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JPRS-UMS-85-009

5 December 1985

USSR Report

MATERIALS SCIENCE AND METALLURGY

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5 December 1985

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MATERIALS SCIENCE AND METALLURGY

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ANALYSIS AND TESTING

UDC: 538.653.1

INFLUENCE OF PLANAR EXTENSION ON DOMAIN STRUCTURE AND MAGNETIC PROPERTIES
OF FERROSILICON

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49,
No 8, Aug 85, pp 1568-1572

DRAGOSHANSKIY, Yu. N. and SHEYKO, L. M., Institute of Metal Physics,
Urals Scientific Center, USSR Academy of Sciences

[Abstract] The influence of biaxial extension on the domain structure and shape of magnetostriction curves was studied on single crystals of the alloy Fe-3%Si in plates 50 x 50 x 0.2 mm with the surface at an angle of not over 10 degrees from the (011) plane. The domain structure was observed by means of the meridional magneto-optical effect in reflection. Biaxial stress was created by force uniformly distributed along the side edges of the specimen perpendicular to the edges. The change in magnetic losses under the influence of coatings was determined by a watt meter in a closed magnetic circuit on strips cut from the sheets at various angles to the rolling direction. The results showed that biaxial stress as a function of magnitude and ratio of the two stresses may either increase or decrease the width of domains, magnetic losses and magnetostriction. The maximum positive effect in the material under the influence of magnetically active coatings can be expected with good crystallographic texture and with planar stresses of about 15 MPa with a stress ratio close to unity.

References 12: 8 Russian, 4 Western.

[13-6508]

UDC: 538.658.2

DOMAIN STRUCTURE AND PROCESS OF MAGNETIZATION OF AEROSILICON BICRYSTALS

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1573-1575

KATAYEV, V. A., STARODUBTSEV, Yu. N. and DRAGOSHANSKIY, Yu. N., Urals University imeni A. M. Gorkiy; Institute of Metal Physics, Urals Scientific Center, USSR Academy of Sciences

[Abstract] A study is made of curves of magnetization and domain structure of bicrystalline Fe-3%Si over a broad range of fields. A bicrystal measuring 120 x 10 x 0.25 mm was used with the intercrystalline interface passing approximately through the middle of the specimen. Domain structure was observed by means of the meridional effect and static magnetostriction was measured by tensometers. The process of magnetization of the bicrystalline specimen can be represented as follows: in magnetizing fields of up to $50\text{A}\cdot\text{M}^{-1}$, magnetic switching is performed at the permeability which is the average for the two crystals; as the magnetic field intensifies, a closing domain structure is formed at the crystalline interface, compensating for the magnetic charges related to the different inductions in the neighboring crystals and magnetization of the disoriented crystal by the neighboring crystal with ideal orientation occurs in these fields. In fields of over $1000\text{A}\cdot\text{M}^{-1}$, the closing domain structure disappears and magnetic scattering fields arise at the intercrystalline interface. References 10: 3 Russian, 7 Western.

[13-6508]

UDC 546.98:543.257.5

AMPEROMETRIC DETERMINATION OF PALLADIUM IN CATALYSTS

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 51, No 8, Aug 85 (manuscript received 19 Nov 84) pp 2-4

ZAKHAROV, V. A., ZABOTIN, P. I., DRUZ, S. V., and AKULOVA, G. V., S. M. Kirov Kazakh State University and the Institute of Organic Catalysis and Electrochemistry of the Kazakh SSR Academy of Sciences in Alma-Ata

[Abstract] Amperometric titration with potassium iodide was used to determine palladium concentration in skeletal nickel catalysts and impregnating palladium solutions. A weighed quantity of 0.02 to 0.2 grams of catalyst, or five to 10 milliliters of impregnating palladium solution was placed in a heat-resistant beaker. Ten to 15 milliliters of concentrated HNO_3 was added. The test solution was heated until it completely decomposed and was then boiled down to a volume of two to three milliliters. The cooled solution was transferred to a graduated flask and topped up with distilled

water. A two to five milliliter aliquot of this solution was placed in a beaker, and enough 0.1 M background solution of KNO_3 was added to make 20 milliliters. This solution was titrated with 0.01 or 0.005 N KI on a visual amperometric device with its rotating platinum signal electrode set at +0.8 volts. Current strength was recorded on an M 194 galvanometer. The presence of chloride ions in surplus multiples up to 200 did not affect either the shape of the amperometric curve nor the results of palladium titration. With larger surplus multiples (300 to 500) of chloride, the amperometric curve became somewhat flatter in the region of the terminal point of titration, and the results of palladium titration were extremely low. In the presence of nitrite ions, the palladium titration results were extremely low, and the shape of the titration curves was rather flat. This effect was eliminated by boiling down the test solution with concentrated nitric acid. Figures 1; references 5: 4 Russian, 1 Western.
[2-13050]

[No UDC provided]

USING VARIABLE-CURRENT POLAROGRAPHY TO ANALYZE CONVERSION COATINGS FOR NITROGEN-HARDENED STEEL

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 51, No 8, Aug 85 pp 18-19

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[Abstract] The research was done to modify previous methods of determining the concentration of NH_4^+ ions in corrosive media and to study the dissolution kinetics of nitrogen-hardened steels. Five milliliters of 0.05 M Na_2SO_4 solution was placed in a graduated flask. Ten milliliters of 0.3 M potassium citrite was added to the solution. The pH was brought up to 5.0 using 0.1 M NaOH and 0.05 M H_2SO_4 . Three milliliters of 40% formaldehyde was then added and the flask was topped up with distilled water. This solution was placed in a polarographic cell where the oxygen was removed with the aid of electrolytic hydrogen. A PU-1 universal polarographic peak of the product of the interaction between ammonium and formaldehyde ions registered more positively (E equals approximately -1.1 volts) than the reduction peak for formaldehyde (E = -1.6 volts). A greater concentration of potassium citrite (which was used to prevent the iron from affecting the interaction of the ammonium and formaldehyde ions) resulted in the growth of the depolarizer's reduction current and improved peak morphology. The values of the methylenimin reduction currents as a proportional function of NH_4^+ ion concentration and iron as a proportional function of its concentration were used to determine simultaneously their concentration in the corrosive media. The polarization parameters were: $v = 2$ millivolts per second; $A = 10$ millivolts; current range of 2.5. Figures 1; references 3 Russian.
[2-13050]

[No UDC provided]

A DEVICE FOR TESTING METAL HARDNESS AT HIGH TEMPERATURES

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 51, No 8, Aug 85 pp 81-82

ZMIYEVSKIY, V. I., ZAMILATSKIY, Ye. P., and SMIRNOV, G. N.

[Abstract] This device consists of a vacuum chamber equipped with a heating unit, a load device, a specimen loading mechanism, a lifting mechanism, and a work platform. Design modifications in the specimen loading mechanism and in the work platform have made it possible to securely load and hold the specimen being tested in the center of the work platform. The loading mechanism was made in the form of two coaxially rotating disks. Rods of varying length are incorporated into the surface of the platform to hold the specimen. The lifting mechanism consists of an electric motor with a reduction gear and a screw mechanism for ease in handling the specimens. This device is capable of consecutive testing of 15 cylindrical specimens 16 millimeters in diameter within a temperature range of 293 to 2200 K. Each specimen can be pricked 300 to 400 times without have to renew the hermetic seal of the chamber. This device was used to test various refractory materials such as 5VTs niobic alloys. Some of the properties tested were hardness, tensile strength, and yield stress as functions of temperature. A practically linear reduction in hardness was observed with an increase in temperature. The other functions behaved in similar fashion. The correlation curves for tensile strength and hardness as a function of temperature were similar to curves obtained from experimental results. This device demonstrated that it can efficiently and reliably evaluate metal hardness at elevated temperatures. Figures 2; references: 4 Russian. [2-13050]

UDC: 539.4

KINETICS OF DEFORMATION AND DAMAGE ACCUMULATION IN CONCENTRATION ZONES UPON NONISOTHERMAL LOW-CYCLE LOADING

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 14 Jun 84) pp 19-24

KAZANTSEV, A. G., GUSENKOV, A. P. and CHERNYKH, A. N., Institute of Machine Science, USSR Academy of Sciences

[Abstract] Data are presented on durability of specimens of steel type 15Kh2MFA with elastic stress concentration coefficients of 2.5 and 3.5 under nonisothermal loading. Specimens used had gage sections 1.5 mm thick and 40 mm wide, with sharp side notches and circular central apertures. The specimens were heated in a low-inertia furnace with type KGM quartz-halogen lamps. The specimens were held in water-cooled clamps. Test

temperatures varied from 100 to 500°C. The number of cycles to failure was found to depend on the phase of application of the temperature cycle to the loading cycle. Durabilities with loading nad temperature in phase were close to the data for a constant temperature of 500°C. In counterphase, the number of cycles to failure averaged two to five times higher. In all cases the divergence of durability calculated considering quasistatic damage accumulation from experimental durability values did not exceed the corresponding divergence of smooth specimens. The differences in durabilities with isothermal and nonisothermal loading conditions resulted only from the deformation properties of the material in the temperature range studied. References 11: all Russian.

[10-6508]

UDC: 620.198.8:620.178.16.3.81

INFLUENCE OF STRESS CONCENTRATION ON FATIGUE AND CORROSION-FATIGUE PROPERTIES OF VAL10 ALUMINUM CASTING ALLOY AND AK6 ALUMINUM FORGING ALLOY

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 7 Jul 83) pp 24-29

KARLASHOV, A. V., POLISHCHUK, V. M., GNATYUK, A. D. and BELETSKIY, V. M.,
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[Abstract] Experimental studies were performed on the influence of a circular notch on fatigue and corrosion-fatigue resistance of specimens of VAL10 alloy with grade 3 porosity and AK6 alloy, considering the anisotropy of its mechanical properties. Specimens with a smooth gage section and with stress concentrators 10 mm in diameter were tested on a type MUI-6000 testing machine. The fatigue resistance of VAL10 was found to depend on the porosity of the specimens, while the anisotropy of fatigue properties of AK6 as a function of texture direction was slight. Stress concentrators decreased the endurance of AK6 by 36 to 40%, regardless of test base length. The decrease VAL10 did depend on test base, being 24% for $5 \cdot 10^4 - 10^6$ cycles, 24 to 40% for $10 - 20 \cdot 10^6$ cycles. As porosity of VAL10 specimens increased, the influence of stress concentrators on durability decreases. In corrosive media the endurance of AK6 decreases by 45 to 53%, both along and across the orientation of the texture. Corrosive media have practically no influence on durability of notched VAL10 specimens at 32 to 70 MPa. References 8: all Russian.

[10-6508]

INFLUENCE OF TEMPERATURE ON MICROPLASTICITY AND CYCLICAL STRENGTH OF
1201 ALLOY

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 16 Dec 83) pp 29-31

SEREGIN, G. V., Novosibirsk

[Abstract] A study is made of the influence of test temperature on microplasticity and fatigue durability of aluminum alloy type 1201. Diagrams of cyclical deformation of cylindrical specimens by torsion were compiled to study the microplastic properties of the alloy. Microplasticity parameters produced by this method were compared with results of fatigue testing of flat specimens by extension. Microdeformation by torsion was conducted at 77, 173, 223, 292, 323, 373, 423 and 473 K, with a deformation rate of 10^{-5}s^{-1} . The friction stress preventing movement of dislocations was found to be practically independent of test temperature. There is a safe cycle stress amplitude for which the cyclical durability of the specimens approaches infinity. At temperatures above room temperature, this amplitude has little to do with test temperature and correlates well with friction stress. References 8: all Russian.
[10-6508]

UDC: 539.4

LOW-CYCLE FATIGUE AND CRACK RESISTANCE OF BOILER PIPES AND STEAM LINES
MADE OF 12Kh1MF STEEL

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 12 May 83) pp 31-35

ZELENSKIY, V. G., FEDOSEYENKO, A. V., SARKISYAN, V. A. and SEVRYUGIN, V. V.,
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[Abstract] A study is made of the characteristics of low-cycle fatigue and crack resistance of 12Kh1MF steel by testing specimens and actual sections of steam lines made from a single batch of pipe with 194 mm outside diameter and wall 36-39 mm thickness. Low-cycle fatigue and crack resistance tests were performed, plus standard long-term strength tests and tests of chemical composition and mechanical properties. The test results all corresponded to the technical requirements for steam lines and were average for this type of steel. At all stress levels, failure occurred without deformation. The ratio of the number of load cycles to failure after formation of cracks to the total number of cycles to failure was 0.2-0.5, varying with the stress level. Crack development rate in steam lines during testing with mean crack depth 13-17 mm was significant, $1.76-3.5 \cdot 10^{-2}$ mm per cycle. References 4: all Russian,
[10-6508]

STUDY OF CRACK RESISTANCE OF CORROSION-RESISTANT GLASS-REINFORCED PLASTICS
BY ACOUSTICAL EMISSION METHODS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 28 Dec 83) pp 35-39

NAUMETS, V. N., NIKIFOROV, A. T., GUZ, I. S., BULAKH, V. V.,
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[Abstract] The crack resistance of corrosion-resistant glass-reinforced plastics (CRGRP), the resistance of the material to formation of cracks and resistance to propagation of existing cracks, is determined by an acoustical emissions method. Studies were performed on flat wedge-shaped specimens. Composite specimens were exposed in the unstressed state to aqueous solutions of alkali and hydrochloric acid by immersion in the corrosive media in glass desiccators contained in heat chambers. The specimens were tensile-tested before and after exposure to the corrosive media. Acoustical emission signals were recorded in analog form in the 100 to 2,000 kHz band. The signals were used to establish the stages of formation and propagation of cracks for all types of CRGRP. The experiments indicate that the theoretically defined variation between coefficients expressing the rate of formation and of development of cracks in CRGRP composites needs further study. References 10: all Russian.
[10-6508]

CONTACT FATIGUE UPON LOW-CYCLE LOADING OF WC-Co HARD ALLOYS DESIGNED
FOR PRESSURE WORKING OF METALS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 4 Jul 83) pp 39-42

FALCOVSKIY, V. A., KURALINA, M. V., TRAVUSHKIN, G. G. and TYABLIKOV, Yu. Ye.,
All-Union Scientific Research and Planning Institute of Refractory
Metals and Hard Alloys

[Abstract] Results are presented from studies of contact fatigue with continuous recording of damage upon compression loading of hard alloys designed for the manufacture of punching dies. New alloys were studied, made of high temperature powders -- large grain materials with tungsten carbide grain size 3.5-4.0 microns (VK10KS, VK15KS and VK20KS) and medium grain with grain size 2.2-2.5 microns (VK15S). For comparison, the standard alloy VK20 with grain size 2.2-2.5 microns was also studied. The longest life between reworking was that of VK15-S (about 990,000 stamps). The test method allows an approximation under laboratory conditions of the actual

loading conditions of the dyes, permitting prediction of the behavior of the alloy under operating conditions. All of the alloys made with high temperature tungsten and tungsten carbide powders had better resistance to microfracture than the VK20 alloy based on low-temperature powder.

References 2: both Russian.

[10-6508]

UDC: 621.039.531

METHOD AND INSTALLATION FOR STUDYING RESISTANCE OF STRUCTURAL MATERIALS TO CYCLICAL LOADING UNDER NEUTRON BOMBARDMENT CONDITIONS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85

(manuscript received 7 Aug 84) pp 83-86

KISELEVSKIY, V. N., KHARITONOV, D. F., STEPCHUK, N. P. and ALYABYEV, A. G., Institute of Strength Problems, Ukrainian Academy of Sciences, Kiev

[Abstract] The materials of the first stage of a thermonuclear reactor experience powerful cyclical loading under conditions of stress relaxation induced by radiation. The 'Neytron-5M' installation developed at the Institute of Strength Problems, Ukrainian Academy of Sciences, can be used to test materials for such conditions. Exposure of the test equipment to neutron bombardment makes accurate testing difficult. This article reports cyclical torsional testing of thin-wall cylindrical specimens on this machine. When tests are performed within the reactor, the loading device must be placed in the research channel of the reactor, which is evacuated and then filled with helium under low pressure. The power and measurement cables are run out of the reactor to a distribution panel through which they are connected to the control rack which is located outside the reactor room. References 2: both Russian.

[10-6508]

UDC 621.74.08:669.13

AUTOMATIC DIGITAL DETERMINATION OF CHEMICAL COMPOSITION OF LIQUID IRON

Moscow LITEYNOYE PROIZVODSTVO in Russian No 8, Aug 85 pp 23-24

FAYNZILBERG, L. S., candidate of technical sciences, VLASENKO, Yu. V., engineer, TUKHIN, E. Kh. and SHELKOVYY, E. A., candidates of technical sciences

[Abstract] A new way of monitoring the chemical composition of liquid iron by a thermographic method is described. The method determined CE

and carbon and silicon content on the basis of a thermogram of the crystallization of the test iron. The operator thus can determine CE, C and Si parameters in order to determine the features of the final product. Features of the use of the thermogram are described. The analytic equipment has Soviet and US patents. Since thermogram details are made available during the cooling process, production corrections are possible. Production tests with more than 100 thermograms have verified the effectiveness of the "Chugun" (Iron) digital analyzer at the Stankolit plant's cupola furnaces. The device can efficiently determine temperatures and plot functions from the thermograms to identify trends.

[11-12131]

MOTION OF PARTICLES IN PRODUCTS OF GAS-MIXTURE DETONATION

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 26 Jan 83) pp 49-51

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[Abstract] In an experiment with spray deposition of Al_2O_3 powder on a substrate by heating and condensation, such a powder with an initial dispersion of 40 μm was injected from an originally 50% full batcher into a cartridge 2 cm in diameter and 2 m long containing an acetylene-oxygen mixture. Injection of that powder by relaxation of the pressure in the batcher and the resulting suction effect was followed by detonation of the gas mixture. The motion of Al_2O_3 particles carried by the resulting shock wave from the cartridge to the substrate presenting a barrier across the path was monitored by conventional scanning through a slit as well with a luminescence photometer and a piezoelectric pressure transducer. An earlier study has already revealed that the surface temperature of Al_2O_3 particles in such a process remains almost constant at 3000 K during their discharge. The results of this study indicate that they begin to glow only upon impact on the substrate-barrier and that maximum impact velocity is attained with the plane of the substrate-barrier inclined at a 36-50° angle to the axis of the cartridge. The many bright streaks recorded along the path of the shock wave are images not of Al_2O_3 particles but of inhomogeneities in the stream of detonation products. References 4: all Russian.
[8-2415]

DEFORMATION AND VARIABLE LOADING OF METAL-POLYMER TWO-LAYER PLATES

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 85
(manuscript received 22 May 84) pp 409-416

MOSKVITIN, V. V. deceased, Moscow State University imeni M. V. Lomonosov,
and STAROVOYTOV, E. I., Belorussian Institute of Railroad Transportation
Engineers, Gomel

[Abstract] The known theorem regarding deformation under a variable load is extended to heterogeneous bodies, specifically to composite plates consisting of metal and polymer layers. A simple two-layer plate is first considered under a load which deforms it from the natural state, its metal layer conforming to Kirchhoff's hypotheses and its polymer layer conforming to Reissner's hypothesis of a rectilinear noncontractible deformed normal. On this premise, displacements and strains in both layers are linearly related to displacements of points in the median plane of the metal carrier, to shear strains in the soft liner, and to deflection of the plate as a whole. The corresponding equations of equilibrium as well as the boundary conditions for this problem are derived from the appropriate variational principle involving forces and moments, all forces and moments then being resolved into their linear and nonlinear components. The system of equations contains the Ilyushin plasticity function as well as a function characterizing the rheonomic plasticity of the metal and a function describing the physically nonlinear properties of the polymer, the latter function assumed to remain always smaller than unity and thus appearing as a "small parameter". The problem is reduced by successive approximations to a linear homogeneous problem of transient thermoelasticity with complementary forces. It is solved for successive instants of time corresponding to changes in the load. The procedure, adapted for numerical solution on a YeS-1022 computer, is demonstrated on a circular plate in alternating flexure under a cyclic axisymmetric load. References 6:
all Russian.

[5A-2415]

PROPERTIES OF CARBON-GLASS PLASTIC MATERIAL UNDER PURE FLEXURE

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 85
(manuscript received 12 Jun 84) pp 417-422

ZHIGYN, I. G., PAVLOV, G. A., GORBAN, V. G. and POLYAKOV, V. A., Institute of Polymer Mechanics, LaSSR Academy of Sciences, Riga

[Abstract] A representative series of hybrid composite plastic materials, namely combinations of T-P-GVS-9 glass cloth and LU-P-0.2 carbon tape with PN-609-27 polyester resin as binder, was tested for load capacity under pure flexure depending on the volume (thickness) ratio and the distribution of components. Another purpose of the experiment was to establish the feasibility of testing such materials by simple methods applicable to nonhomogeneous beams. The test specimens were 3.2-3.5 mm thick plates consisting of carbon-fiber and glass-fiber layers, the carbon fibers oriented parallel to the cloth substrate and impregnated with resin. These plates had been vacuum-pressed in special molds for uniform buildup of pressure from the center to the edges so as to ensure a stable thickness of monolayers with the maximum volume fraction of reinforcement. Three kinds of structures were thus produced and tested: 1) double-layer plates with a carbon-fiber upper layer and a glass-fiber lower layer; 2) symmetric triple-layer plates with a glass-fiber layer between two carbon-fiber layers of same thickness; 3) asymmetric triple-layer plates with a glass-fiber layer between two carbon-fiber layers of different thicknesses. In each case increasing the thickness of the carbon-fiber layers at the expense of the glass-fiber so as to maintain the same total plate thickness was found to increase the effective modulus of elasticity and the load capacity of the plate. A symmetric triple-layer plate was, moreover, found to have consistently a higher load capacity than an asymmetric one. The experimental data correlate well with theoretical values of the modulus of elasticity based on the relations of beam mechanics with known physical properties of the materials and geometrical dimensions of the layers. References 9: 7 Russian, 2 Western (both in Russian translation).
[5A-2415]

COMPARATIVE CREEP ANALYSIS OF UNIDIRECTIONALLY ORIENTED COMPOSITE MATERIALS WITH VARIOUS KINDS OF REINFORCING FIBERS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 85
(manuscript received 26 Jun 84) pp 431-436

PLUME, E. Z., Institute of Polymer Mechanics, LaSSR Academy of Sciences, Riga

[Abstract] The creep characteristics of composite materials with unidirectional reinforcement are first calculated generally from the corresponding strain tensor and Boltzmann-Volterra integral equation, with the creep kernel approximated as a sum of exponential terms

$$K_{1111}^m(t-t') = \frac{\lambda_{1111}^m}{k} \sum_{i=1}^k \beta_i e^{-\beta_i(t-t')} \text{ following an approximation of}$$

experimental stress-strain curves through minimization of the corresponding target functional

$$\phi = \frac{1}{M \cdot L} \sum_{i=1}^M \sum_{j=1}^L [(\epsilon_{ij}^{\text{calc}} - \epsilon_{ij}^{\text{meas}}) / \epsilon_{ij}^{\text{meas}}]^2 \rightarrow \min (L -$$

number of strain points at each stress level, M- number of curves in that family). On this basis are then evaluated the creep characteristics and relevant other rheological parameters of composite materials with four different kinds of reinforcement (glass fiber, organic fiber, boron fiber, carbon fiber), all containing EDT-10 epoxy resin as binder, under various loads and in correspondingly various states of stress. The results reveal that the strain ratio $\epsilon_{ij}(t)/\epsilon_{ij}(0)$ (at time t and at time t=0 respectively) is an accurate indicator of creep and that the tensor of creep kernels for composites with glass-fiber, boron-fiber, carbon-fiber reinforcement, but not with organic-fiber reinforcement, can be determined from a single scalar function of time. In the case of organic-fiber reinforcement the error of such a determination increases with increasing volume fraction of such a reinforcement. References 13: 11 Russian, 2 Western.
[5A-2415]

STRESSED-STRAINED STATE OF TRIPLE-LAYER HONEYCOMB PANELS WITH CARBON-PLASTIC SHEATHS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 85
(manuscript received 9 Aug 84) pp 486-491

SHCHERBAKOV, V. T., VEDNEVA, V. S., KIRILLOV, Yu. V. and MURATOV, V. M.

[Abstract] The load capacity of triple-layer flat and cylindrical panels containing a low-modulus honeycomb filler between two high-modulus carbon-plastic sheaths is determined theoretically and from experimental data, following an analysis of their stressed-strained state under a compound four-point flexural and axial compressive loads. Tests were performed on girders, which are much more easily clamped and tested in tension or compression than plain panels with relatively thin carbon-plastic sheaths. Calculations were made by the finite method, including a triangular triple-layer panel as a special finite element, according to the "FRONT" program. The data thus obtained, including the effective moduli of elasticity and Poisson ratios, cover three reinforcement schemes: $(+30^\circ/0^\circ_{1/2})_s$, $(+45^\circ/0^\circ_{1/2})_s$, $(+60^\circ/0^\circ_{1/2})_s$ with 0.65 or 0.63 mm thick sheaths and correspondingly 5 or 10 mm high filler. Anisotropic carbon filler KMU-4L and orthotropic fillers of PSP-2N polystyrene foam, aluminum, and paper were considered for both testing and calculations. References 7: all Russian.
[5A-2415]

CORROSION

UDC: 621.791.052:669.296'293:620.193.2

CORROSION RESISTANCE OF WELDED JOINTS IN ALLOY OF ZIRCONIUM WITH 2.5% NIOBIUM IN HYDROCHLORIC, SULFURIC AND PHOSPHORIC ACIDS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 4 Oct 84) pp 53-56

NERODENKO, M. M., Doctor of Technical Sciences, ONOPRIYENKO, L. M.,
GORBAN, V. A., and GONCHAROV, A. B., Engineers, Institute of Electric
Welding imeni Ye. O. Paton, Ukrainian Academy of Sciences

[Abstract] A study is made of the influence of methods and conditions of welding, the composition of the welding atmosphere and the heat treatment used on the corrosion resistance of welded joints in a zirconium alloy in boiling hydrochloric, sulfuric and phosphoric acids. The alloy contained 2.5% Nb, 0.056% O, 0.0006% H and 0.0067% N. Helium arc and argon arc welding was performed with an infusible tungsten electrode. The joints had good corrosion resistance in all three acids at the boiling temperature if the acid concentration was not over 30, 70 and 40% for hydrochloric, sulfuric and phosphoric acids, respectively. Joints welded at 1.68 cm/s in helium containing not over 0.001% water vapor and nitrogen had good corrosion resistance. Corrosion resistance can be significantly increased by heat treatment of the joints in air at 740 K for two hours.

References 11: 10 Russian, 1 Western.

[6-6508]

CORROSION RESISTANCE OF JOINTS MADE BY DIFFUSION WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 28 Sep 83; in final form 5 Jun 84) pp 59-61

MIKHEYEV, A. A., Candidate of Technical Sciences, Krasnoyarsk Polytechnical Institute, KAZAKOV, N. F., Deceased, Doctor of Technical Sciences, Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy, and FINKELSHTEYN, A. V., Doctor of Technical Sciences, Siberian Institute of Technology

[Abstract] The corrosion of joints obtained by diffusion welding is studied. The significance of the diffusion process responsible for formation of the heterogeneous seam metal structure is determined. The influence of technological welding parameters on corrosion resistance of joints is studied. The experiments involved the corrosion resistant steel type 12Kh18N10T and the magnetic alloy 49K2F, containing 48-50% Co, 1.7-2.1% V, remainder iron. Bimetallic joints of these materials are widely used in industry. Specimens were welded at 1170, 1220, 1270 and 1320 K, pressure 9.8 MPa, welding time 20 minutes. It was determined that the degree and nature of the change of electrode potential in the welding zone are determined to a great extent by electrode composition, i.e., are dependent on diffusion processes. Microscopic x-ray spectral analysis showed that the diffusion of chromium and titanium from the corrosion resistant steel into the magnetic alloy leads to the formation of a transition zone between the two metals with corrosion resistance higher than that of the magnetic alloy. The corrosion resistance of the joint is influenced by other factors than diffusion as well, resulting from thermal deformation processes during welding. An increased tendency toward corrosion is observed in welded joints obtained at temperatures less than 1270 K, a result of insufficient development of diffusion processes at the lower temperatures. References 6: 5 Russian, 1 Western. [6-6508]

INCREASING THE CORROSION RESISTANCE OF WELDED JOINTS IN A85 ALUMINUM

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 5 Oct 84) pp 62-64

ZOTOV, M. I., Engineer, DOVBISHCHENKO, I. V., Candidate of Technical Sciences and TRUSH, A. I., Engineer, Institute of Electric Welding imeni Ye. O. Paton, Ukrainian Academy of Sciences

[Abstract] A comparison is presented of the effectiveness of various methods of eliminating edge incomplete melting defects in explosively welded lap joints in A85 aluminum. Methods compared include melting of the defect area by manual and mechanized argon-arc welding in combination with cold hardening of the metal and without cold hardening, as well as mechanical working. The criterion of effectiveness of the method was the corrosion resistance of joints in 50% nitric acid at the boiling point, test time 20 hours. Melting of the edges with mechanized argon-arc welding and subsequent cold hardening of the melted metal is judged effective. Elimination of defects by mechanical working can prevent extension of corrosion along the straight interface edge. If the plate which is thrown by the explosion contains 0.22% iron and 0.1 silicon, its corrosion resistance decreases, making this composition unsuitable for nitric acid production equipment. References 4: all Russian.
[6-6508]

UDC 620.194

EFFECT OF MEDIUM pH ON HYDROGEN PERMEABILITY OF PASSIVATING FILMS AND RATE OF GROWTH OF CORROSION CRACKS IN 40KhN STEEL

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 4 May 84) pp 22-25

DMYTRAKH, I. N. and GRABOVSKIY, R. S., Physico-Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, L'vov

[Abstract] Scholarly opinion holds that hydrogen embrittlement is the key force behind formation of corrosion cracks in high-durability steels under static loads. Electrochemical reactions on the surface related to the pH factor of a corrosive medium are a contributing factor. The present article reports on the connection between medium pH and hydrogen permeability of the passive layer at the electrolyte-metal interface. Highly durable, rigid 40KhN tempered at 860°C was subjected to an aqueous solution of NaCl with pH of 6.5-6.7. Tests were conducted at 25°C. Static corrosion resistance to cracking was studied by pure bending under load. Experimental results indicated that the pH of the medium not only played a role in hydrogen formation, but also altered the hydrogen permeability of passive

films at the medium-metal interface. As pH increased, hydrogen permeability declined, especially in the range of $3 < \text{pH} < 4$. Development of corrosion cracks was analogous. References 24: 20 Russian, 4 Western. [7-12131]

UDC 669.15.018.8:539.56:669.788

ROLE OF MARTENSITE CONVERSION IN HYDROGEN EMBRITTLEMENT OF UNSTABLE AUSTENITE STEELS

Kiev FIZIKO-KHIMICHESKAYA MEKhanIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 25 Oct 83) pp 29-32

MAKSIMOVICH, G. G., TRETYAK, I. Yu., IVASKEVICH, L. M. and SLIPCHENKO, T. V., Physio-Mechanical Institute imeni I. V. Karpenko, UkSSR Academy of Sciences, Lvov

[Abstract] The plasticity and durability of unstable austenite steels depend on the intensity of martensite conversions during deformation; these processes are regulated by alloying parameters and mechanical and thermo-mechanical factors. The present article reports on features of deformation martensite conversions and hydrogen embrittlement of 12Kh18N10T and 06Kh18N5G9AB steels with various procedures for hydrogen application. Samples tempered at 1273 K, some of which were hydrogenated at 35 MPa and 623 K for 5 hours were subjected to short-term tension. Phase transformations during hydrogen embrittlement were attributed to preliminary deformation in air at room temperature at 10^{-4} s^{-1} . Results showed that martensite conversion in 12Kh18N10T steel began at about 20% deformation regardless of test conditions. A correlation between changes in the quantity of alpha-martensite and the degree of embrittlement is suggested. In 06Kh18N5G9AB steel, martensite conversion in hydrogenated samples was more intensive, so that relaxational limits were reached more quickly. Its plasticity did not decline appreciably in an external hydrogen medium, but fell noticeably after prior hydrogenation during tension in either a hydrogen or a neutral medium. This steel had better durability and plasticity than the 12Kh18N10T steel. References 9: 7 Russian, 2 Western. [7-12131]

EFFECT OF INHIBITORS ON ELECTROCHEMICAL CONDITIONS DURING TESTS OF SPECIMENS OF 40Kh STEEL FOR STATIC CORROSION CRACKING RESISTANCE

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 28 Mar 84) pp 32-37

RATYCH, L. V. and SLOBODYAN, I. M., Physio-Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, L'vov

[Abstract] Study of inhibitors of corrosion cracking that retard both the initiation and spread of cracks has been based on tests of cracking resistance without consideration of surface electrochemical factors. The present article reports on various inhibiting mechanisms affecting electrochemical conditions on the surface and at the top of stationary cracks. The methodology involved drilling holes for capillaries that contained an antimony oxide pH indicator and an agar-agar conductive mixture for electrolytic contact. Corrosion tests were made on 40Kh steel, which has 0.44% C, 0.45 Mn, 0.22 Si, 0.022 P, 0.020 S, and 0.79% Cr. After oil hardening at 860°C and subsequent tempering at 200°C for a total of two hours, inhibitors with anode action ($K_2Cr_2O_7$ and $NaNO_2$) or cathode action ($ZnSO_4$) were tested on the steel specimens. Results showed that in distilled water, the pH factor gradually declined while the differences in electrical potential increased, intensifying corrosive processes. Significant amounts of anodic-action inhibitors (more than 0.04 M of potassium bichromate, and 0.1 M of sodium nitrite) were required in order to prevent formation of atomic hydrogen and subsequent embrittlement. Regardless of the concentration, zinc sulfate increased H_2 formation and resultant corrosion. References 16: 12 Russian, 4 Western.
[7-12131]

UDC 559:539.4.01

PHOTON EMISSION IN DEFORMATION AND FAILURE OF METALS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 27 Feb 84) pp 51-57

TUPIK, A. A., VALUYEV, N. P. and BELEN'KIY, A. Ya., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin, Moscow

[Abstract] Various physical phenomena accompany deformation and failure of metals, including non-thermal electromagnetic irradiation, a luminescence that is distinct from the thermal irradiation during deformation. Complete definition of the two types of radiation, however, can only be achieved by spectral analysis. The present article reports on study of the temporal features of photon emission and its possible physical mechanisms. The procedure used involved registration of electromagnetic radiation, light

isolation, and thermostatic control. Samples in the form of parallelepipeds were scored to provide a starting point for cracking, then loaded symmetrically while the physical factors enumerated above were measured. All of the steels and ferrous alloys tested, as well as other elements with varying chemical activity and bonding energy, showed evidence of the electromagnetic radiation, in the spectral range of 300-1100 nm for steels and 650-1500 nm for alloy D16. No special radiation was associated with the failure of the metals, since any radiation caused by the failure of interatomic bonds and dislocation motion was simultaneous. Optical radiation related to chemisorption is discussed. Definitive resolution of the question of the origin of radiation during deformation of metals requires further research. References 13: 11 Russian, 2 Western.
[7-12131]

UDC 539.375

CRACKING RESISTANCE OF POLYCARBONATE AND POLYMETHYLMETHACRYLATE AT HIGH LOADING RATES

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 18 Jan 84) pp 80-83

YEREMENKO, A. S., NOVIKOV, S. A., SINITSYN, V. A. and GIRIN, A. S.,
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[Abstract] Recently the linear mechanics of failure have received considerable attention in regard to the failure characteristics of polymer materials, whose mechanical properties depend greatly on temperature and rate factors in loading. The present article reports on a method for high-speed testing of crack resistance using a Hopkinson compound rod (HCR) and a special split-axis specimen. The HCP provided a diagram of load-shift in the compressed rod in traditional tests. In the present tests, disks of polymethyl methacrylate (PMMA) and polycarbonate (PK-1) were examined in a temperature range of -15 ± 1 to $+20 \pm 1$ °C, with regulation of the loading rate, and simultaneous analysis of splitting. A linear correlation was observed until the sudden failure. The dependency at -15 °C is shifted to the right, indicating the rate of temperature increase as load increases in PMMA. References 12: 9 Russian, 3 Western.
[7-12131]

EFFECT OF HARDENING TREATMENTS ON MICROFLUIDITY OF STEELS AND BRONZES

Kiev. FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 4, Jul-Aug 85 (manuscript received 12 Jan 84) pp 83-86

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[Abstract] Resistance to minor plastic deformations, or microfluidity, is an important characteristic of structural alloys that determines resistance to fatigue and wear, dimensional stability, and mechanical hysteresis. The present article reports on study of the effects of heat treatment, including annealing, hardening, hardening tempering, plastic deformation and low-temperature strain aging on microfluidity. One to three stages of deformation tempering were noted in the range of residual deformation of $4 \cdot 10^{-7}$ to $1 \cdot 10^{-4}$ for the test materials. The amount of carbon was a key to the parameters examined. The first stage of microfluidity was observed in "armco-steel", while it did not appear in 45, 65G or U8A steel. Up to a certain level, plastic flow was connected to the heterogeneous formation of dislocations and shifts in edge components. In a third stage, microfluidity is defined by the separation of dislocations from impurity clouds, activation of helical components and the development of transverse slippage. Deformation aging of steels markedly increased the critical microfluidity tension (20+150%) and the rate of deformation hardening at stage II (9+12%) (the lower values indicate natural aging). Critical microfluidity tension approached the yield point. In contrast to steels, bronzes showed increased resistance to deformation at all stages of microfluidity. The tests helped determine the upper limits of stability. References 5: all Russian.
[7-12131]

FERROUS METALS

IRREPLACEABLE METAL

Moscow KHIMIYA I ZHIZN in Russian No 7, Jul 85, pp 2-7

[Article by Academician Aleksandr Ivanovich Tselikov]

[Text] "Revolutionary changes are needed--a transition to basically new technological systems and latest-generation equipment, which will provide the highest efficiency." This was the task put before our country's national economy by the April 1985 CPSU Central Committee Plenum. Such technological systems include new ferrous-metallurgical processes and rolling methods developed in the USSR. These make it possible to produce massive machine-building machines not by traditional chip-removal machining techniques, but by pressure-working techniques. In this article, leading Soviet scientist Academician Aleksandr Ivanovich Tselikov (1904-1984) discusses these processes, which are providing great savings in machine building.

In recent years, many new structural polymer materials have appeared and are widely used in various sectors. In automobile building alone, over 60 different plastics are used. Of special interest are composite polyamides and glass-reinforced plastics having high specific strength and corrosion resistance, which in some cases is even higher than that of stainless steel.

The best grades of steel have lower specific strength than some fibers made of carbon, boron, silicon compounds and other nonmetals. These fibers are the basis for the composite materials already widely used in machine building. The recent startup of diamond and cubic boron nitride (borazon) production has caused a turnaround in the tool industry: in some cases, the best high-speed steels, alloyed with tungsten, molybdenum or cobalt, are already becoming of secondary importance.

And, in the future, the role of nonmetallic materials should rise constantly: their technology and quality will be improved. They will increasingly replace metals. But, it shouldn't be forgotten that existing metallurgical production, especially ferrous-metal production, is much more efficient than the production of new nonmetallic materials. Therefore, the replacement is occurring and continue to occur more slowly than would be required by the interests of machine building.

The replacement of machine-building materials is also complicated by the fact that each of the metals (and there are about 70 of them) have special physical and chemical properties which are often unique. Therefore, it is still simply impossible to replace them in many cases. Actually beryllium, lithium and magnesium alloys have the highest specific strength. Transformer and many other iron-based electrical alloys will hardly find worthy replacements in the foreseeable future. Zinc is a unique metal for current sources. Copper and silver are the best electrical- and heat-conducting materials. It will be a long time before tungsten, molybdenum and titanium lose their value as refractory metals and alloying elements for many types of steel. Aviation and space need highly heat-resistant alloys, such as niobium, tantalum and zirconium alloys. Production of superconducting alloys, such as niobium with tin and titanium, is now beginning.

There is no doubt that the obvious successes in developing modern nonmetallic materials will somewhat reduce the growth rates of several metallurgical processes, but metals in general will retain their significance as the main material in machine building and in most of the other metal-consuming sectors of the national economy for decades to come. According to the boldest forecasts, polymers and composites by 1990 will replace no more than 10 percent of the ferrous metals and about 30 percent of the non-ferrous metals.

In short, metals remain irreplaceable in our civilization, and the demand for them will increase in the future.

At the base of the Clarke pyramid, which illustrates the content of chemical elements in the earth's crust, is oxygen (47 percent), while at the top is the heat-resistant metal rhenium, which is the rarest (about 10^{-7} percent). Near the pyramid's base we find the four main materials of all machine-building structures: aluminum (8.8 percent), iron (4.65 percent), magnesium (1.87 percent) and titanium (0.57 percent). At the very apex of the pyramid are the unique refractory metals: tungsten, molybdenum and niobium. Their content in the earth's crust is insignificant: niobium, 0.001 percent; molybdenum, 0.00011 percent, and tungsten, 0.0001 percent--only one fifty-thousandth that of iron.

It is natural to expect that given the exhaustion of natural resources characteristic of our times, the scarcity would most of all be felt in the upper part of the pyramid. In fact, for a long time, steel containing around 18 percent tungsten was considered the best high-speed steel and was one of the most common. But in the last 10-15 years, it has begun to be replaced by alloys containing half as much tungsten and 5 percent molybdenum. This replacement, however, does not solve the problem of conserving refractory metals, since molybdenum is no less scarce than tungsten, and is even more expensive. That is why the search continues for high-speed steels with low contents of expensive and scarce alloying elements. These include carbonitrided tungstenless steels and hard alloys based on titanium compounds.

It is no less natural to expect that aluminum, the most common metal in our planet, must rise to first place as a structural material for modern machine building. Aside from abundance, aluminum has other advantages: light weight (the specific mass is one third that of iron), corrosion resistance and relatively high electrical conductivity. Aluminum and its alloys are well suited for press working and can be used for precision die casting in extremely complex molds. Therefore, subsequent machining is almost completely eliminated. Very important is the fact that, in contrast to steel, the strength properties of aluminum alloys (including their resilience) are not reduced at low temperatures. This is very important for structures used in the North.

However, there are important factors which limit the use of aluminum. The first of these is the large expenditures needed to obtain alumina from ores, since many ores are fairly poor. The second factor is the large electricity consumption needed to electrolyze alumina. To produce a ton of metallic, molten aluminum, 14,000-16,000 kWh of electricity must be used, about 30 times more than needed to melt a ton of steel in an arc furnace.

Aluminum and its alloys undoubtedly have a big future. But, if we do not respect this most common metal and if we neglect to recycle wastes and scrap, then it's doubtful that enough energy resources can be found in the world to bring aluminum production up to even 20-30 percent of steel production.

By volume, steel is half as expensive as aluminum and by weight, one ninth as expensive. The cost ratios are even more striking if one compares the specific strengths of rolled steel, aluminum and its alloys. Therefore, when the weight of a structure is not of primary importance, steel will undoubtedly be preferable. In general, aluminum cannot totally replace steel.

Steel remains, and for a long time will remain, the most widely used metal in machine building, industrial construction, pipeline transport and other economic sectors. USSR steel production in 1983 totalled 153 million tons (about 570 kg per capita), including 103 million tons of rolled steel (about 460 kg)*.

Economic calculations indicate that in the next stages of ferrous-metallurgy development, funds will be more effectively invested in improving metal-product quality, rather than in boosting output. With higher quality metal, many consumers of rolled products and pipe will be able to greatly reduce their specific consumption of steel.

The 24th, 25th and 26th party congresses, which have discussed the tasks of the last five-year plans, have consistently emphasized that the development of metallurgical production must be combined with more efficient use of metal in the national economy. This approach will become even more

* In 1984, total steel production in our country reached 154 million tons, and rolled steel production, 107 million tons. Eds.

important in succeeding five-year plans. First of all, technological processes aimed at improving metal quality are becoming more efficient; high-productivity and automated equipment is being developed. Secondly, due to the unavoidable transition to poorer and less accessible ores and to the use of ever-more-expensive coking coals, the cost of the metal itself is expected to increase.

It is appropriate to bring in some interesting statistics. Over the entire history of mankind until the beginning of this century, about 1.2 billion tons of ferrous metals were produced, while over 11 billion tons of steel and iron were produced in 75 years of this century. If the rates of production and consumption of iron do not drop in the future (and they are not expected to), in the next 50-60 years, the world reserves of first-category iron ores, which total 150-200 billion tons (total worldwide proven reserves are estimated at 370 billion tons, of which about 30% belong to our country), will begin to be exhausted. Thus, the wide use of poor and uneconomical ores of the so-called C₂ category is not too far off. And it will possibly begin before the machines, devices and other metal structures now in use are ready to be scrapped and remelted.

The transition to poorer ores is now occurring even in our country, which is among the leading countries in terms of proven iron-ore reserves. In 1950, the average iron content in raw ore was 51 percent, while in 1980, it was 35 percent. Every year, the percentage of raw-materials and basic-materials expenditures in the cost of production increases.

It is very obvious that the designated measures to conserve ferrous metals are not only extremely urgent and economically justified, but are simply unavoidable. An important measure among these is to continually expand the use of scrap metal (including scrap iron).

The percentage of scrap in the raw-material base of domestic ferrous metallurgy is increasing every year. The current five-year plan called for the construction of three small plants to operate exclusively on this raw material. Two of them are already built, and construction of the third is to be completed by the end of 1985. The incoming scrap is sorted and melted in electric furnaces. The molten steel is cast into ingots on continuous casters. These castings are then rolled in blanks of various shapes.

It is well known that the technico-economic indicators of this type of plant are poorer than those of traditional metallurgical enterprises. The main reason is low labor productivity, due to the small capacity of the equipment. If traditional rolled shapes are to be produced at mini-plants, then the construction of such plants could hardly be justified. Indeed, the specific capital expenditures for production of one ton of reinforcing steel should be about 2.3 times higher than the similar costs for the existing Krivoy Rog Metallurgical Plant. The expected costs to convert one ton of steel--from steel melting to output of the final rolled product--is about 3.5 times higher at mini-plants than at large-scale enterprises.

Finally, the labor productivity (quantity of finished rolled steel per year per worker) should be about 25 percent less than at the Krivoy Rog Plant. This is clearly an inefficient approach to scrap use.

Research and development on more efficient production processes using scrap metal have been carried out for several years by: the All-Union Scientific-Research and Project-Design Institute of Metallurgical Machine Building (VNIImetmash), the Urals Scientific Center of the AN SSSR [USSR Academy of Sciences], Tulachermet Production Association, the AN SSSR's Metallurgical Institute imeni A.A. Baykov, the Central Scientific-Research Institute of Ferrous Metallurgy and the AvtoZIL Production Association. We have concluded that small-capacity metallurgical plants using scrap metal must be designed for production not of standard rolled products, but of new, special types of rolled products. New metallurgical processes and rolling methods have been developed in our country, but so far they have only been used very cautiously; this is partly because there are no similar processes used in foreign countries. Need it be said that this is a dubious reason? What, then, are these processes?

Many massive machine-building products should already, in our opinion, be made not by traditional chip-removal machining processes, but by more progressive and economical methods: pressure-working techniques. I reported on such processes, developed by VNIImetmash, at the General Meeting of the USSR Academy of Sciences in 1975 when I received the M. V. Lomonosov Medal. The most interesting of these processes is gear rolling. A round blank is first rolled between rolls to form a trough-shaped rim. (In this process, high-frequency current heats only the blank surface.) Then the blank is transferred to another set of rolls with specially profiled teeth, where the gear teeth are formed on the blank. This method is far more economical than rough milling. First of all, the tooth hardness is about 30 percent higher, due to size reduction of the metal structure during pressure working. Secondly, metal consumption is reduced by 20-30 percent and labor productivity is sharply increased. One machine of this type can replace 10 gear-milling machines. The Chelyabinsk Tractor Plant was the first in the world to implement this progressive technology. They are now successfully using eight new machines.

Another economical type of rolled product is variable-diameter axles and shafts, which are needed for almost all machines. Rolled shafts for electric motors, gear boxes, reducers etc. are cheaper than forged or lathe-turned shafts. This saves an enormous amount of metal. For example, recessed shafts for gear boxes are now rolled directly before grinding, achieving metal savings of 35 percent.

The next logical technological step is to produce machine-building parts by pressure-working methods using continuously cast blanks, rather than traditional rolled blanks. And, it is especially advantageous to use scrap metal for the production of these blanks. This simultaneously solves two problems: using scrap to produce new, economical types of rolled products and improving production efficiency by partial utilization of the waste heat from steelmaking, with subsequent hot deformation of the metal.

Usually, the molten steel is poured through a vertical mold. First, a starter piece is put into the mold; then, the molten steel partially solidifies and the casting forms sufficiently strong walls. Then, it is pulled downward. Below, this continuous casting is cut into individual blanks of the proper length. The castings then go directly to rolling before they are allowed to cool down. This continuous-casting process is well known; it was developed by Soviet metallurgists. It is now widely used both here and abroad.

The height of the vertical crystallization zone increases proportionally to the square of the casting cross-sectional area. Therefore, when producing blanks of large cross section, either the working area must be at a high level, or the mechanisms receiving the solidified castings must be in a very deep pit. In the early 1960's, this shortcoming of machines with vertical solidification zones was eliminated: the casting is now lowered along a curve, and then straightens out on a horizontal roller conveyor.

Recent research done by VNIImetmash and Tulachermet Association showed that steel can also be continuous-cast in horizontal molds. True, this causes certain difficulties because of uneven solidification of the steel when it touches the back wall of the mold. However, an original design solution was found: the horizontal mold is equipped with two outlets, since two solidification fronts form in the melt entering the mold: one on each side. Steel is poured from the ladle into an holding reservoir, then into the tundish and the mold. The castings leave from both sides of the mold onto roller conveyors, where they are cut to the proper length. The process is continuous until the ladle is emptied. This machine is very simple, requires neither soaking pits nor high buildings and can be installed in any steel-casting shop. Thus, the transition from the traditional method of steel teeming into ingot molds to the new method requires only insignificant capital investment.

This principally new process of continuous casting permits the use of a large-cross-section metal strand. It results in higher productivity and better working conditions, while fully ensuring structural evenness over the entire casting length.

The USSR State Planning Committee and USSR Ministry of Ferrous Metallurgy gave this new process high marks. They are considering the possibility of using such machines at many existing plants, but we consider them most promising for use at plants consuming scrap steel.

The development of such a plant would achieve two main goals. First, not only would scrap metal be converted, but also new types of rolled products would be produced; these products would provide great savings as replacements for traditional rolled products in machine building. In addition, production efficiency would be much higher because of metal conservation, reduced capital expenditures and reduced demand for labor resources.

The general layout of such a plant would be: raw-material storage, where the scrap is sorted and prepared; electric arc furnaces for melting the scrap; horizontal continuous casting machines; special thermostatic chambers which retain the casting's heat as it passes through to a screw-rolling mill; specialized mills to produce gears, axles and various forms of sleeves and other parts shaped like solid or hollow bodies of revolution.

We calculated that if such a plant had a capacity of 260,000 tons of molten steel per year, a metal savings of 40 percent, or not less than 100,000 tons per year, would be achieved due to the use of new technological processes and the production of new, economical rolled products. The savings result mainly from the reduction in chip formation: when remelting chips, 20-30 percent of the metal burns away.

It was also calculated that the one-time capital expenditures for establishing this production capacity would be 25 percent lower. Finally, a such a plant would have higher labor productivity due to the use of new technological processes, replacing less efficient forging-stamping and metal-cutting equipment with high-productivity machines. This will free up about 1,000 workers, such as machine-tool operators and forge operators.

We are used to building giant metallurgical plants which produce millions of tons of rolled products. But small plants which remelt scrap, produced finished products from it and produce not even a single gram of chips are today no less important. They will permit us to save iron ore and produce even more of the irreplaceable metal.

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TWO INTERVIEWS WITH METALLURGISTS

Moscow TEKHNIKA I NAUKA in Russian No 4, Apr 85 pp 1-4

[Interviews with A. I. Manokhin, corresponding member of the USSR AS [Academy of Sciences]; Lenin and USSR State Prize winner and director of the USSR AS Institute of Metallurgy (interview conducted at USSR AS Institute of Metallurgy) and N. P. Lyakishev, corresponding member of the USSR AS; Lenin and USSR State Prize winner and director of the Central Scientific-Research Institute of Ferrous Metallurgy [TsNIIchermet], USSR Ministry of Ferrous Metallurgy (interview conducted at TsNIIchermet) by L. Barastova, honored cultural worker of the RSFSR; dates of interviews not given]

[Text] In his speech at the CPSU Central Committee Plenum on 11 March 1985, CPSU Central Committee General Secretary M. S. Gorbachev said: "Our task is to achieve a critical turnaround in putting the national economy on a path of intensive development. We must, we are obliged, to reach the most advanced scientific-technical positions and to reach the highest world level of labor productivity in a short time." This thought articulated by M. S. Gorbachev is fully applicable to ferrous metals production, one of the basic and most capital-intensive and labor-intensive sectors of the economy.

The CPSU Central Committee and USSR Council of Ministers recently adopted a decree "On the Growth and Re-Equipment of the Ferrous Metals Industry and the Significant Quality Improvement of Metal Products as the Most Important Structural Material."

How does modern metallurgy help solve the urgent tasks of the ferrous metals industry: 1) to supply the economy with the necessary quantity of metal, in the necessary forms and of the necessary quality that will permit more efficient use of it and 2) improve the effectiveness and efficiency of production? The directors of two institutes spoke about this to our correspondent. One is A. I. Manokhin, corresponding member of the USSR AS, Lenin and USSR State Prize winner and director of the

USSR AS Institute of Metallurgy. The other is N. P. Lyakishev, corresponding member of the USSR AS, Lenin and USSR State Prize winner and director of TsNIIchermet.

First Interview

At the entrance to the USSR AS Institute of Metallurgy [IMET] is a bust of the famous Russian metallurgist A. A. Baykov. The institute now bears Baykov's name, thanks to a proposal by Academician I. P. Bardin. At various times, many leading scientists have worked here, including N. T. Gudtsov, I. I. Oding, A. M. Samarin, N. S. Kurnakov and others. There is a portrait on the wall of Ivan Pavlovich Bardin, founder and first director of the institute; he was a great theoretical and applied scientist and an ardent patriot of our metals industry. The present IMET director, A. I. Manokhin, worked as a roller in a rail-beam shop, was a research worker at the TsNIIchermet Institute and was director of Tulachermet Scientific Production Association.

IMET is the only metallurgical institute in the Academy of Sciences. In contrast with other sector institutes, its task includes solving intersector problems involving the ferrous and non-ferrous metals industries and other economic sectors.

[Question] We began our conversation with A. Manokhin with a question about which of these problems occupies a leading place in the institute's work.

[Answer] There are three main problems which our scientists are working on today. They are: the integrated use of raw materials, the development of a new energy base for ferrous metals production and changing the structure of metal consumption in the country by developing powder metallurgy.

The first problem is integrated use of raw materials. The modern metals industry has great demands for initial raw materials, especially for the production of individual metals. But monomineral raw materials do not exist in nature. The classification of ores as ferrous or non-ferrous is arbitrary. Components such as copper, cobalt, lead, zinc, gold, sulfur and rare-earth metals are lost when the ferrous metals industry refines iron ores. The specifics of modern production are such that up to 90 percent of the rock mass becomes waste: the beneficiation tailings, metal-production slags, coal dust etc. Many mineral substances are irretrievably lost in the form of smoke, dust and gas released into the air by enterprises or in the form of untreated wastes discharged into the water.

Calculations show that the proven world reserves of many commercial-grade ores for the major metals will be exhausted in the next century, even if their consumption grows at minimum rates. If you take the maximum level of per-capita metal consumption for the world to be, for instance, the present level in the USA, where 5 percent of the world's population uses 40 percent of the world production of molybdenum, 45 percent of the aluminum and 33 percent of the copper, then the known reserves of copper, for instance will last for only 6 years, and those of molybdenum, for one year.

The Soviet Union, with its rich resources, is not yet threatened with raw-materials shortages. But, if the present production technology, with its sector orientation toward metals and its great demands for raw materials, continues for the next 100 years, then the threat of mineral-reserve exhaustion will become a real one.

Meanwhile, as I. P. Bardin wrote, our socialist planned system, as nowhere else on earth, permits the integrated use of all forms of raw materials, semifinished goods and wastes from one type of production as initial materials for other types of production. The work begun by I. P. Bardin in this area made it possible to practically completely solve the raw-material problem, based on the principles of metal and intermediate-product recycling and integrated raw-material use. This principle was adopted by the United Nations as the basis for solving the world's developing raw-material crisis. This principle also serves as the basis for developing the scientific principles of closed-loop production--a qualitatively new stage in industrial organization.

[Question] Where in our ferrous-metals industry are problems of integrated raw-material and waste use being successfully solved and what will be done in the near future in this direction?

[Answer] An excellent example of a managed approach to this problem is the Azovstal Plan. They have learned how to fully use blast-furnace and open-hearth slags: they make construction materials, granulated slag for cement production, pumice, crushed stone and even phosphate fertilizers for agriculture from these slags. Old slag dumps are being mined.

However, as yet we have few such enterprises. The slag dumps of the Krivoy Rog Basin, for example, have "reserves" of over 300 million tons of ore with an iron content of 38-45 percent and over 500 million tons of oxidized quartzites. And the slags of several mining enterprises in Kazakhstan contain two to three times more metal than do the ores being mined. At the Norilsk Combine, iron-bearing production wastes are simply buried in the ground, at a cost of about 60 rubles a ton.

Even more urgent is the problem of using production wastes for secondary extraction of non-ferrous metals. Secondary extraction of magnesium, for example, is only 1/36 as expensive as production of primary magnesium, while secondary production of aluminum is 1/20 as expensive, nickel 1/10 as expensive and zinc 1/4 as expensive as primary production of these metals.

[Question] What practical ways do you see of solving the problem of integrated raw-material use?

[Answer] This problem should be resolved in three successive stages. First, the scale of by-product-metal extraction must be expanded at sector enterprises. Second, we must create subsectors or sectors which will produce artificial raw material from by-product concentrates and wastes (we have developed, in particular, methods of producing artificial tungstates, calcium titanate and niobates for the production of tungsten, ferrotitanium

and ferroniobium). And finally, we must form regional industrial complexes to extract all the useful components from local raw materials, primarily on the Kola Peninsula, in the Norilsk region and in several territories adjacent to the Baykal-Amur Main Line. Our institute is working along all three directions.

[Question] Will this new approach to integrated raw-material and waste use influence the ecology of this country's industrial regions?

[Answer] Undoubtedly. We're not just talking about preventing air and water pollution--that is, direct effects on the environment. We also must take into account the need to free up large land areas, including agriculturally productive areas. Hundreds of thousands of hectares are covered by mountains of rock and waste dumps. These have accumulated over the years and, unfortunately, are continuing to accumulate.

[Question] The second problem which you named as one of the most important was the development of a new energy base for metal production. In various stages of the industry's development, there were different energy carriers and reducing agents: charcoal, blast-furnace gas and fuel oil, then coke and electricity and, in the last two to three decades, natural gas and iron and oxygen came into wide use. Will the new energy base replace these?

[Answer] The resources of organic reducing agents and energy carriers are rapidly decreasing. Coking coals are now scarce, while natural gas is needed primarily for organic synthesis. This, as well as the need to protect the environment, forces us to think about the wide use of hydrogen and nuclear energy in metal production.

Production of hydrogen from water, using power generated by nuclear electric power stations, will not only permit changes in metal production processes, but will also permit the broad organization of metal powder production. Powder metallurgy makes it possible to produce new materials with unique physical properties, raise labor productivity, conserve much metal and develop new no-waste and non-toxic technological processes. As you can see, the problem of establishing a new energy base for metal production is closely linked with the third scientific-technical problem on which we are working: changing the structure of metal use in the economy, based on the development of powder metallurgy.

Parts made of metal powder are one-third as expensive as those produced by machining rolled metal. They can be used to replace parts made of bronze, brass, copper and other non-ferrous metals, and this replacement (for example, using iron-graphite powder instead of bronze) will save both capital investments and labor resources.

The following powder-metallurgy products will be very important: 1) materials used in stationary and transport units with operating temperatures of 1300-1500°C; 2) ultralightweight high-strength materials for space equipment and devices to develop the Pacific Ocean and 3) materials with special properties for fusion power generation, for machine building, electronics, radio engineering and other industrial sectors.

Finally, powder-metallurgy methods will provide great advantages in the production of new structural materials, primarily composite materials with metallic matrices. Predictions for the years 1990-2000 are that 50-60 percent of airplane structural parts will be made of composite materials.

Our country has a leading place in the scientific developments in a number of directions of powder metallurgy. For instance, our iron-copper antivibration alloys have no analogs in world practice. Their use in diamond drilling has raised labor productivity by 20 percent and reduced diamond consumption by 40-50 percent. The production of a bimetallic tool made of high-speed-steel powders makes it possible to save 100 tons of tungsten, 90 tons of molybdenum, 60 tons of chromium, 60 tons of cobalt and 40 tons of vanadium for every 1000 tons of metal produced.

No less effective is the use of powder metallurgy methods for the protection of metals. The country's annual metal losses due to corrosion, wear and fatigue are as high as 70-80 billion rubles. Up to 15 million tons of steel are lost due to corrosion alone. An effective means of increasing the service life of metal structures, machine parts and mechanisms is to use protective powder coatings. The wide use of such coatings in the economy will increase the service life of structures by 20-25 years, increase by 3- to 5-fold the life of parts operating in friction assemblies and conserve 8 to 10 percent of the metal produced in the country.

However, further development of powder metallurgy, an important scientific direction which has started a highly efficient industrial sector, requires that many more problems be solved. It also requires the great attention and combined efforts of large scientific and production staffs. We must remember that technical progress in many economic sectors today depends on how fast scientific-technical achievements in that area can be practically implemented.

[Question] Obviously, the linking of science with production is of no small importance in realizing science's achievements in this direction. What capabilities, in particular, does the institute have for practical experiments and verification of its scientific work?

[Answer] Our institute is equipped with excellent, even unique, equipment. We now have everything necessary, including industrial equipment, to conduct the most complicated experiments. And, the facts that the existing experimental bases have been transferred to our institute and new bases have been established--in Moscow, Tula, Kaluga and a number of other regions--show the tireless attention of party and leading Soviet agencies to the development of metallurgy and to the industrial implementation of its achievements. Thus, the working traditions of I. P. Bardin are continuing: Bardin combined the institute and the Tulachermet Scientific-Production Association into a single institution.

Second Interview

TsNIIchermet is the scientific center of the ferrous metals industry. It was here that many ideas were conceived and new directions for metals production development were worked out. These directions were then realized in production processes at plants in this country and abroad. These directions have established the authority of Soviet ferrous metallurgy around the world. Among these inventions are: continuous steel casting, direct reduction of iron, the oxygen-converter process and many others. The institute was one of the main participants in the development of long-range plans for the complete reconstruction and re-equipment of the ferrous-metals industry in the near term and until the year 2000.

...It is early morning in winter. The work day at the institute has not yet begun. It is quiet. All the laboratories are still closed. There is a light shining in the director's office. This is Nikolay Pavlovich Lyakishev's habit--to work quietly, alone, before the others come to work, when he's not bothered by telephone calls, administrative duties, conferences and the almost daily visits of specialists from other institutes, enterprises and organizations, both Soviet and foreign. Nikolay Pavlovich has the delightful ability to remain extremely calm, concise, laconic and businesslike in an unusually fast-paced working environment. This is how I have known him for many years--earlier as a scientific worker at the institute, then as laboratory director, secretary of the institute's party bureau and now, institute director and assistant chairman of the Central Administration of the Ferrous Metallurgy Scientific-Technical Society and editor-in-chief of the world-renowned journal on materials-research methods, ZAVODSKAYA LABORATORIYA.

[Question] We don't have much time to talk, so therefore I asked him to talk about only the main subject: to characterize the basic directions of scientific-technical progress in the ferrous metals industry. This progress is largely determined by the work of the sector's Central Scientific-Research Institute.

[Answer] This is an extremely broad topic. In brief, I can say that scientific-technical progress in the ferrous metals industry is directed toward developing and implementing metal production processes that: 1) will help develop materials which meet modern requirements; 2) can be performed with minimum energy, material and labor expenditures (using more abundant types of fuel and energy) and 3) do not harm the environment.

[Question] Specifically, what new technologies in the most important ferrous metals production subsectors will be developed with the participation of your institute?

[Answer] For blast-furnace production, a smelting technology is being developed wherein hot reducing gases are blasted into the furnace on cold oxygen. This increases blast-furnace productivity by 20 percent and reduces the specific coke rate by 25 percent and unit natural gas consumption by 100 cubic meters per ton of iron. The coke rate will be

reduced by 12-15 kg per ton of iron by using pulverized coal first with natural gas, and then without it.

Besides a number of well-known measures such as improving the charge composition, raising the blast temperature from 1100 to 1250° C, increasing the gas pressure in the furnace and others, scientific-research and test-production work is being planned for the partial replacement of coke with coal in the charge, as well as the development of a new process to replace the blast-furnace process. This process will be feasible in a smelting-reducing installation operating on coal and oxygen and will produce an intermediate product similar to iron.

Big changes are in store for steel production. They involve the replacement of outmoded open-hearth furnaces with converters and electric furnaces. Combination blast methods will be widely used. This will permit the increased use of scrap in converters, improve process productivity and reduce iron losses in slags and exhaust gases.

Blast-furnaceless production of metals, which began with the construction of the Oskol Electrometallurgical Combine, will be further developed.

Scientists and electrometallurgists consider that their main task is to increase the intensity of melting in electric furnaces, based on new furnace designs and modern technology. The plasma process--a modern, mobile and more ecologically acceptable process--will be greatly developed. Non-furnace treatment of metals--so-called "ladle metallurgy"--will be widely disseminated. This involves tapping the metal from the furnace and then bringing it up to the required quality in the ladle, using vacuum refining and treatment with gases and powdered reagents. Special attention is being given to implementing a method of argon-oxygen refinement for stainless, electrical-sheet steel and other steels. This process will greatly improve metal quality.

All new steelmaking shops will be equipped only with continuous casters, including some which feature a somewhat lower casting temperature. Scientific research shows that this permits a higher casting rate and makes the continuous casting more uniform over its length.

Scientific work in rolling and pipe production is aimed at regulating the metal deformation and temperature conditions. This controlled rolling can be done on existing equipment only after it is rebuilt and after new equipment is designed to meet the requirements of this process. Metallurgical machine building faces similarly large tasks. The solution of these problems will result in products not only with improved standard properties, but also with properties that can't be achieved through other methods (especially low embrittlement temperature, extremely high resilience etc.). Relatively low-alloy metal produced by controlled rolling can be economically replace high-alloy steel in a number of parts.

Low- and high-temperature thermomechanical treatment, including such new processes as quasi-hydrostatic extrusion and high-temperature gas extrusion, will be widely used to produce metal with special properties.

Metallurgy will solve a number of problems in the near future, including:
1) the production of coated metal, particularly corrosion-resistant metal;
2) the use of effective microalloying elements, such as niobium, in low-alloy steels for increased strength; 3) use of nitrogen as an alloying element and 4) development of new steels.

[Question] Will you share the experience of your institute in cooperating with other scientific institutions and enterprises to solve problems that jointly concern several economic sectors, rather than just a single sector?

[Answer] I'll give you a typical example. This is the work which was awarded a State Prize in 1984. It is called: "Multifaceted Scientific-Technical Work to Develop and Implement Modern Industrial Technology of Metallurgical Conversion of Phosphorous Iron Ore, Which Produces Highly Efficient Types of Rolled Sheet Steel and Expands the Mineral/Raw-Material Base of the USSR." We did this work jointly with the Karaganda Metallurgical Combine, the Urals Scientific-Research Institute of Ferrous Metals, the All-Union Scientific-Research and Project Institute of Mechanical Processing of Minerals, the Urals Scientific-Research Institute of Mechanical Processing of Minerals and the Chemico-Metallurgical Institute of the KaSSR Academy of Sciences.

This work involves the use of ore reserves in the Lisakovsk, Ayat and other deposits in Kazakhstan and West Siberia, which had been considered problematical until recently. These ores have a low iron content (32-36 percent), high phosphorus (0.6 percent) and alumina (4.5 percent) contents, and are difficult to beneficiate. This project required a theoretical investigation and experimental research. Then a technology for pelletizing these ores was developed, followed by test-commercial and commercial verification. The ores are smelted in 2700- and 3200-cubic-meter blast furnaces. The phosphorous iron is then converted in 300-ton converters using modern methods of steel refinement and melting intensification.

Without going into the details of the problems that had to be overcome in this work, which can be fully understood only by specialists, I can tell the broad readership of this magazine about the results of this intense work by scientists and production workers.

The new technology is continuous through all stages of conversion, which makes possible the steady operation of modern installations and production levels higher than the rated capacities. It also makes it possible to organize the production of highly efficient types of flat-rolled products, such as side rails for KamAZ trucks and cold-rolled dynamo steel and sheet steel. In addition, new resource-conserving technological processes were developed which: 1) produce phosphorous converter slags for agricultural needs, in accordance with the plans for realizing the Food Program; 2) produce the electrical steel needed by industry and 3) produce wear-resistant cast-iron parts for railroad transport. This is only one of the many examples of fruitful cooperation between several institutes and enterprises.

[Question] How would you characterize the innovation of this important work?

[Answer] The innovation is confirmed by 53 USSR inventor's certificates; patents in England, Sweden, Japan, Czechoslovakia, Australia and Holland; license agreements with companies in Austria, Hungary and West Germany and many publications. Nearly all the developments were awarded medals at the USSR Exhibition of National Economic Achievements.

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CSO: 1842/247

WHO SHOULD CONTROL ELECTRIC SMELTING?

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 12 Jul 85 p 2

[Article by Gasik, M., Dean of the School of Electrometallurgy, Chairman of the Department of Electrometallurgy at the Dnepropetrovsk Metallurgical Institute imeni L. I. Brezhnev, and Corresponding Member of the Ukrainian SSR Academy of Sciences]

[Text] The main path of development of the steel-smelting industry is the phasing out of martensite steel production and continued growth of steel smelting in oxygen converters and electric smelters. In accordance with the program of reconstruction and technical re-equipping of ferrous metallurgy, provisions have been made for replacing martensite production by more modern electric-steel-smelting and oxygen-converter production. This program is gradually being implemented: the Oskolskiy electrometallurgical combine and the Belorussian and Moldavian metallurgical plants have started operation and new electric smelters have been started up in a number of electric steel-smelting factories of metallurgical and machine-building enterprises.

The demand for electrometallurgical engineers has, naturally, increased also. However, plans for the training and graduation of specialists in this promising profession have still not been developed. Most metallurgical, industrial, and polytechnical institutes of higher learning in the country continue to train metallurgical engineers following programs in which the study of martensite production takes up the lion's share of the time devoted to the formative disciplines. As a result of such "planning" less than half of the demand for electrometallurgical engineers in a number of sectors, and primarily ferrous metallurgy, is satisfied. As an example, the Dnepropetrovsk Metallurgical Institute was to have provided 20 electrometallurgical engineers to the Dneprospetsstal factory this year according to the plan, but only 12 engineers could be provided. For this reason, the engineering positions for electrometallurgists are often filled by specialists in other, even unrelated specialties.

It is evident that the USSR State Planning Committee, the USSR Ministry of Higher and Secondary Specialized Education, the USSR Ministry of Ferrous Metallurgy, and other interested ministries must take immediate measures to prevent further exacerbation of the situation. Electrometallurgical engineers are now being trained during the day at the Moscow Institute of Steel and Alloys, the Dnepropetrovsk and Siberian Metallurgical Institutes, and at the Donetsk, Chelyabinsk, and Georgian Polytechnical Institutes. All these institutes have highly qualified professors and instructors as well as a good material-tech-

nical base required for expanding the training of specialists in electro-metallurgy.

Taking advantage of this possibility will make it easier to solve the problem of speeding up scientific-technical progress.

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CSO: 1842/209

PHYSIO-CHEMICAL AND METALLURGICAL PROPERTIES OF BLAST FURNACE SLAG IN QUATERNARY SYSTEM $\text{CaO-SiO}_2\text{-Al}_2\text{O}_3\text{-MgO}$ WITH ADDED FeO

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 85 (manuscript received 12 Jul 84) pp 17-21

KUKHTIN, T. I., DUNAYEV, N. Ye., SLEPTSOV, Zh. Ye., BYKOV, M. S. and YANKOVSKIY, A. S., West Siberian Metallurgical Combine

[Abstract] Step-by-step reduction of iron oxide via the $\text{Fe}_2\text{O}_3\text{-Fe}_3\text{O}_4\text{-FeO-Fe}$ scheme at above 570°C permits formation of primary slags in blast furnaces with a high content of ferrous oxide. Study and examination of the properties of blast furnace slags in the quaternary system $\text{CaO-SiO}_2\text{-Al}_2\text{O}_3\text{-MgO}$ with added FeO has shown that FeO content declines from 48 to 3.0-3.4 percent during reduction. The FeO content in the slags studied did not exceed 12 percent. Some 120 synthetic slags were studied with varying amounts of the four components and 1, 2 or 5% ferrous oxide; slags with 3, 6, 9 and 12 percent oxide were also studied. The viscosity of slags with Al_2O_3 and MgO contents at 10 percent and basicity of 0.5, 1.0 and 1.5 was measured repeatedly for each slag and the average values taken as the final result. For example, slag at 1.07 basicity with 33.2 percent FeO and 10.72 percent Al_2O_3 content declined in viscosity from 1.0 to $0.05 \text{ N}\cdot\text{s}/\text{m}^2$ when the temperature was increased from 1100 to 1350°C . Reduction of ferrous oxide from magnesium slags brought about a marked increase in viscosity, despite Mg 's stabilizing effect. The results indicated that reduction of ferrous oxide in contact with heated coke during entry of primary slags into lower levels of blast furnaces had a retarding effect on the reduction of their viscosity as temperature increased. Consequently, early formation of ferrous slags cannot facilitate forced introduction of blast furnace charges due to the deterioration of their fluidity during the reduction of ferrous oxide. References 11: all Russian.

[245-12131]

STUDY OF EFFECT OF VARIOUS FACTORS ON SEPARATION OF IRON AND SLAG IN MAIN CHANNEL WHEN LEAVING BLAST FURNACE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA
in Russian No 8, Aug 85 (manuscript received 28 Apr 84) pp 21-24

KOTOV, V. I. and KALASHNYUK, P. G., Dnepropetrovsk Metallurgical Institute

[Abstract] The importance of thorough separation of iron and slag in the main channel of blast furnaces and various factors affecting it have been studied in a model of a 5000 m³ blast furnace built on a scale of 1 : 25. Not only geometric, but physical and hydrodynamic similitude were preserved to the maximum extent. Slag was simulated by kerosene and VM5 vacuum oil, while iron was modeled by an aqueous solution of zinc chloride. Pressure in the upper channel was kept as close to natural as possible. Calculations based on the model process are presented. Calculations indicate that as the diameter of the tap hole increased, iron and slag were more thoroughly mixed, thus avoiding loss of iron in the transfer from the main channel to the next processing step. References 4: 3 Russian, 1 Polish.
[245-12131]

SPLASH FORMATION IN LIQUIDS DURING BELOW-LEVEL PURGING OF CONVERTER BATHS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA
in Russian No 8, Aug 85 (manuscript received 4 Sep 84) pp 29-33

MESHALKIN, A. P., PROSVIRIN, K. S., OKHOTSKIY, V. B. and KOLGANOV, G. S.,
Dnepropetrovsk Metallurgical Institute

[Abstract] Earlier theories on upper purging of converter baths noted the loss of liquids during the process. Cold modeling using plexiglass and hot modeling at a temperature of 1550°C in a magnesite crucible were used to evaluate purging results at various pressures. The results indicated the nature and height of splashes caused by blow purging procedures. Calculations for bottom and side deep purging show the merging of currents in the purging process. Results showed that splash height was essentially the same during surface and bottom blow purging. Despite the significant difference in physio-chemical processes and design, there were clear qualitative and quantitative analogies in the processes. The theoretical bases presented in the calculations can be applied to practical cleaning processes for converter baths. References 11: 5 Russian, 6 Western.
[245-12131]

EFFECT OF MELTING CONDITIONS ON STRUCTURE OF R6AM5 STEEL

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA
in Russian No 8, Aug 85 (manuscript received 29 Jul 84) pp 76-78

RASPOPOVA, G. A., BARYSHEV, Ye. Ye. and BARUM, B. A., Urals Polytechnical
Institute

[Abstract] Previous studies aimed at the optimization of the melting of R6AM5 have recommended increased temperature and more mixing of the molten metal. In test steels the skeletal eutectic structure has been missing, while in production steels it accounts for about 9%. The second important feature of the test steel structure was its honeycomb structure, while the third feature was the increased etching potential on the periphery of large granularized inclusions formed of vanadium carbonitride. In production steel, these components were more homogenized into the structure. Results indicated that melting by the test process improved peripheral structure, while in the pore zones a plate structure appeared instead of the expected skeletal eutectics. The chemical composition of the dendrite cells also changed. References 4: all Russian.
[245-12131]

TRIBOTECHNICAL CHARACTERISTICS OF BALL BEARING STEEL AFTER CHROMIZING

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA
in Russian No 8, Aug 85 (manuscript received 13 Nov 84) pp 89-93

OGANESYAN, G. L. and DUBININ, G. N., Moscow Institute for Civil Aviation
Engineers

[Abstract] Corrosion and wear of rings and races cause bearing failure; this emphasizes the importance of studying ball bearing steel to improve bearing surfaces. The present article reports on the effect of chromizing on the tribotechnical features of ShKh15 and 55M5FA steels. A gas method of chromium saturation in a mixture of 50 percent Cr, 47 percent Al_2O_3 and 3 percent NH_4Cl at 850-1000°C was used, with a saturation time of 1-9 hours. Since the extreme hardness of the carbide layer of test bearings ensured high wear resistance, a corresponding study was made of specimens of the test steels that had undergone chromizing at 950°C for 6 hours, and residual tension in the diffusion zone was determined to correlate the results of the various combinations tested. The data obtained showed that increasing the relative wear resistance of the test steels correlated with increased residual tension of compression and electron emission, thus confirming the importance of both structural and energy states of bearing surfaces in determining wear resistance. Chromizing of ShKh15 steel at

950°C for 6 hours brought about worsened mechanical properties, such as impact strength, but at 850°C, and with subsequent standard heat treatment, those properties improved. For 55SM5FA steel, the process at 950°C, with subsequent standard heat treatment, brought an 18% improvement in impact strength. References 2: all in Russian.
[245-12131]

UDC: 669.15.018.583:621.794.62:538.653.11

INFLUENCE OF ELASTIC-STRESS STATE CREATED BY COATINGS ON THE MAGNETIC PROPERTIES OF THE ALLOY Fe-3%Si

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1576-1580

PUZHEVICH, R. B., BORISENKO, V. G. and CHISTYAKOV, V. K.

[Abstract] A study is made of the influence of tensile stress on magnetic properties of the alloy Fe-3%Si as a function of the degree of textural perfection (110)[001], amplitude of magnetic induction upon remagnetization of the material, surface status and specimen thickness. Several groups of specimens measuring 0.30-0.35 x 30 x 280 mm with different values of magnetic induction B_{2500} . The value of this parameter was used to judge the degree of perfection of the texture. The effectiveness of the influence of elastic tensile stresses on decreasing magnetic losses in the alloy increases with an increase in textural perfection, crystalline size, amplitude of magnetic induction used in magnetization of the material and a decrease in specimen thickness. The influence of a magnesium silicate oxide layer on magnetic losses is ambiguous. It is characteristic that losses increase with imperfect crystallographic texture and decrease in a highly textured material. The use of special electric insulating coatings have high magnetic activity for the alloy is desirable if the stresses of over 10 MPa created by the coating decrease $P_{1.7/50}$ by an average of 0.03-0.05 $W \cdot kg^{-1}$ and more. With the proper composition of phosphate electric insulating coatings, the tensile stress created in the matrix and resulting decrease in magnetic losses increase with increasing coating formation temperature. References 13: 5 Russian, 8 Western.
[13-6508]

UDC: 558.221:539.26

INFLUENCE OF LASER PROCESSING ON STRUCTURE AND MAGNETIC PROPERTIES OF ANISOTROPIC ELECTRICAL-SHEET STEEL

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1581-1584

BRASHEVAN, G. A., PETRENKO, A. G., FEDOROVA, S. V., POPOVA, I. A., DIVINSKIY, V. V., MEDVEDOVSKAYA, L. A. and KHAN, M. G., Institute of Precision Alloys; Central Scientific Research Institute of Ferrous Metals imeni I. P. Bardin; All-Union Scientific Research and Planning-Design Institute of Electrothermal Equipment

[Abstract] A study was made of the influence of the contactless method of controlling domain structure by irradiation with a laser beam on anisotropic electrical-sheet steel. A continuous carbon dioxide laser was used. The nonmoving laser beam was used to make tracks on the specimens which were moved beneath it by an automatic manipulator. The studies showed that reducing the quantity U , called the energy input and representing the energy of radiation per unit of surface area, below a certain threshold U_1 does not allow production of stresses sufficient to produce smaller domains. If U exceeds a certain value U_2 , a labyrinth structure is produced, causing deterioration of magnetic properties of the steel. References 3: 1 Russian, 2 Western.

[13-6508]

UDC: 669.018.354.21

STRUCTURAL DEPENDENCE OF LOSSES UPON REMAGNETIZATION OF ANISOTROPIC SILICON STEEL

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1585-1587

KAZADZHAN, L. B., POPOVA, L. N. and SAKIR, N. P., Novolipetsk Metallurgical Combine imeni Yu. V. Andropov

[Abstract] A study is made of the separate and combined influence of grain size and shape, perfection of crystallographic texture (110)[001] and thickness of strip specimens of anisotropic silicon steel (3%Si) on remagnetization losses. Studies were performed on strip specimens 0.24-0.36 mm thick. Total remagnetization losses and their components were measured by standard methods. The level of losses upon remagnetization of anisotropic high quality silicon steel was found to be determined primarily by the crystallographic texture, depending mostly on disorientation of crystallites in the [001] direction relative to the rolling direction. The influence of texture is quantitatively greater than the influence of grain size or

changes in final strip thickness. The minimum possible losses upon dynamic remagnetization of anisotropic steel with relatively perfect structure are achieved by decreasing grain size in the direction of rolling and producing optimal grain size across the rolling direction. References 3: 1 Russian, 2 Western.
[13-6508]

UDC: 669.018.524.85

MAGNETIC PROPERTIES AND STRUCTURE OF Fe-Si ALLOYS OBTAINED BY RAPID MELT COOLING

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1588-1592

BULYCHEVA, Z. N., MIRONOV, L. V., STEPANOV, A. N., SAVVIN, A. N., OVCHAROV, V. P. and NIKOLAYEVA, T. G., Central Scientific Research Institute of Ferrous Metallurgy; Central Scientific Research Institute of Ferrous Metals imeni I. P. Bardin

[Abstract] A study is made of the magnetic properties, structure and texture of Fe-Si alloys containing 3.0, 4.5 and 6.0 mass % Si. Specimens, sheets 0.50-0.60 mm thick, were obtained in the cast state by crystallization in water cooled rolls at a speed of $1 \text{ m}\cdot\text{s}^{-1}$. The cooling rate with this method is 10^{-3} - $10^{-4} \text{ }^\circ\text{C}\cdot\text{s}^{-1}$, two orders of magnitude lower than when amorphous and microcrystalline alloys are produced. Some of the specimens were cold deformed by rolling to sheets 0.30, 0.20 and 0.10 mm thick. Specimens containing 6% Si could be rolled only when heated to 400-500°C, since no improvement in ductility was observed in the experiments. The specimens were studied immediately after crystallization and after heat treatment in a vacuum on the order of 10^{-4} torr, at 800-1200°C, for two hours, cooling at $100^\circ\text{C hr}^{-1}$. The lowest losses were obtained in specimens with 6% Si 0.20 mm thick manufactured by deformation of a cast blank. Comparison of the curves for 6% Si specimens 0.35 mm thick manufactured by the usual technology and deformation of a cast blank show the superiority of the latter. In specimens with 3% Si, the two technologies are virtually identical in terms of magnetic losses, which are significantly greater than those for the alloy with 6% Si. Reference 1: Western.
[13-6508]

UDC: 669.018.524.85

BASIC REGULARITIES OF STRUCTURE FORMATION IN Fe-Si ALLOYS QUENCHED FROM THE LIQUID STATE, DYNAMICS OF STRUCTURAL CHANGES

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1593-1602

GLEZER, A. M., MOLOTILOV, B. V. and SOSNIN, V. V., Institute of Precision Alloys; Central Scientific Research Institute of Ferrous Metals imeni I. P. Bardin

[Abstract] A comparison is presented of the mechanical properties of rapidly quenched materials with those produced by ordinary methods. Structural changes occurring over a broad range of temperatures and related changes in mechanical properties of Fe-Si alloys are also discussed. Alloys consisting of Fe + 5.8 to 17.1 at.% Si were obtained as thin strips by spinning from a melt. The strips were 10 to 30 m in length, 20 to 40 micrometers thick, 0.8-10 mm wide. Heat treatment was performed in a vacuum by isothermal annealing at 300 - 1150°C for one half hour. Structural studies were performed by scanning electron microscopy and electron transmission microscopy. The Fe-Si alloys produced were strong and ductile in comparison to similar alloys produced by ordinary methods. The differences do not result from the dimensional effect, but rather are genuine material values. Higher strength results from well developed grain fragmentation in the rapidly cooled alloys and the presence of a high volumetric density of vacancy defects, prismatic loops and micropores, which form obstacles for the movement of dislocations. The high ductility results from the smaller grain size and the developed polygonal structure, plus a significant contribution of more mobile dislocations with Burger's vector $a \langle 100 \rangle$. References 10: 4 Russian, 6 Western.

[13-6508]

UDC: 669.15.779.781.787

STRUCTURAL RELAXATION AND QUASITEXTURE IN STRIPS OF AMORPHOUS MAGNETICALLY SOFT ALLOYS

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1603-1605

MAKAROV, V. P., Deceased, KUZ'MISHKO, V. P., MATSUK, V. G. and MOLOTILOV, B. V., Institute of Precision Alloys, Central Scientific Research Institute of Ferrous Metals imeni I. P. Bardin

[Abstract] A study was made of the magnetic properties and domain structure of strip specimens measuring 150 x 10 x 0.03 mm made of amorphous alloys $Fe_{75}Ni_3Si_9B_{13}$ (AS1) and $Fe_{75}Mo_3Si_9B_{13}$ (AS2) after various heat treatments.

Thermomagnetic, thermomechanical and thermomagnetic-mechanical treatment were performed in a vacuum furnace with compensation of the terrestrial magnetic field. The statistical magnetic characteristics were determined from the hysteresis loops measured under quasisteady regmagnetization conditions. The induced magnetic anisotropy constants were determined with restructuring of the domain structure from longitudinal to transverse by transmission of direct current along the specimen. An analysis is presented of the nature of processes of structural relaxation occurring in the amorphous matrix upon heat and mechanical treatment. Plastic deformation of up to 2% facilitates formation of a quasitexture, and the decrease in coercive force in this case indicates the homogeneous nature of plastic flow. Tensile stresses activating the process of structural relaxation form a directed, topologically similar order or quasitexture which leads to uniaxial magnetic anisotropy. With tensile stresses of over 600 MPa there is an increase in the rate of plastic deformation, the process of plastic flow becoming inhomogeneous. The number of defects in the amorphous matrix increases, leading to a sharp increase in coercive force and decrease in far magnetic order. The quasitexture of the amorphous matrix thus formed as a result of heat and mechanical treatment is stabilized during structural relaxation, leading to annihilation of areas of excess free volume. References 5: 2 Russian, 3 Western. [13-6508]

UDC: 669.018.712.25

SUBBOUNDARIES IN SECONDARY RECRYSTALLIZATION GRAINS, THEIR FORMATION AND USE TO INCREASE ELECTROMAGNETIC PROPERTIES OF THE ALLOY Fe-3%Si

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1624-1628

GUBERNATOROV, V. V., KURLYANDSKAYA, G. V., BRYSHKO, N. A. and SOKOLOV, B. K., Institute of Metal Physics, Urals Scientific Center, USSR Academy of Sciences

[Abstract] Experimental results are presented to demonstrate the influence of unfavorable sectors in the formation of subboundaries in secondary recrystallization grains of Fe-3%Si, discussing the reasons for disorientation of separately growing crystal particles, analyzing other possible mechanisms of formation of subboundaries during grain growth and discussing the problem of control of the number of such defects and their influence on the electromagnetic properties of the alloy. Studies were performed on a large number of single and polycrystalline specimens of Fe-3%Si produced by the Novolipetsk Metallurgical Combine, rolled on a laboratory quarto mill with roll diameter 50 mm and annealed in a vacuum furnace with various heating rates. The macrostructure of the specimens was determined by etching in boiling 30% aqueous hydrochloric acid, the microstructure by electrolytic etching in 50% aqueous chromic anhydride solution. Powder figures were used to study the magnetic domain structure in large secondary

recrystallization grains. The mechanism of formation of subgrains upon secondary recrystallization suggested in this work is related to the formation of growth centers and their subsequent development. The number of grains with substructure depends on the rate of heating during annealing for secondary recrystallization. The substructure formed in the process of secondary recrystallization grain development decreases the width of the major magnetic domains and stimulates the formation of seeds of domains upon magnetic switching, which should be reflected in a decrease in the level of specific losses in the electrical-sheet steel. References 6: 5 Russian, 1 Western.
[13-6508]

UDC: 669.018.817.32

USE OF SMALL DEFORMATIONS TO REGULATE THE TEXTURE OF ELECTRICAL-SHEET STEEL

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49, No 8, Aug 85, pp 1629-1632

GOL'DSHTEYN, B. Ya., SAVINSKAYA, A. A. and GERSHMAN, R. L., Scientific Research Institute of Metallurgy

[Abstract] A study is presented of texture changes upon recrystallization and the possibility of increasing the cubic component in the texture of electrical-sheet steel. Studies were performed on the alloy Fe-3%Si. Cold rolled strips which underwent decarbonizing annealing at 850°C for five minutes were found to have a texture of (112)-(113)[110]_{+20°C} with scattering to (111)[112]-(011) and (110)[001]. Mean grain size was 27 micrometers. Specimens were deformed by cold rolling on a laboratory mill with roll diameter 105 mm and fixed compression 1-8% and annealed in a vacuum furnace at 900°C for three hours. The use of small, regulated deformations was found to allow regulation of the textural state of the matrix over a broad range during subsequent recrystallization annealing. The use of this operation in the production of isotropic electrical-sheet steel can decrease regmagnetization losses. References 5: all Russian.
[13-6508]

PAINTING STAINLESS STEEL WITH ALTERNATING CURRENT

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 4, Jul-Aug 85
(manuscript received 6 Mar 84) pp 24-27

MOGORIN, N. V., Kishinev

[Abstract] Stainless steels with relatively thick oxide films for protection and appearance receive wide use. The present article reports on a simplified electrolyte with reduced temperature in a process which provided a variable asymmetrical flow by using a 5% solution of sulfuric acid. Increases in the capacitor current along with increased frequency and reduced polarization resistance caused the electrode to function as a condenser, with a significant decline in "Faraday" current. This phenomenon was used in testing electrodes with thin oxide films. Films on steel Kh25 formed at a potential of +0.3 V in a 50 Hz current were composed of Fe₃O₄ oxide. The electronogram for the film on Kh20N80 was amorphous, with no crystalline structure. The films appeared to be highly resistant to corrosion and had an attractive appearance. References 11: 10 Russian, 1 Western.
[9-12131]

UDC 621.74:669.13

BASIC TRENDS IN IRON CASTING PRODUCTION

Moscow LITEYNOYE PROIZVODSTVO in Russian No 8, Aug 85 pp 1-3

SHUMIKHIN, V. S., doctor of technical sciences and VARENİK, P. A.,
candidate of technical sciences

[Abstract] Iron accounts for more than 70% of all Soviet castings and 76.8-82.7% of castings outside the USSR. This popularity is due to cost-effective production and excellent service properties. The wide variety in microstructure imparts to iron excellent wear and corrosion resistance and other properties. Some shortcomings, such as low strength in grey cast iron with graphite flakes, high energy consumption to produce more malleable and durable wrought iron, and limited applications of grey iron, need to be overcome. Of particular concern is the low level of Soviet production of iron with spherical graphite particles (ISG), a variety offering considerable improvements in durability. The authors emphasize production and pricing factors that would encourage more production of ISG iron, which accounts for 40% of US castings and replaces both forged iron and steel products. In machine-building, ISG is best suited for replacing cast parts of grey iron and steel, as well as for forgings. It saves on capital, metal use and repairs in comparison to all three, but is less effective for forgings. A one-sided approach to complex modifiers has led to a sharp increase in the cost of castings made from ISG. Retooling and improvements in casting production have resulted in better products and product assortment along with reduction in resource use and labor costs.
[11-12131]

STATUS AND PROSPECTS FOR DEVELOPING EQUIPMENT AND TECHNOLOGY FOR IRON SMELTING

Moscow LITEYNOYE PROIZVODSTVO in Russian No 8, Aug 85 pp 4-6

DIBROV, I. A., candidate of technical sciences

[Abstract] Developments in technology and equipment for iron mills is closely tied to the durability and other service features of the end product, as well as plant capacity and raw material considerations. Many products made of steel in the USSR are made of iron with spherical graphite particles (ISG) in other countries. While 89% of Soviet iron is melted in cupola furnaces, mostly of small capacity (0.5-4 tons), that number has shifted 8% in favor of electric furnaces in the past 10 years. Further development of casting production for machine-building requires modern smelting methods that will improve quality with better resource and energy economy, as well as improve working conditions and environmental protection. Inadequate development of key components of electric furnaces has impeded progress in use of that technology. Induction crucible furnaces have shortcomings in thermal features, feed systems, temperature evenness, and labor input. Nonetheless, they are feasible where energy is cheap, the scrap is of high quality and there is a wide variety of iron produced. Electric-arc furnaces have both advantages and shortcomings. Their efficiency rating is 80-85%, 10-15% better than for induction furnaces, but where superheating is required that efficiency drops to 20%. Burning slags facilitate metallurgical processes. Future plans include elimination of blast furnaces pig irons in casting production and their replacement with steel scrap, increased use of automation with cupola furnaces of 10-30 t/hour capacity, wider use of induction crucible furnaces, channel and arc furnaces, modernization of existing cupola furnaces of over 5 t/hour capacity with preheating equipment, and replacement of smaller furnaces with more modern types.

[11-12131]

INDUCTION CHANNEL FURNACES, AN EFFECTIVE MEANS OF IMPROVING ECONOMIC PARAMETERS IN IRON CASTING PRODUCTION

Moscow LITEYNOYE PROIZVODSTVO in Russian No 8, Aug 85, pp 25-26

STOLOV, M. Ya., candidate of technical sciences

[Abstract] Current tasks for smelting equipment developers include automation, ecological acceptability and efficient energy use. The present article discusses the three types of furnaces now in use in the USSR: cupola, induction crucible and arc furnaces, in terms of economic

factors under various production conditions, in comparison with induction channel furnaces in use at relatively few locations. They have been used chiefly for mixing and distribution, due to their small capacity, but the furnace at the Novokakhovskiy Electrical Machine Building Plant (The All-Union Scientific Research Institute for Electrothermal Equipment, in conjunction with the Physics Institute of the LaSSR Academy of Sciences, helped to solve some of the technical problems) is a high-capacity unit. Details of the furnace are described. Induction channel furnaces can be used in conjunction with other types of equipment in both new and reconstructed installations. They can also be used for smelting non-briquetted scraps. The environmental impact of induction channel furnaces is much like that of crucible furnaces. Pollutant emissions depend on contaminants in the charge and noise is slight. No supplemental mixer furnaces are required, which in itself represents energy savings. Labor savings and efficient processing of scrap metal are further advantages of this type of furnace. References 5: 2 Russian, 3 Western.
[11-12131]

UDC 621.74:669.131.7

COLD-RESISTANT HIGHLY DURABLE IRON WITH SPHERICAL GRAPHITE FOR ZIL
AUTOMOBILE CASTINGS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 8, Aug 85 pp 30-31

EKSANOV, V. A., KHAMBAZAROV, A. M. and LISACHENKO, N. Ye., engineers and
DRONYUK, N. N., candidate of technical sciences

[Abstract] In the casting shop of the Mtsensk Aluminum Castings Plant of the ZIL Production Association, new compositions and technology for iron with spherical graphite particles (ISG) for parts for ZIL trucks which operate in various climates have been developed. Test parts of ISG were made to replace standard parts of forged iron, cast steel and rolled steel, and the composition and processing technology were developed for ISG parts intended to function at -60°C . Various alloys containing magnesium were tested, and a modifier labelled ZhKMK-4R from the Chelyabinsk Electrometallurgical Combine was selected. A ferrite-pearlite iron with spherical graphite and no structurally free carbides was produced. The Si, P, Mn and Cr content were limited to obtain the required cold resistance. Reduction of temperature and duration of heat treatment of ingots during their conversion from wrought iron to ISG permitted reduction in cleaning operations and eliminating warping of the ingots.
[11-12131]

DEPENDENCE OF CAST STRUCTURE OF LARGE STEEL INGOTS ON THEIR CHEMICAL COMPOSITION

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2, Apr-Jun 85
(manuscript received 26 Jan 84) pp 8-14

FESENKO, A. N., LATASH, Yu. V., GLUSHCHENKO, V. G., VORONIN, A. Ye.,
KRUTIKOV, R. G. and BIKTAGIROV, F. K., Institute of Electric Welding
Imeni Ye. Ol Paton. UkSSR Academy of Sciences, Kiev

[Abstract] The structurization of 15 ton and larger steel ingots now produced by batch electroslag casting (method developed at the Institute of Electric Welding) is analyzed theoretically, for purposes of better process control and corroboration of experimental data. Attainment of a columnar rather than equiaxial structure has been found to depend not only on the mode and the rate of heat dissipation, but also on the inclusions as well as on the alloying elements and their concentrations in the melt, which directly influence the crystallization process. A criterion for uniform and steady rate of unidirectional crystallization is founded on the basis of the Jackson relation $G/R \geq \tan \alpha \cdot C_0(1-k)/Dk$ (G - temperature gradient in the melt ahead of the crystallization front, R - crystallization rate= velocity of crystallization front, $\tan \alpha$ - slope of the liquidus line on the constitution diagram, D - diffusion coefficient for nonmetallic inclusion (C,Si,P,S) or alloying element, C_0 - initial concentration of the second component in the melt, k - coefficient characterizing the equilibrium distribution of an inclusion or alloying element between the solid phase and the liquid one). This relation, appropriately extended for application to steel with any number of impurity and alloying elements, is formulated suitably for evaluation of the parameter

$$P = \sum_i^n \tan \alpha_i \cdot C_{0i} (1-k_i) / D_i k_i \text{ by means}$$

of a planned 3-level factorial experiment. Numerical results obtained accordingly for three representative carbon steels (St3sp, St20, St45) and nine representative alloy steels (three chromium steels and six-chromium-nickel steels) confirm that the structurization during crystallization not only differs from grade to grade but also varies for each grade of steel depending on the composition within the range assigned to it. The composition must therefore be considered in controlling this process. References 17: 12 Russian, 5 Western (3 in Russian translation).

[4-2415]

PARTITIONING OF SLAG-METAL EMULSION AND REMOVAL OF LIQUID NONMETALLIC INCLUSIONS FROM METAL IN FIELD OF CENTRIFUGAL FORCES

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2,
Apr-Jun 85 (manuscript received 27 Sep 83) pp 15-19

LAKOMSKIY, V. V., MARINSKIY, G. S., BOGACHENKO, A. G., MEDOVAR, B. I.,
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Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev

[Abstract] The process of centrifugal electroslag casting is evaluated from the standpoint of its hydrodynamics. The flow of molten metal and the motion of liquid inclusions are analyzed, taking also into account gravitation and buoyancy of the latter. Four different characteristic ranges of behavior are distinguished and correlated to four ranges of the Reynolds number: 1) $N_R < 2$, laminar flow of metal around spherical inclusions; 2) $2 < N_R < 910$, flow of metal around vibrating flattened spheroidal inclusions; 3) $910 < N_R < 1920$, motion of stable flat inclusions; 4) $N_R > 1920$, motion of large pileate inclusions. The parameter which defines and governs these different modes of partitioning is

$$A = \frac{\sigma_{\text{met/incl}}^{3/2} \rho_{\text{met}}}{\sqrt{g} \mu_{\text{met}} \sqrt{\rho_{\text{met}} - \rho_{\text{incl}}}}$$

(σ - surface tension at metal-inclusion interface, ρ - density, g - acceleration of gravity, μ_{met} - dynamic viscosity of liquid metal), while the velocity of buoying or falling inclusions depends also on their radius but differently within each range of centrifuge speed and Reynolds number. Numerical calculations for 12CrNi-3A steel with flux yield practical estimates of the smallest size of inclusions which will be eliminated from the molten metal during centrifugal casting. According to these estimates, inclusions smaller than 20 μm in diameter will be retained in the metal at conventional casting speed (500 rpm). Figures 1; references 9: all Russian. [4-2415]

CONCENTRATION OF ALLOYING COMPONENTS DURING ROLLING OF ELECTROSLAG INGOTS WITH VARIABLE CHEMICAL COMPOSITION

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2, Apr-Jun 85
(manuscript received 12 Sep 83) pp 19-21

NIKITENKO, Z. L., SHVARTSER, A. Ya., SHVARTS, V. Ya. and STOYKO, V. P.,
Donetsk Polytechnic Institute

[Abstract] Lengthwise rolling of ingots is considered when the chemical composition of the ingot material varies regularly in the direction of rolling. The concentration profile of an alloying element is described by the equation $C = f(x)$, while the crystallization isotherm and thus also the shape of the metal bath are described by the equation $y = \phi(x)$. The composition of the bath at the instant when the metal crystallizes is assumed to be uniform over the cross-section, with interdiffusion of alloying elements not significantly distorting the longitudinal composition profile. On this basis expressions are derived for calculating the concentrations of alloy components at any point along such an ingot and thus the distribution of those components at any instant of time. Numerical data pertaining to 2N2Sh steel indicate how the composition of rolled strip or sheet can be controlled by varying the reduction. References 4: all Russian.
[4-2415]

PHYSIO-CHEMICAL ASPECTS OF SMELTING OF Cr-Si-Mn STEELS

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2, Apr-Jun 85
(manuscript received 3 Aug 83) pp 22-26

NIKITIN, B. M., NOVIKOV, V. P. and NIKITIN, S. B., Institute of Instrument Making, Sevastopol

[Abstract] Smelting of Cr-Si-Mn steels is considered as a process involving the quaternary system $Fe, Fe^{2+} - Cr, Cr^{3+} - Si, Si^{4+} - Mn, Mn^{2+} || O^{2-}$. The system of chemical and thermodynamic equations describing all independent multicomponent oxidation-reduction reactions including the complex deoxidation of metal and slag components is derived on the basis of the corresponding right-hand rectangular trihedral prism in the three-dimensional constitution diagram. From these equations are calculated the equilibrium concentrations of the three alloying elements at the appropriate smelting temperature for five grades of these steels. While the theoretical equilibrium concentrations agree closely with actual experimentally determined ones, the agreement is not so close with concentrations according to conventional equations based on a single, though strong, deoxidizing element in the electroslag smelting process. Both methods of calculation yield the

same oxygen concentration in these steels, however, probably because of the appreciably reduced deoxidizing effect of silicon in the presence of a high chromium concentration. References 10: 8 Russian, 2 Western (both in Russian translation).

[4-2415]

UDC 655.668.4

DIFFUSION MODEL OF MASS TRANSFER OF IRON IN A "PEARLITIC STEEL-AQUEOUS COOLANT CARRIER" SYSTEM

Moscow TEPLOENERGETIKA in Russian No 6, Jun 85 pp 7-9

YEFIMOV, A. A., candidate of chemical sciences and MOSKVIN, L. N., doctor of chemical sciences

[Abstract] A drop in the rate of corrosion of pearlitic steels in water has been associated with the formation of surface oxide films. The present article reports on an attempt to develop a general model for the formation of such oxide films as a process of mass transfer in a pearlitic steel-aqueous coolant system. Calculations of heat transfer between metal and solution in the absence of developed film boiling are usually attributed to the laminar flow of liquid on the interfaces. Figure 1 shows a diffusion model of metal dissolution in which all changes in concentrations of metal ions are in the range of the diffusion layer near the interfaces of the dissolving metal. Calculations are presented to explain this process. Increasing the concentration of O_2 in a turbulent flow beyond critical values leads to increased flow of certain compounds toward the metal and accelerates the formation of a protective oxide film. The complexone that interacts with the Fe^{2+} flow forms $Fe(II)$ complexonates and stabilizes the iron in the solution in a ion-dispersed state. Further development of the diffusion model would provide solutions to a number of practical problems related to selection of aqueous regimens. The model can also be regarded as a working hypothesis for planning corrosion experiments. References 16: 15 Russian, 1 Western.

[232-12131]

EFFECT OF PROLONGED HIGH TEMPERATURE AGING ON OPERATING PROPERTIES OF
15Kh1M1F STEEL

Moscow TEPLOENERGETIKA in Russian No 6, Jun 85 pp 45-47

SMIRNOVA, A. P., MINTS, I. I., candidates of technical sciences and
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[Abstract] As the number of operating hours of the power equipment of thermoelectric power plants exceeds 10^5 hours, forecasting of likely service life takes on increasing importance. High-temperature aging is an effective parameter for such prediction. The effect of prolonged aging was assessed for hot-rolled 15Kh1M1F steel (0.16% C, 0.35% Si, 0.64% Mn, 1.47% Cr, 0.95% Mo, 0.29% V, 0.022% S and 0.020% P). The structure was examined at room temperature, prior to aging at 600°C for 10^4 hours. X-ray analysis showed no recrystallization. Short-term tests showed that durability decreased slightly while plasticity was retained, impact strength was cut at normal temperature but increased somewhat at 560°C , and the cold brittleness threshold increased markedly. Further testing showed the emergence of reversible temper brittleness in the test steel, which was not attributed to emission of Mo_2C particles, but was related to molybdenum loss by the alloy. Aging weakened the effect of the structural state on long-term durability of the material, and aging at 600°C for 10^4 hours caused a marked decrease in the impact strength of the test steel. References 8: 7 Russian, 1 Western. [323-12131]

UDC 621.311.22.655.668.4

PRESERVATION OF CARBON STEEL POWER EQUIPMENT WITH CALCIUM HYDROXIDE SOLUTION

Moscow TEPLOENERGETIKA in Russian No 6, Jun 85 pp 66-68

SHCHAVELEVA, G. A. and MIKHAYLOV, A. N., engineers, Chemical Service of Mosenergo (Moscow Regional Power System Management Administration), Heat and Electric Power Plant No 12

[Abstract] Intensive corrosion affects power equipment that is exposed to moisture and air. Mosenergo has studied calcium hydroxide solutions as corrosion inhibitors for various high-carbon steels, such as 12Kh1MF, used for boilers. A solution of $\text{Ca}(\text{OH})_2$ forms a thin precipitate of CaCO_3 upon contact with the atmosphere, and thus the solution should not be exposed to air. $\text{Ca}(\text{OH})_2$ solutions were superior to those formed of NaOH. The mechanism of the protective coating included dissolution of the metal into positive ions which caused excessive negative charges and subsequent

adsorption of ions of the Ca^{2+} inhibitor. The solution was effective for both clean and contaminated metal surfaces, and field tests at Thermoelectric Center No 12 of Mosenergo confirmed that the coatings formed using $Ca(OH)_2$ inhibited vorrosion in steam boilers and other power production equipment. Calcium hydroxide is not neither scarce nor toxic and can be used with other chemicals such as sultates following simple procedures. References 4:
all Russian.
[232-12131]

NON-FERROUS METALS AND ALLOYS; BRAZES AND SOLDERS

ULTRAPURE ALUMINUM

Moscow KHIMIYA I ZHIZN in Russian No 8, Aug 85 pp 2-6

[Article by V. Stantso, special correspondent of KHIMIYA I ZHIZN:
"Ultrapure"]

[Text] The road leads upward. Waves on Lake Varzob, rather stormy this time of year, roll toward us as we drive past. We quickly pass by the textile-workers' sanitorium and several pioneer camps. The mountain air is pure...

A unique form of production is located here in the small village of Kondara. There are a maximum of 50 residents in Kondara. An equal number come in from Dushanbe to work here. They make aluminum here--the most common metal on earth. But this is the only place where grade OSCh-18-4 aluminum is produced. The numbers designate that this metal has purity up to four decimal places (99.9999 percent Al) and that 18 impurities are monitored. The pure mountain air is an extremely favorable condition for this production, which, by the way, is non-polluting. But, we will return to that later.

Transforming Purity

There is a 1-kg ingot on the desk of Professor A. V. Vakhobov, doctor of technical sciences. This aluminum was cast over five years ago. Nonetheless, it is not tarnished. There is an oxide film, of course, but it is very thin and even, so that the white, silvery metal (as aluminum is frequently described) actually looks white and silvery.

The Laboratory of High-Purity Metals and Precision Alloys was organized in the Chemistry Institute imeni V. I. Nikitin of the TaSSR Academy of Sciences in 1968. The laboratory initially studied alkaline-earth metals: calcium, barium and strontium, as well as their alloys. Interest in aluminum came later, when the Tajik Aluminum Plant, one of the sector's leading plants, was built and when ultrapure aluminum took on practical significance in electronics.

Purity transforms metals. Before titanium was sufficiently purified, it was of little interest in engineering. Aluminum's history is different: today, it is the most massively produced and most important of all

non-ferrous metals. But purity is even transforming aluminum. Most of all, high purity has an effect on such properties as electrical conductivity, plasticity and chemical stability. Aluminum's corrosion resistance increases by an order of magnitude with each additional nine after the decimal point. At the same time, its reflectance is improved, and the metal is a better electricity and heat conductor.

A few words about the main use of ultrapure, Tajik aluminum. As a conductor, its use has permitted a manyfold increase in the density of integrated circuits, the most important microelectronic components.

It has also turned out that at low temperatures (not super-low, or "liquid-helium" temperatures, but at more moderate "liquid-hydrogen" temperatures, about 20 K), 99.9999-percent-pure aluminum becomes hyperconductive: its conductivity increases many thousandfold. This is not superconductivity, when electrical resistance falls practically to zero, but the metal's resistance is much lower than that of normal metals. Scientists still do not know the causes of this phenomenon, but they are beginning to try practical applications. Another important factor is that, at these low temperatures, 99.9999-percent-pure aluminum does not become brittle.

This aluminum is also of interest to stomatologists. It is truly a good metal for crowns and cast teeth. It is chemically passive and causes no galvanic phenomena in the mouth, although saliva is an electrolyte and is fairly corrosive...

Special alloys were made from this ultrapure aluminum. With a microaddition of strontium, it became so hard that lathe cutters began to jump. Yet, this is aluminum, which is usually so soft and pliant...

Purity transforms and transfigures metal.

Order of Events

The famous English physicist Cecil Frank Powell loved to tell a story about Benjamin Franklin. A certain woman asked Franklin about the practical possibilities of his electrical inventions, to which Franklin replied: "Madam, what use is there for a newborn?"

In our time, the problem of finding a use for a "newborn" is more urgent than in Franklin's time. Not coincidentally, the acceleration of scientific-technical progress and the practical implementation of the latest scientific achievements were addressed at the July Conference of the CPSU Central Committee and the General Conference of the USSR Academy of Sciences this March.

There are other implementation mechanisms than the one used by the staff of this small laboratory of a relatively small institute of a republic academy. But, theirs is worth discussing, since the result has been very significant. This method has provided the country with tons of a metal with unique properties. It is practically impossible for one small academy

laboratory with a staff of 15 to accomplish this. The group of specialists working on the problems of this unusual metal has gradually and, I would say, rationally expanded as scientific information has accumulated about ultrapure aluminum.

Today, the Laboratory of High-Purity Metals and Precision Alloys has four "branch firms." One is the Laboratory of Corrosion-Resistant Materials, founded two years ago in the same institute and headed by candidate of technical sciences I. N. Ganiyev. Right in Kondara, there are two branch laboratories in the Special Design-Technology Bureau of the TaSSR Academy of Sciences. They are really experimental-production laboratories! And, finally, the Department of Analytical Chemistry of the Tajik State University imeni V. I. Lenin studies methods of analyzing ultrapure metals and is actively engaged in analysis itself.

Of course, there are staff limitations. Therefore, the work supervisors periodically have to shift staff members (as a rule, their own students and, no less importantly, their adherents) from the main laboratory to the branches and back. This is done for the general good and in the interests of the young metal scientists' professional and working development.

There are no "dispassionate observers" here, it seemed to me. There are constant contacts with electronics scientists, and electronics expert R. A. Altynbayev is on the staff of the main laboratory. And he is right at home--professionalism is appreciated here. From the start, the only people who have not gained respect are those who work haphazardly and who are indifferent to traditions and to their work. They work very intensely here--when and as much as necessary. And, it's not divided between "pure" and "impure": those who work only with fundamental science and those who do only applied research. That is the reason they do not have implementation problems. They study the metals and alloys themselves, and they develop the technology themselves (taking into account, of course, world-wide and domestic experience). They themselves organized unique production and gave the country this necessary metal.

But, modern science does not live by staff-workers alone. It also needs equipment and test-production facilities. The equipment in the laboratory is not exceptional or series-produced, but rather taken, as a rule, from specialists in allied engineering fields. The same goes for the facilities, although circumstances were of some help. Not long ago, there was a fluorite mine in Kondara. The miners worked out the vein, and then left. They left behind two two-story buildings in rather poor shape. But, there were walls, as well as water and pure mountain air. There was also a high-voltage line passing nearby. This was enough, for in six months the forceful, energetic Vakhobov and his students had established a unique production process.

Truly, Vakhobov has one very personal, individual appeal. Both within and outside of the republic, the professor is known not only as a metal scientist. He is also a mountain climber (first-class) and heads the Dushanbe Mountain-Rescue Service. As the chairman of the republic's Federation of Tourism, he develops new and interesting routes.

In the loggia next to the the professor's office is an Abalakov backpack, packed and ready for action: you never know... But the mountains are not a vacation. "A smart person won't go into the mountains," says an old tourist song, but this is, of course, humorous self-irony. Actually, strong people go to the mountains--strong both physically and professionally. As a rule, they are intelligent as well. Very often, Vakhobov finds among them like-minded people, advisors and sometimes simply co-workers.

While I was there, two women arrived at the laboratory: a theoretical physicist from Odessa and a specialist on new current sources from Moscow. Both were interested mainly in the hyperconductivity of Vakhobov's metal. But, the interesting thing is that one found out about OSCh-18-4 aluminum from a scientific publication, while the other found out from a vacation trip. The result was the same: the cooperation of scientific collectives, separated not only by thousands of kilometers, but also by notorious departmental boundaries.

Today, many people are willingly and actively cooperating with the Metallurgical Laboratory of the Dushanbe Chemical Institute: physicists from Novosibirsk, Tashkent, Minsk and Kiev and chemists from Moscow and Gorkiy. The Leningrad All-Union Aluminum-Magnesium Institute and the Moscow State Scientific-Research and Project Institute of the Rare-Earth Metals Industry are also willingly supporting joint relationships.

Zone Melting In Kondara

Now it is time to talk about how the people in Kondara make metal so pure that there is only one atom of impurity for every million aluminum atoms. This is done by zone melting; this is the traditional, sometimes called mercury, method, which has long been used to produce high-purity metal.

The raw material for 99.9999-percent-pure aluminum is the purest grade of commercial aluminum: A-995. The task is to transform metal 99.995-percent pure into metal 99.9999-percent pure.

In order to add those last two nines, the metal is first put into a 1.5-meter long boat made of pure graphite and then is melted in a vacuum furnace. Preliminary vacuum refining takes two to three days. This stage removes from the metal any gaseous impurities, as well as sufficiently volatile alkaline and alkaline-earth metals. Then, the aluminum is cooled and sent to zone remelting.

The zone-melting section in Kondara is headed by candidate of chemical sciences M. K. Biktemirova who, like G. A. Kozarenko and F. U. Obidov, participated in all the preliminary work for the production of OSCh-18-4 aluminum. She was not there on the day I arrived. Therefore, my guides were young, "non-degreed" heads of other sections: N. N. Antipova and N. N. Dergunov. The former heads the chemical treatment and machining of finished ingots, while the latter runs the vacuum holding installation.

Six ingots weighing many kilograms each are zone-melted simultaneously. Six graphite-cylinder boats, shaped more like hollowed-out Indian canoes, are placed in a quartz-glass shell. There is an evacuated space inside of them in which a three-turn inductor, encircling the graphite container, moves slowly along the container. It moves very slowly, imperceptibly slowly. All six inductors are synchronized. Below the inductors are the dark-red bands of the glowing graphite. If you catch a glimpse, you can see right through the boat to the molten metal.

The melting zone passes several times from one end of the ingot to the other, according to a strict, experimentally determined schedule. The impurities become concentrated at the ends, while the metal in the middle becomes so pure that after it is cut on a lathe, it is again pickled with aqua regia to remove microimpurities from the cutting materials. Then the silver metal, aluminum, becomes truly silvery and gleaming. Its new coarse-crystalline structure can be seen: long monocrystals extending longitudinally along the ingot.

I must note that the final chemical treatment of the ingots is not done in Kondara, but in the city. It's all for the sake of purity.

They jokingly told me that Vakhobov would soon build not only a solar-power installation, but also a beauty (anti-beauty?) parlor. They said (and he himself confirmed) that powder and nail polish can be sources of contamination.

The beauty parlor hasn't been established yet. The return-water-supply basin in Kondara is operating. It wasn't easy to chisel it out of solid rock, but they did it anyway, because the production of ultrapure metal must not be allowed to pollute the environment.

The Fifth Nine

Production is production, but science does not stand still. When 99.9999-percent-pure metal has given all or nearly all that it can, it is natural to think about 99.99999-percent-pure. This is primarily out of curiosity about what is beyond the next boundary. One could expect that the next stage of purification will show some new properties of this very well-known metal.

Analytical chemistry is the sticking point: it's very difficult to trap several impurity atoms out of a billion aluminum atoms. And do you think it's easy to achieve such a purity? Zone melting in a graphite crucible-boat will not suffice. Although weakly, carbon still dissolves in aluminum. They tried to rinse out the boat from inside using molten OSCh-18-4 aluminum. The rinsing was expensive, and the results were variable. Purity of 99.99999 percent is possible only with crucibleless zone melting.

They obtained a series-produced Kristall apparatus and adapted it to their needs. It has a very high vacuum (10^{-7} mm Hg) and two inductors. One

inductor (the small one) melts the zone, while the other (larger) one prevents the molten metal from leaking: a magnetic field holds the metal in place. The result is even greater removal of sulfur, gallium, scandium, copper and manganese impurities than is the case with OSCh-18-4 aluminum. The content of other impurities was below the sensitivity of neutron-activation analysis, which can detect concentrations of 10^{-6} to 10^{-9} percent.

How does one cut metal like this? Cutting blades and milling cutters would contaminate it. A laser cutter will not work because the reflectance of ultrapure aluminum is such that the laser beam is reflected back practically without losses. Possibly, this property will someday be put to use, but for now the young laboratory engineers are cutting the super-pure (99.99999 percent) with a spark electric-impulse cutter. The discharge between the wire and the ingot makes it possible to remove samples for analysis without touching the ingot.

Another problem is how to best use the contaminated ingot ends. High-purity aluminum is an expensive metal. Its production must become wasteless. Some things have already been thought of: additional remelting, precision alloys... Originally, they studied binary alloys; now they have begun studying ternary, quaternary and multicomponent systems. Rare-earth elements in these alloys show great promise. There is still research to be done on the possible use of ultrapure aluminum in solar engineering...

There are several photographs beneath the glass on Professor Vakhobov's desk: pictures of his wife and children, naturally. Another picture is one of a group of tourists climbing a mountain. Anvar Vakhobovich's clear handwriting can be seen on several pieces of paper sticking out of a folder containing tourist materials. The papers are the specification for a new tourist route: "On the third day, the tourists travel to the Murguzorskiye Ozera Tourist Base and take a warm-up trip to the Gurg Dara Gorge (Volch'ye Gorge). Then the circle-route part of the trip begins..."

It is now dark. The institute is nearly deserted. People are still working in the metallurgical laboratory, because soon the exhausting summer heat will come, and Professor Vakhobov will disappear from his metal-science colleagues for a time. He will be somewhere in the foothills, waiting for word over his mountain-rescue radio. Or, he'll be taking people over a new route which he has designed himself.

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SCANDIUM AND FOSKAN

Moscow KHIMIYA I ZHIZN in Russian No 8, Aug 85 pp 7-10

[Article by candidate of chemical sciences, V. B. Kalinin]

[Text] Things are also alive; you only need to know how to bring them to life." This line from "One Hundred Years of Solitude" by Gabriel Garcia-Marquez is appropriate to begin this story about scandium, an element which has lain dormant for over 100 years.

Having the strength of steel and the lightness of aluminum (as well as enviable refractoriness), scandium nonetheless has remained unused: the worldwide volume of scandium production is probably less than the total weight of publications about the element and its compounds. There is no other element in the first four periods of the periodic table which has such a fatal combination of wonderful properties and lack of industrial use.

The main reasons for this are the dispersity of scandium and the lack of scandium deposits. There is only one way to wake up the dormant power of scandium: to find compounds whose unique properties would be without competition in some field of modern engineering. Such an outcome would be very welcome for scandium.

Real Sources

Element No 21 has its mineral sources: the very rare thortveitite, bazzite and egonite. They are of no industrial value. A more promising source of scandium is titanium slags from the refining of ilmenite concentrates, although the scandium content in them does not exceed tenths of a percent. The secondary recovery of scandium during the integrated refining of various ores can provide a reliable raw-material base for the element.

Scandium is extracted from ilmenite-concentrate wastes using phosphorylated cellulose. After holding surgical cotton or cotton cloth in a solution of orthophosphoric acid and urea, the material is dried at 130° C. Phosphate groupings are added as a result of interaction with the long polymer molecule of cellulose. Some of the groupings are immediately attached to ammonium ions NH_4^+ . The ammonium form of phosphorylated cellulose is further transformed into the H-form and rinsed in dilute sulfuric acid. This results in a sufficiently effective and inexpensive cation exchanger

which can selectively extract scandium. Scandium, as we mentioned earlier, has a greater affinity for phosphate groupings than does titanium.

An ion exchanger in the form of a continuous conveyor belt selectively extracts the scandium from solutions which have more iron or titanium ions than scandium ions. So, scandium can be obtained. If only it had a use.

There is much scandium in nature: about the same amount as lead, and 150 times more than silver. It has been realistically proven that tens of tons of it could be produced per year. But it will stop being unemployed only when buyers are found for expensive, but unique, items made of scandium. (Seven years ago, one gram of scandium oxide cost about three dollars on the world market.) If customers are found, production will increase. If production increases, the price will fall...

This is an elementary relationship. And, as a result, it is still, you could say, a vicious circle.

Element No 21 has tried several times to break out of this circle. Its chemistry has developed fairly quickly. This naturally increases the chances of finding that unique compound that will break the circle. The only bad thing is that chemists, who are producing and studying endless numbers of phosphates, arsenates, vanadates, tungstates and other scandium compounds, frequently do not know the needs of many areas of engineering. And process and design engineers, in turn, are not able to follow the particulars of chemistry development. Nonetheless, there are at least several scandium compounds and alloys now known that might be of interest to the modern engineer.

Twenty years ago, KHIMIYA I ZHIZN (Nos 7-8, 1965) wrote about one of the first attempts to break the vicious circle. Scientists in our country had developed computer memory elements based on scandium-bearing ferrites. Electronics, however, found an alternative for scandium-bearing ferrites, and the "awakening" did not occur.

There are now annually over 1,000 publications in scientific journals about scandium compounds and alloys. Once in a while there is something technically encouraging among the publications. It was reported, for example, that an addition of 1 percent scandium increases the hardness of aluminum alloys 2- to 3-fold, while simultaneously improving their plasticity. The possibility of using scandium phosphate and vanadate as red phosphors for color-television tubes was discussed. An alloy of scandium and plutonium-238 was proposed for use in implanted heart pacemakers. Also of interest is a report on the sharp increase in the hardness of titanium carbide when scandium carbide is added to it. This binary carbide has a hardness close to that of diamond. Metal-halogen mercury lamps with scandium iodide have also proven themselves. Their light is similar to sunlight. However, the production and use of scandium is still measured in kilograms per year.

Now, apparently, is the time to tell the story of one of the recently discovered phosphates of this element, which might be... Well, we'll not repeat our main theme again.

What Is Foskan

Eleven years ago, working on his candidate's dissertation in the chemical department of Moscow State University, this author obtained some small, quite undistinguished-looking white crystals of a binary phosphate of scandium and sodium. It was easy to determine its composition: $\text{Na}_3\text{Sc}_2(\text{PO}_4)_3$. The three Russian words for phosphate, scandium and sodium were later combined to produce the name foskan. The first surprising thing about this binary phosphate was its unexpectedly high fusion temperature: around 1800°C .

Chemists try to study new compounds by all possible means in order to discover their properties. I began to determine its structure, and again found something unexpected. It turned out, surprisingly, that there were many voids in the structure of $\text{Na}_3\text{Sc}_2(\text{PO}_4)_3$. Crystallo-chemical analysis of the structure made it possible to predict that the new compound should have ferroelectric properties and high ion conductivity.

Within several years, this binary phosphate was obtained at one of the institutes of the USSR Academy of Sciences, and then at the Massachusetts Institute of Technology. The authors of both works also focused their attention on the high cation conductivity of foskan.

In the last five years, the number of publications on this compound and its analogs has increased sharply. Intensive research on foskan and solid solutions based on it is being conducted in our country, for example, at the Physico-Chemical Institute imeni L. Ya. Karpov.

Interest in foskan is determined above all by its exceptionally high ion conductivity, comparable to the conductivity of electrolyte solutions. This makes binary scandium-sodium phosphate a promising solid electrolyte for such things as sodium-sulfur batteries.

Several words are in order about this device.

Usual Arrangement Reversed

A sodium-sulfur battery (storage battery) is an electrochemical current source in which the electrodes are not solid substances, but rather molten sodium and sulfur. Rather than a liquid, the electrolyte in this case is a thin ceramic membrane made of a material with cation conductivity.

Conductivity permits the movement of Na^+ cations, while the electrons travel through the external circuit (for more details, see the article by Yu. D. Tret'yakov, *KHIMIYA I ZHIZN*, No 2, 1978). Such solid highly conductive electrolytes are called super ion exchangers. The reaction of sodium with sulfur forms polysulfides.

Sodium-sulfur batteries have record-high energy capacity: one order of magnitude higher than the widely used (and ecologically far from safe) lead storage batteries. It has been calculated that an electric car with a sodium-sulfur battery could travel 500 km between rechargings.

The ideal sodium-sulfur battery has not yet been developed. There are several reasons for this. First, there are very few known super ion exchangers, and they are not satisfactory in all respects. Second, a ceramic material made of solid electrolyte must be strictly single-phase, non-porous, mechanically strong and corrosion-resistant in molten sodium; in addition, it must not conduct electrons. So far, these requirements have been best met by ceramics made of sodium β -aluminates (their approximate composition is: $\text{Na}_2\text{O} \cdot n\text{Al}_2\text{O}_3$, where $n = 3-5$ or $9-11$), with a small admixture of MgO . However, it is technically difficult to synthesize these ceramics because of their high sintering temperature (about 1600°C). At that temperature, the ceramic's composition changes, and Na_2O becomes noticeably volatile.

Admixtures of non-conducting phases appear, and the conductivity decreases. The mechanical strength is also reduced.

Therefore, any substance with a conductivity close to that of the best sodium β -aluminates, but which can be produced at lower temperatures, could be considered as a promising super ion exchanger. One of those substances which is being intensively studied in laboratories in the USA, France, Japan and other countries is nasicon. This word is short for the words natrium (first two letters), super ion exchanger (si) and the English word conductor. An approximate composition of this super ion exchanger is $\text{Na}_3\text{Zr}_2(\text{SiO}_4)_2 \cdot (\text{PO}_4)$.

Nasicon has long been considered as a real candidate for the solid electrolyte in sodium-sulfur batteries, since its conductivity is almost equal to that of β -aluminates, while its sintering temperature is 400° lower. Unfortunately, it was only recently determined that this super ion exchanger is unstable in contact with molten sodium (because the ceramic contains traces of zirconium dioxide in glassy inclusions). The ceramic's two-phase state leads to intense electrochemical corrosion when it is in contact with molten sodium. And this means that nasicon cannot compete with the β -aluminates. And now, remember the formula for foskan, and compare it with that of nasicon. See the similarity? Therefore, chemists at many institutes and companies are now interested in foskan, which is now a leading contender as the optimum super ion exchanger.

The synthesization temperature of $\text{Na}_3\text{Sc}_2(\text{PO}_4)_3$ is only 1200°C , lower than that of β -aluminates (the affinity of Sc for PO_4 groupings helps). The ion conductivity of foskan at 300°C is about the same as that of sodium β -aluminates, while preliminary data on the corrosion resistance of foskan in molten metals is promising. But foskan's high ion conductivity is not its only valuable property. There are others.

Temperature Metamorphoses

Foskan has a three-dimensional open structure made up of a combination of ScO_6 octahedrons and PO_4 tetrahedrons. The small Na^+ cations travel freely through the broad voids formed by this structure. The voids are interconnected, forming conductivity channels which pass through the structure in all directions.

Similar to sulfur, iron and many other simple and complex substances, foskan exists in several polymorphic forms, which can be transformed into one another and back. So far, three have been determined: α , β and γ .

When the $\alpha \rightleftharpoons \beta$ and $\beta \rightleftharpoons \gamma$ phase transformations occur, the foskan framework is practically unchanged, while the sodium atoms are rearranged, becoming more evenly distributed in the crystal space as the temperature increases. It is interesting that when heated from room temperature to 66° C (the $\alpha \rightarrow \beta$ transformation), foskan contracts. There are very few inorganic materials with a negative coefficient of thermal expansion.

The γ -form of foskan, which exists at temperatures above 166° C, has the highest cation conductivity. The sodium atoms then freely "flow" along the conductivity channels, as there are no geometric barriers to prevent them from crossing from one void into another. At the same time, there are fewer sodium atoms than places to which they can be distributed. The medium-temperature (from 66 to 166° C) β -form of foskan is also ion-conductive, but to a lesser degree than the γ -form. In this case, some of the sodium atoms are still held in the lattice and prevent ion flow.

When the super-ion-exchanging properties of foskan were discovered, a natural question arose immediately: can this be achieved without scandium?

So far, no. Replacement of the Sc^{3+} ion with smaller cations causes a sharp drop in conductivity. Thus, foskan analogs such as binary phosphates of sodium and chrome or sodium and iron have conductivities an order of magnitude lower. Apparently, the magnitude of the ion flow is regulated by the dimensions of the narrowest place through which the sodium ions must flow. If the dimensions of the triangular boundaries connecting the voids are reduced, the conductivity channel is practically closed. If this narrow place is made too large, by replacing Sc^{3+} ions with those of larger radius (such as yttrium or lutecium), a similar structure is not obtained.

The low-temperature (below 66° C) form of foskan is interesting mainly as a ferroelectric. However, there are hundreds of known ferroelectrics, but only 20 or 30 super ion exchangers. Therefore, I believe foskan will most likely show its value in this capacity, although its other unusual properties are worthy of attention.

In conclusion, I would like to invite the readers of KHIMIYA I ZHIZN, especially those who are interested in the future of element No 21, to celebrate Scandium Day, which will take place on the steps of the MGU Chemistry Faculty on the second Saturday in May, 1986. Who knows--maybe by then scandium's fortunes will have changed.

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SOME PROPERTIES OF ZINC HYDRIDE

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 6 Dec 83) pp 1329-1331

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[Abstract] Zinc hydride was experimentally synthesized according to the reaction ZnI_2 (13.76 g) + 2LiAlH_4 (3.24 g) $\xrightarrow{\text{Et}_2\text{O}:\text{C}_7\text{H}_8 = 155:363}$ ZnH_2 + 2LiI + 2AlH_3 . The white product of this reaction (2.2 g) contained 88.22 wt.% Zn, 8.08 wt.% Al, 0.52 wt.percent Li, 0.79 wt.percent C, 3.32 wt.percent H₂, remainder I. Electrical measurements indicate that the material is a dielectric with an electrical conductivity (holes) of the order of 10^{-14} S/cm at room temperature in darkness, but becomes a photoconductor (electrons) when exposed to radiation at wavelengths below 365 nm with an intensity of approximately $2.6 \cdot 10^{-4}$ W/cm². In an atmosphere of iodine vapor, the photocurrent decreases by a factor of 3-4 and the dark current increases by a factor of 2-3. In an argon atmosphere a gaseous mixture containing principally hydrogen but also traces of CO₂, CO, H₂O is released, first slowly during the initial period and then faster during the induction period, as in a typical topochemical reaction. The length of the induction period decreases with rising temperature, becoming hardly noticeable at 90-95°C. The electrophysical properties and the thermal decomposition kinetics of ZnH₂ are similar to those of AlH₂, but the process of photoconduction and hydrogen release in ZnH₂ are characterized by a smaller inertia, also, the quantum yield of photolysis is lower and shifted toward shorter wavelength. Pretreatment of ZnH₂ with ultraviolet radiation was found to accelerate the thermal decomposition process. The authors thank V. P. Popov for participation in this study. References 12: 11 Russian, 1 Western.
[1-2415]

COMPOSITION AND STRUCTURE OF Mg-Ag ALLOYS NEAR Mg_3Ag

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 15 Dec 83) pp 1332-1334

PROKOFYEV, M. V., KOLESNICHENKO, V. Ye. and KARONIK, V. V., State Scientific Research, Planning and Design Institute of Alloys and Nonferrous Metals Treatment

[Abstract] An experimental study of Mg-Ag alloys containing 74-78 atom.% Mg was made, for the purpose of clarifying contradictory available data on the phase equilibrium in the magnesium-rich range of the Mg-Ag system which includes the Mg_3Ag solid solution. Specimens of these alloys were produced in corundum crucibles inside an electric resistance furnace, under a VI-2 flux, using 99.92% pure Mg and 99.99% pure Ag. The melt was poured into steel molds and then either quenched in water or air-cooled inside the furnace. The ingots were annealed under vacuum at 400°C for 200 hr, their equilibrium being monitored by x-ray phase analysis in a DRON-2.0 diffractometer using a Fe K_α radiation source and by microstructural examination under an MIM-7 optical microscope. The results have revealed formation of an ϵ' -phase with a body-centered tetragonal lattice along the ϵ -phase (Mg_3Ag) with a face-centered cubic lattice, also a eutectic α -Mg + ϵ' phase but hardly any β -phase (MgAg). The ϵ' -phase was isothermally annealed at 200-250-300-350°C, with no change within 2000 h at 200°C, an $\epsilon' \rightarrow \epsilon$ transformation within 100 h at 250°C, and with the ϵ' -phase disappearing within 100 h at 300-350°C. References 10: 3 Russian, 7 Western.
[1-2415]

UDC 546.78

PHOSPHORUS IMPURITY IN TUNGSTEN SINGLE CRYSTALS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 5 Dec 83) pp 1348-1351

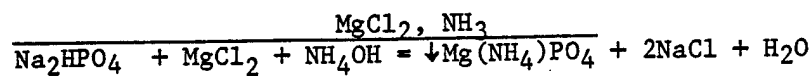
BURKHANOV, G. S., VLASOVA, I. V., KIRILLOVA, V. M. and SAVITSKIY, V. M. [deceased], Institute of Metallurgy imeni A. A. Baykov, USSR Academy of Sciences

[Abstract] A study of phosphide inclusions in tungsten single crystals with low carbon and oxygen contents was made, for the purpose of evaluating their contribution to brittleness and establishing an effective method of purification. Specimens of the four principal tungsten ores (huebnerite - $MnWO_4$, ferberite - $FeWO_4$, wolframite - $(Fe,Mn)WO_4$, scheelite - $CaWO_4$) were chemically and metallurgically processed for both concentration and purification, to reduce the phosphorus content to 0.05-0.1 Wt.% or one tenths of its original level in the tungsten powder. Subsequent decomposition

of the ore concentrate produced a solution of Na_2WO_4 containing 0.5-4 g/dm³ of phosphorus and arsenic, the former entering the solution as Na_2HPO_4 salt. The last stage of purification proceeded according to the scheme

Na_2WO_4 solution

+



Analysis of the W-P system (including three compounds: W_3P , WP , WP_2) based on the constitution diagram and on measurements by the neutron-activation method with use of high-resolution Ge(Li) detectors has revealed that the phosphorus content is approximately the same in all ores and in single crystals grown by the plasma-arc method. Those single crystals, containing $(20-35) \cdot 10^{-4}$ wt.% P when sintered and $19 \cdot 10^{-4}$ wt.percent P when precipitated from the gaseous phase, were further examined by the method of extraction replicas and thin foils under two electron microscopes: JEM-200 and JEM-1000 with accelerating voltages of 200 kV and 1000 kV respectively. Phosphorus has been found to appear as tungsten phosphide in the form of individual fine and coarse inclusions or clusters, all of them constituting stress concentrators and thus being the likely cause of cold shortness. References 9: 5 Russian, 4 Western. [1-2415]

UDC 669.046:669.15'295

EFFECT OF LIME ADDITIVES ON SILICOTHERMAL REDUCTION OF TITANIUM

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 85 (manuscript received 19 Apr 84) pp 147-148

DERYABIN, Yu. A., SMIRNOV, L. A. and MUKHACHEVA, A. V., Urals Scientific Research Institute for Ferrous Metals

[Abstract] The authors studied processes of silicothermal reduction of titanium from slags made from Kachkanar pellet smelts, mixing the slags with ferrosilicon and lime. After the material was melted completely, the graphite crucible was cooled at air temperature. Results showed that with 15% ferrosilicon of grade FS90, the titanium was reduced more completely than with the same amount of FS75 ferrosilicon; reducing the ferrosilicon content resulted in more titanium remaining in the alloy. Small amounts of lime resulted in an increase in residual titanium, but with larger amounts, the activity of calcium oxide and reduction of calcium enhanced Ti reduction. References 2: all in Russian. [245-12131]

EFFECT OF ATMOSPHERE ON TITANIUM LOSS DURING ALLOYING WITH STAINLESS STEEL

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA
in Russian No 8, Aug 85 (manuscript received 26 Dec 84) pp 149-150

NEYGEBAUER, G. O., NABOKO, A. N. and ROZHKOVA, N. A., Siberian Metallurgical
Institute

[Abstract] It is generally considered that titanium loss when it is alloyed with stainless steel is the result of oxidation with FeO, MnO, Cr₂O₃ and SiO₂. Yet processes that avoid contact with these oxides have succeeded in raising the yield only up to 60%. The present article reports on a study of the atmosphere as a cause for these losses, by comparing losses in alloying 08-12Kh18N10T steel in atmospheric and argon media. A 70 percent pulverized ferrotitanium mixture was alloyed in a ladle with up to 0.5% silicon added and heating to 1700°C for 30 seconds. Allowances were made for nitridation and deoxidation of the metal. Results showed that the protective argon medium cut titanium losses due to oxidation from 27 to 14%, thus permitting 80% of input titanium to be utilized in the alloy. [245-12131]

ANODE DIFFUSION AND ELECTROCHEMICAL TREATMENT OF SOLID ALLOYS BASED ON CHROMIUM AND TITANIUM CARBIDES

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 4, Jul-Aug 85
(manuscript received 6 Nov 84) pp 11-14

DAVYDOV, A. D., KLEPIKOV, R. P., MALOFEYEVA, A. N. and MOROZ, I. I., Moscow

[Abstract] While refractory chromium and titanium alloys are in wide use, there are numerous problems in shaping them due to their hardness. The present article reports on patterns of anode behavior and electrochemical treatment of three materials: 85% Cr₃C₂ with 15% Ni (1), 70% TiC, 25% Ni and 5% Cr (2), and 70% TiC, 15% Ni and 15% Mo (3). A potentiodynamic method with a linear sweep of anode potential at 1.2 V/minute was used to test disks revolving at 2500 rpm. Intensive diffusion in alloy 1, like pure chromium and chromium carbide, began at a positive potential greater than 1.2, while diffusion in alloys based on TiC began at about 2 V in solutions of NaCl and NaNO₃. In the latter, alloy 3 dissolved in an irregular fashion. In general, the results indicated that under laboratory conditions these alloys can be worked by electrochemical methods such as those tested. NaCl can be used with all three, while NaNO₃ was effective with alloys 1 and 2, although with alloy 2 markedly greater dissolving occurred in NaCl than in NaNO₃ until the voltage reached 18 V. The treated surfaces tended to be rough due to uneven diffusion of alloy components. References 10: all Russian. [9-12131]

INTERRELATIONSHIPS OF CERTAIN PARAMETERS OF ROUGHNESS, CONSTANT OF APPROXIMATION OF SUPPORT CURVES AND DENSITY OF CURRENT ANODING OF SURFACE LAYER OF AO-6 ALUMINUM ALLOY

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 4, Jul-Aug 85
(manuscript received 11 Jan 83) pp 27-28

INDIN, B. V., Kharkov

[Abstract] The initial part of a support curve is described by the formula $\eta_s = b_\epsilon v$ where η_s is the relative surface, ϵ the relative proximity and b, v are the parameters for approximation of the initial portion of the curve. The calculations based on this formula were tested using samples made of an aluminum tin-containing alloy AO-6, which was anodized in an aqueous solution of sodium chloride at current densities of 1.5, 7.5, 10 and 17 A/cm². At 7.5 A/cm², a surface with high oil absorption and adequate supporting surface was obtained. The sharp increase in these parameters between 7.5 and 10 A/cm² confirmed earlier notions on the chemical interaction between water and aluminum. References 2: both in Russian. [9-12131]

UDC 669.187.2:621.187.1(620.18+002.612)

STRUCTURE AND PROPERTIES OF THICK CHROMIUM CONDENSATE LAYERS

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2, Apr-Jun 85
(manuscript received 3 Apr 84) pp 41-45

DIDIKIN, G. G., GRECHANYUK, N. I. and MOVCHAN, B. A., Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev

[Abstract] An experimental study of thick chromium condensate layers was made for the purpose of determining their structure and properties such as heat resistance and thermal stability depending on the purity of raw chromium and on the deposition process parameters. The condensate was produced from granules of Kh00 pure chromium 5-10 mm in diameter as well as from ingots of Kh00 pure chromium and ERKh, VKh-1 grades 70 mm in diameter, It was produced in the form of sheets 0.8-1.2 mm thick and 220x360 mm² in area by electron-beam evaporation of two charges located 230 mm apart and subsequent deposition of chromium vapor on substrates 850-1000°C hot under a nominal vacuum, with the residual pressure varied over the $1.2 \cdot 10^{-3}$ - $1 \cdot 10^{-1}$ Pa range and at a rate varied over the 2-3.75 um/min range. An underlayer of ZrO₂ prestruck on the substrate surface facilitated separating the chromium condensate sheets from the latter. They were then stabilized by annealing at 900°C under a vacuum of $1.33 \cdot 10^{-2}$ Pa for 1 h. The structure of chromium condensate was examined metallographically under an MIM-7 optical microscope. Its microhardness was measured with a PMT-3 tester under a 100 g load. Other mechanical properties were measured at room temperature by bending under

a 3-point load producing a strain rate of 1 mm/min. The results reveal an appreciable role of interstitial nitrogen and oxygen, their concentrations having been found to increase with relaxation of the vacuum and with slowing down of the evaporation as well as with higher impurity of the raw material. Interstitial nitrogen and oxygen reduce the grain size of chromium and thus increase the microhardness of chromium condensate sheet with an attendant decrease of its plasticity. A high oxygen content is detrimental, therefore, because it facilitates formation of chromium oxide. Meanwhile, the temperature at which transition from ductile to brittle fracture occurs rises proportionally to the oxygen and nitrogen concentration. As a trade-off, highest strength and plasticity were obtained with Kh00 and ERKh chromium by evaporation at a rate within 20-30 $\mu\text{m}/\text{min}$ and deposition under a vacuum not below $1.33 \cdot 10^{-2}$ Pa so as not to reduce the nitrogen content below 0.005% and the oxygen content below 0.07%. References 1: Western. [4-2415]

UDC 669.187.2:621.365.91.621.187.1(539.2+620.17).001.5

STRUCTURE AND PROPERTIES OF VACUUM-DEPOSITED CONDENSATE OF NONSTABILIZED ZrO_2

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 2, Apr-Jun 85 (manuscript received 3 Oct 83) pp 45-49

LAVRENOVA, L. Yu., GRECHANYUK, N. I. and MOVCHAN, B. A., Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev

[Abstract] An experimental study of vacuum-deposited thick condensate of nonstabilized ZrO_2 was made, the purpose being to determine its crystalline structure and microstructure as well as relevant mechanical properties. The condensate was deposited in layers up to 175 μm thick at rates of 1.46-2.80 $\mu\text{m}/\text{s}$ on four different substrates: 0.5 mm thick molybdenum, 1.0 mm thick niobium, 1.0 mm thick St3 steel and 1.5 mm thick EI-868 steel. Their microstructure was examined under MIM-7 and MMP-2R optical microscopes as well as under a REM-200 scanning electron microscope, their crystalline structure was determined on the basis of x-ray diffraction in a DRON-3 instrument, their microhardness was measured with a PMT-3 tester under a 50 g load, their open porosity was measured by a special method more powerful than optical microscopy, and their density was measured by weighing on an ADV-200 analytical balance with distilled water as working fluid. The results reveal two distinct structural zones in such a condensate of pure ZrO_2 , regardless of the substrate material and regardless of the orientation of the ZrO_2 vapor stream relative to the substrate. This bizonality is attributable to temperature differences within the condensate volume, with correspondingly different transformations occurring in each zone and with temperature equalization being impeded by the low thermal conductivity of ZrO_2 . An important parameter of the condensation process has been found to be the angle at which the ZrO_2 vapor stream impinges on the substrate. Reducing the angle decreases the microhardness of the

condensate and increases its proneness to brittle fracture with an attendant increase of porosity. The microhardness, moreover, changes abruptly at the interface between the two zones. The optimum range of that incidence angle was found to be $90 \pm 15^\circ$. References 9: 8 Russian, 1 Western.
[4-2415]

NON-METALLIC MATERIALS

UDC 666.76-492.2.001.5

DEPENDENCE OF GRANULATION OF REFRACTORY POWDERS AND OF GRANULE CHARACTERISTICS ON PROPERTIES OF POWDER

Moscow OGNEUPORY in Russian No 8, Aug 85 pp 6-10

CHUDNOVA, N. M. and USATIKOV, I. F., Ukrainian Scientific Research Institute of Refractory Materials, and DEGTYAREVA, E. V., Kharkov Institute of Automobile Highways imeni Ukrainian Komosomol

[Abstract] Seven grades of refractory powder (aluminas GK, G-00 plain, G-00 calcinated at 1500°C without additive, with MgO, washed in HCl, fused mullite, chamotte, on Latnaya clay, Chamotte on Pologi kaolin) were analyzed for chemical composition and mineral composition as well as basic mechanical properties, the purpose being to determine the dependence of granulation process parameters such as crushing time and of granule characteristics on all those factors. The data on open porosity, apparent density, mechanical strength and shrinkage of powder granules indicate that the Al₂O₃ content in the raw material is the major governing factor. High strength and minimum shrinkage were found to be attainable with a raw material characterized by high dry density and low internal friction, namely material with the maximum α-Al₂O₃ content. References 3: all Russian. [247-2415]

UDC 666.762.11:539.4.015

FRACTURE RESISTANCE OF REFRACTORY LAMINATE-GRANULAR Al₂O₃-BASE MATERIAL

Moscow OGNEUPORY in Russian No 8, Aug 85 pp 10-13

VLASOV, A. S., Moscow Chemical Technology Institute imeni D. I. Mendeleev, IVANOV, D. A. and FOMINA, G. A., Moscow Aviation Technological Institute imeni K. E. Tsiolkovskiy

[Abstract] The authors have produced a laminate-granular corundum by pressing batches of cubic granules and subsequently sintering the compact. Specimens of this material were structurally examined and tested for mechanical properties, especially for fracture resistance in terms of

critical stress intensity and specific crack initiation energy as well as for shrinkage. The material consists of alternating dense and porous layers. Increasing the volume fraction of porous layers from 30% to 90% was found not to influence the relative linear shrinkage but to appreciably increase the open porosity. The material has a high fracture resistance, owing to multiple branching of cracks along porous layers and along intergranular interfaces. References 9: 7 Russian, 2 Western.
[247-2415]

UDC 666.762.34.046.512

FUSED FORSTERITE AS REFRACTORY MATERIAL

Moscow OGNEUPORY in Russian No 8, Aug 85 pp 31-34

TRESVYATSKIY, S. G., Institute of Materials Science Problems, UkSSR Academy of Sciences, STRELOV, K. K., Ural Polytechnic Institute imeni S. M. Kirov, VISLOGUZOVA, E. A. and VYDRINA, Zh. A., Nizhmetagil Metallurgical Combine imeni V. I. Lenin, and PEREPELTSYN, V. A., Eastern Refractory Materials Institute

[Abstract] Fused dunite containing forsterite as the principal phase is considered for use as refractory material, smelting in an electric-arc furnace having been found to be an expedient method of producing it. Addition of crushed fused periclase does not improve its quality, owing to the large difference between the respective melting points, but addition of 5% graphite facilitates complete reduction of all impurity oxides. Its zonal structure, microstructure and chemical composition before and after calcination were analyzed along with its mechanical and thermal properties. The results of the study indicate the feasibility of obtaining pure forsterite by electric-arc smelting of natural magnesium orthosilicate, with FeO, Fe₂O₃, Cr₂O₃, MnO easily reduced and concentrated in the ferroalloy which constitutes 6-8% of the material. V. Ya. Karpenko and N. M. Lisenko assisted in the experimental smelting of dunite. References 3: all Russian.
[247-2415]

OPTICAL AND STRUCTURAL PROPERTIES OF $Zn_xCd_{1-x}S$ FILMS PRODUCED BY SOLID-PHASE SUBSTITUTION

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 26 Dec 83) pp 1286-1289

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[Abstract] Films of $Zn_xCd_{1-x}S$ were produced by substitution of Zn atoms in ZnS films on quartz, pyroceramic, or crystalline gypsum substrates, those films having been produced from ZnS powder by vacuum evaporation at a buildup rate of 4-6 Å/s under a residual pressure of $6.6 \cdot 10^{-4}$ Pa. The optical properties of $Zn_xCd_{1-x}S$ ($1 \geq x \geq 0$) films were measured with a Specord UV-VIS spectrophotometer (measurement error $\pm 0.5\%$), and their microstructure was analyzed with an EG-100M electron diffractograph and also under an EVM-100A transmission electron microscope. The results reveal the formation of an ultrafine-disperse condensate in 30-70 nm thick films deposited on substrates at 100-120°C. Annealing of ZnS in CdCl₂ vapor at 300-450°C, resulting in a gradual transition from pure ZnS to pure CdS, was found to cause recrystallization to a 100-200 nm size with attendant transformation from cubic to hexagonal lattice. No such transformation occurs during annealing of ZnS in an argon atmosphere. The process is essentially one of the $ZnS + (1-x)CdCl_2 \rightarrow (1-x)ZnCl_2 + Zn_xCd_{1-x}S$ reaction. The product of this reaction is highly photosensitive in the blue region of the spectrum. References 8: 7 Russian, 1 Western.
[1-2415]

EFFECT OF GRAPHITE COCRYSTALLIZATION GROWTH OF DIAMOND SINGLE CRYSTALS IN METAL-CARBON SYSTEM

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 7 Dec 83) pp 1316-1320

LAPTEV, V. A., POMCHALOV, A. V., BELIMENKO, L. D. and SAMOYLOVICH, M. I., All-Union Scientific Research Institute of Mineral Raw Materials

[Abstract] A study of diamond crystallization in a metal-carbon system was made in order to determine the effect of attendant graphite crystallization on the process. A special series of experiments was performed under conditions favoring spontaneous growth of diamond single crystals, at temperatures of 1150-1250°C under pressures of 4.2-4.5 GPa. Polycrystalline graphite served as the source of carbon, and binary alloys of Ni, Mn, Co served as solvents. Residual graphite after the process was mechanically separated, whereupon three groups of specimens were further examined:

1) specimens of graphite which had been in contact with the molten metal and did not contain any diamond; 2) specimens of metal, mainly in the form of 0.05-0.8 mm thick film, separating diamond from the carbon sources; 3) specimens taken from the reaction zone and containing metal as well as diamond and recrystallized graphite. Some specimens were treated with hot HCl for 5-15 min for dissolution of the metal, or with a mixture of chromium salts for selective preferential oxidation of the original polycrystalline graphite. Subsequent microstructural examination with an electron diffractometer and under an MBI-15 optical microscope as well as under an IEM-6a electron microscope revealed an inhibiting effect of graphite crystallization on spontaneous growth of diamond single crystals during synthetic production of the latter, with a high probability of graphite single crystals also forming in the process. References 10: 9 Russian, 1 Western. [1-2415]

UDC 546.824'431

POINT DEFECTS IN AND PROPERTIES OF BARIUM TITANATE

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 21, No 8, Aug 85
(manuscript received 23 Dec 83) pp 1389-1398

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[Abstract] The effect of point defects in barium titanate on the electrical conductivity of this crystalline material is analyzed theoretically, this property of BaTiO₄ single crystals and polycrystals being the one most sensitive to presence of such defects. The current carrier concentration at moderate temperatures (423 K) is calculated on the basis of conventional semiconductor statistics, assuming a known concentration of defect centers which produce energy levels within the forbidden band. The two possible situations are considered, namely a non-degenerate weakly compensated n-type semiconductor and a strongly compensated one with "frozen" current carriers. Calculations and corroborating measurements pertaining to BaTiO₄ crystals undoped and doped with 1 atom.percent La or 0.5 atom.percent Fe, then quenched from 1470 K under various partial oxygen pressures (pure oxygen, air, pure nitrogen) reveal four distinct ranges of the p_{O₂}-conductivity

characteristic: high n-type conductivity at the low-p_{O₂} end, low n-type conductivity and then low p-type conductivity, high p-type conductivity at the high-p_{O₂} end. The quenching oxygen pressure which corresponds to exact

compensation of donors by acceptors and thus to transition from the second range to the third range with an attendant sharp drop of electrical conductivity, is highest for BaTiO₄<La> and lowest for BaTiO₄<Fe>. The third range, low p-type conductivity following exact compensation, is of special interest on account of the correlation between activation energy and

electrical conductivity within this range. The electrical properties of polycrystalline barium titanate are further influenced by three defect-related phenomena. These are a nonuniform distribution of point defects upon cooling, an anomalously sharp rise of electrical resistivity upon heating to within a definite temperature range (Heywang posistor effect), and an anomalous rise in electrical conductivity followed by its drop to original level as the doping level in subsequently air-annealed and air-cooled barium titanate is increased. Depending on doping and heat treatment, therefore, barium titanate behaves as a low-resistance normal semiconductor, a posistor, an intergranular barrier capacitor, or a normal dielectric. References 26: 11 Russian, 15 Western (3 in Russian translation).

[1-2415]

PREPARATION

ROLLING WITHOUT CONTACT

Minsk IZOBRETATEL I RATSIONALIZATOR in Russian No 6, Jun 85, pp 6-7

[Article by IZOBRETATEL I RATSIONALIZATOR special correspondent Ya. Massovich]

[Text] That day, Professor Shapovalov was sullen. The experiment, which he had so painstakingly set up, had failed because of a graduate student's oversight. Karpov accepted the reprimand, and the only recourse was to begin again. And the goal was clear. It is known that when iron undergoes cyclical temperature changes in the transition region between crystalline states, it can become saturated with hydrogen and swell. What is not precisely known is how long this will continue and at what parameters. And look what happened! Instead of a swollen specimen in the hydrogen-filled chamber, there was a flowing mass of metal. The temperature had apparently gone above the melting point of iron. But, Karpov had important documentation: the recorder chart. It showed that the temperature cyclically varied between 850 and 950 degrees, as specified in the experimental program. How the metal had heated up to 1540 degrees was a riddle. Or did it really heat up?

Several days later, Professor V. I. Shapovalov publically rescinded the reprimand to graduate student Karpov. Repeated experiments gave the exact same results as the first experiment, although all chance elements should have been eliminated. Above all, all possible secondary influences on the specimen were eliminated. They finally suspected the magnetic field created by the solenoid heater: maybe it was adding the heat. They made a bifilar winding. They backed up the thermocouple with a pyrometer. Despite all precautions, the new effect was repeated again and again. Clearly, a new phenomenon had been discovered. They decided to put off their planned work and study this anomaly.

It was important to find the exact boundaries of this "disorder." They varied the specimen heating and cooling rates; selected different hydrogen pressures in the furnace; filled the furnace with argon, helium and mixtures of hydrogen and inert gases. They cyclically varied the metal temperature in a range close to that of the first experiment. The phenomenon was most pronounced at a hydrogen pressure of 5 atmospheres and thermal-cycling rate of 200 degrees per minute. Under these conditions, the blank became twice as long in a little over 5 minutes. This would seem

to be a good time to delve into theory, but graduate student Karpov again rocked the boat: he dared to doubt the obvious.

The thermal softening of metal means that its density is reduced. Of course. However, the experiment showed differently. Up to a 1.5-fold elongation of the specimen, the iron density not only did not decrease, but increased and actually became higher than the initial density. They calculated the elongation using the standard formula and were surprised again: it should not have exceeded two percent. In fact, the specimen grew 5-fold after 500 thermal cycles.

This was not the last puzzle. They noticed that the new effect in iron occurs not at the beginning of the temperature fluctuations, but after a certain incubation period. They decided to verify this as well. They heated the blank until it deformed to a significant degree, then cooled it and returned the metal to its original shape. This material was again placed in the furnace and temperature cycling began. Now, the metal was dormant for a shorter period of time. The anomalous superplasticity occurred after only 5-7 thermal cycles. In other words, the iron had a memory effect.

The scientists of the Metals-Science Department of the Dnepropetrovsk Metallurgical Institute, where the anomaly was first discovered, are still not able to completely explain this phenomenon. But that which is already known can be useful in those technologies where materials operate under conditions of periodically changing temperatures in a rich hydrogen atmosphere.

The scientific search helped to produce an invention. The idea of so-called directional auto-deformation somehow arose during discussion of graduate student V. Yu. Karpov's dissertation (Karpov is now a candidate of sciences). They thought that if heating and cooling could be carried out with a constant temperature gradient, then the metal-transformation zone should shift from one end of the sample to another. Multiple travel of such a wave kind of flattens the blank from the hot end toward the cold. The idea turned out to be feasible, and the scientists easily received an inventor's certificate for "a new method of processing metals and alloys" (Inventor's Certificate No 1,044,424).

Today, it's not easy to obtain items made from such metals as Armco iron and manganese. I leaned toward the window of the chamber and was thunderstruck. For no apparent reason, the metal floated in a thin train from the hot zone to the cold, filling the mold. In a few minutes, a small gear and a tube were produced.

The research is continuing.

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CSO: 1842/246

HOMOGENEITY OF REFRACTIVE COMPONENT IN PSEUDOALLOY FORMING DURING
REDUCTION OF COMPLEX OXIDE SYSTEM WO_3 - MoO_3 - CuO

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 24 Sep 84) pp 1-5

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[Abstract] An experimental study of the W-Mo alloy produced from various raw materials was made, this alloy forming during simultaneous recovery of both metals from a quasi-binary mixture of their oxides WO_3 and MoO_3 . The purpose was to determine the dependence of its degree of homogeneity on the nature of the raw batch and on the reduction process parameters and, also to determine the effect of copper oxide added to the batch and being reduced in the process. The experiment was performed with three batches: 1) mechanical mixture of oxides in molar ratio $WO_3:MoO_3:CuO=0.5:0.5:1$; 2) mechanical mixture of oxides $W_{0.5}Mo_{0.5}O_3$ and CuO in equimolar ratio; 3) copper tungstate molybdate $Cu(W_{0.5}Mo_{0.5})O_4$. Reaction was made to proceed in two stages, the initial stage at four different temperatures ($300-400-500-600^\circ C$) and the final stage at $800^\circ C$ for 1.5 h each time. The quality of the resulting alloy was evaluated by x-ray diffraction analysis, from concentration histograms and intensity distributions of (321) spectral lines, as well as by conventional phase analysis at critical instants of time during the reaction. The difference between the products obtained from the three batches was most appreciable after initial reduction $300^\circ C$, the alloy produced from the $W_{0.5}Mo_{0.5}O_3 + CuO$ mixture being most homogeneous (almost complete homogeneity being attainable from pure $W_{0.5}Mo_{0.5}O_3$). Raising the temperature of initial reduction decreased the homogeneity of this alloy and of the alloy produced from the $Cu(W_{0.5}Mo_{0.5})O_4$ compound, but increased the homogeneity of the alloy produced from the $WO_3 + MoO_3 + 2CuO$ mixture. Raising the temperature of initial reduction above $300^\circ C$ ($400-600^\circ C$) equalized the homogeneity of the three products, a major factor here being the slowness of final reduction at $800^\circ C$. References 7: 4 Russian, 3 Western.
[8-2415]

FEASIBILITY OF PRODUCING Cd-Zn ALLOY POWDERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 14 Jun 84) pp 6-10

VOLKOV, L. V., SHKURYAKOVA, S. P. and NGUEN BAH KHAY, Leningrad
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[Abstract] The feasibility of producing Cd-Zn alloy powders by simultaneous discharge of cadmium and zinc ions from simple electrolytes such as sulfate solutions has been demonstrated experimentally, despite the large difference between the standard potentials and despite the fact that discharge of zinc ions does not become depolarized. It requires reduction of cadmium ions at the limiting level of diffusion current and subsequent precipitation of a powder deposit on the electrode. The cathode potential must, accordingly, be more negative than -0.6 V. While Cd-Zn alloys are deposited on the cathode at potentials more negative than -0.76 V, no zinc appears in the deposit at potentials more positive than that and only dendritic deposit of cadmium appears at potentials more positive than -0.6 V. A characteristic feature of the alloy powders is that particles do not fall off the cathode but form a sponge weakly bonded to the substrate surface. Cathodic polarization curves of cadmium ion reduction from sulfate solutions with various concentrations were plotted. Measurements established a dependence of the zinc content in the powder on the cathode potential during precipitation and of the zinc-to-cadmium ratio in the powder on the current density. The results reveal a saturation of the zinc content as the cathode potential exceeds -0.9 V in the negative direction and an almost constant zinc-to-cadmium ratio over the $1000-15,000$ A/m² wide range of current density. Varying the Zn²⁺ concentration at a constant Cd²⁺ concentration does not alter the alloy composition but only changes the precipitation potential, while varying the Cd²⁺ concentration at a constant current density changes the Zn content in the alloy powder reflectively regardless of the Zn²⁺ concentration in the electrolyte. Continuous enlargement of the deposit surface during a galvanostatic process causes the powder composition to become a function of buildup time and to be controllable only through regulation of the electrolyte composition. Either galvanostatic or potentiostatic precipitation of these alloy powders can therefore be effective, but it is preferable to maintain a constant deposit level throughout the process by continuous tapping rather than to allow buildup until removal of the entire product at the end of the process. References 3: all Russian. [8-2415]

PROPERTIES OF TiC POWDERS PRODUCED FROM TITANIUM OR TITANIUM-ALLOY CHIPS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 25 Jun 84) pp 12-16

KIPARISOV, S. S., LEVINSKIY, Yu. V., PADALKO, O. V., PETROV, A. P.
and DEULINA, I. P., Moscow Institute of Fine Chemical Technology

[Abstract] A low-cost method of producing TiC powders has been developed, namely from titanium or titanium-alloy chips by carbidizing them in two stages in graphite crucibles. This was done experimentally with chips of VT-1, VT-3-1, and VT-20 titanium alloys under three different conditions; 1) under vacuum; 2) in an argon atmosphere; 3) in a hydrogen atmosphere. Granulometric analysis of the product, after comminution of the sintered mass by tumbling for 15 min with hard-alloy balls in a vibrator-mill containing ethyl alcohol as immersion fluid, revealed an approximately same grain size distribution regardless of the process condition, with the mean size of most carbide grains respectively 7.9, 8.2, and 8.3 μm . Chemical analysis revealed an approximately same content of bound carbon regardless of the process condition, and slightly less bound carbon but much more detrimental free carbon in carbide produced in a hydrogen atmosphere. This leaves an argon atmosphere or vacuum as suitable alternatives the levels of oxygen and nitrogen as well as those of bound and free carbon under those conditions were found to be comparable, whether VT-3-1 or VT-20 chips or technically pure titanium or VT-1 alloy chips had been used. The alloying elements (Al, Cr, Mo, Zr) were found to remain in the carbide. Microstructural examination under a scanning electron microscope revealed morphological differences between titanium carbide produced by this process and the one produced by the conventional carbon-thermal process. The microhardness was found to be approximately the same. The performance as abrasive material being the same, it costs only up to 2 rubles/kg to produce TiC powder from chips and this amount to a 2:1 or even 3:1 cost advantage over TiC powder produced by the conventional carbon-thermal method. References 7: 6 Russian, 1 Western (in Russian translation).
[8-2415]

DEFORMATION OF Al-Cu POWDER BODIES DURING LIQUID-PHASE SINTERING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 12 Dec 84) pp 39-43

SAVITSKIY, A. P., ROMANOV, G. N. and MARTSUNOVA, L. S., Institute of Strength Physics and Materials Sciences, Siberian Department, USSR Academy of Sciences

[Abstract] A dilatometric study of Al-Cu powders was made for monitoring the volume changes at various temperatures during the sintering process. Powder of ACD-1 aluminum was mixed with powder of electrolytic copper, the latter added in amounts of 1-6 wt.% and its grain size not exceeding 50 μm , producing a mixture with an initial porosity of 21-23%. Temperature and volume were recorded synchronously, also continuously each, for measurement of volume changes over the critical 560-640°C temperature range. The results reveal expansion followed by shrinkage at higher temperatures and expansion with negligible or no subsequent shrinkage at lower temperatures. Copper plays a significant role in the volume changes, diffusion of copper atoms from the melt into aluminum particles being the principal mechanisms and the solubility of copper in aluminum being limited. The behavior of these powder mixtures during sintering depends, accordingly, on the copper content in accordance with the Al-Cu constitution diagram: shrinkage never follows expansion at temperatures which correspond to equilibrium within the solid-solution (α -phase) range and shrinkage always follows expansion at temperatures which correspond to coexistence of both solid and liquid phases. The amount of shrinkage, moreover, increases with higher copper content as well as with higher sintering temperature. With the aid of these data is established an analytical relation between relative volume change $\epsilon = \Delta V/V_0$ and atomic concentrations of copper in the mixture (C), of copper in the solid phase after diffusion from the liquid phase (C_S), and of the solid phase in the liquid phase after dissolution (C_L), this relation $\epsilon = [C_S(1 - C) - CC_L]/(1 - C)(1 - C_S - C_L)$ also allowing determination of the copper content in the solid phase from the deformation of the powder batch during sintering. Calculations of that copper content at the instant of maximum volume change yield values which correspond to the atomic concentration of copper in the mixture, within experimental accuracy, but generally exceed somewhat the total copper content and even more the solubility of copper in the solid phase. References 11: 7 Russian, 4 Western.
[8-2415]

SOLID-PHASE INTERACTION AND DIFFUSIONAL HOMOGENIZATION OF Fe-Cr₃C₂-Mo₂C
COMPOSITE POWDERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 23 Nov 84) pp 44-48

ANTSIFEROV, V. N. and OVCHINNIKOVA, V. I., Perm Polytechnic Institute

[Abstract] The effect of alloying carbides Cr₃C₂ and Mo₂C on the structural uniformity of sintered powder steel is evaluated on the basis of experimental data and known interaction processes in this ternary system. Dissolution of the carbides and homogenization of the alloy were monitored in a system consisting of a 20-98 wt.% Fe (high-purity 13-2 carbonyl iron) base with 0-40 wt.% Cr₃C₂ and 0-40 wt.% Mo₂C in alcohol suspension added. The powder mixture was sintered in a carbon bed, to avoid loss of carbon, in an atmosphere of dry hydrogen. The carbide phases in the alloy were identified by a special method of nondestructive analysis. The degree of alloy nonhomogeneity was estimated quantitatively on the basis of x-ray spectral microanalysis under a scanning electron microscope as well as through determination of the respective concentration variance coefficients. The results indicate a strong dissolution of the carbides with attendant formation of a γ -phase solid solution with highly uniform distribution of both alloying metals and carbon, which imparts a high degree of structural uniformity to the thus produced steel. References 5: 4 Russian, 1 Western. [8-2415]

EFFECT OF ADDED BORON ON PHASE COMPOSITION OF TiC-TiNi ALLOYS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 10 Nov 84) pp 63-65

AKIMOV, V. V., KULKOV, S. N., PANIN, V. Ye. and GORLACH, V. V.,
Siberian Automobile and Highways Institute

[Abstract] An experimental study of TiC-TiNi alloys produced by sintering of powder with addition of boron was made, for the purpose of determining the effect of boron on the phase composition and thus also the physico-mechanical properties of the product. Boron can remove impurities from the alloy by facilitating a favorable interaction of TiNi and TiC, while it can also form borides through chemical interaction and thus introduce new phases into the system. Amorphous boron was added to the powder mixture containing acetone in doses of 0.5-10 vol.%. After thorough mixing for 10-21 h, to ensure a uniform distribution of the boron, the resulting 0.5TiC + (0.5-x)TiNi + xB powder batches were compacted to a porosity not exceeding 40% and sintered at 1280-1300°C under a vacuum of $7 \cdot 10^{-2}$ Pa, and then

slowly cooled. The structure of the product was examined under an MIM-8 optical microscope with x300 and x900 magnification. The phase composition was determined on the basis of x-ray diffraction in a DRON-3 instrument with a Cu K α source. The diffractograms revealed existence of TiNi₃ and TiB₂ phases as well as traces of a TiB₅ phase along TiC and TiNi. Both porosity and microhardness of the sintered product were found to depend on the boron content, the former peaking to a maximum of under 10% and the latter dipping to a minimum of HRA 5 at a 3 vol.% B content - a manifestation of the dual role of boron. In small amounts within 2.5 vol.%, therefore, boron is beneficial without altering the phase composition of the TiC-TiNi alloy too much. References 3: all Russian.

[8-2415]

UDC 621.762

IMPROVING PERFORMANCE OF HARD-ALLOY PLATES BY THERMOMAGNETIC ABRASION TREATMENT

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 5 May 83) pp 65-70

SHLYUKO, V. Ya., GRIDASOVA, T. Ya., OLIKER, V. Ye., ZHORNYAK, A. F., KARPOVA KARPOVA, L. A. and ZLENKO, A. A., Institute of Problems in Materials Sciences, UkSSR Academy of Sciences; Kiev Polytechnic Institute; Dnepropetrovsk Hard-Alloys Manufacturing Plant

[Abstract] The performance of polyhedral plates made of hard alloys with high-resistance coatings, and thus not remachinable, is greatly enhanced by magnetic-abrasive polishing. This treatment not only smoothens and straightens the cutting edges while ensuring the proper rounding radius, but particularly lengthens the tool life and reduces the failure rate associated with chipping. The efficiency of this treatment can, in turn, be enhanced by ensuring a sufficiently large difference between hardness of the abrasive tool component and hardness of the treated material. Increasing the hardness of the former is not practical, inasmuch as the limit has already been approached with inclusions of extra-hard refractive compounds and the use of diamond grains is uneconomical because of their high cost and weak bonding to a ferromagnetic matrix. It is preferable to lower the hardness of the treated material, namely softening the surface layer, which can be achieved by high-temperature oxidation. The resulting brittle porous oxide layer is easily removable by mechanical means. An additional advantage of such a heat treatment is the possibility of localizing the removal of material within a prescribed area, with the other areas properly protected. This combined thermomagnetic-abrasion treatment was evaluated experimentally on plates made of TN20, KNT16, T5K10, T15K6, VK6, VK8 alloys with Fe-TiC, Fe-ZrC, Fe-NbC, Fe-WC, Fe-WC-TiC, Fe-Al₂O₃ magnetic-abrasive powders. An important factor is matching the magnetic-abrasive powder, whose performance depends on the plate material, according to the results of metallographic examination under a

scanning electron microscope, and whose elements enter the new layer, according to evidence obtained by x-ray spectral microanalysis. The thickness of this new layer depends on the treatment mode as well as on the treated material and on the composition of the magnetic-abrasive powder.

References 21: 17 Russian, 4 Western.

[8-2415]

TREATMENTS

A NEW POLYMER FOR THE HEAT-TREATMENT SHOP AND THE OPERATING ROOM

Moscow KHIMIYA I ZHIZN in Russian No 7, Jul 85 pp 8-9

[Article by M. G. Voronkov, corresponding member, USSR Academy of Sciences]

[Text] The Irkutsk Institute of Organic Chemistry of the Siberian Department, USSR Academy of Sciences, has long been investigating water-soluble high-molecular compounds. One of the results of this work is the synthesis of a new polymer based on polyacrylic acid: an incomplete ferric salt of polyacrylic acid with an iron content of 0.05-0.5 percent.

Its formula is: $-(\text{CH}_2-\text{CHCOOH})_m-(\text{CH}_2\text{CHCOOFe}_{1/x}^x)_n^-$, where $m > 150$; $x = 2$ and 3; $n = 50-100$. The new polymer is called PK-2.

In the tradition of our institute, the researchers began to seek practical applications for PK-2, as is done for all other newly synthesized substances. Two (so far) areas of application have been found.

Mankind has known how to harden steel since before the start of recorded history. Red-hot daggers, sabres, yataghans and swords were immersed in olive oil to harden the blades. If especial hardness was needed, the ancients even went so far as to use a cruel technology: the blade was plunged into the stomach of a slave sentenced to death.

Today, petroleum oils are usually used to quench steel, although water and aqueous solutions of mineral salts and bases are sometimes used, as well as certain organic polymers. Water is not the best quenching medium: after parts are immersed in it, they often warp and crack. Water was formerly used for quenching in rural blacksmith shops, while in recent times it is used in the heat treatment of unalloyed and low-alloy steels. Petroleum oils have a gentler effect on the metal and therefore are good only for cooling high-alloy steels, although oil quenching does not always give steel the necessary hardness.

Quenching is not an ecologically clean process. What follows is a description of what occurs in the heat-treatment shop of a large machine-building plant. A bridge crane brings a basket with red-hot steel parts to a large oil bath. When the basket is lowered into the oil, a veritable explosion occurs: a flame shoots up, the shop is filled with smoke, soot, oil vapors and products from the oxidation and thermal decomposition of hydrocarbons. But, the unhealthy working conditions in

heat-treatment shops and the large expenditures for the construction, operation and repair of large ventilation systems and fire-protection devices and cooling the quenching baths are not the only problems. The processes of oil bituminization and oxidation caused by the red-hot metal entering the bath reduce the oil's cooling capacity, contaminate the bath and cause burn-on to form on the quenched parts. Cleaning the spent oil baths and re-using the oil residues are not only somewhat difficult, but also cause environmental pollution. Washing the quenched parts and removing the oil and burn-on before machining are also not cheap. Finally, every year, petroleum-based oils become scarcer.

The Laboratory of Polymerization Processes (headed by Candidate of Technical Sciences V. Z. Annenkova) of the Irkutsk Institute of Organic Chemistry has developed a aqueous quenching medium (AQM) based on PK-2 polymer. This medium can be used to quench parts of any size and shape made of any grade of steel. The machine-science faculty of the Irkutsk Teachers' Institute and the Leningrad Kirovskiy Zavod Association also took part in the development of the new quenching medium.

In contrast to quenching oils and all other types of aqueous quenching media, AQM is non-flammable, does not pollute the environment or the quenched parts, is absolutely non-toxic and does not give off harmful or foul-smelling emissions during quenching. Therefore, heat-treatment shops no longer need large ventilation systems, and the risk of fire is eliminated. AQM is superior to all other quenching media in that it can be used in a wide temperature range (from 4 to 100° C), it is highly stable and greatly improves the metal quality. Finally, the service life of the AQM is many times greater than oils and other traditional media. There are no problems with re-using the spent quenchant: its content can be easily corrected by adding water and the hydrous polymer solution.

Since AQM is a 1-percent aqueous solution of PK-2 polymer (with several additives), then one can certainly say that oil has been usefully replaced by water.

Metallurgists saw the advantages of the new quenching medium immediately. Extensive and successful production tests were conducted after laboratory research at Kirovskiy Zavod PO [Production Association] in Leningrad and at the Heavy Machine-Building Plant imeni V. V. Kuybyshev in Irkutsk. AQM is already being used to quench various grades of steel in the heat-treatment shops of these enterprises, as well as at other plants in the country. The metal-working industry's great interest in AQM is evidenced by the fact that Kirovskiy Zavod and Kaztraktorodetal' PO (Alma-Ata) have built shops to produce PK-2 polymer and the quenching medium based on it.

The Irkutsk Institute of Organic Chemistry and Kirovskiy Zavod have received requests for AQM from dozens of ministries and hundreds of enterprises in every corner of the country. However, neither the plant, the institute nor the Usolye-Sibirskoye Chemical-Pharmaceutical Combine, where PK-2 polymer is produced on a test-commercial scale, are able to fulfill the requests. The problem isn't only insufficient equipment capacity, but rather a shortage of the basic raw material: acrylic acid. It is

hoped that the question of commercial production of PK-2 polymer will soon be decided.

The reader shouldn't be surprised that PK-2 polymer is produced at an enterprise of the medical industry, the Usolye-Sibirskoye Chemical-Pharmaceutical Combine. The new polymer is needed by doctors as well as metallurgists: a new localized-action styptic (hemostatic) compound, ferakril, has been developed on the basis of this PK-2.

The hemostatic-effect mechanism of this compound is basically different from all other styptic substances. Ferakril forms complex compounds with blood proteins; the coagula of these compounds block the bleeding. Therefore, it stops bleeding effectively in people with normally coagulating blood, as well as in those suffering from hemophilia, hemolytic and hypoplastic anemia and other similar diseases. The hemostatic effect is achieved quickly and reliably, and no secondary bleeding is observed. All that is needed to stop bleeding is to apply a cloth soaked with an aqueous solution of the compound.

The new compound will conserve donated blood and bandage materials, make the surgeon's work easier and reduce the duration of operations. When ferakril is used in the post-operative period, the erythrocyte coagulation reaction is not increased, nor is the quantity of leucocytes. The hemoglobin level (due to the low blood loss) is not significantly reduced, and no intravascular blood clots occur. Wounds heal without suppurating. In addition, ferakril has bactericidal and pain-killing effects.

All of this promises wide use of this preparation in all areas of surgical practice, including stomatology, as well as for first aid at production facilities, in sports and at home. The colorless, scentless preparation should replace tincture of iodine and green antiseptic, which leave unsightly brown or green spots on the skin. Finally, ferakril is recommended for veterinary use.

Ferakril has undergone multiple testing in the research laboratories of the institut's Biology Department (Candidate of Biological Sciences V. B. Kazamirovskaya, director) and in the Central Blood-Transfusion Institute, as well as extensive clinical testing in the country's surgical clinics. The USSR Ministry of Health has approved its use in medicine. The medicinal form of ferakril (a one-percent aqueous solution in vials) is produced by the Khabarovsk Chemical-Pharmaceutical Plant. Production of a bandage material impregnated with a ferakril solution is also planned.

These are the first two areas of application for the new polymer. The first areas, that is, because gradually other equally interesting and effective areas are being defined. We may possibly return to the story of this polymer at a later date.

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CSO: 1842/245

UDC 666.762.2-186

NONCALCINATED REFRACTORY MATERIALS BASED ON QUARTZ GLASS

Moscow OGNEUPORY in Russian No 8, Aug 85 pp 34-37

MITYAKIN, P. L., Department of Physical Technical Problems of Metallurgy, Siberian Department, USSR Academy of Sciences

[Abstract] Refractory materials have been obtained experimentally without calcination, by using a dispersion of quartz glass from the Podol'sk plant (99.7% SiO₂ + 0.1% Al₂O₃) as binder and filler in a hydrosol of silicic acid from the Cherepovets plant. Products made of these materials were, after heat treatment, tested for open porosity and compressive strength over the 110-1300°C temperature range. Both these principal performance indicators have, furthermore, been optimized on the basis of a planned factorial experiment involving purity of raw material and phase transformations during heat treatment. The porosity can be reduced to 14.3% and the strength can be raised to 26 MPa, without degradation up to 1300°C, by combining heat treatment with moisturization. Yu. A. Vasilyev at the Nizhnetagil Metallurgical Combine assisted in heat treatment and testing of specimens. References 6: all Russian.
[247-2415]

UDC 669.15'24'26-194:539.52

EFFECT OF MICROSTRUCTURE PARAMETERS ON HOT DEFORMATION PROCESS FOR TWO-PHASE STEEL

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 85 (manuscript received 14 Mar 84) pp 40-42

ROSTOVITSEV, A. N., LARICHEVA, L. P., PERETYAT'KO, V. N. and LEVIUS, A. M., Novokuznetsk Pedagogical Institute

[Abstract] Use characteristics of metals and alloys are related to microstructural features that arise during forming. Since previously results, rather than processes, have been studied, the present article reports on automatic structural analysis using the "Epiquant" analyzer. The samples

studied were of 08Kh18N10T steel with a dispersed mixtures of phases containing up to 10% beta-ferrite. They were stretched at 1100°C with a constant rate of true deformation of 0.03 sec^{-1} . Logarithmic deformation, extrapolated yield strength, modulus of initial hardening and limits of tempering, other deformation parameters and flow stress in the steady state were recorded. Due to structural variations, replication of the tests was impossible, so that the tests are to be regarded as provisional. Nonetheless, calculations made it possible to determine the impact of individual elements of the microstructure on the process of hot plastic deformation. Pulverization of austenite granules, the loss of defect packing energy and increased bonding of the austenite promoted high-temperature tempering with small amounts of beta-ferrite. References 9: all Russian. [245-12131]

UDC 621.771.23.016.3.01

KINEMATIC AND GEOMETRIC PARAMETERS OF DEFORMATION FOCUS IN TWO-LAYER COLD ROLLING OF THIN SHEETS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 85 (manuscript received 11 Nov 84) pp 43-50

SOKOLOVSKIY, V. I., NOVGORODOVA, N. G. and PESIN, Yu. V., Urals Polytechnical Institute

[Abstract] A two-high cold rolling mill for thin stock developed by the Urals Polytechnical Institute, the Dnepropetrovsk Ferrous Metallurgy Institute and the Uralmash Production Association involves simultaneous rolling and immediate bonding. The present article reports on factors in the focus of deformation that affect the final product, such as slippage during shaping. The initial factors considered were starting and final thickness, stretched bands, and other mechanical characteristics. Calculations presented show that the neutral angles for thin-sheet rolling in calculated and experimental data are comparable. Specific rolling diagrams and calculating formulas are given, along with pressure and final product parameters that permit determination of coordinates of neutral points, angles of deflection relative to horizontal, mean pressure on contact surfaces, and final thicknesses of layers in the two-layer product. References 10: all Russian. [245-12131]

FORMATION OF AUSTENITE UPON HOT ROLLING OF FERROSILICON

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 49,
No 8, Aug 85 pp 1649-1651

SUMIN, A. V., KONONOV, A. A., MOGUTNOV, B. M., PROKLOVA, A. N. and
YUNAKOVA, I. V., Institute of Precision Alloys; Central Scientific
Research Institute of Ferrous Metals imeni I. P. Bardin

[Abstract] A study is made of the conditions of formation of austenite and its distribution in a hot rolled strip. The alloy studied contained about 0.045% C and 3.0% Si by mass. The distribution of austenite decomposition products and their volumetric fraction were determined using a structural analyzer. If austenite is formed before or during the process of deformation, the products of its decomposition are located in rows in the direction of rolling. The products of decomposition of austenite formed after deformation are located primarily along the grain boundaries of the ferrite. Thus, to produce a dispersed and uniformly distributed austenite, hot rolling should be performed in the temperature area of formation of that phase. The maximum quantity of austenite is formed at 1100-1150°C. In order to reduce grain size, achieve uniform distribution of austenite and products of its decomposition through the cross section of the strip, hot rolling must be performed in the temperature area in which the gamma phase is formed. References 3: 2 Russian, 1 Western.
[13-6508]

UDC 621.762.04+621.771.237

ROLLING THIN TAPE MADE FROM POWDER

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 85
(manuscript received 25 Oct 84) pp 31-34

LOZHECHNIKOV, Ye. B., RAPOPORT, L. A., SELEMENEV, A. P., SHUMSKIY, S. S.
and YURKOV, S. V., Belorussian Polytechnic Institute

[Abstract] The process of rolling thin tape made of powder is analyzed for controllability of tape thickness. Calculations are based on the theoretical interrelation between tape thickness, tape density, and powder density depending on the rolling speed and the roller geometry as well as on the extrusion factor, with the maximum rolling speed limited by the requirement of tape continuity and uniform air filtration through the powder. Experiments were performed with iron powder in an SPP-7 "Quarto" type rolling mill built by the Minsk Production Association for Manufacture of Automatic Production Lines. An evaluation of the results indicates how the rollers must be selected and designed to allow regulation

of the tape thickness over the 1.36-0.54 mm range. Control tests indicate that with rollers 40/130 mm in diameter iron powder can be rolled down to a 0.21 mm thick tape and titanium powder can be rolled down to a 0.18 mm thick tape, at a nominal rolling speed of 25 mm/s and at temperatures of 20-900°C depending on the powder composition. References 5: all Russian.
[8-2415]

UDC: 621.787.4

SURFACE HARDENING OF GAS TURBINE ENGINE VANES IN AN ULTRASONIC FIELD

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 85
(manuscript received 14 Mar 84) pp 68-71

YATSENKO, V. K., STEBELKOV, I. A., PRITCHENKO, V. F., MIKHAYLOV, S. B. and KICHAYEV, Yu. P., Zaporozhye.

[Abstract] The effectiveness of hardening of gas turbine vanes by surface plastic deformation in an ultrasonic field is largely determined by the selection of the optimal conditions. The optimal conditions for surface hardening refer to the conditions of deformation providing sufficient durability of the vanes under alternating loadings and the capability to withstand impact bending loads when foreign objects enter the engine. Tests of the fatigue properties of specimens of VT8 and EP718 alloys were undertaken to determine the optimal hardening conditions. Specimens were hardened in an ultrasonic field using balls 2.35 and 1.3 mm in diameter in a special ultrasonic device for ten minutes. Fatigue testing of cantilever mounted specimens was conducted in a type VEDS-200 vibrating test stand on the basis of 10^7 cycles until the appearance of macroscopic cracks. The greatest effect was observed upon hardening of VT8 or EP718 by 1.3 mm diameter balls. The use of 2.35 mm diameter balls actually decreased the endurance of VT8 by 2%. Strain hardening does not actually increase the resistance of the vanes to impact loading. Superior strength characteristics are achieved by vibration polishing. The test results indicate that exposure to the 1.3 mm balls in the ultrasonic field should not exceed five minutes, which ensures a significant increase in endurance of the vane without decreasing impact load resistance. References 3: all Russian.
[10-6508]

WELDING, BRAZING AND SOLDERING

UDC: [621.791.052.08:620.179.16]:681.3

INFORMATION-MEASUREMENT SYSTEM FOR ULTRASONIC TESTING OF WELDED JOINTS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 11 Jan 84; in final form 15 Feb 85) pp 68-70

MITROFANOV, O. A., Engineer, RADKO, V. P., Candidate of Technical Sciences,
BENKOVSKIY, V. V. and ANOP, I. A., Engineers, Institute of Electric Welding
imeni Ye. O. Paton, Ukrainian Academy of Sciences

[Abstract] Studies have shown that the probability of detecting defects such as oxide films and others which produce very small returns in ultrasonic defectoscopy can be increased by statistical processing of a file of echo signals recorded on the defectoscope. This method has been implemented on an Elektronika-60 microcomputer and UD-10UA ultrasonic defectoscope which is controlled by the computer. A flowchart of the testing algorithm and a structural diagram of the interconnection of the devices in the system are presented. The operation of the system is described for testing of a welded joint in a sheet structure. The system for detecting and recording defects has been tested experimentally and found to operate satisfactorily. References 5: all Russian.
[6-6508]

UDC: [621.791.753.5:669.14].001.24

KINETICS OF INTERACTION OF MULTICOMPONENT METALS AND SLAG DURING WELDING UNDER FLUX ESTIMATED BY CALCULATION

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 1 Jun 84) pp 19-24

BORONENKOV, V. N., Doctor of Technical Sciences, and SALAMATOV, A. M.,
Candidate of Technical Sciences, Urals Polytechnical Institute
imeni S. M. Kirov

[Abstract] The authors have created a mathematical model which reflects the kinetics of chemical reactions during welding under flux and allows

prediction of the composition of the welded seam considering the interaction of the metal with the slag in the electrode and the bath, continuous renewal of the interacting mass of metal and slag in each stage, presence of electrolysis upon shunting of a portion of the current by the liquid metal, simultaneous occurrence of all reactions in each stage, and the influence of diffusion of all reagents on the rate of each reaction.

References 20: 19 Russian, 1 Western.

[6-6508]

UDC: 621.791.4:539.378.3

PRODUCTION OF VACUUM-TIGHT JOINTS IN MATERIALS BY DIFFUSION WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 6 Dec 83; in final form 30 Oct 84) pp 25-28

KONYUSHKOV, G. V., Doctor of Technical Sciences, Saratov Polytechnical Institute

[Abstract] A study is made of the production of vacuum-tight joints in materials for the electronics industry by diffusion welding. It is found that increasing the vacuum while maintaining a primarily reducing atmosphere intensifies the removal of oxide films at temperatures below 800°C and improves contact formation conditions for diffusion welding. Under conditions typical for diffusion welding pores are healed and crystals deformed, decreasing hydrogen permeability by at least an order of magnitude. Blowing of a mixture of helium and hydrogen through gaps between parts to be welded during welding makes it possible to determine the moment when a joint becomes vacuum-tight. References 6: all Russian.

[6-6508]

UDC: 621.791.79.048.053:539.214

INFLUENCE OF CHEMICAL COMPOSITION OF FLUX ON DUCTILITY OF SEAM METAL IN ELECTROSLAG WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 8, Aug 85
(manuscript received 5 Jun 84; in final form 5 Feb 85) pp 57-58

MODZHUK, M. D., Engineer, ROSHCHIN, M. B., Candidate of Technical Sciences and POTAPOV, N. N., Doctor of Technical Sciences, Scientific-Production Association of Central Scientific Research Institute of Heavy Machine Building

[Abstract] In order to determine the influence of chemical composition of flux on composition of type 10GN2MFA steel, electroslag remelting of

electrodes was performed in a crystallizer using three experimental fluxes plus type OF-6 standard flux. The SiO_2 content in the experimental fluxes was 12, 19 and 31%, the CaF_2 content 47, 39 and 28%. The content of CaO and Al_2O_3 in all fluxes was 18 and 22%, respectively. The experimental fluxes had higher SiO_2 and lower CaF_2 content than type OF-6 flux. The use of fluxes with higher silica content resulted in the formation of silicate inclusions such as spessartite, mullite, etc., in the surfaced metal, which do not cause stresses upon heating as does alumina. This helps to increase the ductility of the metal of the seam upon repeated heating.

References 5: all Russian.

[6-6508]

EXTRACTIVE METALLURGY AND MINING

NORILSK MINING-METALLURGICAL COMBINE DESCRIBED

Moscow SOVETSKAYA ROSSIYA in Russian 12 Jul 85 p 4

[Article by Anatoliy Lvov, Aleksandr Protsenko, and Aleksandr Shchegolev: "We Are from the City of Norilsk!"]

[Text] Today the inhabitants of Norilsk are celebrating the 50th anniversary of the creation of their Norilsk Mining and Metallurgical Combine imeni A. P. Zavenyagin which has already been awarded an order three times.

What is Norilsk? You do not answer right away. For a start, here is a local riddle: "if you go south for a long time, where will you arrive?" The answer is a simple one (for a person who knows). "At the Arctic Circle." South--to the Arctic....! One must go no more or no less than 400 kilometers.

Life is difficult here. The first explorer of the Taymyr, the Russian traveler Aleksandr Middendorf (he was 26 years old then) wrote: "Unbearable cold suddenly enveloped us. At first sharply, feeling like injections with needles and hundreds of glass splinters, it began to burn our faces and took our breath away because our mouths convulsively tightened with the onslaught of air..."

In Defiance of the Elements

Yes, it is cold here. At times it is very cold. This is so even though the official weather reports state that the mercury never fell below -57.5 degrees in Norilsk's latitude, while in Yakutiya, for example in Oymyakon, the intense cold at times reaches -71. However, Norilsk (along with Dudinka) has the full right to be considered the coldest city on earth: intense cold and wind visit it simultaneously (which is not so in Yakutiya) and, to be more accurate, they are permanent residents there. Therefore, the weather is defined not in degrees but in harshness force--a term which was born in the Antarctic: the degrees are added to double the wind velocity number. During some winters the harshness of the weather reaches a force of 99.

One must add to this that the snow is on the ground here for an average of 286 out of the 365 days, the thickness of the snow cover reaches up to 14 meters (an average of seven meters), and the polar night lasts for 45 days. It was assumed that normal living is impossible here, a "watch method" is necessary.

Half a century has passed since then. This is today's fact: 260,000 people now live in Greater Norilsk (this includes Kayerkan and Talnakh, satellite settlements in the recent past which received the status of independent cities only two years ago). It is an ordinary large city. Yet the climate in the Taymyr has not changed. The question comes up: why was it necessary to build a large modern city in so inhospitable a place? This is the answer: "As a result of the selfless labor of the Norilsk people and the great single-minded work of party, trade union, and Komsomol organizations, a large diversified economy for the production of non-ferrous metals has been created in a short period of time under the severe conditions of the polar regions. The products manufactured by the combine's collective have important significance in the business of speeding up scientific and technical progress in the national economy of the country..." (This is from the greeting of the CPSU Central Committee and the USSR Council of Ministers to the laborers, engineering and technical personnel, and office workers of the Norilsk Mining and Metallurgical Combine imeni A. P. Zavenyagin and to all participants in the creation and development of the Norilsk industrial region).

The mining and metallurgical combine--the country's leader in non-ferrous metallurgy, has given life to this city. The "three whales" on which Norilsk stands are nickel, copper, and cobalt. This city is the discoverer of the ore treasures of the polar regions. It has lit the path to them. It has kindled the eternal flame of metallurgy in a territory where "the mercury is in a solid state for a third of the year" as the 19th century authors expressed themselves.

Strongly-Tempered People

This is a slight digression about the citizens of Norilsk. About 130,000 people were born in Norilsk during the 50 years of its existence. This is in the literal sense. However, there are many more than that who firmly established themselves in this severe land as individuals and as citizens. There are more than a million Norilsk people if you count those who lived here more than three years, who stood watch in a blizzard and at night, and who in one way or another left their footprint on the history of mastering the Taymyr. You do not talk about everyone but here are several bits of evidence.

Yevgeniy Astashin arrived in February 1973 to construct the underground workings of the new Oktyabrskiy mine. He was a volunteer. Up to this time he had worked at the oldest Norilsk mine--Zapolyarnyy and he became a brigade leader there and the originator of the first high-speed mine sinking in the Extreme North. Then came the construction of the Talnakh pioneers and the Mayak and Komsomolskiy mines. He lacked neither fame nor money. At the Oktyabrskiy mine, according to the forecasts of the geologists, the working conditions promised to be difficult.

Only 20 people arrived with Astashin at the new mine and they had to supplement the brigade with beginners--yesterday's soldiers. The conditions of the 700th meter return air level turned out to be considerably poorer than expected. Each meter of mine-sinking was a struggle and an unsteady roof kept dumping tens and hundreds of rock cubes into the finished workings. Work was not up to speed here. The deadline for turning the mine over for operation was

steadily approaching. It was already clear to everyone that the Oktyabrskiy would not yield ore by the projected date; that is, everyone except Astashin.

They made a portable metallic casing with a shielding that was pushed forward and, under this protection, they sharply speeded up the sinking work. Then, when the unsteady rocks were left behind, Astashin moved his team to a record. In honor of the opening of the 25th party Congress, they sank in one month a single mine face of 371 running meters--such speeds had not yet been known in Norilsk. For many years of selfless labor, the esteemed miner Ye. P. Astashin was awarded the Orders of Lenin and the October Revolution and he was given the lofty titles of Hero of Socialist Labor and winner of the USSR State Prize.

Giant of the Polar Region

The Norilsk Combine is just about all there is in Norilsk: the largest mines and metallurgical plants in the industry, power and transportation enterprises, its own railroad and Dudinka port--the largest in Siberia, its own science and machine building, a complex of building industry enterprises permitting the construction of mines, plants plus 200,000 square meters of housing a year, as well as shops, schools, kindergartens, clinics, sport structures, and other social, cultural and everyday services. Yet it is its own city--the management of housing and public utilities also belongs to the combine. It regulates trade. It has food industry enterprise--bread, the entire gamut of dairy products plus ice cream (one and a half tons a day), sausage, non-alcoholic beverages. It manages the supply system without which there would be no combine and no city because there are thousands and thousands of kilometers to the closest centers of civilization. It has Pioneer camps near Minusinsk, three sanatoria (near Norilsk, in Sochi, in the Moscow area), two state farms--in Norilsk and near Krasnoyarsk, and many other things.

Is this a natural economy? No. It is a gigantic complex whose fixed production capital is estimated today at eight billion and more rubles. The combine is the most efficient form for organizing life in the North. The unique versatility of the huge enterprise has been dictated primarily, of course, by its geographical remoteness from inhabited places. The Norilsk citizens say about Moscow, Krasnoyarsk, and other cities: "there, on the mainland." This is even though the Taymyr is a peninsula and Norilsk is located on its southern border. However, it is nevertheless far away. It is more than three hours by plane (if you do not sit around for a week because of bad flying weather), or five and a half days by river diesel engine ship (from June to September), or more than a week via the Northern Sea Route. They dream about the time when a railroad will stretch to Norilsk. Maybe then they will stop considering themselves "islanders."

New Tasks

The combine has rapidly grown and developed during the entire 50 years of its existence. Capital investments for construction amount to many billions of rubles.

Now it is at a new stage. It is already underway in the present five-year plan. We asked Hero of Socialist Labor and USSR Supreme Soviet deputy Boris Ivanovich Kolesnikov, who since his youth has tied his fate to Norilsk and has gone through all the stages here in managing a collective and production and since 1974 has headed the combine, to speak about it.

"The tasks facing the combine's collective are common to the whole country," Boris Ivanovich said. "Accelerated movement to the path of intensive development is required. What does this mean for the people of Norilsk? It means, first of all, a sharp increase in production effectiveness, a growth in labor productivity, and a decrease in operating expenses. Yes, Norilsk will yield the nation a considerable profit. However, it can and must be greater and state expenditures for the construction of mines and plants must be paid for more quickly"

"In the 12th and subsequent five-year plans, the combine will not be able to significantly increase the production of non-ferrous metals--the explored ore reserves are sufficiently great but not infinite. Moreover, their extraction is becoming more complicated and expensive every year. Under these conditions the question arises of maintaining the level achieved for metal output and even a certain growth with smaller expenditures."

"The intensification of the combine's diversified economy--this is also the significant increase in the quality level of their own machine building, i.e., an improvement in the operating properties of articles and spare parts manufactured at the enterprises of the combine's machine service. It is also an increase in the between-repairs time period for basic equipment operation."

"The work ahead is enormous and in various directions. For example, only 40 percent of scrap metal--the unavoidable companion of any repair and any reconstruction--is being reprocessed today in Norilsk. The remaining "previously-used" metal is being exported to the 'mainland.' An enormous amount of rolled metal is being delivered here along the Yenisey and the Northern Sea Route. Is this inefficient? Of course it is. We are planning to build a special plant which will reprocess all of the available scrap metal to obtain rolled metal and shaped metal sheets..."

Creators of Their Own Fate

Here are two other biographies. Dzhonson Khagazheyev came to Norilsk 25 years ago. The young specialist hoped, thanks to northern wages, to deck himself out, save some money, and then return to his native Northern Caucasus. He even dreamed from his first pay of buying a lot of curds and feasting to his heart's content. He bought the curds. The pay was not especially resented. Soon afterwards he completely forgot about his departure. At 28 he became chief of the agglomeration shop which was at that time the most complicated and unstable division at the combine. Then he "dragged" the smelting shop of the copper plant from a collapse; then the entire copper plant. He was thrust into the Nadezhdinskiy Metallurgical Plant and there moved from breakdown to breakdown... In summation, Dzhonson Talovich Khagazheyev is director of the Nadezhdinskiy Plant today. He carried out a gigantic modernization there and achieved high production efficiency. The plant is now a stably operating enterprise and has fulfilled the yearly socialist pledges in honor of the 50th birthday of the combine.

But the director is not stopping--he is transferring all industrial brigades to a multiple contract with mutual material responsibility. It has already had an effect here--the figures for material and power resource savings have grown sharply and metal extraction has increased. The pay of the metallurgists has also grown.

Three days ago D. T. Khagazheyev and five other Norilsk people were awarded the lofty title of Hero of Socialist Labor.

Here is another example of what a person can achieve in Norilsk. Vladimir Borbat also arrived here with a brand-new institute diploma. He was from Sverdlovsk. Nine years later the 32 year old engineer of the mining and metallurgical experimental research shop defended his doctoral dissertation. Then he headed a department at the Norilsk Industrial Institute. V. F. Borbat has dozens of patents and more than 150 scientific works to his credit.

A Very Beautiful City

The housing areas of Greater Norilsk cover a total of 990 hectares and almost four million square meters are located in this space. Is this crowded? How shall we put it... In 40-degree intense cold with a 20-meter wind there are no strolls and the school, kindergarten, store, and bus stop must be quite near. Thus they design and build so that everything necessary is within a 300-meter radius. On the lovely summer days the people flock to the tundra, to tourist centers (each enterprise has its own), or to the city beach at Dolgoye Lake. The swimming season here at times lasts for two months, and sometimes it does not open at all (the exception is the "walrus", a chapter of which exists in Norilsk).

But there are many "normal" sports activities in Norilsk. According to reports, the Zapolyarnik sports club, physical culture and sports each keeps a third of the Norilsk citizenry busy.

We will not color the truth: the supply of sports structures in Greater Norilsk is far from ideal and construction possibilities are limited for the present. But, on the other hand, excellent sports halls have started to appear in enterprise ABK's [administrative and public building wings] in recent years. At present the best ABK is at the copper-smelting plant: it has a sports hall, pool, sauna, radiation therapy rooms as well as an excellent assembly hall, library, chess club, technical training rooms, dispensary, savings bank, order department, and a complete reception center for everyday services. The Nadezhdinskiy Plant people are following in the footsteps of the copper smelters and ABK's are also gradually being turned into cultural and sports palaces here.

There are also entertainment centers in the cities of Norilsk, Talnakh, and Kayerkan: culture palaces and clubs, the Zapolyarnyy theater which raised its curtains for the first time on 6 November 1941 and will probably celebrate a new home this year (center of the city, an individual design). There are also movie theaters, a cafe, and restaurants.

This city is beautiful and is becoming more comfortable for its inhabitants each year. But...

The North Remains the North

On a February evening in 1979 a television transmission from Moscow was suddenly interrupted and the serious, slightly gaunt-looking face of the combine director B. I. Kolesnikov appeared on the Norilsk television set screens. His report was short: a misfortune had befallen the city--a breakdown had occurred on the Messoyakha-Norilsk gas pipeline. Measures were being taken but there was a request for the people of Norilsk--keep calm and composed and also decrease, as far as possible, hot water usage; otherwise it would be difficult to maintain the temperature in the heat radiators.

That winter of 1978-1979 was uncommonly severe even for the Taymyr. The old residents did not remember such a year where the mercury firmly "froze" below the 50-degree mark for almost two months. The strong wind did not let up for even a day. Nevertheless, the city worked at its normal work pace. The heat and electric power plants, which received an uninterrupted supply of natural gas from the left bank of the Yenisey and from the Messoyakha and Soleninskiy gas fields, were operating at full capacity. And suddenly--an accident, a hydrodynamic shock, which tore both lines of the gas pipeline.

Measures had to be taken immediately. What kind of measures? Switching the TETs's/heat and electric power plants/ from gas fuel to coal was one. The urgent restoration of the damaged gas mainlines was the second. Operating on coal, the Norilsk TETs's could not provide the city with the necessary amount of heat--that was why the citizens of Norilsk were requested to limit hot water expenditure. (It later came to light that immediately after the combine director's television appearance, expenditure increased for half an hour--they finished washing, finished the laundry, etc.--and then it fell sharply and did not rise again until the breakdown was repaired).

All personnel plus workers from the central repair services were called to the heat and electric power plants. Work on switching the boilers to coal proceeded at a speeded-up pace. But coal itself turned out to be inadequate: since 1971, after the transfer of all Norilsk enterprises to gas, all of the mines were closed and coal was extracted only at the Kayerkan pit in small amounts for industrial needs. On the very first day after the accident, the extraction volumes doubled here--the miners labored like Stakhanovites.

Volunteers came to the city party committee and to the association Norilsk-gazprom/Norilsk Gas Industry Association/. They were dressed in fur and had knapsacks in which they placed tools alongside a week's supply of food. Welders, oxy-gasoline cutting torch operators, suspension line riggers and installers came. They demanded to be sent to the line. Explanations that the breakdown was being repaired at full speed and that help was not required there in the tundra did not have an effect: "then send us where we are needed!" This was at the TETs to unload dump cars of coal which had arrived at the TETs. The return of tickets to Aeroflot reservation offices increased sharply in those days: vacationers did not want to abandon their city in its misfortune.

The main battle for Norilsk was on the gas pipeline route. According to the calculations of specialists, it required no less than a month to repair such damage under normal conditions. But it had to be done in ten days. In idiotic 53-degree intense cold the emergency brigades did the impossible: they hammered in piles, dragged pipe, and they welded, welded... They went into the warm vans only when ordered and they slept only 2-3 hours at a time. When they woke up, they asked: "How are things there in the city?"

The city lived. The temperature in the buildings did not get above 10-12 degrees (it fell lower if the windows were not properly caulked), but the dining halls and stores were in operation and there were rehearsals for the next performance at the theater. All of the combine's enterprises were operating. There was no confusion and no panic. The northerners endured the ordeal at the hands of the North.

In seven days (seven days, in toto!) the city once again received full heat.

So it is in the inhabited and settled Extreme North. The incident, it is true, is exceptional but it proves once more that here, in the polar regions, a person must be internally prepared for any surprises.

Not by Work Alone

This city is famous not only for metal and not only for miners and metallurgists. Vladimir Pyavko lived in Norilsk, graduated from school, participated in amateur theatricals, and worked as a driver. After the army, he entered the theatrical institute. He was taken on as a trainee by the Bolshoy Theater and studied at La Scala in Milan. The soloist of the state academic Bolshoy Theater of the USSR, honored artist of the republic (now a USSR people's artist), winner of international competitions, a world-known dramatic tenor, then came to his native city. He reported back to his fellow countrymen--he sang at the combine's palace of culture, the machine plant, a construction site, and on television. We listened with pride to the artist--our own!

Here is another example. The worker Ivan Varlamovich Rekhlov collected post-cards and picture reproductions in his free time. The subject matter was the life and activities of V. I. Lenin. The collection grew over time and copies of well-known canvases and then also originals began to appear in it. The subject matter was also broadened. They knew about the passion of this Norilsk worker in many cities of the country and abroad. The most important publishing houses and museums of Europe, Asia and America later considered it an honor to be in correspondence with the world famous collector. His unique collection of paintings and drawings became the foundation of the Shushenskaya picture gallery. The books of V. I. Lenin published in one hundred languages and the richest artistic Leniniana occupy a special place in the Rekhlov exhibitions.

What is Next?

In conclusion, we have a question for the first secretary of the Norilsk city party committee Igor Sergeevich Aristov, a Norilsk person with 25 years of service: "What do you see in the future for Norilsk?"

"That is, what do I see for the future of the Norilsk Combine? These two notions, in my view, are inseparable. I believe that the combine must grow and expand. We recall what was said in the report by comrade M. S. Gorbachev at a conference in the CPSU Central Committee on the questions of speeding up scientific and technical progress: 'The basic reserves in achieving the highest effectiveness lie at the junctions of industries... All of this places on the agenda the question of creating organs to direct the large-scale national economic complexes.'"

"Look at what the combine is today: it is not only the director of the Norilsk industrial region. It has supply centers in Krasnoyarsk, Murmansk, Arkhangelsk, and Kaliningrad; construction in Minusinsk, Sochi, and in the Moscow area. I am talking about the combine's own sub-units. The Norilsk people are now connected by joint labor with the entire country and many foreign firms. But does this joint labor always 'operate' with the required effectiveness? Alas, this is not always so. It is possible that some enterprises and NII's/scientific research institutes/, in order to more easily solve long-range problems, could be included today in the combine.

"Possibilities for the further development of our region are enormous. Today the combine manufactures as finished products or semimanufactures 14 elements of Mendeleev's table. Is this the limit? Of course, not."

"A greater independence than it now has is required for the more successful operation of the Norilsk Combine. The VPO/all-union production association/ Nikel/Nickel/, to which the combine belongs, is practically a brake against accomplishing many long-range and interesting things. I believe that it is high time for the USSR Ministry of Non-Ferrous Metallurgy to switch to a two-link stage of management, especially since the more or less serious questions concerning the combine are being resolved not in the association."

"I would like to reproach economic science. We love to repeat the phrase: 'Norilsk--the finished model for mastering the Extreme North.' A model--yes, but is it finished? At the beginning of the next century the Extreme North of our country will begin to be developed at an heretofore unprecedented pace. Clear and precise recommendations on how to better, more economically, and more reliably work at this are needed today. It would seem that here we have a fine opportunity in a relatively isolated region where there is everything necessary--a material and technical base and experienced personnel--to master under experimental conditions the best methods for the total assimilation of large territories and for their management. However, this subject does not attract the scholars for some reason. And time goes by..."

In the clear night weather the alpha of Ursa Minor gives light to Norilsk. People usually call it the polar star. It has been a guiding beacon at all times for the pioneers, the first ones to pass through here, the discoverers. It has already been giving light to the people of Norilsk for half a century. Let it shine!

Biographical Facts

Birth: On 23 June 1935, a decree of the USSR Sovnarkom/Council of People's Commissars/ on the construction of the Norilsk Combine was adopted. On 1 July, the first builders arrived at Dudinka on the steamship "Spartak."

First steps: The experimental metallurgical plant began operation on 18 June 1938. The first matte was obtained at the Malyy Metallurgical Plant on 10 March 1939. On 16 June, Norilsk received the status of worker's settlement. (It became a city on 15 July 1953).

Participation in the Great Patriotic War: The first electrolytic nickel was obtained on 29 April 1942. In 1944 alone, Norilsk gave the country more pure nickel than was received from the United States under Lend Lease during all of the war years. Combat airplanes, removed from the front, carried the metal to defense plants.

Second birth: Talnakh ore was discovered on 24 August 1960. Prospects for the combine's development were repeatedly broadened. The construction of the Talnakh mines and settlement began in April 1962. The first train of rich copper and nickel ore arrived in Norilsk on 29 March 1966.

Significance for the country: The decisions of three party congresses contained separate paragraphs on the tasks of the Norilsk people in mastering the underground storehouses of the Taymyr.

Development of the city: the first secondary school was opened on 1 September 1938. In August 1943, an FZO/factory training/ school for 900 students was opened. On 5 October 1944, the mining and metallurgical tekhnikum accepted its first students and a hospital, movie theater, sports hall, stadium, and ski center were constructed. The construction of the first five-story building was completed in December 1946. The first paneled building was constructed in 1961.

A million square meters of housing, 25 kindergartens, 10 schools, 8 clinics, and a number of trade and public catering enterprises and cultural and sports establishments are now being built in Greater Norilsk during the five-year plan.

Awards: The Norilsk Combine was awarded the Order of Lenin (1965), the Order of Labor Red Banner (1976), and the Order of the October Revolution (1985). The city of Norilsk was awarded the Order of Labor Red Banner (1971), the Norilsk Combined Geological Survey Expedition--the Order of Labor Red Banner (1966), and the Norilsk city Komsomol organization--the Order of Labor Red Banner (1966).

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CSO: 1842/215

UDC 622.7.017.2:622.368.2

ENRICHMENT OF MAGNESITES FROM KRASNOYARSK REGION

Moscow OGNEUPORY in Russian No 8, Aug 85 pp 22-26

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[Abstract] Four specimens of magnesite rock from the Verkhoturovskoye deposit for chemical content and grain size distribution, these specimens ranging from "pure" to ones with talcum or dolomite inclusions. The purpose was to determine the feasibility of magnesite enrichment by the gravitation-flotation method, as had been recommended earlier for magnesite rock from the Talskoye deposit on the basis of four 1.0-1.5 ton specimens and one 610 t specimen. This mechanical method alone was found to be inadequate for lowering the iron and silicon content in Kirgiteyskoye magnesite, nor for lowering the iron content in Latvian magnesite, but rather requiring the aid of chemical processing. In a pilot semiindustrial operation magnesite of the 300-0 mm fraction was comminuted into a 25-0 mm fraction and heated in a rotating electric furnace, first to 650-700°C for decarbonization and then to 900-950°C for chlorination. This process yielded a grade-1 periclase concentrate of better quality than Talskoye periclase and much better quality than the grade-3 raw magnesite. References 4: all Russian. [247-2415]

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