacement of low-output, obsolete and worn-out mine transport equipment, mechanization and automation of production processes, improvement in forms of socialist competition, and increased worker labor productivity.

The following principal measures must be carried in order to meet the targets of the 11th Five-Year Plan pertaining to mining operations and providing raw materials to enterprises of ferrous metallurgy and other branches and sectors of the economy:

Borovichi Refractories Combine: construct and put into production the Okladnevo Mine, with an annual output capacity of 400,000 tons of refractory clay; proceed with development of the second unit of the Ust'ye-Brynkino Mine; continue adoption of KMSh and ChPU continuous miners in underground mining operations, bringing mechanization of preparation and production to 90-100 percent; increase the volume of crushing of overburden limestone for the construction industry and maintenance of in-mine and spoil dump roads; perform a group of renovation operations at the Volgino Mine;

the Suvorovskoye Mine Administration: complete construction of pit facilities and reach designed output capacity in refractory clay production in the Vostochno-Bezovskiy section; complete construction on and put into operation a truck garage with outside parking for BelAZ-540 and KrAZ-256B dump trucks; assemble and put into operation an Esh-10/70A walking excavator in the Vostochno-Bezovskiy section; convert fireclay shop and boiler house operations over to natural gas; improve the quality of repair and maintenance of process equipment in this shop; prepare technical documentation for mine construction to work the Ul'yanovskoye refractory clay deposit; reclaim and replant areas disturbed by mining operations in Section No 14 and the Kuleshovskiy section;

Semiluki Refractories Plant: complete relocation of the gas and communications line at the Sredniy Mine and intensify overburden removal operations on the forward benches; complete construction and bring on-line industrial facilities at the Belyy Kolodets and Strelitsa Blizhnyaya mines; renovate the overhead cableway between the plant and the Belyy Kolodets Mine, with the aim of boosting its capacity to 750,000 tons per year; expand the refractory clay storage area at the plant site in order to boost volume of fireclay shipped to customers to not less than 200,000 tons per year; reclaim and replant land disturbed by mining activities; prepare technical documentation for development of the quartz sand production section for refractory linings at the Strelitsa Blizhnyaya Mine; complete preliminary studies at the Strelitsa Blizhnyaya and Belyy Kolodets mines for the purpose of improving mining operations, with the employment of ESh-10/70A and Esh-6/45 walking excavators;

Bogdanovich Refractories Plant: step up construction and movement on-stream of production facilities and housing at the Kul'durskiy brucite mine, bringing the facility up to designed output; accomplish further improvement of mining operations at the Yuzhnaya Poldnevaya Mine, producing refractory clays, and at the Kul'durskiy brucite mine;

Eastern Siberian Refractories Plant: construct and bring into production a department for concentration and briquetting of refractory clays from the Troshkovskoye deposit; complete construction, bring on-stream and reach designed output at the refractory clay pit; prepare design documentation mining and land allocation formalities, and commence construction of priority facilities at the Savinskiy Magnesite Combine;

Magnezit Combine: accelerate construction and excavation operations at the Magnezitovaya Mine; complete renovation of DOF No 1; complete construction and reach designed output at the Tsentral'nyy and Zapadnyy mines of the Nikol'skiy section of the magnesite deposit; accelerate construction of industrial facilities and housing in the new microrayons; renovate equipment in the existing magnesite concentration in heavy suspensions department; build the second magnesite concentration in heavy suspensions unit; perform construction and preparation work for delivering grade IV magnesite from special storage sites to DOF No 2; prepare design documentation and build a third magnesite crushing and concentration line at DOF No 2; complete preliminary studies and perform preparation work on the south edge of the Karagayskiy pit for siting waste rock dumps; prepare design documentation and construct an overhead cableway for transporting crushed magnesite to TsMP-2 rotary furnaces 5 and 6; reach designed output of a commercial-scale unit for magnesite concentration by a chemical method; prepare design documentation, land and mining allocation formalities for pit expansion in the Galyaminskoye molding sand deposit section; perform preparation work for constructing a pit in the Berezovskiy section of the magnesite deposit; step up work on increasing magnesite production in the Palenikhinsko-Mel'nichnyy section;

Pervoural'sk Dinas Refractory Brick Plant: strip overburden and commence working the southern section of the Gora Karaul'naya quartzite deposit; perform major overhaul of the crushing and grading mill; build a hard-surface road between the mine and the crushing-grading mill;

Tarasovskoye Mine Administration: build a rail spur and storage facility for shipping quartzite and quartz sands; organize selective digging of quartz sands for shipment to customers; prepare design documentation and commence construction of a new pit; fabricate and install at the pit a facility for screening material in order to reduce the hauling of waste rock to the crushing and grading mill;

Yuzhno-Ural'sk pit of Soyuzmetallurgprom: complete construction of pit facilities and bring refractory clay output up to the designed figure;

the mining enterprises of the Ukrogneupornerud Republic Production Association: accomplish construction of a refractory clay pit in the Block No 9 section; expand production of molding sand in the Sukhoy Yar section of the Chasov Yar Refractories Combine;

Druzhkovka Mine Administration: prepare design documentation, land and mining allocation formalities, accomplish construction and bring on-stream a pit in the Western Section of the Novorayskoye refractory clay deposit; accomplish renovation of the molding sand pit on the Bantyshevskoye deposit;

Kirovograd Mine Administration: step up geological exploration activities and confirmation of refractory clay reserves in the new Left Bank section, prepare design documentation and begin construction of a pit in this section;

Priazovskoye Mine Administration: step up preparatory activities for expanding the production of refractory clays and kaolin in Section No 1; continue construction of approach spur and in-pit tracks;

Vatutino Refractories Combine: accomplish construction, movement on-stream and achievement of designed output at the Murzinskiy kaolin pit; construct an experimental commercial-scale kaolin concentration unit;

Ovruch Mine Administration: cut and prepare for working lower levels of the quartzite deposit at the presently operating pit; begin preparation of technical documentation for working a new quartzite section.

Growth in volume of converter steel production at metallurgical plants in the southern and central part of this country in the 11th Five-Year Plan makes it necessary to increase production of top-grade tar-dolomite refractories.

It has been established on the basis of amassed experience as well as laboratory experiments and full-scale tests that the highest-quality raw material for making tar-dolomite refractories is dolomite from the Bosninskoye deposit, which is produced by the Kavdolomit Quarry Administration. Reserves of these dolomites are practically unlimited for the foreseeable future.

This quarry is to undergo renovation in the 11th Five-Year Plan, with the aim of increasing production of Bosninskoye dolomite to 1 million tons per year and satisfaction of the requirements of enterprises of the USSR Ministry of Ferrous Metallurgy and Ministry of Construction Materials Industry.

During the period of renovation and development of the Bosninskiy quarry, beginning in 1981, dolomite from the Tkvarchel'skoye deposit is to be utilized, produced by the quarry of the Rustavi Metallurgical Plant. In the 11th Five-Year Plan the converter shops of the metallurgical plants of the Urals, Siberia and Kazakhstan will be supplied with refractories the manufacture of which will involve magnesite powders from the Magnezit Combine and dolomites from the Alekseyevskoye deposit.

In the 11th Five-Year Plan obsolete and worn-out mining transport and auxiliary equipment is targeted for replacement at enterprises producing refractory raw materials. On this basis there will be obtained further improvement of mining operations and increased labor productivity with the aim of increasing production volume and meeting plan-specified raw materials production targets.

It necessary to step up exploration of the Kriushanskoye (Annenskoye) refractory clay deposit for the Semiluki Refractory Plant; the Ul'yanovskoye deposit for the Suvorovskoye Mine Administration; refractory clay sections adjacent to the Nizhne-Uvel'skoye deposit; the second unit section of the Yuzhnaya Poldnevaya refractory clay pit; the Zapadnyy section for the Druzhkovka Mine Administration; the Left-Bank refractory clay section for the Kirovograd Mine Administration; refractory clay and kaolin sections of the Polozhskoye deposit for the Priazovskoye Mine Administration; kaolin sections near the town of Zvenigorodsk for the Vatutino Refractories Combine.

The 26th CPSU Congress has specified an ambitious program of further growth and development of our country's industry, including ferrous metallurgy, of which the refractories industry is an integral part.

The Soyuzogneupor All-Union Production Association, the Ukrogneupornerud Republic Production Association, and all enterprises of the refractories industry have elaborated measures aimed at successful enterprise growth and development, improvement of production technology, mechanization and automation of production processes, adoption of scientific and technological advances, scientific organization of labor, improvement in the quality of produced refractory raw materials, and establishment of safe and highly productive working conditions.

To achieve successful accomplishment of the assigned tasks, it is necessary to communicate the targeted measures to each and every worker and to support accomplishment of these tasks with appropriate high-output mine transport and auxiliary equipment, material-technical resources, and scientifically substantiated organization of labor, working daily on indoctrinating working people in a spirit of excellent production discipline and responsibility for the assigned task. Mine workers of the refractories industry will apply all their resources, knowledge and experience in order honorably to accomplish their assigned task.

3024
CSO: 1842/22

UDC: 669:66.018.4; 66.043.2

HIGH-TEMPERATURE HEAT-INSULATING MATERIALS

Moscow VYSOKOTEMPERATURNYYE TEPLOIZOLYATSIONNYYE MATERIALY in Russian 1981 (signed to press 25 Mar 81) pp 2-11

[Annotation, table of contents and introduction from book "High-Temperature Heat-Insulating Materials", by Samuil Mikhaylovich Kats, Izdatel'stvo "Metallurgiya", 3,720 copies, 232 pages]

[Text] This volume presents the first systematized information in the area of technology and properties of high-temperature heat-insulating and heat-shielding materials based on refractory metals and their compounds, oxide ceramics, carbon-graphites, and composites. New methods of obtaining them are examined, as well as specific features of employment in furnaces, testing equipment, power generating equipment and other structures operating at high temperatures (2500-3200°C). The author presents calculated characteristics and methods of estimating the principal physical-mechanical properties of highly porous materials of cellular-powder, foam and fibrous structure.

This volume is intended for engineers and technicians employed at scientific research institutes, higher educational institutions, design institutes and design offices of the metallurgical, machine building and chemical industries, working in the area of development and application of these materials.

Contents

INTRODUCTION

Heat-insulating and heat-shielding materials are extensively employed in the most diversified areas of metallurgy, power engineering, machine building, and construction. In recent years extremely high-temperature materials, with a working temperature from 1500-2000 up to 3000-3500°C have become increasingly important.

Increased requirements in such materials in the metallurgical industry are due to increased temperatures in heating, roasting and melting furnaces. It is also due to the necessity of further increasing the efficiency and economy of equipment and production processes as well as equipment boosting.

Extremely high-temperature insulations and heat shields (linings, coatings, screens) are required in foundry operations, especially in die casting, in press forging (for insulating induction heater-containers), in the aerospace industry (for insulating gas turbines and combustion chambers), in thermal converters, in test equipment for testing materials and structures, and in a number of other areas of technology. A substantial increase in operating temperatures should be expected in coming years in nuclear power engineering, in rocket engines and spacecraft, magnetohydrodynamic generators, in vacuum arc furnaces, etc.

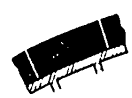
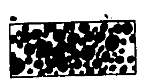
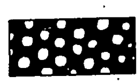
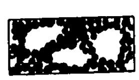
The need for heat insulation and shielding for the temperature range 2000-3500°C, which exceeds the operating temperature of the majority of conventional high-temperature thermal insulating materials based on oxides, metals and other heat-resistant materials, has required the development and application of new alloys and composites in these materials, in particular possessing the requisite mechanical properties at the specified temperatures. In connection with this, attention was focused on compounds of refractory metals with carbon, nitrogen, boron, as well as various composites. The heat-insulating properties of such materials are determined chiefly by their highly porous structure. This dictated the development of new industrial processes for producing highly refractory compounds in the form of foam materials, felts and other porous bodies. Theoretical methods were developed for analyzing the physical-mechanical properties of various highly-porous bodies, processes of molding and sintering, etc. In addition, the specific features of these materials and the conditions of their employment required the development of special methods of bonding, reinforcement, application of coatings, gaseous-phase deposition, new structural forms of composites, reflective shields, etc. Thus there has developed in recent years the area of heat-insulation and heat-shielding technology, which should be called ultrahigh temperature, as an addition to existing categories of high-temperature or highly refractory materials with a melting point of up to 2000°C.

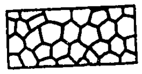
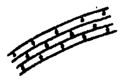
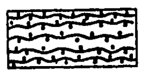
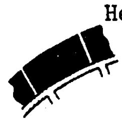
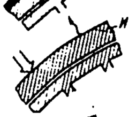
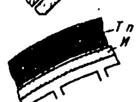
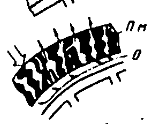
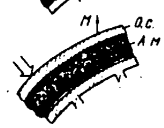
We shall first discuss the general classification of heat-insulating and heat-shielding materials contained in Table 1.

Thermal or heat insulation serves to limit the conductive, convective or radiation heat exchange between the insulated medium and its environment. Heat insulation is employed either independently or as a component part of a heat-shielding device.

Heat shielding serves as a barrier separating the protected structure from the effect of a hot environment, and is in the form of a coating, facing, lining, or more complex layer of compact or porous materials. Requirements on heat-shielding and heat-insulating materials differ, although in many cases their function coincides.

Table 1. Classification of High-Temperature Heat-Insulating Materials

Type	Designation	Diagram	Peculiarities and Areas of Application
1	2	3	4
			Heat-Insulating Materials
I	Nonporous		
I.1	Isotropic		Material: refractory oxides; thermal conductivity 2-6 w/(m°K); high strength; heat resistance 2200-2500°C
1.2	Anisotropic		Material: pyrographite, BN; thermal conductivity 1-2 w/(m°K); high strength; high cost
II	Highly-porous		Heat resistance to 3000°C; all refractory materials employed
II.1	Powder: loose		Porosity 20-60 percent; thermal conductivity 0.01-2 w/(m°K); does not bear load, requires packing; high specific surface; significant rate of ablation by vaporization; danger of caking of finely dispersed powders
	bound (granular)		Porosity 20-40 percent; thermal conductivity 5-30 w/(m°K)
II.2	Cellular		Porosity 10-70 percent; structural stability at high temperatures; relative thermal conductivity λ/λ_0=0.8-0.1. Simplicity of manufacture
II.3	Cellular-cellular		Porosity 30-80 percent; relative thermal conductivity λ/λ_0=0.5-0.05; enhanced mechanical properties
II.4	Cellular-powder: loose bound (granular)		Porosity 50-85 percent; relative thermal conductivity λ/λ_0=0.2-0.03; enhanced mechanical properties

1	2	3	4
II.5	Foam		Porosity 50-99 percent; relative thermal conductivity λ/λ_0=0.3-0.01; enhanced mechanical properties
II.6	Multiple-screen		Material: graphite, refractory metals and compounds, screen thickness 0.05-2 mm; low radiant and conductive thermal conductivity [10^{-3}-10^{-2} w/(m°K)]; maximum temperature 2200°C
III	Fibrous		
III.1	Non-fabric (felt)		Fiber material: oxides, carbon-graphites, oxygen-free compounds; porosity 50-99 percent; relative thermal conductivity λ/λ_0=0.1-0.001
III.2	Fabric		Low strength. High Heat resistance
III.3	Composite		Porosity 30-70 percent. Enhanced strength and rigidity
		Heat-Shielding Devices	
IV.	Barrier		
IV.1	Facing (lining)		Material: oxides, graphites; heat resistance to 2500°C; thermal conductivity 0.5-10 w/(m°K)
IV.2	Coatings		Material: oxides, metals, metal-like cermets (carbides, borides, nitrides) and ceramic-like cermets (SiC, BN, etc); heat resistance to 3000°C
V.	Heat-radiating		
V.1	"Hot" design		
V.2	"Cold" design		
VI	Heat-absorbing		
VI.1	Passive heat absorbers		
VI.2	Active cooling systems: cooling by sweating		
	film cooling		
VII	Self-destructive (ablation)		
VII.1	Non-carbonizing		
VII.2	Carbonizing		

Note: Э -- screen; И -- insulation; Т.п. -- heat absorber; П.м. -- porous material; О -- coolant; А.м. -- ablation material; О.с. -- carbonizing (or permeable) layer

The principal characteristics of heat-insulating materials are their maximum operating temperature and coefficient of thermal conductivity.

High-temperature insulating materials can be subdivided into four groups on the basis of temperature level:

1. With a maximum operating temperature up to 700°C. These include many general-use construction and industrial insulating materials, organic and inorganic: mineral wool, glass wool, cellular concretes, foamglass, asbestos, sovelite, kaolin and other heat-insulating materials.

2. Refractory, fibrous and loose insulating materials with a maximum operating temperature to 1750°C, chiefly based on oxide ceramics of SiO_2, Al_2O_3, MgO, ZrO_2, $ZrSiO_4$, lightweight fireclay and silica brick insulation.

3. Highly refractory porous insulation materials with a maximum operating temperature to 2300-2500°C -- of corundum, magnesite, chrome-magnesite and zirconium dioxide, as well as of highly refractory oxides of beryllium, yttrium, scandium, etc.

4. Especially high-temperature insulating materials with a maximum operating temperature in excess of 2500°C. Insulation of this group is made of carbon-graphitic materials, based on refractory metals and their compounds and alloys, as well as of certain oxides: ThO_2, HfO_2.

Commercially manufactured heat-insulating materials of the first two groups [158-160] [bibliography not included] are currently classified not by coefficient of thermal conductivity but by volumetric mass. They are subdivided into grades (15-700) according to volumetric mass (kg/m^3). The coefficient of thermal conductivity of conventional heat-insulating materials at room temperature ranges from 0.03 to 0.17 w/(m°K) for moderately efficient and to 0.25 w/(m°K) for low-efficiency insulating materials.

This estimate shifts considerably in especially high-temperature heat insulating materials. In the temperature range 2000-3000°C a thermal conductivity of 2-6 w/(m°K) is generally considered satisfactory, while insulation with a thermal conductivity of 1-2 w/(m°K) is considered very effective. Therefore in a number of instances certain highly porous materials are examined in this book, which were not designed specifically for utilization as insulation but possess low thermal conductivity. All insulating materials can be subdivided into four basic types by type of pore structure (see Table 1).

The first type includes certain nonporous materials possessing low thermal conductivity at high temperatures. A thermal conductivity of less than 6 w/(m°K) at a temperature of more than 1800°C can be claimed by many oxides: HfO_2, ThO_2, UO_2, ZrO_2, Y_2O_3, Sc_2O_3, Al_2O_3 [6].

Some pyrolytic anisotropic materials possess satisfactory heat-insulating properties [$\lambda < 2$-3 w/(m°K)] in a direction normal to the surface of deposition: various kinds of pyrographite at 2500-2800°C, and boron pyronitride at temperatures up to 2000°C.

The other kinds of heat-insulating materials achieve a reduction in thermal conductivity as a consequence of their porosity. An extensive class of highly porous insulating materials (Type II) can be subdivided into several groups: powder, cullular, cellular-powder, and foam.

The porosity of powder (granular) materials (Type II.1), with loose pouring or sintering of tightly packed grains does not exceed 0.3-0.6. Loose powder insulating materials possess low thermal conductivity due to considerable thermal resistances in the contacts between individual particles. Therefore not only poorly conducting oxide but also carbon-graphite, carbide and other powders the intrinsic thermal conductivity of which is high are employed in these materials. Friable cellular-powder loose materials (Type II.4), the porosity of which is 0.7-0.9, possess even less conductive thermal conductivity. In these materials, however, as a consequence of an increase in size d of the cellular pores, there is a substantial increase in heat transfer by radiation between particles, a multiple of d and T^3. One substantial limitation in the employment of powder and other porous insulating material with a large active surface figure is the considerable ablation as a consequence of vaporization and elevated temperatures. The refractory metals tungsten, rhenium, niobium, molybdenum, dense graphite, and carbides of tantalum, niobium, hafnium, and zirconium possess the lowest rate of evaporation in a vacuum. For example, the vaporizability of particles of tungsten 200 microns in diameter (specific surface $f_{sp}=1.65 \times 10^{-3}$ m^2/g) at 2500°C is 0.5%/h. The rate of removal of like particles of zirconium dioxide at 2500°C is significantly greater -- up to 97%/h. Usually removal of 20% of mass is considered allowable in estimating resource of loose powders, just as other highly porous insulating materials. We should note that the rate of evaporation of materials in an inert gas is as a rule 5 to 10 times less than in a vacuum. In addition, as a consequence of the low heat conductivity of powder insulating materials, temperature in these materials drops off sharply through the thickness of the layer.

Widely used cellular-powder materials with a porosity of up to 0.9 possess excellent heat-insulating properties; they are obtained mostly from oxides by the methods of gasification, expansion, or introduction of burning additives. The best materials of this type can operate at temperatures up to 2300°C and have a thermal conductivity of not more than 1-2 w/(m°K). Employment of highly porous insulating materials in stressed structures is limited due to the sharp decrease in strength and creep resistance.

Foam materials, which can be manufactured today out of practically all refractory substances, possess superior mechanical properties. Successes achieved in this area have made it possible to obtain highly effective foam thermal insulating materials (Type II.5) -- graphite foams, carbide foams and others with a porosity of up to 0.85-0.99 and a coefficient of thermal conductivity of 2-3 w/(m°K). The principal methods of obtaining them are based on utilization of carbonizing plastic foams. Highly porous heat insulating materials based on ceramic and carbon microspheres have become particularly widespread.

The class of fibrous insulating materials (Type III) is developing the most intensively at the present time. Fibrous insulating materials combine excellent heat-insulating properties and convenience of utilization in the form of flexible mats, sheets, felt pads, and cloths. Fibrous insulating materials possess mechanical properties which are superior to cellular and other highly porous materials of equal porosity.

Materials of high-temperature heat-shielding systems can be broken down into heat-shield barrier facings, radiation-type heat-dispersing systems, heat-absorbing systems, and self-destruction (ablation) coatings.

Thick-walled barrier-type facings. In many furnaces, high-temperature flues and combustion chambers the metal or ceramic structure which forms the hot cavity should be faced with a more highly refractory layer. Such a layer, assembled of separate prefabricated components, serves to protect the main load-bearing structure from the effect of hot gases, melts, and abrasive particles. It is made of heat-resistant oxides, non-oxide ceramics, metals, and carbon-graphites. A refractory facing of oxides is extensively employed in melting refractory metals, in aerospace vehicles as jet and rocket engine exhaust nozzle inserts, and to heat-shield leading edges and nose cones which heat to 2200-2750°C.

The majority of oxide refractory linings are also heat insulators, which reduce heat losses to the environment, and therefore should possess minimal thermal conductivity. Considerable efforts are directed at reducing brittleness and increasing the heat resistance of oxide linings. This is achieved as a result of reinforcing oxides with metal, oxide, and nitride filaments, impregnation with resins and thickening with pyrolytic carbon, as well as creation of a microcrack structure.

Thin barrier-type coatings can be single and multiple layer, and in chemical composition can be metal, cermet (metal-like and ceramic-like), oxide and silicate. In the simplest case a heat-shielding coating is formed directly on a metal surface. Some coatings possess comparatively poor thermal conductivity and can appreciably reduce the heat flow to the shielded metal structure. Heat-insulating properties are improved with the application of porous coatings, by plasma vaporization coating, for example. Employment of refractory metals (molybdenum, tungsten, niobium, tantalum) as heat-shielding coatings and layers is connected with their high operating temperature, low volatility in a vacuum and in gases, and high reflectivity. Refractory metal coatings deposited on graphite from gaseous phase improve its gastightness, wear resistance and erosion resistance in high-temperature oxygen-free environments.

Crystalline oxide coatings are extensively employed as heat-insulating coatings. Drawbacks of oxide coatings include poor heat resistance, brittleness, poor cohesion with protected surfaces, and limited refractoriness.

Many metal-like and ceramic-like cermet coatings possess high hardness, resistance to wear, and refractoriness. Coatings of metal-like compounds based on silicides, borides, and carbides of d-transition metals possess comparatively high thermal conductivity, which ensures their heat resistance, but their heat-insulating properties are diminished. Of special interest among heat-shielding coatings based on ceramic-like compounds with high refractoriness and resistance to wear are coatings of pyrolytic boron nitride, boron carbonitride, α-SiC, AlN.

Radiation-type heat-dispersing systems are suitable for shielding against large radiant flows. An equilibrium temperature can be achieved in a thin outer layer with high reflectivity, whereby the bulk of the arriving heat flow is reflected back into the surrounding medium. Heat insulation is one of the component elements in these systems. With interior placement of insulation, a metal power-generation structure -- facing shields -- is subjected to external heat flows. Such a design is sometimes called "hot" (Type V.1). Exterior facing can be of smooth or corrugated metal sheets with protective coatings, equipped with stiffeners, in the form of girders or honeycombs, for example. Facing can be uncooled or have supplementary cooling, but in all cases the exterior surface should have high radiating capacity or reflectivity.

A "cold" design is extensively employed, especially in electric furnaces, a design in which the heat insulation proper is subjected to external heating, this insulation being placed on the surface of a metal shell (Type V.2), or heat insulation faced with a denser lining, which also has comparatively poor thermal conductivity.

Other types of high-temperature heat-shielding systems -- heat-absorbing and self-destruction (ablation), which are characterized by short duration of operation, characteristic chiefly of space hardware, are not examined in this volume; information on formulas and the mechanism of destruction of the principal classes of these heat-shielding coatings is given in [14]. Therefore we shall limit ourselves to the classification in Table 1.

Heat-absorbing devices include systems which employ passive heat absorbers, with gas and hydrodynamic cooling, as well as containing partially removed materials.

Systems with passive heat absorbers are based on utilization of the heat capacity of a material possessing high values of specific heat and coefficient of thermal conductivity. In addition to accumulation of heat due to a material's heat capacity, part of the applied heat is radiated by the exterior surface. High thermal conductivity is essential for uniform heating of the heat absorber, avoiding substantial temperature fluctuations. To prevent intensive heat transfer to the protected structure, addition insulation is placed between it and the heat absorber (Type VI.1).

Heat absorbers employed for heat shielding can operate for a very short period of time. With very high thermal loads and high friction stresses, active gas- and hydrodynamic cooling systems are employed (Type VI.2). They include cooling systems in which cooling agent is fed into the flow through porous material, and systems with film cooling.

Heat-insulating materials employed in the range 1500-1700°C are not examined in this volume, since they are described in detail in [158-160]. The same applies to the manufacturing process and properties of commercially-manufactured highly refractory oxide materials discussed in books written by prominent Soviet investigators [2, 16, 19, 21, 130].

Principal attention in this volume is devoted to especially high-temperature materials, including those based on oxygen-free compounds and graphites, which make it possible to achieve operating temperatures of 3000-3500°C, including the most effective fibrous, cellular-powder, foam and multiple-screen insulating materials.

Selection of an optimal (for specific applications) type and parameters of heat-insulating materials, as well as a scientifically substantiated area of technology in developing a new heat insulating material with specified properties is possible only if one takes into account the functional relationship between the physical-mechanical properties of the material and the specific features of its concrete porous structure. Toward this end the book undertakes to examine various properties of the basic types of porous bodies based on an analysis of their generalized structural models. In view of the complexity and diversity of actual porous structures, such a model analysis cannot be considered completed. The aim of this work was further development of theory and practice of especially high-temperature insulating materials on the basis of a critical examination, synthesis and classification of the latest advances in this field.

3024
CSO: 1842/33

MISCELLANEOUS

UDC: 629.12.002.3(075.3)

MATERIALS SCIENCE AND SHIPBUILDING

Leningrad MATERIALOVEDENIYE DLYA SUDOSTROITELEY in Russian 1981 (signed to press 24 Jun 81) pp 4-6, 246-248

[Introduction and table of contents from book "Materials Science for Shipbuilders", by Viktor Vasil'yevich Andreyev, Izdatel'stvo "Sudostroyeniye", 18,000 copies, 248 pages]

[Text] INTRODUCTION

Various materials, the number of which is increasing year by year, are utilized in the shipbuilding industry.

In the past ships were constructed of wood, and it was not until the 19th century that iron began to be employed in building ship hulls, and later Bessemer and open-hearth steel plate. Up until approximately 1945 carbon steel was the principal material in Soviet hull construction. After the Great Patriotic War low-alloy steel began to be extensively employed for ships' hulls. Today almost all large vessels are built of high-grade carbon and low-alloy steels.

Aluminum-magnesium alloys began to be utilized in shipbuilding in the 1930's. Earlier attempts had also been made to use aluminum alloys. At the end of the 19th century, for example, torpedo boats were built in Russia of aluminum alloys, but they failed to receive recognition at that time due to poor corrosion resistance and strength. Extensive employment of high-strength and corrosion-resistant aluminum-magnesium alloys in the shipbuilding industry began in the 1950's. Structural components made of these alloys weigh half as much as corresponding steel ones. This makes it possible to increase a vessel's load-carrying capacity, to increase its speed or lessen the horsepower of the propulsion units. These alloys are used in building ship superstructures, hulls of hydrofoil vessels, rescue vessels, etc.

Extensive employment of new materials, such as plastics, is a characteristic feature of modern shipbuilding.

A ship is a complex man-made structure, construction of which requires a large quantity of diversified materials: carbon and alloy steels, aluminum-magnesium alloys, titanium and titanium alloys, copper and copper alloys, cast iron, concrete, wood, plastics, paints and varnishes, etc.

Material is selected on the basis of the requirements imposed on a vessel, structure or component part (mechanical strength, durability, economy, reliability, etc). By making a correct choice, one can increase a vessel's reliability and service life, increase its speed and load-carrying capacity, reduce its weight, reduce operating costs, reduce cost of construction and increase labor productivity in construction.

A mastery of materials science will help determine the question of the suitability of the material for specific purposes.

Materials science is the science which investigates the composition, methods of producing, physical, chemical and mechanical properties, methods of heat treatment and combination chemical and heat treatment of materials, as well as their function.

The fundamentals of this science were laid down in the third decade of the 19th century, when a general concept was formed of the structure of metals and alloys and when commercial methods were developed for producing steel and the fundamentals of heat treatment were elaborated. From that time forward physical metallurgy began to assume increasing importance in determining questions of the suitability of metals for various uses, production of alloys with specified properties, imparting to them the required properties with the aid of heat treatment and combination chemical and heat treatment, etc.

The fundamentals of theory and the scientifically substantiated technology of heat treating steel were laid down in the writings of D. K. Chernov (1839-1921) on the metallography of iron and steel, which gained international recognition. He also developed the theory of crystallization, created one of the most advanced quenching methods -- isothermal hardening, and pointed out the advantages of crystallization under pressure and centrifugal casting.

The biggest discovery of the 19th century was the periodic law of D. I. Mendeleyev (1834-1907), which enables one to establish the relationship between properties, composition and structure of metals and to predict change in both physicochemical and mechanical properties.

Further successes in physical metallurgy are inseparably linked with the names of Soviet scientists N. A. Minkevich, S. S. Shteynberg, N. T. Gudtsov, N. S. Kurnakov, A. A. Baykov, A. A. Bochvar, G. V. Kurdyumov, and many others.

Today plastics and other nonmetallic materials are utilized throughout the economy, the creation of which became possible thanks to the work of A. M. Butlerov on theory of the chemical structure of organic compounds; S. V. Lebedev, who demonstrated the possibility of the commercial manufacture of synthetic rubber; V. A. Kargin, who performed structural investigations of polymeric materials, and others.

The 26th CPSU Congress assigned industry large tasks. For example, the "Principal Directions of Economic and Social Development of the USSR for 1981 and 1985 and the Period up to 1990" specify that the ferrous metallurgical industry is to produce in 1985 117-120 million tons of finished rolled ferrous metal products. Cold-rolled sheet output is to increase by 50-150 percent. Electric furnace steel production is to increase by 60 percent; in nonferrous metallurgy aluminum output is to increase by 15-20 percent, copper by 20-25 percent, nickel and cobalt by not less than 30 percent, with a production increase in zinc, lead, titanium, magnesium, precious metals, as well as tungsten and molybdenum concentrates, niobium and other alloying elements; in the chemical and petrochemical industry there is to be an increase in production of synthetic rubbers, replacing natural rubber, with increased production of high-grade polymers with prescribed technical characteristics. Improving the quality of produced materials and their economical utilization in the economy are no less important tasks.

CONTENTS

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