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and also (curve 4) for a specimen which, after being heated to 540°C, was cooled to room temperature. The relationship between the impact strength and the duration of the tempering at 540°C of specimens quenched from 900°C, 1000°C, and 1150°C, is graphed in Fig 6. The curves on Fig 7 show the temperature dependence of S of (1) an untreated specimen, and (2) a specimen quenched from 1000°C tempered for 2 hours and cooled in water. Fig 8 shows the dependence of the height of the peak on the duration of the tempering treatment carried out at 300°C, 350°C, 400°C and 450°C. Finally, the dependence of ln Δ/Δ_0 (where Δ_0 is the height of the peak of untreated specimen, and the height of the peak after tempering) on the duration of the tempering treatment at 300, 350, 400 and 450°C, is graphed in Fig 9. It can be seen that all the curves of the logarithmic decrement plotted against temperature for specimens quenched from various temperatures (Fig 5), exhibit a peak at approximately 350°C. Since the mechanism causing the 350°C peak was completed at temperatures lower than 540°C, it is concluded that this peak is

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not associated with the process leading to temper embrittlement. Analysis of the experimental results indicates that the height of the peak was related to the time and temperature of the tempering treatment. An expression (Eq 5) was derived for the maximum rate of coalescence of the precipitated carbides: $v_{max} = 100\varphi(T)$, %/sec. The graph of the function $\varphi(T)$ shown on Fig 10 is characterised by two values of temperature T: $T = T_0$ at which $v_{max} = 0$, and $T = \Theta$ at which v_{max} approaches infinity. On the basis of the results of the present investigation the following hypothesis was postulated: In the initial stages of tempering the martensite formed during quenching is partially decomposed, thus relieving the internal stresses and increasing slightly the impact strength. At higher temperature, the decomposition of martensite is intensified and the precipitated carbides are enriched in the atoms of the alloying elements. This results in a weakening of the bond between the adjacent carbide particles, and leads to the pronounced drop in the impact

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strength which is typical of the first type of temper brittleness. The most complete decomposition of martensite and consequent segregation of carbides takes place at temperatures higher than T_o. During this stage, a strengthening of the bond between the discrete metal phase occurs which results in an increase of the impact strength. At temperatures above θ, the strength of the bond between the discrete particles within the grains continues to increase, which creates conditions favourable for further coalescence of the alloying elements and their migration to the grain boundaries. The latter process may be responsible for the second type of temper brittleness encountered in the 450 to 550°C range. At still higher temperatures, the widening range of the solid solubility of the alloying elements in α iron permits dissolution of these segregated impurities into the grain boundary regions: material quenched from such temperatures is ductile because the impurities are held in the solid

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solution. Brittleness induced by slow cooling is caused by gradual precipitation of impurities at the grain boundaries. These considerations led the authors to the conclusion that the "solution-precipitation" theory is probably the most correct of any yet expounded on the reversible temper brittleness.
There are 11 figures and 19 references, of which 9 are Soviet, 8 English and 2 German.

ASSOCIATION: Institut Mashinovedenniya AN SSSR (Institute of Machine Construction of the AS USSR)

SUBMITTED: October 14, 1957

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SOV/24-58-7-27/36

AUTHOR: Lozinskiy, M.G. (Moscow)

TITLE: Some Relations in the "Elastic" Movement of Alpha-cobalt Microvolumes During Heating and Stretching (Nekotoryye zakonomernosti "uprugogo" peremeshcheniya mikroob"yemov al'fa-kobal'ta pri nagreve i rastyazhenii)

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, 1958, Nr 7, pp 134 - 135 + 2 plates (USSR)

ABSTRACT: The author refers to his investigations of the deformation of polycrystalline metals and alloys by high-temperature metallographic methods (Refs 1-3). These showed that elastic deformation of individual micro-volumes inside and on the surface of grains is reversible only when the stresses set up do not lead to a definite energy barrier being surpassed. Inter-atomic forces in the crystal lattice cause the displaced volumes to return. This is illustrated schematically in Figure 1 and by a series of photo-micrographs (Figure 2) of the same portion of a polished surface of grade K-000 cobalt in the course of an experiment on a type IMASh-5M installation (which has been described in Ref 4). This series shows the appearance and disappearance of different types of surface relief as the

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specimen was kept at 400 °C in a vacuum of 10^{-5} mm Hg and subjected to tensile stresses. The crystallographic orientation of a given zone and its position relative to adjacent zones can affect the tensile-stress value at which relief is formed (Figure 3 shows the zone of a pure-cobalt specimen where fracture took place after 15 minutes at a higher stress value than those corresponding to Figure 2). A chemically etched alpha-cobalt surface is shown in Figure 4. The author concludes that his results prove beyond doubt the existence of the "elastic" movement and refers to B.M. Rovinskiy's work (Refs 5-7) with iron and tungsten. He proposes to extend his own work to other pure metals and alloys. There are 4 figures and 7 Soviet references.

SUBMITTED: March 29, 1958

SOV/129-58-11-3/13

AUTHORS: Sokolkov, Ye. N., Candidate of Technical Sciences, Lozinskiy, M. G., Doctor of Technical Sciences and Antipova, Ye. I., Engineer

TITLE: Structure of Grain Boundaries and Heat Resistance of Austenitic Steel (Struktura granits zeren i zharoprochnost' austenitnoy stali)

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1958, Nr 11, pp 19-25 + 4 plates (USSR)

ABSTRACT: Hardening of the boundaries of austenitic grains, detected during impact bending tests and also as a result of static tensile stresses at liquid nitrogen temperature (Ref 6), leads to the assumption that the hardening is accompanied by an increase in the resistance to plastic deformation at elevated temperatures. Therefore, it was considered advisable to investigate the influence of the structure of the grain boundaries in the austenitic steel 60Kh4G8N8V on the creep speed. After hardening from 1100-1150°C, this steel has an austenitic structure and possesses a high impact strength, 30-40 kgm/cm². Ageing in the range of 600-800°C results in separating out of a carbide phase which brings about a drop in the impact

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strength to 3-5 kgm/cm^2. The development of brittleness is accompanied by inter-crystallite type disruptions. It was established that rolling of steel at 900 to 1000°C under conditions excluding recrystallisation of austenite leads to a reduction in the brittleness. The authors considered it of interest to compare the established influence of plastic deformation on the impact strength with the creep speed at elevated temperatures. The experiments were effected by means of the test device IMASh-5M which permits studying the micro-structure during heating and tensile tests in vacuum (Refs.7-9). The material was prepared for the investigations as follows: the blanks were heated to 1200°C and allowed to cool to the rolling temperature (1000-1100°C). Rolling with a reduction of 25% was effected on a laboratory rolling stand. For preventing recrystallisation of the work hardened austenite, the metal was cooled immediately afterwards in water, whereby the time interval between the end of the rolling and the cooling process amounted to no more than 0.2-0.3 sec. A part of the blanks which were not subjected to deformation were also hardened from 1000-1100°C. Following that, the blanks were

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aged for a duration of four hours at 750°C and then specimens were cut out to a shape as shown in Fig.1. The flat surface of the specimen was ground and chemically etched for the purpose of revealing the structure. The etched structure was conserved during subsequent heating to 900-1000°C in vacuum and this enabled observations of the changes in the structure during plastic deformation. For measuring the deformation during the tests a number of indentations were made on the ground surface; these were arranged perpendicular to the axis of the specimen with spacings of 6 mm; during the tests the distance between the individual indentations were measured with an accuracy of ± 1μ. The specimen was heated by passing current directly through it, whereby the temperature was controlled by a thermocouple which was welded onto the specimen. All the changes in the structure observed during the tests were recorded by photographing one and the same spot of the ground surface. The micro-structures of the specimens after three heat treatment regimes are reproduced in Fig.2, whereby the duration of ageing in all cases was 4 hours at 750°C. The test results graphed in

Fig.3, i.e. the changes in the elongation of the steel 60Kh4G8N8V with various initial structures as a function of the test duration at 900°C and an initial load of 5 kg/mm², show that the behaviour of the specimens differs greatly for differing initial structures. It can be seen from Figs.4 and 5 that in ordinary specimens,as well as in specimens preliminarily deformed at 1000°C,cracks will appear and develop along the boundaries of the austenitic grains. The influence of partial recrystallisation at elevated temperatures on the heat resistance is graphed in Fig.3; a special experiment (curve 4) shows to what extent the creep speed can increase when crystallisation develops. On the basis of the obtained results the following conclusions are arrived at: For the investigated alloy an increase in the heat resistance will be brought about by such changes of the structural state of the austenitic grain boundaries which result in an intensive distortion of the preliminary plastic deformation under conditions excluding development of recrystallisation; a decrease in the creep speed is linked with braking of the plastic

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deformation along the boundaries of the austenitic grain; hardening of the alloy is apparently also determined by a change in the fine structure throughout the entire body of the grain.
There are 5 figures and 9 references, 8 of which are Soviet, 1 Czech.

ASSOCIATIONS: Institut fiziki metallov UFAN SSSR (Institute of Metal Physics, Ural Branch of the Ac.Sc., USSR) and Institut mashinovedeniya AN SSSR (Institute of Mechanical Engineering, Ac.Sc., USSR)

1. Steel--Structural analysis 2. Grains (Metallurgy)--Boundary layer 3. Grains (Metallurgy)--Crystal structure 4. Austenite--Metallurgical effects

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LOZINSKIY, M.G.

AUTHOR: Rustem, S.L. 129-4-12/12

TITLE: All-Union Conference on industrial use of high frequency currents held in Leningrad. (Vsesoyuznoye soveshchaniye po promyshlennomu primeneniyu t.v.ch. v g. Leningrade).

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1958, No.4, pp. 61-64 (USSR).

ABSTRACT: The conference held in November, 1957 was convened by the Leningrad Scientific and Technical Society of the Engineering and Power Generation Industry (Leningradskoye Nauchno-Tekhnicheskoye Obshchestvo Mashinostroitel'noy i Energeticheskoy Promyshlennosti). The task of the conference was to report on advanced experience, to discuss achievements in this field outside the Soviet Union and to evolve recommendations for expanding the use of high frequency in industry and introduction of progressive technology and also evolving organisational measures for improving the quality of high frequency equipment and apparatus. The conference included sections for induction heating technology, metals technology, non-conducting materials and equipment.
Candidate of Technical Sciences, M.A. Spitsyn (NII TVCh imeni V. P. Vologdin) read the paper "New developments in the field of industrial application of high frequency

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currents". In this paper he outlined the most important trends in the use of high frequency heating between 1955 and 1957 dealing with surface hardening of components with complicated configurations; high speed gas carburisation using induction heating; heating right through of blanks for forging, stamping and rolling; development of apparatus for controlling heat treatment processes and automation and mechanisation in large batch and mass production. During the last three years the following technological processes have been developed which are based on induction heating:

1. Two-frequency "hardening" of the surface of toothed gears with average moduli. First, heating is effected with a frequency of 1000-2500 c.p.s. during which the heat is generated mainly at the bottom of the tooth gap and, following that, radio frequency is fed to the inductor for a duration of 0.5 to 0.8 sec for heating the tips of the teeth. Subsequent quenching permits obtaining a hardened layer which reproduces the shape of the teeth.

2. Gas case hardening of toothed gears using induction heating ensures a sharp increase of the speed of the

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chemical-heat treatment and is used successfully in the automobile industry.
3. Hardening of the drilling bits for use in the oil industry.
4. "Bright" annealing of steel strip.
5. Two-frequency heating of steel blanks for heating by applying pressure, particularly for rolling.
6. Heating and hardening of leaf springs on automatic machines.
7. High speed tempering of hardened components using high frequency heating etc. For automating technological processes, the following are at present manufactured: An automatic machine for heating and hardening of leaf springs; manipulator for horizontal forging machines; automatic machines for hardening of small components. Of the new apparatus used in induction heating, the author mentioned a stabiliser of the temperature of components being heated, a photo-electric pyrometer with a direct reading off of the temperature, relay for dosing the energy, etc. Of particular interest were the data he gave on the two-frequency heating of gears. The entire process

takes only a few seconds and can be used in mass production for heat treatment of gears with average moduli. Heating of blanks which are to be shaped by applying pressure is also effected by two-frequency induction heating using 50 c.p.s. current for heating to 700-750°C followed by heating with high frequencies to 1100-1150°C. The two-frequency induction heating reduces the consumption of electricity in the case of heating right through of blanks. For tempering and annealing of weld joints, induction heating with 50 c.p.s. and with higher frequencies is used. The paper of M. G. Lozinskiy, Doctor of Technical Sciences, Institute of Engineering Technology, Ac.Sc. USSR (Institut Mashinovedeniya AN SSSR) dealt with the problems of strength of surface hardened components and the features of high frequency heating. The deformation detected by the author in engineering magnetic steels "45" and "40X" forms in the surface layer as a result of magnetostriction caused by the a.c. electromagnetic field of the inductor. On a smooth surface of blanks consisting of magnetic steels which were subjected to repeated cycles of heating and cooling, "mounds" and

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"valleys" form at spacings equalling the half-wave of the supersonic oscillations generated by the high frequency. In non-magnetic steels no such phenomenon was observed. It was also observed that with increasing number of cycles, heating-cooling, the diameter of the cylindrical specimens in the heating zone increases, whilst the height of the specimens decreases. Furthermore, the author reported on the method of G. V. Uzhik which enables increasing the static strength up to 300%; this is achieved by using h.f. heating of a thin layer in the zone of stress concentrations at the surface of steel components. Thus, for instance, cylindrical specimens made of hardened 40X steels with a stress concentrator in the form of a notch will be 2.5 times stronger if the notch zone is tempered by using h.f. heating. M. G. Lozinskiy considers that use of the method of strengthening applying h.f. tempering of the stress concentration zones will permit evolving specifications which would justify more rational designs than those used hitherto.

K. Z. Shepelyakovskiy (ZIL) read the paper "On reducing the hardenability as a means of achieving contour (surface)

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hardening of toothed gears of average moduli". For this purpose a steel with low hardenability, ЭИ 937, was used. Gears made of this steel, of 180 mm dia. with a modulus of 4.2, were heated by means of an 8000 c.p.s. current of 100 kW capacity for a duration of 24 secs. The heating was effected in a ring-shaped inductor after which the gears were moved into a ring-shaped shower with a fixed direction of the holes. The teeth and the rims of the gears were subjected to hardening. The strength of the hardened teeth was investigated by loading until failure. In the case of gears made of the steel 30ХГТ (after carburisation and hardening) this load was 15.6 tons, for the steel ЭИ 937 the load was 16 tons. In the case of hardening of gears made of the steel ЭИ 937, a minimum deformation occurs, the fluctuations along the pitch circle after hardening amounted to 0.01-0.02 mm. In some cases the contact strength should be increased by increasing the carbon content to 0.6-0.7%.

I. L. Glukhanov, V. N. Bogdanov, Ye. D. Makarova, H.F. Scientific Research Institute imeni V.P. Vologdin (NII TVCh imeni V. P. Vologdina) presented a paper on

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surface hardening of gears by induction heating with two frequencies. The method ensures heating along the contour of gears with moduli of 3.5 to 5. During heating with a lower frequency (1000 to 2000 c.p.s.), the bottom of the tooth gap is heated intensively, whilst at radio frequency (300 000 c.p.s.) the tip of the tooth is heated. The same inductor is used for both frequencies. The heating with the lower frequency lasts 2.5 to 4 secs; thereby, the specific power consumption is 1.5 to 1.7 kW/cm^2. Heating with the higher frequency is effected for 0.5 to 0.7 sec using a specific power of 1.1 to 1.2 kW/cm^2. The 1000 c.p.s. current is generated by a 500 kW rotary generator, whilst the 300 kc/sec current is generated with an oscillator circuit of 400 kW rating. During hardening of gears made of steel "45" cracks occur and, therefore, the carbon content was reduced and alloy steels 36Г2С, 35СГ etc. are being used. For fracturing a tool of a surface hardened gear a force of 9.5 to 17 tons is required, whilst the force required for fracturing case hardened gears after hardening, made of the steel 18ХГТ, did not exceed 10 tons per tooth. Gears produced by using

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two-frequency hardening wore down three times faster than gears produced according to the old technology. Therefore, in the further tests the steels 65Г, 50ХГ, 40ХН and 40ХНМА were used.
The paper of N. M. Rodigin, Ural Branch of the Ac.Sc. USSR (Ural'skiy Filial AN SSSR) was devoted to the new method of induction heating of steel strip. The novel feature consists in the fact that the electro-magnetic field produced by an alternating current is directed perpendicular to its surface and not in the longitudinal direction of the strip. This enables using economical sources of current of elevated frequency, namely, rotary generators. The required temperature distribution along the width of the strip is ensured by an appropriate configuration of the magnetic path and by an air gap between the poles. This method can be used for annealing cold rolled strip, for heating and for preheating of strip during rolling, pickling, deposition of coatings, etc.
V. N. Bogdanov and V. A. Peysakhovich reported on the practical application of the above method for annealing thin strip in the Leningrad Steel Rolling Mill (Leningradskiy

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Staleprokatniy Zavod). The optimum frequency depends on the thickness and the width of the strip. For a thickness of 0.2 to 0.6 mm and a width of 100 mm it is recommended to use a current of 8000 c.p.s.; for strip of 200 mm a current of 2500 c.p.s. and for a width of 400 mm a current of 1000 c.p.s. On heating strip to 700-900°C, the uniformity of the temperature along the breadth of the strip is ± 25°C. For heating, a two-turn inductor was used, whereby the conductors of the current and of the magnetic flux were water cooled. This method was applied in the case of bright annealing of cold rolled strip. For a speed of movement of the strip of 25 m/min the required power was 200 kW (for a frequency of 2500 c.p.s.). The productivity of the equipment equalled 1 ton/hr. The specific power consumption during induction heating is 180-190 kWh/ton. Compared with annealing in chamber furnaces, this method has a number of advantages since thereby the productivity per m^2 of production space is increased two to threefold, the annealing time is reduced by several hundred times, uniform mechanical properties are ensured along the entire length of the

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strip coil and welding together of the strip during annealing is prevented. The specific consumption of electricity is higher for induction heating than for electrical furnaces.

V. N. Gridnev, Doctor of Technical Sciences, Kiyev Polytechnical Institute (Kiyevskiy Politekhnicheskiy Institut) dealt with the influence of the speed of heating on the structure and the properties of steel. Apparatus was built for the investigations which enabled simultaneous recording of several physical parameters so that the following could be oscillographically recorded: temperature, change in the length of the specimen and in its electric resistance and also current intensity in the inductor. The recording was effected with a speed of 50 to 10 000°C/sec and the dilatometric curves were recorded with a speed of 60 000°C/sec. The following binary alloys were investigated - Fe-Cr (up to 8%); Fe-Si (up to 3%); Fe-Ti; Fe-W; the C content was about 0.02%. Steels containing 0.1; 0.45; 0.54; 0.77 and 1.12% C were also investigated. The author has established that during heating of annealed carbon-free alloys, the

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transformation temperature does not depend on the speed of heating and the magnitude of the volume effects depends on the composition of the alloy and the preceding heat treatment. When heating annealed iron-carbon alloys, the transformation temperature is determined by the speed of heating and by the initial structure. On heating hardened low alloy carbon-free alloys, the transformation temperature compared to that in the alloys in the annealed state does not change at all in some cases (Fe-Si; Fe-Ti), whilst in other cases it decreases by 30 to 40°C (Fe-Cr and Fe-W). On heating hardened steels, the dilatometric recordings show clearly the volume changes caused by the martensite decomposition and by the phase transformation; the decomposition cannot be suppressed not even at heating speeds of 60 000°C/sec. At high heating speeds of hardened steels, the phase transformation takes place in the range of 700°C, i.e. at lower temperatures than the transformation during slow heating. Investigations of the influence of the heating speed on the structure and properties of hardened, carbon and alloy steels in the case of electric tempering showed that at elevated

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heating speeds a favourable combination can be obtained of the strength and ductility and also an increased resistance to wear which is of practical interest. In their paper I. N. Kidin, Doctor of Technical Sciences, and Yu. A. Bashnin, Moscow Institute of Steel (Moskovskiy Institut Stali) expressed the view that the higher the heating speed the larger will be the temperature range in which phase transformations will take place. Experimental data show that pearlite-austenite transformations proceed in the range of higher temperatures. In the case of high frequency hardening, higher temperatures are required than in the case of heating in an ordinary furnace. This is attributed to the fact that the phase transformations proceed with a higher speed due to the more rapid rise in the temperature and due to the sharp acceleration of the dissociation of carbides and the diffusion of carbon in the ferrite. The authors showed that it is justified to introduce a new thermal parameter, namely, the speed of induction heating in the range of phase transformations. This would enable the plotting of diagrams of preferential and permissible

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hardening regimes which would conserve the character of generally valid relations under conditions which are reproduceable in normal production.
V. P. Pleshachkova (TsNIITMASh) read an interesting paper on the deformation of surface hardened steel. H.F.surface hardening permits reducing the deformation of the steel. The author investigated the influence on the deformation of the following factors: heating temperature, cooling speed, depth of the hardened layer, structure of the starting material and also of the temperature and time of heating in the case of low temperature tempering. The results have shown that in the case of h.f. surface hardening of ring specimens with small height to diameter ratios (1:4; 1:7) produced from various steels, the deformation manifests itself in a decrease of the outside diameter and an increase in the height and in the inner diameter. An increase in the temperature leads to an increase in the deformation along the outside and inside diameters and manifests itself less on the height of the rings. The deformation of rings made of alloy steels

 is greater than for rings made of carbon steels under

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equal conditions of heating and cooling. Cooling in a 30 to 35% solution of glycerine and a 5% solution of potassium permanganate brings about a reduction in the deformation and in the crack formation, particularly in the case of alloy steels (40X, 40XH). Tempering at 140 to 200°C reduces the dimensions as compared to the hardened state and thereby the changes in the dimensions of the height and the internal diameter are compensated but the changes of the external diameter are amplified. Increase of the tempering temperature brings about an increase of the deformation.
Representatives from Roumania and East Germany participated in the Conference. The German delegate, E. Trippmacher, reported on the designs of compact h.f. transformers with built-in magnetic paths produced in East Germany.
NOTE: This is a complete translation and not an abstract.

AVAILABLE: Library of Congress.

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SOV/129-59-1-5/17

AUTHORS: Lozinskiy, M.G., Doctor of Technical Sciences and Simeonova, I.S., Engineer

TITLE: Certain Relations Governing the Deformation of Technical Iron During Cyclic Temperature Fluctuations (Nekotoryye zakonomernosti deformatsii tekhnicheskogo zheleza pri tsiklicheskikh kolebaniyakh temperatury)

PERIODICAL: Metallovedeniye i Termicheskaya Obrabotka Metallov, 1959, Nr 1, pp 15 - 19 + 4 plates (USSR)

ABSTRACT: Investigations by the authors of the relations governing the deformation of commercial iron (0.03% C) under tension and presence of a temperature gradient in the longitudinal direction of the specimen revealed that a "super-high plasticity takes place" which is characterised by the formation of two necks on the specimen and by the occurrence of a rapid sliding deformation. Prior to the experiments, the specimens were annealed for two hours at 1 000 °C in vacuum. During the experiments, the specimens were heated by passing through them a low-voltage AC, so that a temperature gradient was produced in these specimens with a peak temperature at the centre. The temperature distribution in the specimen is graphed in Figure 1 for peak heating temperatures of 800 and

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1000 °C, respectively; in each specimen, a range of temperatures was generated, varying from about 400 °C at the edges and 1 000 °C in the centre. The characteristic of the cyclic change of the specimen temperature is graphed in Figure 2; each cycle was of 60 sec duration and consisted of heating to 800 °C and holding it for 2 sec at that temperature, then heating it to 1 000 °C and again holding it for 2 sec at that temperature, followed by cooling to 800 °C. In Figure 4 (plate), 8 microphotographs are reproduced of the surface of the central zone of the iron during the tensile tests and during isothermal holding at 1 000 °C. In Figure 5, 10 microphotographs are reproduced of the surface of the central zone of the specimen during tensile tests (σ = 0.33 kg/mm^2) and cyclic temperature fluctuations of 800 to 1 000 °C. In Figure 6, microphotographs are reproduced of the surface of the neck zone during cyclic temperature fluctuations. In Figure 8, photographs are reproduced of the specimens prior to the tests and after various test cycles. The deformation of the central

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Certain Relations Governing the Deformation of Technical Iron During Cyclic Temperature Fluctuations

zone of the neck during tensile stresses and cyclic temperature fluctuations between 800 and 1 000 °C in the central zone are graphed in Figure 7. In Figure 9, is graphed the dependence of the change in the distance between the centre of the neck and the edge on the maximum temperature in the centre during cyclic tests. The following conclusions are arrived at: 1) under certain conditions of cyclic heating and cooling, a sharp decrease in the resistance to deformation in tensile loading is observed which leads to the formation of two necks; the two necks are located in zones with the temperatures $720 \rightleftarrows 850$ °C; 2) appearance of failure foci in sections with a temperature lower than in the middle part of the specimen is attributed to the influence of non-uniform distribution of carbon inside the grain and also to the carbon concentration outside the boundaries of the grains and the blocks. In the case of local heating and cooling of individual zones in the specimen up to the temperatures of polymorphous $\alpha \rightleftarrows \gamma$ transformation, the proceeding reconstruction of the

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crystal lattice disturbs the coherent bonds of the atoms and this will result in a sharp drop in the resistance to deformation only in those parts of the grain which are enriched with carbon; 3) if the holding time at the limit temperature values is increased, this detected phenomenon is no longer observed. There are 9 figures and 6 references, 4 of which are Soviet, 1 Czech and 1 German.

ASSOCIATION: Institut mashinovedeniya AN SSSR (Institute of Mechanical Engineering of the Ac.Sc.USSR)

SOV/180-59-1-12/29

AUTHORS: Lozinskiy, M.G., and Fedorovskiy, A.Ye. (Moscow)

TITLE: Influence of Vanadium, Tungsten, Chromium and Molybdenum on the Internal Friction and Rate of Ageing of Technical Iron (Vliyaniye vanadiya, vol'frama, khroma i molibdena na vnutrenneye treniye i skorost' stareniya tekhnicheskogo zheleza)

PERIODICAL: Izvestiya Akademii Nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1959, Nr 1, pp 64-70 (USSR)

ABSTRACT: The authors have previously shown (Ref 1) that alloying elements have an important effect on the value of the internal-friction peak due to the presence of intruded atoms in the alpha-iron lattice. They now describe a new series of experiments to elucidate the nature and mechanism of this effect by measurement of the internal friction of technical iron alloyed with various quantities of vanadium, tungsten, chromium and molybdenum. The alloys were melted in a 50 kg induction furnace and subjected to two-hour annealing. The alloys were hot-forged into 12 mm diameter rods, from which test pieces 8± 0.01 mm in diameter and 200 mm long were prepared for internal friction measurements by grinding. The

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Influence of Vanadium, Tungsten, Chromium and Molybdenum on the Internal Friction and Rate of Ageing of Technical Iron

measurements were carried out on a type IMASh-6 installation with resonance-frequency bending oscillations of a freely-suspended test piece, as previously described by the authors (Refs 1-3). To find the influence of alloying elements on the rate of ageing test pieces were water-quenched after heating at 680°C for 30 minutes, the rate being evaluated from the change in the height of the internal-friction peak with respect to ageing time. All ageing test pieces were subjected to isothermal heating at 115 ± 2.5°C. The results are shown in Figs 4 and 5 as internal friction versus temperature curves for various compositions of Fe-V and Fe-W alloys, respectively, and in Fig 6 for Fe + 4% Mo in the annealed and hardened states. The dependence of the internal-friction peak values on ageing time (minutes) at 115°C is shown in Fig 7. The microstructures of the specimens are shown in Figs 1-3. From discussions of their own and published results the authors conclude that, although a final decision on the mechanism of the effects of vanadium and chromium on the rate of ageing is not yet possible, it appears that in some circumstances hardening fails to fix

SOV/180-59-1-12/29

Influence of Vanadium, Tungsten, Chromium and Molybdenum on the Internal Friction and Rate of Ageing of Technical Iron

the state of solid solution with intruded atoms. Since tungsten additions to technical iron accelerate solid solution decomposition in the second stage and shorten the first stage of ageing they must increase the mobility of intruded atoms in alpha-iron, representing a decrease in their diffusion activation-energy. Chromium has the opposite effect and also smooths out the transition from the second to the third stages. Both elements increase the solubility of nitrogen and carbon in the alpha-iron lattice. On the effect of the elements on internal friction the authors suggest that the influence of vanadium is mainly due to its combination with nitrogen atoms but state that no estimate can yet be given of the vanadium concentration necessary to eliminate the peak. The effect of tungsten is less than that of vanadium and is explained mainly in terms of grain size and the state of precipitation of impurities. It had been shown previously by the authors (Ref 1) that molybdenum in concentrations of about 2% has little effect on the

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Influence of Vanadium, Tungsten, Chromium and Molybdenum on the Internal Friction and Rate of Ageing of Technical Iron

internal friction peak; with the 4 and 12% Mo alloys now used complex effects were obtained which the authors discuss in terms of intruded-atom mobility.

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There are 7 figures, 1 table and 9 references, 6 of which are Soviet and 3 English.

ASSOCIATION: Institut mashinovedeniya AN SSR (Machinery Institute, AS USSR)

SUBMITTED: September 1, 1958

SOV/180-59-3-10/43

AUTHORS: Lozinskiy, M.G. and Mirotvorskiy, V.S. (Moscow)

TITLE: Some Rules for the Change in Micro-Hardness of Technical Iron on Heating over a Wide Range of Temperature and Extension in a Vacuum

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1959, Nr 3, pp 52-61 (USSR)

ABSTRACT: The authors developed the type IMASh-9 testing machine at the Institut mashinovedeniya (Machinery Institute) AN SSSR (AS USSR) in 1958. It is intended for the measurement of alloy micro-hardness in a vacuum at temperatures from room to 1300°C with tensile stresses up to 60 kg/mm^2 and indentor loads of 2 to 50 g. The construction of the machine is shown in Fig 1: the left hand diagram shows the machine ready for selecting the test spot or for measuring the indentation; the right hand ready for indentation. The figure does not include the indentor position-adjusting screws. A general view is given in Fig 4 to 6 and the circuit in Fig 5. One face of the test piece (Fig 2) is polished: its overall length is 70 mm. The indenter (Fig 3) is fitted with a diamond or artificial sapphire tip, 5 mm

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Some Rules for the Change in Micro-Hardness of Technical Iron on Heating over a Wide Range of Temperature and Extension in a Vacuum

long and 3 mm in diameter. The diamond cannot be used with carbide-forming alloys and temperatures over 900°C. The indentation is photographed with a type MFN-2 camera and measured with a type AM9-2 or AM9-3 ocular micrometer. Heating is by direct passage of an electric current and temperature is measured with a thermo-couple welded to the middle part of the test piece and a type EPD-12 electronic potentiometer. Evacuation is effected by a type TsVL-100 oil-vapour pump backed by a PVN-20 rotary pump, the vacuum being measured with a type VIT-1 gauge. 10 to 20 indentations were made per test piece which had before the test been annealed in vacuum at 950°C (for 1 hour) to remove surface work hardening produced by the polishing. As an example the authors gave the curve of micro-hardness against temperature (Fig 7) obtained for technical iron with indentor loads of 50 g applied for 15 sec in a residual pressure of 10^{-5} mm Hg. The curve shows a steady fall from 0 to 200 and about 320 to 870. A maximum occurs at about 300°C and there are smaller peaks

Card ~~2/4~~ 2/3

SOV/180-59-3-10/43

Some Rules for the Change in Micro-Hardness of Technical Iron on Heating over a Wide Range of Temperature and Extension in a Vacuum

at 910 and 1020. Fig 8 shows corresponding photomicrographs of the iron surface. Another series of experiments was carried out to find the influence of tensile stress on micro-hardness of iron at temperatures up to 1000°C. Ten indentations were made at each of the stresses chosen, at a given temperature separate experiments being done at different temperatures. The results (Fig 9) show that micro-hardness has a minimum at definite stress values which decrease as the temperature rises. The rise in micro-hardness at higher stress values is considerable: the authors attribute these increases to work hardening due to plastic deformation. The authors hope to extend their work to the influence of prolonged loading over a wide temperature range on strength values as estimated from micro-hardness. There are 9 figures and 10 references, 7 of which are Soviet, 2 English and 1 German.

ASSOCIATION: Institut mashinovedeniya AN SSSR (Institute of Machine

~~Card 3/4~~
3/3

18.8100
18.7100

67295

SOV/180-59-4-32/48

AUTHORS: Lozinskiy, M.G. and Erlikh, L.B. (Moscow, Odessa)

TITLE: Magneto-Elastic Effect in Induction Heating 18

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1959, Nr 4, pp 200-202 (USSR)

ABSTRACT: Usually, the effect of the stressed state on the magnetic permeability is ignored in induction heating. In reality, for most carbon steels in magnetic fields of medium and high intensity, tension reduces the permeability somewhat whilst compression substantially increases the permeability. This effect would have little significance in practice if a uniform stress existed throughout the heated body (except for a variation in the duration of heating). In fact, the stress distribution is non-uniform. This causes a non-uniform distribution of temperature. An example is the well known striped heating observed before the entire surface reaches the Curie point temperature. The distance between the stripes is known to be inversely proportional to the square root of the frequency. A physical explanation of this effect is given on the basis of the magneto-elastic effect and an approximate analysis yields the same formula

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Magneto-Elastic Effect in Induction Heating SOV/180-59-4-32/48

previously obtained by observation. Basically, the phenomenon is due to the formation of slight corrugations in the compressed heated outer layer. Another result of the magneto-elastic effect is the bright glow emitted by the edges of the cylinder when the end faces and side surfaces are still cold. It is stated that the effect shows promise as a method of experimental investigation of the stressed state in the surface layer of machine components. There are 2 figures and 6 Soviet references.

SUBMITTED: February 6, 1959

Card 2/2

SOV/129-59-5-8/17

AUTHORS: Dr.Tech.Sci. M.G. Lozinskiy, and Engineer Ye.P Sinodova

TITLE: Investigation of the Temperature Dependence of the Hardness of Iron-Molybdenum and Nickel-Molybdenum Alloys (Issledovaniye temperaturnoy zavisimosti tverdosti zhelezomolibdenovykh i nikel'molibdenovykh splavov)

PERIODICAL: Metallovedeniye i Termicheskaya Obrabotka Metallov, 1959, Nr 5, pp 35-40 + 1 plate (USSR)

ABSTRACT: The results are described of investigations carried out in the Institute of Mechanical Engineering, Ac.Sc. USSR, (Institut Mashinovedeniya AN SSSR) relating to the study of iron-molybdenum and nickel-molybdenum alloys by means of short-duration and long-duration hardness measurements. The materials for the specimens were produced in a 50 kg capacity induction furnace. The iron-base alloys contained respectively 4% Mo (alloy 204) and 12% Mo (alloy 212). The nickel-base alloys were alloyed respectively with 7% Mo (alloy 307) and 25% Mo (alloy 325). As can be seen from the diagram (Fig 1) the alloys 204 and 307 remain in the entire temperature range single-phase alloys and do not become transformed. The alloys 212 and 325, which had higher molybdenum contents, are

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two-phase alloys in the state of equilibrium and after quenching from the single-phase range they are prone to dispersion hardening. The alloys 204 and 307 were investigated after vacuum annealing at 900°C for two hours followed by slow cooling in the furnace. The alloy 212 was investigated after quenching from 1200°C in oil; the alloy 325 was investigated after quenching in water from 900°C. By means of hardness measurements, the kinetics of ageing of the alloys 212 and 325 at various temperatures were studied. The influence of ageing on the microstructure of the alloy 212 can be followed from the microphotos reproduced in Fig 2 (plate). The results are described of the short-duration hardness measurements at 20 to 1000°C in vacuum for the alloys of the systems Fe-Mo and Ni-Mo (see graph, Fig 4). The duration of applying the indentor in each case was one minute. Data on the kinetics of ageing of experimental alloys in the temperature range of 300 to 1000 °C are graphed in Figs 5 and 6. The temperature dependence of the "long-duration" hardness, i.e. of the hardness values measured

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Investigation of the Temperature Dependence of the Hardness of Iron-Molybdenum and Nickel-Molybdenum Alloys

with load application times of 30, 300 and 3000 secs, are given and discussed. It is shown that a concentration of the alloying element (molybdenum) which shifts the alloy from the single-phase range to the two-phase range, brings about a hardening in the entire investigated temperature range. In the range up to 700°C dispersion hardening takes place in two-phase alloys, as a result of which there will be a sharp increase in the hardness. Investigation of the long-duration hardness of nickel alloys containing 7 - 25% Mo has shown that for the ageing alloy 325 the hardness at 600 to 700 °C is higher than it is at 500°C and the difference between the values of the hardness measured with indentation durations of 30 and 3000 secs (which characterises the tendency to creep of the material) is approximately the same at 500, 600 and 700 °C. An increase to 800 - 900 °C in the temperature of testing long-duration hardness of the alloy containing 25% Mo revealed that this alloy softens more intensively than an alloy containing 7% Mo. At 1000 °C nickel-base alloys showed the same degree of softening for various

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Investigation of the Temperature Dependence of the Hardness of Iron-Molybdenum and Nickel-Molybdenum Alloys

Mo contents and the character of the curve of the hardness versus duration of applying the indentation load is similar to that obtained in tests at 500 to 600 °C. The elastic properties of the alloys, which are characterised by the values of the modulus of elasticity, are little influenced by an increase in the molybdenum content (within the investigated limits) and with increasing test temperature the modulus of elasticity decreases monotically. The values of the logarithmic damping decrement of oscillations (internal friction) did not change in any of the investigated alloys up to 500°C. However, on increasing the heating temperature further the damping intensified sharply; in single-phase alloys

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Investigation of the Temperature Dependence of the Hardness of Iron-Molybdenum and Nickel-Molybdenum Alloys

this process began at lower temperatures than in two-phase alloys.
There are 8 figures and 5 Soviet references.

ASSOCIATION: Institut Mashinovedeniya AN SSSR (Institute of Mechanical Engineering, Ac. Sc. USSR)

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18.8200

SOV/180-59-6-5/31

AUTHORS: Lozinskiy, M.G., Simeonova, I.S., and Fedorovskiy, A.Ye. (Moscow)

TITLE: On the Behaviour of Pure and Commercial-Grade Iron during Deformation under the Conditions of Cyclic Temperature Fluctuations

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1959, Nr 6, pp 24-36 (USSR)

ABSTRACT: The object of the present investigation, carried out at the Institute of the Science of Machines, Ac.Sc. USSR, was to study the effect of cyclic temperature fluctuations on the kinetics of the deformation of commercial-grade iron (containing 0.03% C) and high purity material (containing 0.002% C) stressed in tension, with the view of determining the effect of small alloying additions on the character of the deformation of specimens under these conditions. The experiments were conducted in vacuum, the tensile test pieces being heated by low voltage, high current resistance heating. The shape of the test pieces of square cross-section area (3 x 3 mm), with one of the sides polished for metallographic examination, is illustrated in Fig 1a, showing the flexible bars (details 2 and 3) supplying the power, terminal screws

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On the Behaviour of Pure and Commercial-Grade Iron during Deformation under the Conditions of Cyclic Temperature Fluctuations

(details 4 and 5), and the swivel-type grips (details 6 and 7). Since a larger quantity of heat was conducted away from the ends of the test pieces, and since their cross-section area was larger than that of the gauge length, a temperature gradient was set up in the test pieces; this temperature gradient, in specimens with the maximum temperature of 800 and 1000 °C, is illustrated in Fig 16, where the temperature (°C, horizontal axis) is plotted against the distance (mm) from the centre of the test piece. The temperature of the centre of the specimen was made to fluctuate between 800 and 1000 °C. The circuit diagram of the automatic temperature controller and automatic recorder of the number of the cyclic temperature changes is shown in Figs 2 and 3; Fig 2 also shows the arrangement of the test piece in the vacuum chamber, and a metallurgical microscope, mounted in the lid of the vacuum chamber, and used to study the structural changes taking place in the test pieces during the experiments. The first significant fact observed was that "necking" of the commercial-grade iron

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specimens occurred not in the centre of the test piece, but at two points situated symmetrically on both sides of the "hot zone" (about 10 mm from the centre), where the temperature fluctuated between 750 and 850 °C. (Two necks were formed when the time at the lower and higher temperatures did not exceed 60 sec; when the test piece was held at the temperature for longer periods, only one neck in the centre of the specimen of the test piece was formed). This, apparently anomalous, effect was attributed to several factors. While the overall carbon content of the investigated material was 0.03%, the local carbon concentration, particularly at the grain and block boundaries, could be considerably higher. Bearing in mind that the temperature of the $\alpha \rightarrow \gamma$ transformation changes from 910 to 721 °C when the carbon content varies from 0 to 0.83%, it will be seen that the C-rich, grain-boundary regions in the central part of the tensile test piece whose temperature fluctuated between 800 and 1000°C remained in the γ-iron range throughout the experiment, while in the interior of the grains (blocks), each

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temperature fluctuation was accompanied by the $\alpha \rightarrow \gamma$ (heating) or $\gamma \rightarrow \alpha$ (cooling) transformation. The situation in the parts of the specimens, where the temperature fluctuated between 750 and 850 °C, was quite different; here, the interior of the grains retained their α-iron structure throughout the experiment, while the grain-boundary regions were undergoing the $\alpha \rightarrow \gamma$ and $\gamma \rightarrow \alpha$ transformations. The strength of the γ-phase is considerably higher than that of the α-phase, and this fact accounts for the high resistance to deformation of the central (hot) part of the test pieces where the grain boundaries retained their γ-phase structure throughout the duration of each test. Regarding the regions of "critical" temperatures, where the necking occurred, it should be remembered that the mechanical properties of iron are adversely affected by the $\gamma \rightleftarrows \alpha$ transformation, which is accompanied by a partial loss of the coherent bond between the atoms and by volumetric changes which set up internal stresses in the microvolumes of the material undergoing the

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transformation; it was for this reason that applied stresses as low as 0.33-0.55 kg/mm2 were sufficient to cause deformation (necking) in those parts of the test piece in which the carbon-rich grain boundaries were continuously undergoing the $\alpha \rightleftarrows \gamma$ transformation. This view was confirmed by the fact that, when specimens of high purity iron were tested under the same condition, one neck only was formed in the centre of the test piece (the table on p 28 gives the chemical analysis of the commercial grade (top line) and high purity (bottom line) experimental materials). The process of deformation of commercial-grade iron, subjected to cyclic temperature fluctuations between 750 and 950 °C (the time taken to heat the test piece from the lower to the upper limit of temperature being 10 sec, and the time at the temperature 2 sec), while under an applied tensile stress of 0.33 kg/mm2, is illustrated in Fig 5, where the lower curve shows the variation of the temperature (°C, right-hand scale) and the upper curve the variation of elongation (ε, %, left-hand scale) with time (sec).

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On the Behaviour of Pure and Commercial-Grade Iron during Deformation under the Conditions of Cyclic Temperature Fluctuations

It will be seen that an anomalous increase in the length of the test pieces was observed during cooling through the 800-730 °C temperature range, and that the rate of deformation during heating was highest in the same temperature range. The structural changes occurring in commercial grade iron during the experiments are illustrated by a series of microphotographs (X 204), reproduced in Fig 6, and showing the appearance of the polished surface of the specimen in the region of necking; the temperature of this region fluctuated between 750 and 850 °C, the duration of the heating and cooling cycles being 20 and 12 sec, respectively, and the time at the temperature, 2 sec; the test piece was under a tensile stress of 0.55 kg/mm^2. Fig 6a shows the surface of the test piece before the test; the direction of the applied stress is shown by arrows; the impressions, made by the diamond pyramid used in micro-hardness tests, assisted in assessing the magnitude and character of the localized deformation taking place during the experiments. Fig 6б shows the surface of the

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Deformation under the Conditions of Cyclic Temperature Fluctuations

test piece after 5 min at 1000 °C; faint outlines of the grain boundaries of the α-phase are visible. Figs 6б - ж show the surface of the test piece after 5, 10, 20 and 50 heating/cooling cycles, respectively, and attention is drawn to the formation of cracks in the regions indicated by arrows in Figs 6г and е. The course of deformation of high purity iron, tested under the same conditions as the commercial grade material (except for the stress which, in this case was 0.05 kg/mm²), is illustrated by the microphotographs reproduced in Fig 7, which show the surface of the central (necking) part of the test piece, the temperature of which fluctuated between 800 and 1000 °C. Fig 7a shows the surface of the test piece before the experiments; the appearance of the same surface area, after 5 min at 1000 °C, and after 5, 10, 20 and 50 heating/cooling cycles is illustrated by the subsequent micrographs: the increasing degree of fragmentation of the grains with increasing number of the temperature fluctuations should be noted. The difference in the behaviour of the investigated materials is also

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On the Behaviour of Pure and Commercial-Grade Iron during Deformation under the Conditions of Cyclic Temperature Fluctuations

illustrated by the graph reproduced in Fig 8, where the elongation of the test piece (ε. %) is plotted against the number, n, of the temperature fluctuations for the commercial grade iron extended under 0.55 kg/mm^2 (curve 1) and high purity iron extended under 0.05 kg/mm^2 (curve 2). It will be seen that after 50 cycles, the total elongation of the high purity and commercial grade iron was 13 and 38%, respectively, although the stress applied in the latter wase was eleven times higher than that in the former. Another interesting fact observed by the present authors was the formation and growth of conically shaped protrusions on the surface of high purity iron in the central (hottest) part of the test pieces. The appearance of the commercial grade and high purity iron test pieces after 150 temperature fluctuations (800-1000 °C) is shown in Figs 9a and 9б, respectively (the arrows showing the necking zones); the necking zone of the test piece shown in Fig 9б is shown at a higher magnification (X 7) in Fig 9в. The conical protrusions formed on the high purity iron after

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On the Behaviour of Pure and Commercial-Grade Iron during Deformation under the Conditions of Cyclic Temperature Fluctuations

200 temperature fluctuations are shown in Fig 10a (X 22); microphotographs (X 100 and X 200) of the conical protrusion, marked A in Fig 10, are reproduced in Figs 10б and в, respectively, and show clearly the polycrystalline character of these growths whose formation had also been observed by Cizron and Lacombe (Ref 10), although these workers considered them to be polygonized single crystals. The experimental results reported in the present paper prove that small alloying additions markedly improve the strength of iron strained under the conditions of cyclic temperature variations. They show, also, that an increase in the alloying additions content lowers considerably the temperature of the minimum strength.

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There are 10 figures, 1 table and 10 references, of which 4 are Soviet, 4 English, 1 French and 1 Czechoslovak.

SUBMITTED: July 17, 1959

KHRUSHCHOV, Mikhail Mikhaylovich; BERKOVICH, Yefim Solomonovich; LOZINSKIY, M.G., doktor tekhn.nauk, otv.red.; KOVAL'SKAYA, I.F., tekhn.red.

[Studying the hardness of ice] Izuchenie tverdosti l'da. Moskva, Izd-vo Akad.nauk SSSR, 1960. 48 p. (MIRA 13:7)
(Ice—Testing) (Hardness)

LOZINSKIY, Mikhail Grigor'yevich

High temperature metallography. New York, London, Pergamon Press, 1961.
xix, 434 p. illus., diagrs., graphs, port., tables.
Translated from the original Russian: Vysokotemperaturnaya metallografiya, Moscow, 1956.
Bibliography: p. 461-472.

26242
S/122/61/000/001/009/015
A161/A130

1.1700

AUTHOR: Lozinskiy, M.G., Doctor of Technical Sciences

TITLE: New methods for increasing the strength of steels and alloys used in various machine industry branches

PERIODICAL: Vestnik mashinostroyeniya, no. 1, 1961, 56 - 64

TEXT: The article presents a brief general discussion of the latest development trends with references to non-Soviet publications and concerning whiskers, improved hardening technique (Ref. 4: E. M. H. Lips and H. Van Zuilen, "Metal Progress" v. 66, no. 2, 1954), "ausforming" developed at the Ford Works, "termomagnadynamix" of RDCA, and data obtained with the Soviet TMO [termomekhanicheskaya obrabotka (thermo-mechanical treatment)]. TMO is under development, and the author takes part in the work. It had been discussed in Ref. 12 (Sokolov, Ye. N., M. G. Lozinskiy, Ye. I. Antipova, Struktura granits zeren i zharoprochnost' stali 60X4T8H8B, "Metallovedeniye i obrabotka metallov", no. 11, 1958) and specified in Author's Certificate No. 123545, class 18c, 130, granted Lozinskiy, M.G. and Sokolov, Ye. N. (Ref. 14: "Byulleten' izobreteniy" no. 21, 1959). Its essence is combination of plastic deformation to 25 -35 % (induced

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A161/A130

New methods for increasing the strength ....

after homogenization of γ-solid solution at 1,200°C and subsequent cooling down to 1,100 - 1000°) with immediate cooling which prevents recrystalization and fixes a specific structure caused by deformation. Aging completes the treatment. TMO raises the long-term durabiltiy of austenitic steel and alloys in tests with heating, provided the recrystallization temperature is not exceeded. The strengthening effect works in austenitic steel up to 900 - 950°C. The specific structure produced has "serrated" grain boundaries with 5 - 10 micron protrusions. Besides, grains are split into pieces and the size of the mosaic blocks reduced. The result of the treatment not properly conducted may be the start of recrystallization and formation of fine chains of new grain in the place of the "serrations". The formation of the new grains on the boundaries destroyed the strengthening effect of TMO, but properly done TMO resulted in 4 - 5 times longer time to rupture in tests at 900°C with 14 kg/mm^2 tension stress in comparison to results after usual standard quenching with aging. TMO can be used in basically five combinations with plastic deformation (Figure 9): a - rolling hot blank (3) in rolls (1,2) with several meters a minute into intensely cold zone (4), e.g., a quenching sprayer; b - drawing; c - roll forging; d-stamping (where TMO is complicated), and e - extrusion. The layer of

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specific microstructure is 4 - 7 mm deep, and metal of 10-15 mm is penetrated but in large metal pieces the heat conduction can cause recrystallization and this must be considered. The method is good for local strengthening. A device for this purpose is schematically illustrated (Figure. 10). There are 10 figures and 14 references: 4 Soviet-bloc and 10 non-Soviet-bloc. The latest date references to the English-language publications read as follows: Schmetz, D. R., Shyne J. C., Zackay V. F., Austenitic "cold working" for ultra high strength. "Metal Progress, v. 76, no.1959; Are 1 Million psi Steels Possible? "Steel", v.145, no. 17, 1959; McGuire F. G., Breakthrough on heat treating promises huge gains on strength", "Missiles and Rockets", Sept. 28, 1959; Magnetic Quenching, "Metal Treatment and Drop Forging", v. 27, no. 180, 1960.

ASSOCIATION: Institut mashinovedeniya AN SSSR (Institute of Science of Machines)

S/180/61/000/001/007/015
E021/E406

AUTHORS: Lozinskiy, M.G. and Pertsovskiy, N.Z. (Moscow)

TITLE: Kinetics and Mechanism of Deformation of Metals at High Temperatures and Different Strain Rates

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1961, No.1, pp.96-107

TEXT: Direct observation by microscope or taking of photos of changes in the microstructure of metals and alloys during testing in a wide range of temperatures was not possible until 1960, when a new machine ИМАШ-5С (IMASh-5S) was designed by the present authors and constructed at the Institut mashinovedeniya AN SSSR (Institute of Science of Machines AS USSR). The technical characteristics of the new machine are described and results obtained on the machine on nickel are given. The machine enables tests to be carried out in a vacuum up to 1200°C with a controlled strain rate. Indentations are made on the surface of the specimens with a diamond pyramid to ensure that examination of the same part is carried out each time. Microphotographs of the surface are taken at various intervals during testing. The elongation of the specimen is measured to ± 0.005 mm. The machine

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was used to study the effect of temperature and rate of deformation on samples of commercially pure nickel (99.85% Ni with 0.02 C, 0.06 Si, 0.03 Cu, 0.005 S and 0.002% P). Specimens were heated at 1150°C for 3 hours to give a mean grain diameter of 0.15 to 0.18 mm and a hardness of 65 to 70 kg/mm^2. The samples were tested at 600 and 1000°C with strain rates of 0.5 and 2.8 x 10^2 mm/h. The results are shown in Fig.4. A decrease in rate of deformation results in a marked decrease in the strengthening effect occurring during plastic deformation at a given temperature. Specimens tested at 2.8 x 10^2 mm/hour at both temperatures fractured after a large degree of deformation with a transcrystalline fracture and formation of necking. Specimens tested at 0.5 mm/hour and 1000°C gave a ductile fracture with preliminary formation of necking in spite of the fact that many intercrystalline cracks appeared in the process of deformation. At 0.5 mm/hour rate and 600°C, brittle fracture occurred without any substantial local deformation. Fig.5 - 8 show series of microphotographs taken during testing. An increase in the rate of deformation from 0.5 to 2.8 x 10^2 mm/hour at 600°C results in intensification of the processes of slip in the grains as shown by the slip lines. Increasing the rate from 0.5 to

2.8×10^2 mm/hour at 1000°C results in a change in the mechanism of deformation. With a rate of 2.8×10^2 mm/hour, intensive slip first occurs and with greater deformation recrystallization occurs. At 0.5 mm/hour, no slip lines are seen, migration of grain boundaries occurs, a substructure is formed and intercrystalline cracks are seen. There are 8 figures, 2 tables and 17 references: 10 Soviet and 7 non-Soviet.

ASSOCIATION: Institut mashinovedeniya AN SSSR
(Institute of Science of Machines AS USSR)

SUBMITTED: July 21, 1960

S/129/61/000/002/013/014
E073/E335

AUTHOR: Lozinskiy, M.G., Doctor of Technical Sciences

TITLE: All-Union Scientific-technical Conference on Applying Induction Heating in the Heat-treatment of Metals

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1961, No. 2, pp. 59 - 61

TEXT: The conference was convened by the Gosudarstvennyy Komitet Soveta Ministrov SSSR po avtomatizatsii i mashinostroyeniyu (State Committee of the Council of Ministers, USSR, on Automation and Machine-building), Gosudarstvennyy nauchno-tekhnicheskiy komitet Soveta Ministrov SSSR (State Scientific-technical Committee of the Council of Ministers of the USSR) and the Metals and Heat-treatment Section of the Scientific-technical Society of the Engineering Industry.
It was held on October 28, 1960 in Moscow. 22 papers and 10 communications were read and discussed and there were 378 participants.

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All-Union Scientific-technical Conference on Applying Induction Heating in the Heat-treatment of Metals

Of the papers read, the following are specifically mentioned and summaries of their contents are given:
Doctor of Technical Sciences, Professor I.N. Kidin (Moskovskiy institut stali (Moscow Steel Institute) "The Importance of Electrothermal treatment in Modern Metals Technology".
Candidate of Technical Sciences N.P. Glukhanov (NII TVCh im. V.P. Vologdin) "State and Prospects of Industrial Application of High-frequency Currents".
Candidate of Technical Sciences Yu.M. Bogatyrev (TsNIITMASh) "Through Electrothermal Treatment of Steel".
Candidate of Technical Sciences K.Z. Shepelyakovskiy (Moskovskiy avtomobil'nyy zavod - Moscow Automobile Works) "Surface-hardening of Steel After Deep Heating".
Candidate of Technical Sciences M.N. Bodyako (Fiziko-tekhnicheskiy institut AN BSSR - Physicotechnical Institute AS BSSR) "On Recrystallisation Phenomena During Induction Heating".
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E073/E335

All-Union Scientific-technical Conference on Applying Induction Heating in the Heat-treatment of Metals

Candidate of Technical Sciences M.N. Klimochkin (TsNIITMASh) "Surface Electric Hardening of Spheroidal Cast Iron".
I.S. Demchuk and G.N. Ivanov "Flow-production by Mechanised Bending and Quenching of Rolled Sections Using High-frequency Heating".
Doctor of Technical Sciences M.G. Lozinskiy (Institut mashinovedeniya AN SSSR - Machinery Institute of the AS USSR) "Trends in the Development of Instrument Manufacture and of Equipment in the USSR and Abroad for Induction-hardening of Steel and Cast Iron".
Doctor of Technical Sciences Professor A.V. Donskoy "High-frequency Equipment With Tube Oscillators and Methods of Improving Them".
A.A. Terzyan (Armyanskiy filial VNIIEM - Armenian Branch of VNIIEM) "New Series of Rotary Frequency Converters 12 to 125 kW".

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S/129/61/000/002/013/014
E073/E335

All-Union Scientific-technical Conference on Applying Induction Heating in the Heat-treatment of Metals

V.F. Artem'yev (Uralmashzavod) and I.M. Likhtshteyn (VPTITyazhmash) "Equipment for Quenching Large Components of Machines After High-frequency Induction Heating".
I.P. Russinkovskiy (ENIMS) "Application of Ferrites for Intensifying the Process of Induction Heating".
Candidate of Technical Sciences K.Z. Shepelyakovskiy and I.N. Shklyarov (Moscow Automobile Works) "Automation of the Process of Heat-treatment of Components Using High-frequency Heating".
Doctor of Technical Sciences Professor I.N. Kidin and Yu.G. Andreyev (Moscow Steel Institute) spoke of a new method of nitro case-hardening of steel.
S.Ya. Yaitskov (Moscow Automobile Works) spoke of a method of intensifying induction through-heating of blanks for forging.

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All-Union Scientific-technical Conference on Applying Induction Heating in the Heat-treatment of Metals

Ye.I. Natanzon (Gor'kovskiy avtomobil'nyy zavod - Gor'kiy Automobile Works) spoke of improving the technology of surface-hardening of mass-production components.
G.F. Golovin (NII TVCh im. V.P. Vologdin) spoke of the cooling capacity of fluids in the case of feeding them as sprays.
A resolution was passed relating to eliminating the inadequacies of induction heating and its practical utilisation in engineering, pointing out the extreme importance of wider utilisation of induction heating from the point of view of reaching the targets set by the Seven-year Plan.

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SADOVSKIY, V.D.; SOKOLKOV, Ye.N.; LOZINSKIY, M.G.; PETROVA, S.N.;
ANTIPOVA, Ye.I.; GAYDUKOV, M.G.; MIRMEL'SHTEYN, V.A.

Effect of hot working on the heat-resistant properties of austenitic steel. Issl. po zharopr. splav. 7:202-209 '61. (MIRA 14:11)
(Steel alloys--Thermal properties) (Rolling (Metalwork))

26576
S/129/61/000/008/009/015
E073/E335

18 8200 1045 2808

AUTHORS: Lozinskiy, M.G., Doctor of technical Sciences, Zusmanovich, G.G. and Mirotvorskiy, V.S., Engineers

TITLE: Dependence of the Microhardness of Wear-resistance Coatings on Temperature

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1961, No. 8, pp. 37 - 39

TEXT: For evaluating the performance of the wear-resistant coatings, it is useful to determine their microhardness at elevated temperatures. A. Brenner (Ref. 1 - Journal of Research, Nat. Bureau Standards, Vol. 46, No. 2, 1951) published results on microhardness tests at 300 °C in an inert gas carried out on chromium-plating using loads of 30 - 200 g.

Apparatus was built in 1958 at the institute of the authors which enabled determining the microhardness of metals and alloys at temperatures up to 1 300 °C in vacuum at loads of 5 - 100 g and tensile tests with stresses of 0 - 60 kg/mm^2. The authors studied with this equipment the influence of temperature on the microhardness of nickel-phosphor and of

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Dependence of the ....

chromium coatings using a load of 100 g. The coatings were produced on specimens of commercial iron HV 100 kg/mm^2. The nickel-phosphor coatings were depostted from a solution consisting of 21 g/l. of nickel chloride, 24 g/l. sodium hyperphosphite and 10 g/l. sodium acetate. The coatings contained about 9% phosphor and were 40 - 50 μ thick. The chromium coatings (35-40 μ thick) were deposited from a standard electrolyte at 55 °C, using a current density of 35 A/dm^2. The thickness of the coatings was more than 2.5 times the depth of the indentation at the maximum test temperature. The microhardness of the nickel-phosphor coatings was tested at elevated temperatures directly after the coatings were produced and after heating to 400 °C and holding them at that temperature for 1 hour, followed by cooling in air. Such a heat-treatment ensures better adhesion between the coating and the surface of the component and increases the hardness. The chromium coatings were not heated. The hot microhardness of specimens from

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the steel XBГ (KhVG) was tested after quenching and low-temperature tempering (HRC 63-64). The obtained results enable comparing the temperature dependence of the hardness of this steel with that of the coatings. 15 indentations were made at each test temperature with a sapphire indenter (pyramid with an angle of 136°). The results, H_{μ}, kg/mm^2 versus temperature, °C, are plotted in Fig. 1 (Curve 1 - nickel-phosphor coatings without heat-treatment; Curve 2 - nickel-phosphor coatings after heat-treatment at 400 °C for 1 hour; Curve 3 - chromium-plating; 4 - steel KhVG, HRC 63). The results show that nickel-phosphor coatings have the highest hardness in the temperature range 150 - 350 °C and should be used for improving the resistance-to-wear of components operating at these temperatures. It is advisable to use chromium-plated or hardened steels for components operating at temperatures above 350 °C.

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Dependence of the ....

There are 1 figure, 1 table and 6 references: 4 Soviet and 2 non-Soviet. The two English-language references quoted are: Ref. 1 (in text) and Ref. 3 - M. Hansen, Constitution of Binary Alloys, New York, 1958,

ASSOCIATIONS: Institut mashinovedeniye AN SSSR (Institute of Machine Science of the AS USSR)
Vsesoyuznyy nauchno-issledovatel'skiy institut mekhanizatsii sel'skogo khozyaystva (All-Union Scientific Research Institute for Mechanisation of Agriculture)

Card 4/5

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28899
S/129/61/000/010/001/012
E193/E480

AUTHORS: Oding, I.A., Corresponding Member AS USSR,
Lozinskiy, M.G., Doctor of Technical Sciences,
Antipova, Ye.I., Engineer and Stepanov, V.N., Engineer

TITLE: A study of the mechanism of fracture of austenitic steel in short-time service at 1100°C

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.10, 1961, 10-13 + 4 plates

TEXT: Results are reported of short time (3 to 30 minutes), constant-load and time-to-rupture tests, carried out at 1100°C on austenitic steels ЭХ18Н9 (EKh18N9) (0.07% C, 18% Cr, 9% Ni, 1.56% Mn, 0.31% Si) and 4Х14Н14В2М (4Kh14N14V2M) (0.45% C, 14% Cr, 15% Ni, 2.3% W, 0.6% Mn and 0.34% Si). The test pieces were preliminarily heat treated by heating for two hours at 1100°C in evacuated quartz ampules followed by oil quenching. One face of each heat treated specimen was polished and etched to reveal the microstructure and test pieces with an average grain-size of 30 to 60 (EKh18N9) or 100 to 130 microns (4Kh14N14V2M) were selected. During the tests (carried out in vacuum) the etched side of the test piece, marked by a series of equi-distant

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A study of the mechanism ... E193/E480

(50 microns) microhardness indentations, was facing a window through which microcinephotographs were taken throughout the duration of each test. This made it possible to study each stage of the deformation process by measuring the increase in the distance between the diamond pyramid indentations, and by following the changes in the microstructure. To overcome the difficulties caused by volatilization of the test piece material and its subsequent condensation as a metallic film on the window of the vacuum chamber, a special device was constructed whose detailed description is given in the paper. Some of the typical results are reproduced in Fig.9, showing the strain (ε, %) versus time (minutes) curves for steel 4Kh14N14V2M tested at 1100°C under a stress of 5.5 kg/mm^2; broken curve relates to the total elongation of the test piece, curves marked by numbers give the elongation of microregions bounded by the corresponding diamond indenter marks as shown in the insert in Fig.9. Other observations can be summarized as follows.
(1) The microstructure of the steels studied was revealed after one minute at 1100°C; this was most likely caused by preferential volatilization of the metal in the grain boundary regions.
(2) Intergranular cracks appeared in the very early stages of
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deformation which indicated that, under the experimental conditions employed, creep is associated mainly with intercrystalline slip with very little deformation taking place within the grains.
(3) The total elongation depended upon the applied stress and varied between 17.5 and 25% in steel EKh18N9 and between 8 and 16% in steel 4Kh14N14V2M. This difference was attributed to the larger grain-size of the latter material.
(4) For an equal stress of 2.5 kg/mm^2, the time-to-rupture was 5.5 and 24 minutes on steels EKh18N9 and 4Kh14N14V2M respectively. This difference was also attributed to the difference in the grain-size, since the total length of the grain boundaries which determine the strain accumulated prior to fracture is smaller in a coarse-grained material. There are 9 figures and 3 Soviet-bloc references.

ASSOCIATION: Institut metallurgii i Institut mashinovedeniya AN SSSR (Institute of Metallurgy and Institute of Science of Machines AS USSR)

APPROVED FOR RELEASE: 08/23/2000 CIA-RDP86-00513R000930630002-8"

34534
S/659/61/007/000/021/044
D217/D303

18.1151

AUTHORS: Sadovskiy, V.D., Sokolkov, Ye.N., Lozinskiy, M.G., Petrova, S.N., Antipova, Ye.I., Gaydukov, M.G., and Mirmel'shteyn, V.A.

TITLE: Influence of thermo-mechanical treatment on the high temperature strength properties of austenitic steel

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Issledovaniya po zharoprochnym splavam, v. 7, 1961, 202-209

TEXT: A complex alloy steel of the austenitic class, widely used in industry for manufacturing components for high temperature service, was studied. During ageing of this steel, the complex chromium and vanadium carbides responsible for its strengthening are precipitated. The material was heated to 1180 - 1200°C and rolled at 1000 - 1100°C at a speed of 5.7 m/min. After rolling, the billets were immediately water quenched in order to prevent recrystallization. The cross-section of the billets obtained was 11.5 x 11.5 mm their length, 70 mm, and the reduction due to rolling, 25 - 30 %.

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Influence of thermo-mechanical ...

Control billets were heated simultaneously with those chosen for thermo-mechanical treatment, and were subsequently quenched from the above temperature. All billets, whether thermo-mechanically treated or only heated and quenched, were aged to a hardness of 310 - 320 H_B. After heat treatment, specimens for two series of tests were made from the billets. One series was used for studying structure during high temperature extension in vacuo. This also enabled the degree of deformation to be determined and photographs of the same portion to be taken at various stages of testing. Testing was carried out in a IMASh-5M machine at 900°C and a stress of 9.5 kg/mm^2, using specimens of 3 x 3 mm cross-section, heated by direct passage of current. The second series of tests, in which K.I. Terekhov participated, consisted of the standard tests for long-term strength at 650°C and stresses of 35 and 38 kg/mm^2, as well as at 700°C and a stress of 32 kg/mm^2. For this purpose, specimens of working portion diameter of 5 mm and 50 mm length were used. The microstructure of each specimen was studied in conjunction with these tests, particularly any peculiarities in structure appearing after thermo-mechanical treatment as compared with normal quenching.

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The distribution of deformation along the length of the specimen, the intercrystalline and crystalline plasticity and the formation and propagation of cracks during fracture were given particular attention. It was found that high-temperature plastic deformation of the steel investigated, under conditions in which recrystallization processes are suppressed (thermo-mechanical treatment), leads to a considerable increase in long-term strength. The beneficial action of thermo-mechanical treatment is associated with structural characteristics of the steel which arise during high temperature plastic deformation and are fixed by cooling at a sufficiently high rate. Such characteristics are the complex geometry of grain boundaries, grain fragmentation and further refinement of the fine crystal structure. These structural characteristics of the steel retarded the development of fracture during creep, since (a) the characteristic serrated grain boundary structure retards the amalgamation between micro- and macro-cracks; (b) breaking-up of the fine crystal structure, and an increase in the density of immobilized dislocations render plastic deformation within the grains more difficult. There are 5 figures and 16 references: 15 Soviet-bloc and

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1 non-Soviet-bloc. The reference to the English-language publication reads as follows: P.W. Davies and J.P. Dennison, J. Inst. Metals, 87, 4, 1958.

X

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S/659/61/007/000/026/044
D217/D303

AUTHOR: Lozinskiy, M.G.

TITLE: Present state and direction of future development of high-temperature metallography

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Issledovaniya po zharoprochnym splavam, v. 7, 1961, 233 - 241

TEXT: This paper deals with the present state of high-temperature metallography techniques and with measures to be taken for the further development of this phase of the science of metals. In the first approximation, research carried out by means of high-temperature metallography can be classified as (1) techniques enabling the microstructural changes of specimens to be studied during experiments by direct observation through the microscope, and (2) methods of studying the properties of materials without direct consideration of microstructure. High-temperature metallography methods are divided into three groups: The first group comprises microstructural investigations enabling the kinetics of grain growth to be observed

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at selected heating rates or under isothermal soaking conditions, and the study of development of polymorphic changes, the precipitation of phases and the actual stages of development of corrosion processes (by artificial addition of definite quantities of aggressive media to a vacuum chamber in which the test specimen is placed and by photographing the changes in color of individual grains and grain portions, arising due to color interference in this oxide films). The second group comprises methods for studying strength properties at various rates of thermal and mechanical loading. The third group embraces methods for determining many important properties of metals and alloys (hardness and microhardness, modulus of elasticity and internal friction, thermal and electrical conductivity, coefficient of expansion, intensity of evaporation, and diffusion, etc.) in relation to temperature and time of testing. Methods for the testing of hardness and microhardness at various temperatures are particularly important. Modern instruments for measuring hardness, microhardness, change in hardness on heating and deformation at high tmperatures and X-ray equipment are described. There are 5 figures and 17 references: 16 Soviet-bloc and 1 non-Soviet-bloc.

LOZINSKIY, M.G., doktor tekhn.nauk; ZUSMANOVICH, G.G., inzh.; MIROTVORSKIY, V.S., inzh.

Dependence of the microhardness of wear-resistant coatings on the temperature. Metalloved. i term. obr. met. no.8:37-39 Ag '61. (MIRA 14:8)

1. Institut mashinovedeniya AN SSSR i Vsesoyuznyy nauchno-issledovatel'skiy institut mekhanizatsii sel'skogo khozyaystva.
(Protective coastings) (Metals, Effect of temperature on)

KISHKIN, S.T.; LOZINSKIY, M.G., doktor tekhn.nauk; BOKSHTEYN, S.Z., doktor tekhn.nauk, prof.; SOKOLKOV, Ye.N., kand.tekhn.nauk

Effect of high temperature plastic deformation on the mechanical properties of nickel-base, heat-resistant alloys. Metalloved. i term. obr. met. no.1:38-40 Ja '62. (MIRA 15:1)

1. Chlen-korrespondent AN SSSR (for Kishkin).
(Heat-resistant alloys--Heat treatment) (Deformations (Mechanics))

LOZINSKIY, M.G., doktor tekhn.nauk; BERNSHTEYN, M.L., kand.tekhn.nauk;
VERSHINSKAYA, T.V., inzh.

Investigating the polygonization of molybdenum by high temperature metallography. Metalloved. i term. obr. met. no.1:57-64 Ja '62.
(MIRA 15:1)

1. Institut mashinovedeniya Gosudarstvennogo komiteta Soveta Ministrov SSSR po avtomatizatsii i mashinostroyeniyu i Moskovskiy institut stali.
(Molybdenum--Metallography) (Dislocations in metals)

LOZINSKIY, M. G.

23

AID 985

THERMOMECHANICAL TREATMENT OF STEELS (USSR)

Lozinskiy, M. G.; V. D. Sadovskiy, and Ye. N. Sokolkova. IN: Novyye protsessy obrabotki metallov davleniyem (New processes of press forging metals). Moskva, Izd-vo Akademii nauk SSSR, 1962. 85-93.

S/902/62/000/000/008/015

The two main types of thermomechanical treatment are reviewed: 1) the low-temperature treatment (ausforming), and 2) the Soviet-developed high-temperature treatment which consists of austenitizing, cooling to 900-1000°C (for nonaustenitic steels) or 1000-1100°C (for austenitic steels), plastic deformation with a reduction of 25-30%, and rapid cooling at a rate which ensures a complete suppression of recrystallization and a complete martensitic transformation or a fully austenitic structure in austenitic steel. Since neither type of thermomechanical treatment is applicable, for the time being, under actual production conditions, a compromise, i. e., surface treatment, is suggested. Round articles can be hf-induction-heated [see illustration], surface rolled, and quenched. An "author's certificate" was issued on this method. [DV]

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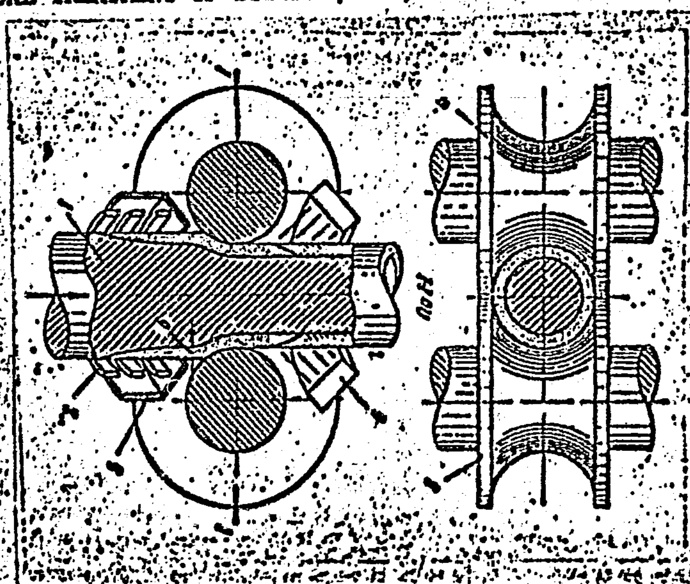
AID 985

THERMOMECHANICAL TREATMENT OF STEELS (USSR)



1 - treated article; 2 - hf induction heater; 3 and 4 - rolls; 5 - heat shield; 6 - sprayer

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37728

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E193/E383

1.1700

AUTHORS: Bokshteyn, S.Z., Kishkin, S.T., Lozinskiy, M.G. and Sokolkov, Ye.N. (Moscow)

TITLE: Thermomechanical treatment of a chromium-nickel-manganese austenitic steel

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye tekhnicheskikh nauk. Metallurgiya i toplivo, no. 2, 1962, 15 - 21

TEXT: The, so-called, "thermomechanical treatment" (TMO) consists essentially of combining plastic deformation at temperatures above the recrystallization temperature with quenching under conditions precluding recrystallization of the plastically deformed material. The effect of this treatment on the structure and properties of various materials has already been studied by other workers. Some additional data on TMO of austenitic steels are presented in the present paper, with particular reference to the properties of these steels after TMO to the ageing treatment and to some characteristics of the diffusion processes. The experiments were conducted on chromium-

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nickel-manganese austenitic steel ЭИ 481 (EI481) specimens, 13 and 60 mm in diameter, the former 150 and the latter 250 mm long. The plastic-deformation part of TMO was effected by rolling at 2.4 m/min in the case of specimens 60 mm in diameter and at 4.5, 7.5 and 13.5 m/min in the case of 13 mm diameter specimens. 25 and 30% reduction was given in each case. Recrystallization of the 13 mm diameter specimens was suppressed by immediate quenching in a water tank mounted on the rolls housing, the time interval between completion of the rolling operation and quenching amounting to 0.2 to 0.3 sec. Rapid cooling of the 60 mm diameter specimens was attained with the aid of a specially designed spraying device. Preheating of the test pieces for rolling was done in air in an electric furnace, the preheating temperature and time being 1 180 °C and 2 hours, respectively. TMO of small (13 mm diameter) test pieces was carried out after cooling them from 1 180 to 1 100 °C. In the case of large (60 mm diameter) test pieces TMO was applied at the preheating temperature and after cooling

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to 1 150, 1 100, 1 050 and 1 000 °C. A number of test pieces were given conventional treatment (water-quenching) to obtain control specimens for comparison. All the test pieces (whether quench-hardened or subjected to TMO) were aged at 680 °C for 10 hours, after which they were given an additional treatment of 10 hours at 790 °C, followed by air-cooling so as to attain hardness corresponding to the indentation diameter $d_{отп}$ = 3.5 - 3.7 mm. In addition to standard tensile tests at room temperature, tests at 650 °C were carried out under conditions of short and prolonged loading, the latter (i.e. creep) tests being conducted under an applied stress of 39 or 43 kg/mm². To study and compare the progress of diffusion processes in material subjected to TMO or given the conventional treatment, the rate of diffusion was measured by a radioactive-tracer technique, entailing cutting a taper section across the diffusion region.

A thin film of Fe^{59} was electrodeposited on the specimens studied, which were then given a 150-hours diffusion-annealing treatment at 800 °C in vacuum, after which both volume and grain-boundary diffusion coefficients were determined. Overall diffusion coefficients were also calculated with the aid of the absorption method. Phase-analysis was used to study the effect of hot plastic deformation on the process of carbide-formation during ageing. Electrolytic extraction of the carbide phase from various test pieces was carried out in a 5% solution of hydrochloric acid in methanol. The anode residues were also examined by X-ray diffraction measurements. Preliminary examination of the microstructure revealed that, irrespective of the rolling speed employed during TMO, full suppression of recrystallization had been achieved in small (15 mm diameter) test pieces only. None of the TMO procedures used on large (60 mm diameter) test pieces had ensured suppression of the recrystallization process. The results of standard tensile tests at 20 and 650 °C, carried out on small specimens, showed that TMO brought about a slight increase in UTS at 20 °C (from 108 - 114 kg/mm^2) but had no effect on the strength of steel at 650 °C. The variation in plasticity was somewhat different.

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Thus, as the rolling speed during TMO increased, the elongation of steel at room temperature decreased below that of specimens heat-treated in the conventional manner and then increased to exceed this value. The same applied to reduction in area which, after TMO entailing deformation by rolling at 13.5 m/min, attained a value of 53.2%, i.e. 25% higher than the value attained after conventional treatment. The results of tensile tests at 650 °C also showed a slight increase in elongation of specimens subjected to TMO, although reduction in area of specimens rolled at 13.5 m/min was somewhat lower than that of the control test pieces. The results of accelerated creep tests conducted on small test pieces under a stress of 43 kg/mm^2 showed that irrespective of the conditions during TMO, the time-to-rupture of the steels studied increased after this treatment by 20-25%. The corresponding increase for specimens tested under a stress of 59 kg/mm^2 amounted to 600%. Metallographic examination of small specimens showed that recrystallization during TMO had been completely suppressed in each of the specimens examined. This was indicated by the absence of new small crystals which
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Thermomechanical treatment ....

were usually formed in recrystallized material along the boundaries of the original grains. A common specific structural feature of all specimens subjected to TMO was distortion of grain boundaries which had assumed a characteristic serrated contour. A distinguishing feature of specimens rolled during TMO at a speed of 4.5 m/min was well-developed sub-structure. The formation of sub-structure was associated with the formation of blocks (several tens of microns in size) in the interior of the grains. The relatively large angular misalignment of these blocks was indicated by the ease with which the block boundaries could be revealed by etching. No such clearly defined sub-structure was observed in specimens rolled during TMO at higher speeds, although in a few isolated instances there was some evidence of block formation. The formation of the fine structure could be attributed to polygonization processes and subsequent decoration of the low-angle boundaries by the solute atoms and second-phase particles. Another specific feature of the structure produced by TMO is the fragmentation of grains, i.e. sub-division of grains into parts whose dimension are commeasurable with the size of the grains themselves. It would appear that fragmentation is mainly a result of intensive twinning taking place during hot plastic deformation. As stated already, none of the TMO procedures applied to large (60 mm diameter) test pieces ensured complete suppression of recrystallization, the extent of which increased with depth so that an unrecrystallized structure was observed only in the very surface layers of the material. In this case TMO had practically no effect on the resistance-to-creep of the steels studied. The results of phase analysis showed that although the chromium-carbide content of specimens subjected to TMO had increased considerably, it was independent of the rolling speed employed in the course of this treatment. The vanadium-carbide content of the material was practically unaffected by TMO. Finally, the results of diffusion studies indicated that after TMO the coefficient of volume diffusion of iron in steel at 800 °C increased fourfold. Since, owing to a general increase in the diffusion mobility, difficulties were encountered in determining the grain-boundary diffusion coefficient, the overall diffusion coefficients were measured by the absorption method. Comparison of the results obtained for test pieces with different structures showed that the overall diffusion coefficient for materials which had undergone TMO was more than twice as high as that for specimens given the conventional treatment. The general conclusion reached was that in addition to the previously established strengthening effect of grain-boundary distortion caused by TMO, the beneficial effect of this treatment on the high-temperature properties of steel was associated with an increase in the quantity of the strengthening phase and, possibly, with refinement of the mosaic structure and formation of slight texture. There are 4 figures and 2 tables.

SUBMITTED: October 11, 1961

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S/129/62/000/001/007/011
E073/E335

AUTHORS: Kishkin, S.T., Corresponding Member of the AS USSR,
Lozinskiy, M.G., Doctor of Technical Sciences,
Bokshteyn, S.Z., Doctor of Technical Sciences, Professor,
Sokolkov, Ye.N., Candidate of Technical Sciences

TITLE: Influence of high-temperature plastic deformation on the mechanical properties of heat-resistant nickel-base alloys

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.1, 1962, 38-40 + 1 plate

X

TEXT: Two Ni-Cr-base alloys were investigated: the low-carbon ЭИ437Б (EI437B) alloy of the standard composition and the ЭИ617 (EI617) alloy, containing 0.12% C and additions of W and Mo. The alloy EI437B was subjected to the following thermo-mechanical treatment: blanks of 16 mm diameter were first soaked for 8 hours at 1080°C and rolled at this temperature at a rolling speed of 4.5 m/min to 30% reduction. 0.2 to 0.3 sec after deformation, the blanks were quenched to supercool the austenite

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and to retain the structure, produced as a result of high-temperature plastic deformation. The blanks were then aged at 700°C for 16 hours. Blanks of the alloy EI617 were heated to 1200°C and stamped in a press, so that an average reduction of 30% was achieved; this was followed by quenching in water. The blanks were then aged at 800°C for 16 hours. The results of static tensile and impact tests at room temperature are given in Table 1. Studies of the influence of thermomechanical treatment on the creep strength of austenitic steels revealed that recrystallization should be prevented during high-temperature plastic deformation since it would cancel out the beneficial effects of the thermomechanical treatment. Microstructural investigations correlated with the results of mechanical tests indicate that the increase in strength and ductility occurs even if recrystallization has not been fully suppressed. The increase in strength is attributed to an increase in the quantity of the carbide phase, to changes in the finely crystalline

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structure of the material and to texturing. The large increase in the ductility of the investigated alloys is obviously due to the absence of intercrystalline fracture. The following participated in the experiments: N.I. Korneyev; T.A.Gordeyeva, Ye.I. Razuvayev, O.N. Podvoyskaya, M.N. Kozlova, L.M. Strizhevskaya, T.A. Volodina, N.F. Lashko, E.V. Polyak, G.N. Korableva, A.V. Bulanov, M.I. Spektor and I.G. Skugarev. There are 2 tables and 7 references: 4 Soviet-bloc references and 3 non-Soviet-bloc. The three English-language references mentioned are: Ref. 4: E.B. Kula, J.M. Ohosi - "TASM", v.52, 1960; Ref. 5: D.J.Schmatz, J.C. Shyne, V.F. Zackay - Metal Progress, v.76, no. 3, 1959; Ref. 7: E.B. Kula, S.L. Lopata - Trans. AIME, v.215, 1959.

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Table 1:

Alloy	Treatment	Mechanical Properties					
		$\sigma_{0.2}$, kg/mm^2	σ_b, kg/mm^2	δ, %	ψ, %	a_k, kgm/cm^2	HB (d_{omn}, mm)
EI437B	Standard (reference specimens)	-	97.0	25.0	20.9	-	-
	TMO *	-	119	32.0	30.7	-	-
EI617	Standard (reference specimens)	71.7	103.7	14.6	10.1	1.8	3.6
	TMO*	93.8	129.6	31.2	25.9	7.8	3.35

* Plastic deformation of supercooled austenite followed by conventional hardening and tempering treatment.

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AUTHORS: Lozinskiy, M.G., Doctor of Technical Sciences, Bernshteyn, M.L., Candidate of Technical Sciences and Vershinskaya, T.V., Engineer

TITLE: Polygonization of molybdenum studied by high-temperature metallographic methods

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no. 1, 1962, 57 - 64

TEXT: Owing to the resultant formation of fine inhomogeneities of the structure and increase in the recrystallization temperature, polygonization of metals brings about an improvement in the mechanical properties, both at room and elevated temperatures. This is particularly important in the case of Mo, which is mainly used in high-temperature applications and, consequently, it is important to establish heat- and mechanical-treatment procedures which would ensure polygonization of this metal and its alloys. Hence the present investigation, in which high-temperature metallographic methods such as described,

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for instance, in Ref. 6 (M.G. Lozinskiy and N.Z. Pertsovskiy - Izv. AN SSSR, OTN, seriya Metallurgiya i toplivo, no. 1, 1961) were used. Experiments were conducted on vacuum-melted Mo containing small additions of Ti and Zr which constituted a solid solution and in which no solid transformation of any kind took place. The cast ingots were first hot-forged and then hot-rolled to 3.5 mm thickness, after which the material was annealed at 1 500 °C for one hour. Part of the annealed strip was rolled at 600 °C to 5, 7, 9 and 13% reduction in thickness and specimens of both annealed and work-hardened alloys were used for taking hardness measurements at 1 050, 1 100 and 1 150 °C. In the other series of experiments, electrolytically polished test pieces of annealed material were extended in vacuum at a constant rate of strain at 1 050 and 1 150 °C and after attaining elongation of 3, 6 and 13% were maintained under a load, photomicrographs of the surface of the test pieces being taken at various stages of this treatment. X-ray diffraction analysis was also carried out on test pieces stressed at elevated temperatures. The results obtained can be summarized as

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follows.
1) Hot hardness of the alloys studied increases with increasing degree of preliminary plastic deformation but the longer the loading time used during the hardness measurements, the lower is the value of hardness obtained. This is illustrated in Fig. 2, where the Vickers hardness (HV) of various specimens is plotted against the loading time (min), the degree of preliminary plastic deformation (%) being indicated on each graph; experimental points denoted by circles, triangles and dots relate, respectively, to test temperatures of 1 050, 1 100 and 1 150 °C. It will be seen that an anomalous increase takes place in specimens preliminarily rolled to 9% reduction and that the hardness of specimens deformed to 13% reduction is higher at 1 150 °C than at 1 050 °C or 1 100 °C.
2) The increase in hardness with rising temperature is relatively small in specimens deformed to 5 and 7% reduction and large in more heavily deformed material, this increase being particularly pronounced in specimens given 9% reduction, which indicates that this treatment brings about polygonization

of the alloy. In Fig. 3 the decrease in hardness (ΔH, kg/mm^2) is plotted against the test temperature, the degree of preliminary deformation being indicated by each curve.
3) The microhardness of the alloy at high temperature also varies with loading time. This is demonstrated in Fig. 4, where the microhardness (HV, kg/mm^2) is plotted against the loading time at 1 050 (graph a) and 1 150 °C (graph б), the degree of preliminary deformation being shown by each curve. It will be seen that the microhardness of all work-hardened specimens tested at 1 050 °C decreases monotonically with increasing loading time; the curves for specimens given 9 and 13% reduction and tested at 1 150 °C show a maximum at 30 and 80 min, respectively. The maximum increase in microhardness with increasing loading times is shown by a specimen deformed to 9% reduction and tested at 1 150 °C.
4) The results of X-ray diffraction analysis show that fragmentation of blocks in the course of plastic deformation is a characteristic feature of Mo and that the degree of