20-114-3-24/60

AUTHOR: Ivanova, V. S.

TITLE: The Intergranular and the Innergranular Character of the Failure of Armko-Iron Due to Fatigue (Mezhzerennyy i vnutrizerennyy kharakter razrusheniya Armko-zheleza pri ustalosti)

PERIODICAL: Doklady Akademii Nauk SSSR, 1957, Vol. 114, Nr 3, pp. 537-540 (USSR)

ABSTRACT: First the author shortly reports on some earlier works dealing with the same subject. The present paper studies the influence of the grain-boundaries upon the process of fatigue. The samples were 1 mm thick, 10 mm wide and 72 mm long, before being tested they were annealed for 2 hours at a temperature of 950°C in evacuated ampules and then they were etched. The testing of fatigue was performed by bending by means of an electromagnetic device at a frequency of 50 cycles. The results of the testing are illustrated by a diagram. The relation between the stress and the logarithm lg N of the number of cycles necessary till the failure at the beginning has a rectilinear character and then, at a stress of 20,5 kg/mm$^2$, undergoes a break. According to the results of the microstruc-

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The Intergranular and the Innergranular Character of the Failure of Armko--Iron Due to Fatigue

ture-analysis the break is connected with the type of the failure. At cyclic stresses above the stretching-strain limit the fatigue failure has mainly an intergranular character. At stresses below the stretching strain limit the failure predominantly occurs along the bodies of the grains. This indicates the following: In the case of a permanent influence of cyclic (and also static) stresses it is necessary to distinguish between the cyclic solidity of the grain-boundaries and the cyclic solidity of the grains themselves. A diagram illustrates the experimental data of the testings of the cyclic solidity of Armko-iron. The experimental points at 20,5 kg/mm$^2$ correspond to the cyclic solidity of the grain boundaries and at 20,5 kg/mm$^2$ they correspond to the cyclic stability of the grain body. In the case of Armko--iron the grain boundaries thus exert an essential influence upon the behavior of Armko-iron in cyclic actions of stress. In actions of cyclic stresses the internuclear plasticity also precedes the processes in the body of the grain that produce the displacement. These observations are in agreement with the data of other authors. Finally the mechanism under-

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20-114-3-24/60

The Intergranular and the Innergranular Character of the Failure of Armko-
-Iron Due to Fatigue

lying these phenomena is discussed. There are 3 figures and 10 references, 7 of which are Soviet.

ASSOCIATION: Institute of Metallurgy imeni A. A. Baykov AS USSR (Institut metallurgii im. A. A. Baykova Akademii nauk SSSR)

PRESENTED: December 29, 1957, by I. P. Bardin, Member of the Academy

SUBMITTED: December 11, 1957

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APPROVED FOR RELEASE: 08/10/2001 CIA-RDP86-00513R000619230004-6"

IVANOVA, V.S.; ODING, I.A.

Changes in microstructure, hardness, and electrical conductivity during the creep process in heat-resistant kinds of steel. Issl. po zharopr.splav. 3:3-11 '58. (MIRA 11:11)
(Heat-resistant alloys--Metallography) (Creep of metals)

IVANOVA, V.S.

24-58-3-18/38

AUTHORS: Gordiyenko, L.K. and Ivanova, V.S. (Moscow)

TITLE: On the Nature of the Sensitivity of Titanium to Stress Concentrations at Alternating Loads (O prirode chuvstvitel'nosti titana k kontsentratoram napryazheniy pri tsiklicheskikh nagruzkakh)

PERIODICAL: Izvestiya Akademii Nauk SSSR, Otdeleniye Tekhnicheskikh Nauk, 1958, Nr 3, pp 121-125 (USSR)

ABSTRACT: The notch sensitivity of titanium under alternating stresses has been stated by different authors in the same Soviet publication ("Metallovedeniye", Sudpromgiz, 1957, pp 175-194 and 196-205, respectively) to be either lower or higher than that of high tensile alloy steel. Attempting to resolve the contradiction, the effect of the surface condition on fatigue strength has been studied on sintered titanium sheet samples of 1 mm thickness, obtained by hot rolling, loaded in an electromagnetic cantilever bending resonance machine at mains frequency. Chemically pickled specimens, polished specimens and specimens pickled after polishing, were compared. Metallographic studies have shown twinning to be the main disintegration mechanism under cyclic loads. At high overloads the twin boundaries may constitute sources of failure, whilst in steel, micro-cracks in slip bands seen in an optical

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24-58-3-18/38

On the Nature of the Sensitivity of Titanium to Stress Concentrations at Alternating Loads.

microscope do not develop and failure occurs largely along the grain boundaries. The surface condition has a large effect on the fatigue strength of titanium. The strength based on 100 000 000 cycles is 40% higher in polished specimens than in untreated specimens (43 kg/mm$^2$ compared with 30). The effect of micro-stress raisers is therefore much higher than in steel. Pickling causes a large scatter of results. A general discussion is included on notch sensitivity in relation to twinning and slipping processes characteristic of different metals and crystal structures. There are 7 figures and 9 references, 4 of which are Soviet, 5 English.

ASSOCIATION: Institut metallurgii, AN SSSR (Metallurgy Institute, Academy of Sciences USSR)

SUBMITTED: October 23, 1957.

Card 2/2 1. Titanium--Stress--Sensitivity

SOV-129-58-6-1/17

AUTHORS: Ivanova, V.S. (Cand.Tech.Sci.), Gordyenko, L. K. (Engineer)

TITLE: Experimental Investigation of Certain Assumptions of the Structural Theory of Creep (Eksperimental'noye issledovaniye nekotorykh polozheniy strukturnoy teorii polzuchesti)

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1958, Nr 6, pp 2-6 (USSR)

ABSTRACT: According to the structural theory of creep proposed by I. A. Oding (Ref.5), an increase, decrease or constant speed of creep is determined by the density of dislocations. A change of the density of dislocations should show itself in a change of the physical and mechanical properties of the metal, for instance, the electric resistance and the micro-hardness, since both these characteristics depend on the crystal structure. To verify this assumption, the authors carried out experiments, measuring the change in the electric resistance and the micro-hardness during the process of creep tests of some high temperature materials. The DC electric resistance was measured, using a special rig so as to ensure constancy of the contact areas and to exclude the possible influence of thermo currents. The electric resistance was determined on cylindrical specimens of 8 mm dia, 200 mm length, and also on flat specimens of 4.5 x

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Experimental Investigation of Certain Assumptions of the Structural Theory of Creep.

9.5 mm, 200 mm long. The experimental error was 0.5% and the variation in the results of measurements in the individual sections did not exceed 0.1 to 0.5%. The graph Fig.1 shows the creep curve for the steel EI-432 during tensile tests with a stress of 22 kg/mm$^2$ at 600°C. The same graph shows the electric resistance measured after 100, 500, 1180 and 1446 hours. During the first test hours the creep proceeded with an attenuated speed whereby an increase in the electric conductivity was observed. However, during accelerated creep the electric conductivity decreased. A decrease in the electric conductivity also occurred for the accelerated stage of creep of the same steel tested with a stress of 18 kg/mm$^2$. These data are fully in agreement with the fundamental assumptions of the structural theory of creep. An increase (decrease) of the creep speed and a decrease (increase) of the electric resistance apparently indicates that the third stage of creep is linked with an increase in the density of dislocations and the attenuating stage of creep is linked with a decrease with time of the dislocation density. As shown in graphs Figs.4 and 5, an

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increase in the micro-hardness was observed during the accelerated stage of creep; these graphs include the results of micro-hardness measurements in the intermediate stages of accelerated creep as well as the micro-hardness after failure. An excessively high increase in the micro-hardness is linked in the first instance with an increase in the density of dislocations and this is satisfactorily explained by the structural creep theory. The following conclusions are arrived at: (1) on the basis of the structural creep theory certain relations governing the change of the electric conductivity and the micro-hardness of high temperature steels during various stages of creep tests are described and experimentally confirmed. (2) The obtained experimental data indicate the correctness of the original theoretical assumptions and permits the conclusion that the proposed methods of investigation of the processes characterising creep are promising from the point of view of further

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SOV-129-58-6-1/17

Experimental Investigation of Certain Assumptions of the Structural Theory of Creep.

development of the structural theory of creep. There are 6 figures and 5 references, of which 2 are Soviet and 3 English.

ASSOCIATION: Institut Metallurgii AN SSSR imeni A. A. Baykova (Metallurgical Institute, Academy of Sciences, USSR, im. A. A. Baykov)

1. Metals - Creep 2. Metallurgy - USSR

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20-119-1-19/52

AUTHOR: Ivanova, V. S.

TITLE: The Fatigue Failure Diagram of Metals (Diagramma ustalostnogo razrusheniya metallov)

PERIODICAL: Doklady Akademii Nauk, SSSR, 1958, Vol. 119, Nr. 1, pp. 71-74 (USSR)

ABSTRACT: In the analysis of the fatigue processes the fatigue curve, which was suggested by Veller already in the past century, is used. But this curve does not comprehend the whole complication of the processes, which cause the failure of the metal. The fatigue processes of a metal can be estimated by far more completely from the diagram of the fatigue failure. The first test of the theoretical constuction of such a metal was performed I.A. Oding (Ref 1); he suggested a diagram, which consists of 3 main lines: Consolidation line, damage line, and fatigue line. But Oding's diagram does not consider the factor of structure. First here 4 rules are shortly given governing the fatigue process, which were discovered in recent years. Referring to these experimental data the following 3 periods of fatigue can be distinguished: The 1st

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The Fatigue Failure Diagram of Metals

period, the so called incubation period, is characterized by the absence of gliding strips, which are visible in an optical microscope. In this state of fatigue the main processes take place at the grain boundaries. On that occasion a plastic deformation accrues by a shifting of the grains at their boundaries and by their mutual rotation. The 2nd period, the so called period of loosening, is connected with the occurring and with the development of submicroscopical cracks in the sliding strips. The sliding cracks develop inside of single grains, but do not surpass the grain boundaries. In this period a vast number of vacant spaces are formed in the crystal lattice. At the development of the submicroscopical cracks to micro-fissures the third fatigue period, the period of failure, starts. In this period the strips of loosening surpass the grain boundaries. The diagram of the fatigue failure, which illustrates these 3 periods, here is represented schematically, i.e. in the coordinates tension vs. logarithm of the number N of the cycles. The meaning of the various lines in the diagram is shown. The

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of specific materials. Various phenomena occurring under specified conditions are studied and reported on. For details, see Table of Contents. The articles are accompanied by a number of references, both Soviet and non-Soviet.

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IVANOVA, V S.

PHASE I BOOK EXPLOITATION SOV/2836

18(7)

Oding, Ivan Avgustovich, Vera Semenovna Ivanova, Vladislav Vasil'yevich Burdukskiy, and Vladimir Nikolayevich Geminov

Teoriya polzuchesti i dlitel'noy prochnosti metallov (Theory of Creep and Long-Time Strength of Metals) Moscow, Metallurgizdat, 1959. 488 p. Errata slip inserted. 3,000 copies printed.

Sponsoring Agency: Akademiya nauk SSSR. Nauchnoy i tekhnicheskoy informatsii. Otdel tekhnicheskoy informatsii.

Ed. (Title page): I.A. Oding, Corresponding Member, USSR Academy of Sciences; Ed. (Inside book): G.V. Popova; Ed. of Publishing House: Ye.N. Berlin; Tech. Ed.: Ye. B. Vaynshteyn.

PURPOSE: This book is intended for scientific and engineering workers in the field of heat-resistant metals and alloys. It may also be useful to students at higher metallurgical and machine-building institutions.

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Theory (Cont.)

COVERAGE: The book contains recent information on the basic laws and mechanism of creep, relaxation and durability of metals. Special attention has been given to the processes which cause creep and relaxation and also to those which result in break-down of metals. The authors approach the problem of heat resistance on the basis of the contemporary theory of imperfections in real crystals. They describe all processes from the point of view of the theory of displacement and vacant places in the crystal space lattices. Academician G.V. Kurdyumov and Professor II. Kornilov are mentioned as having developed other investigative techniques in this field. Separate chapters of the book were written by: Ch. I by I.A. Oding and V.N. Geminov; Ch. II by I.A. Oding; Ch. III by I.A. Oding and V.S. Ivanova; Ch. IV by I.A. Oding and G.A. Tulyakov; Ch. V and Ch. VI by V.S. Ivanova; Ch. VII, VIII, and IX by I. A. Oding and V.V. Burdukskiy; Ch. X by V.N. Geminov. The authors thank Professor I.I. Kornilov and N.V. Grnm-Grzhimaylo, Doctor of Chemical Sciences. He also thanks laboratory workers: L.K. Gordiyenko, Yu.P. Liberov, Z.G. Fridman, T.S. Mar'yanovskaya, and S.Ye.

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Theory (Cont.)

Gurevich. There are approximately 400 references.

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Theory (Cont.)



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Theory (Cont.)



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APPROVED FOR RELEASE: 08/10/2001 CIA-RDP86-00513R000619230004-6"

ODING, I.A.; IVANOVA, V.S.; LIBEROV, Yu.P.

Role of the interface surface on the gradual failure in metals. Issl.po zharopr.splav. 4:3-12 '59. (MIRA 13:5)

(Crystal lattices) (Metallography)

05746

28 (5) SOV/32-25-10-35/63

AUTHORS: 1. Shklovskiy, Ye. I., Rodov, S. M., 2. Parnenkov, I. P., 3. Ivanova, V. S., Stepanov, V. N.

TITLE: News in Brief

PERIODICAL: Zavodskaya laboratoriya, 1959, Vol 25, Nr 10, pp 1240 - 1241 (USSR)

ABSTRACT: 1. For the insulation of resistance transmitters in hydraulic tests, the authors recommend the application of a mixture of technical vaseline + transformer oil in the ratio 2.5 : 1 at low temperatures and 4 : 1 at higher temperatures. The thickness of the insulating layer should amount to at least 2 to 3 cm. For the application of this insulation onto perpendicular surfaces a casting mold is used. The insulation was tested for several months at 25 at. and showed that the resistance between transmitter and surface does not change and does not influence the quality of the transmitter. 2. For the fastening of wire transmitters onto the metal surface to be tested the author uses the waste products of caprone production. The caprone tissue is cleansed from impurities, degreased in hot water, and is then dried (at 50 to 70°). The metal surface is also cleansed,

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after which it is heated by means of a burner to 235° (the melting point of caprone), the caprone tissue is laid on, and after the latter has melted, the wire transmitter is pressed on. After cooling and hardening of the caprone substance measurements may be carried out by means of the transmitter. If tests are carried out in a moist medium, also the transmitter is covered by the caprone tissue. 3. The authors carried out a number of tests in order to find out to what extent the tensions in the endangered cross section of the sample, which are produced by static bending tests, agree with those tensions acting in the case of vibrational stresses. In this connection a tensiometrical amplifier of the type TE-4-54 as constructed by the TsNIITMASh, a loop oscillograph of the type MPO-2 and electric resistance wire-paper-transmitters (90 Ohm resistance) are used. Samples of Armco iron, metalloceramic titanium and magnesium-aluminum alloys were subjected to static and dynamic stresses, and the functions "tension - bending -" are graphically represented (Figure). For iron and titanium the static stresses, with deflections being equal, are by 13% less than the dynamic stresses, whereas in the case of magnalium static stresses are higher by 20% than the dynamic ones. There are 2 figures.

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18 (7) SOV/20-127-1-22/65

AUTHOR: Ivanova, V. S.

TITLE: A New Law in the Fatigue Failure of Metals (Novaya zakonomernost' ustalostnogo razrusheniya metallov)

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 127, Nr 1, pp 86 - 89 (USSR)

ABSTRACT: The author assumes for the purpose of determining the rules governing fatigue failure that the work of plastic deformation used for the destruction of the sample is a constant quantity in the case of any stresses of the symmetric cycle exceeding the fatigue limit. If by $N_1$ the number of cycles is denoted at which submicroscopic cracks begin to form, the relation $R_\sigma(N - N_1)$ = const holds for the work of destruction in the case of a given $\pm \sigma$, where $R_\sigma$ denotes the average value of the work of plastic deformation per cycle. In an earlier paper the author showed that the curve $\sigma(N_1)$ is similar to the curve of Veler. As the process of fatigue failure is preconditioned by coagulation and by the depositing of vacancies at the ends of the sub-

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microscopic cracks, the work $R_\sigma$ may be estimated by proceeding from that work which must be applied to the motion of dislocations during $(N - N_i)$ cycles. For this purpose the author does not investigate the dependence of n on the absolute value of the critical stress $\tau$, but on its ratio to the fatigue limit (i.e. on $\tau/\tau_w$). The exponential law of the distribution of the sources of dislocations is here used in first approximation. After some deliberations the relation $(\sigma_k - \sigma_i) = \alpha$ = const is obtained. Here $N_i$ and $N_k$ denote the number of cycles at the stresses $\sigma_i$ and $\sigma_k$, $N_i$ - the number of cycles corresponding to the beginning occurrence of submicroscopic stresses at the stress $\sigma$; k is the criterion for the survival of the metal, and it illustrates to what extent the durability of the metal changes per unit of stress in the case of a variation of stress. The last written down relation means the following: In metals of the same nature, the difference between the stress causing fatigue failure at a given number of cycles and the stress at which, after this number of cycles, the formation of submicro-

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scopic cracks begins, is a constant quantity. This new constant is described as the constant of metal fatigue. Further, $N_w = N_1^w \exp(\alpha k)$ is found. Here $N_w$ denotes the number of cycles at which the fatigue curve goes over into its horizontal domain (at $\sigma = \sigma_w$), and $N_1^w$ - the number of cycles which correspond to the beginning of the formation of submicroscopic cracks at $\sigma = \sigma_w$. With other words: The number $N_w$ of the cycles at which the fatigue curve extends beyond the horizontal domain depends only on the criterion k of the durability of the metal. The dependence of $N_w$ on k is expressed in the coordinates $k - \ln N_w$ by a straight line. The relation $N_w = N_1^w \exp(\alpha k)$ agrees well with the data obtained by experiment. By using the fatigue constant of the metal it is possible to set up the new criterion of fatigue $\sigma_k = \sigma_w + \alpha$. Using this criterion makes it possible 1) to simplify the fatigue test and 2) to determine the beginning of the damaging of the metal. There are 3 figures and 16 references, 13 of which are Soviet.

A New Law in the Fatigue Failure of Metals SOV/20-127-1-22/65

ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR (Institute of Metallurgy imeni A. A. Baykov of the Academy of Sciences, USSR)

PRESENTED: March 13, 1959, by I. P. Bardin, Academician

SUBMITTED: March 5, 1959

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Ivanova, V.S.

PHASE I BOOK EXPLOITATION SOV/4375

Akademiya nauk SSSR. Institut metallurgii imeni A.A. Baykova

Ustalost' metallov; materialy soveshchaniya po ustalosti metallov 22-24 sentyabrya 1958 g. (Fatigue of Metals; Materials of the Conference on Fatigue of Metals, September 22-24, 1958) Moscow, 1960. 157 p. 3,500 copies printed.

Resp. Ed.: I.A. Oding, Corresponding Member, Academy of Sciences USSR; Ed. of Publishing House: A.N. Chernov; Tech. Ed.: I.N. Dorokhina.

PURPOSE: This collection of articles is intended for mechanical engineers, metallurgists, and scientific research workers.

COVERAGE: The collection contains discussions relating to fatigue failure of metals, fatigue in finished parts, and methods for testing endurance. Included are a critical review of existing theories on metal fatigue, some data on physical regularity patterns, and features of steel failure caused by fatigue. Possibilities for applying a new criterion to the notch sensitivity of metals and high-strength steels are investigated. The mechanism of failure due to

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corrosion fatigue of metals is discussed along with pertinent experimental data. Also presented are the results of testing the fatigue strength of such metal parts as large-size plates and various parts of machines used in the petroleum industry. Problems involved in testing metals for fatigue are examined. No personalities are mentioned. Each article is accompanied by bibliographic references, most of which are Soviet.

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NATURE OF FATIGUE FAILURE





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report presented at the 1st All-Union Congress of Theoretical and Applied Mechanics, Moscow, 27 Jan - 1 Feb '60.

102. J. Dvorak (Prague): The state of stress and deformation of the turbine blades.

103. V. M. Deev (Khartov): On some new forms of the general solution of the three-dimensional problem of the theory of elasticity expressed in harmonic functions.

104. A. A. Derkachev (Stalinabad): Generalisation of the method of steepest descent in structural mechanics.

105. B. V. Deriagin (Moscow), S. V. Nerpin (Leningrad): Surface phenomena in the mechanics of clays.

106. A. E. Desov (Moscow): Experimental data concerning the propagation of vibrations of different frequencies in concrete mixtures.

107. G. Iu. Dzhanelidze (Leningrad): Almansi's problem.

108. M. I. Dlugach (Kiev): A finite difference analysis of cylindrical shells with rectangular holes.

109. M. I. Dlugach (Kiev): Generalization of Mohr's method of determining the displacements in problems of the theory of elasticity.

110. M. D. Dolberg (Kharkov): The construction of solutions of the equations of structural mechanics by means of special uniformly convergent series.

111. L. G. Drapkin (Leningrad): A method of investigating the states of stress and strain and the slip lines in anisotropic multilayer metals.

112. A. V. Diatlov (Dnepropetrovsk): The stability of an obliquely bent beam.

113. L. I. Diatlovitskii, L. B. Rabinovich (Kiev): A problem concerning elastic bodies whose configuration changes in the course of loading, with application to the erection of structures.

114. P. D. Evdokimov (Leningrad): On the shear strength of structural rock foundations.

115. P. D. Evdokimov (Leningrad): On friction in sandy soils and their shear strength.

116. K. E. Egorov (Moscow): The deformation of the ground under an annular foundation.

117. S. S. Eletskii (Moscow): On stresses and strains of thin-walled rods of variable cross section at normal and elevated temperatures.

118. Zh. S. Erzhanov (Dnepropetrovsk): Determination of the pressure on a tunnel facing taking account of the hereditary creep of soils.

119. Zh. S. Erzhanov (Dnepropetrovsk): The integral operator method of determining the creep characteristics of soils from observations in situ.

120. E. F. Ershov (Gorki): The elastic-plastic bending of a bar.

121. A. M. Zhukov (Moscow): Elastic properties of a plastically deformed metals under combined loading.

122. F. A. Zhuravlev, A. F. Zakharevich, N. P. Repnikov (Leningrad): Application of the method of characteristics to the determination of the tension in the cable of a mine elevator.

123. R. A. Zadoian (Erevan): On the propagation of plastic zones in a beam under impulsive loading.

124. L. I. Zaitsev (Moscow): On the surface-head-wave.

125. S. V. Zvezdov, Zh. N. Kats (Leningrad): An experimental study of creep-rupture characteristics of tubes under combined stresses.

126. N. V. Zvolinskii (Moscow): The propagation of an elastic wave due to an underground explosion.

127. A. E. Zelenin (Moscow): On the state of stress in compression and its effect on the construction of Mohr's circles.

128. V. K. Zilova, Ia. B. Fridman (Moscow): The laws of deformation and rupture kinetics.

129. P. L. Ivanov (Leningrad): Flow of water-saturated soils under dynamic loading

130. V. S. Ivanova (Moscow): The hypothesis of energetic similarity in fatigue fracture and the melting of metals.

131. D. D. Ivlev (Voronezh): On the anisotropy of elastic and plastic bodies.

132. L. M. Isotov, Iu. I Iagi (Leningrad): Plastic tension and torsion of thin-walled nickel tubes that have become anisotropic through prior plastic deformation.

133. Iu. N. Ilenko, B. N. Sokolov (Moscow): Investigation of elastic strains and vibrations in aircraft structures by means of electronic computers.

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S/180/60/000/01/013/027
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AUTHOR: Ivanova, V.S. (Moscow)

TITLE: Interpretation of Fatigue of Metals in Terms of Energy and Structure

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, Nr 1, pp 93-100 (USSR)

ABSTRACT: It has been previously shown by the present author (Ref 1) that the process of fatigue (under the conditions of a symmetrical loading cycle) should be regarded as comprising three stages: I - incubation period; II - period in which the sub-microscopic cracks develop to microscopic size; III - period during which microscopic cracks become macroscopic fissures. The demarcation lines between these three stages on a fatigue diagram are shown in Fig 1, where the line ABC is the fracture curve, line A'B'C' corresponds to the start of the formation of sub-microscopic cracks, and line A'C indicates the start of the formation of micro-cracks. Consequently, the following new criteria of the fatigue failure have been established: (1) critical number of reversals ($N_k$) - the number of reversals at which

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irreversible lattice defects (sub-microscopic cracks) begin to appear in the specimen under the limiting stress; (2) critical fatigue stress ($\sigma_k$) - the stress under which fracture occurs after $N_k$ reversals; (3) cyclic constant of fracture ($\alpha$), the numerical value of which is equal to the difference between the critical fatigue stress and the limiting stress, expressed in terms of the tangential stresses, i.e. $\alpha = \tau_k - \tau_w$; (4) limiting number of reversals ($N_w$) - the number of reversals at which fracture will occur in the metal subjected to the minimum stress, required to cause the fatigue failure; (5) cyclic elasticity limit ($\sigma^{4}_{e}$) - the maximum stress which, irrespective of the number of reversals, will not produce irreversible changes in the crystal lattice; (6) endurance coefficient of the metal (k), characterizing the extent to which the life of the specimen changes when the cyclic stress is varied by a unit stress; it is equal to the tangent of the angle of slope of the $\sigma$ versus ln N curve. It can be inferred from the fatigue diagram that the total specific work of fracture, $R_{total}$,

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(per unit volume of the fractured material) consists of: (1) specific work of elastic deformation, A, done to produce the distortion of the crystal lattice during the incubation period; (2) specific work of plastic deformation, R, done during the II-nd and III-rd stages to destroy the interatomic bonds in the critically distorted lattice. If it is assumed that, under the conditions of cyclic loading, both $R_{total}$ and A and R are constant and independent of the amplitude of the applied stress, then $R_{total}N$ = const = C, and

$$A_\sigma(2N_1) = const = C_1 \quad (1)$$

$$R_\sigma[2(N - N_1)] = const = C_2 \quad (2)$$

where: A - mean specific work of elastic deformation at a given amplitude of the stress in a half-cycle; R - mean specific work of the plastic deformation at a given amplitude of the stress in a half-cycle; $N_1$ - number of reversals, corresponding to the end of the incubation period (line A'B'C', Fig 1); N - total number of

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reversals to fracture (line ABC). Solution of Eq (2), obtained previously by the present author (Ref 3), made it possible to combine the criteria, listed above, in the following expression:

$$N_W = N_k e^{ak}.$$

The k versus ln N relationship (see Fig 2) is represented by a straight line; the point at which it intersects the axis of abscissae gives $N_k$, while $a$ is given by tg $\varphi$. The validity of this relationship was confirmed by the results of analysis of about 40 fatigue curves, determined on specimens of various shapes for wrought and cast iron and carbon and alloy steels; at the same time, it was possible to establish that in the case of these materials $a = 3$ kg/mm² and $N_k = 20.10^4$ reversals. The object of the present investigation was to establish, by analytical means, a dependence of $a$ and $N_k$ on certain physical constants of the metals; if such a relationship can be established, the duration of the fatigue tests could be considerably reduced. One of the

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possible ways of approaching this problem was to correlate the energy expended on elastic deformation of the crystal lattice and destruction of the interatomic bonds during cyclic loading with that required to produce the same effect by other means, e.g. by heating. The energy, required to convert the metal from solid to liquid state, is expended on: (1) distortion of the crystal lattice during heating from absolute zero to the melting point, this energy (Q) being given by $Q = C_p T_s$, where $C_p$ - mean specific heat of the metal, and $T_s$ - its melting point (°K); (2) energy, expended on the destruction of the interatomic bonds (process of melting) and equal to the latent heat of fusion, $L_{пл}$). Although the mechanisms of melting and mechanical fracture are different, it can be postulated that they are equivalent in terms of energy, in which case Eqs (1) and (2) become:

$$A_\sigma (2N_1) = C_p T_s \tag{3}$$

$$R_\sigma [2(N - N_1)] = L_{пл} \tag{4}$$

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Having determined $A_\sigma$ and $R_\sigma$, the author arrived at the sought formulae in the form of:

$$N_k = C_p T_s E A_\gamma . \frac{1}{\beta^2} \qquad (7)$$

$$\alpha = \beta \sqrt{\frac{L_{\Pi \Pi}}{C_p T_s} \cdot \frac{G}{E}} \qquad (11)$$

where: E - elastic modulus; A - mechanical heat equivalent; $\gamma$ - specific gravity of the metal; $\beta = \sigma_W - \sigma_e'$ ; G - shear modulus. With the exception of $\beta$, all the physical constants, appearing in Eqs (7) and (11), are known. Since, however, it has been established that in the case of iron and its alloys $N_k = 20.10^4$, and since all other constants in Eq (7) are known, the value of $\beta$ could be calculated from this equation, and was found equal 8.5 kg/mm$^2$. Thus, if it is assumed that, in the first approximation, $\beta$ is constant for all metals, both $N_k$ and $\alpha$ can be easily calculated for any given metal. The results of such calculations, carried out for

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18 metals, are given in Table 1, showing: name of the metal; $L_{пл}$, cal/g - latent heat of fusion; $C_p$, cal/g degree; $t_s$, °C - melting point; G, kg/mm²; E, kg/mm²; γ, g/cm³; $L_{пл}$ $G/C_pT_sE$; α, kg/mm²; $N_k.10^{-4}$. It will be seen that α varied very little from metal to metal, its maximum and minimum values being 3.5 and 3.0 kg/mm², respectively. As was to be expected, the magnitude of $N_k$ varied within wide limits, namely between $1.10^4$ and $56.10^4$ reversals. To check the validity of the derived formula, the author, using various fatigue curves obtained by other workers, determined the critical stress, $\sigma_k$, corresponding to $N_k$ reversals, as quoted in Table 1. The difference between $\sigma_k$ and the endurance limit (expressed in terms of the tangential stresses) gave the magnitude of α. The results, obtained in this manner for iron, aluminium, titanium, and magnesium alloys, are given in Table 2, under the following headings: number of the alloy (Nrs 1-18, iron and its alloys, Nrs 19-30 aluminium alloys, Nrs 31-38 titanium and its alloys, Nrs 39-45 magnesium alloys); grade and chemical

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composition; $N_k.10^{-4}$; $\sigma_k$, kg/mm$^2$; $\sigma_w$, kg/mm$^2$; experimental value of $\alpha' = (\tau_k - \tau_w)$, kg/mm$^2$; calculated $\alpha$, kg/mm$^2$; fatigue testing conditions; source. The calculated and experimental values of $\alpha$ are in good agreement, in spite of the fact that the former were determined for pure metals, the latter for alloys. This is explained by the fact that $\alpha$ is determined by the ratio $L_{\text{пл}} G/C_p T_s E$ which is only slightly affected by changes in the chemical composition. $N_k$ is more sensitive to the changes in the composition of the alloy and (since the values of $N_k$, determined for pure metals, were used for calculating $\alpha$ for various alloys) this probably accounts for the rather large discrepancy between $\alpha'$ and $\alpha$ of alloys Nrs 36, 44, and 45. In all other cases, the values of $\alpha'$ and $\alpha$ were close enough to conclude that the values of $\alpha$ and $N_k$, given in Table 1, can be used to determine the endurance limit (by the method described by the present author in Ref 3) not only for pure metals but also for their alloys, as long as the

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alloying elements are characterized by physical properties similar to those of the base metal. The results of the present investigation proved that the magnitude of the energy required to produce a critical degree of elastic deformation per unit volume, and the energy required to destroy the interatomic bonds in the lattice, strained to the critical point, are independent of the form in which the energy is supplied and are determined only by the nature of the metal.
There are 2 figures, 2 tables and 17 references, of which 5 are Soviet, 2 French, 1 German and 9 English.

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ASSOCIATION: Institut metallurgii imeni A.A. Baykova, AN SSSR (Metallurgical Institute imeni A.A. Baykov, Acad.Sci. USSR)

SUBMITTED: July 9, 1959

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75134
SOV/129-60-3-13/16

AUTHORS: Kornilov, I. I., Ivanova, V. S.

TITLE: At the International Symposium on Problems of Developing Heat-Resistant Materials

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1960, Nr 3, pp 58-60 (USSR)

ABSTRACT: An International Symposium on the above problems was initiated by the Learned Council of the Czechoslovakian Scientific and Technical Society (Nauchnyy sovet Chekhoslovatskogo nauchno-tekhnicheskogo obshchestva). It took place at Marianske Lazne (Czechoslovakia) from September 11 to 13, 1959. Seventy scholars from Czechoslovakia, the USSR, the German Democratic Republic, France, Switzerland, Australia, Belgium, Sweden, China, Poland, Austria, and England participated in the Symposium. The Soviet Union was represented by the authors as well as by M. V. Pridantsev, (Professor and Doctor of Technical Sciences) and A. I. Chizhik (Candidate of Technical Sciences). The agenda included such subjects as (1) creep theory

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and stress-rupture; (2) low-alloy and modified stainless heat-resistant steels; (3) austenitic steels; (4) heat-resistant and special alloys; (5) modern methods of developing heat-resistant alloys; and (6) control and evaluation methods to determine the applicability of heat-resistant materials. The Soviet scholars submitted the following reports: I. I. Kornilov, "Basic Types of Composition vs Heat-Resistance Diagrams"; I. A. Oding, V. S. Ivanova, and Yu. P. Liberov, "Effect of Parting Plane Surfaces on Protracted Failure of Metals"; M. V. Pridantsev, "Problems of Steel and Alloy Heat-Resistance." The papers and discussions of the symposium are published in a supplement to the Journal Hutnicky Listy, Nr 12 (1959).

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S/129/60/000/04/006/020
E073/E535

AUTHOR: Ivanova, V.S., Candidate of Technical Sciences

TITLE: Mechanism of Plastic Deformation in the Case of Cyclic Loading

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1960, No 4, pp 30, 35-37 + 1 plate (USSR)

ABSTRACT: The process of plastic deformation as a result of cyclic stresses has much in common with plastic deformations caused by static loads, in spite of the fact that in the first case no changes in shape can be observed on a macroscopic scale. For static loads there are about eleven possible types of plastic deformation which, according to I. A. Oding (Ref 1), can be sub-divided into the following three groups: slip processes caused by the movement of dislocations, diffusion processes activated by heating, peripheral processes connected with displacements of grains or blocks along their boundaries. Each of these groups of processes is discussed. Microstructure investigations indicate that

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even during cyclic loading the plastic deformation in metals can consist of slip, diffusion and peripheral processes.

There are 7 figures and 11 references, 7 of which are Soviet, 1 French and 3 English.

ASSOCIATION: Institut metallurgii AN SSSR (Institute of Metallurgy, Ac. Sc., USSR)

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E073/E135

AUTHORS: Ivanova, V.S., Oding, I.A., and Fridman, Z.G. (Moscow)

TITLE: Certain Relations Governing Long-Life Strength

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, No.5, pp.33-37

TEXT: In earlier work of the authors and their team (Refs 1-5) a new criterion of high temperature strength was established, namely, the "plasticity resource" $\varepsilon_r$, determined as the time to failure $t_1$ for a given constant stress $\sigma_1$ and an average creep speed $V_1$

$$\varepsilon_r = V_1 T_1 \qquad (2)$$

Assuming that for a given component during service life $t_s$, total deformation $\varepsilon_{tot}$ is permissible and the plasticity resource is $\varepsilon_r$, the remaining reserve plasticity resource will be

$$K_\varepsilon = \frac{\varepsilon_r}{\varepsilon_{tot}} \qquad (3)$$

By carrying out the strength calculations on the basis of the

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plasticity resource, the plastic properties of the metal can be better utilised and, consequently, higher creep speeds and higher rated stresses are permissible. However, calculations of the strength reserve on the basis of $\varepsilon_r$ are difficult in cases in which the metal under consideration has a low plasticity resource. In this case the variance in experimental data makes accurate calculation difficult and prone to dangerous errors. In this paper another criterion is proposed for establishing the reserve strength of machine parts operating at elevated temperatures. The basic idea consists in selecting as the strength criterion the work required for failure C, assuming that it is a constant value and does not depend on the magnitude of the applied stress. Depending on the magnitude of stress and the duration of stress application, various degrees of damage may occur; if the same work C' is spent, the same degree of damage will be achieved for a given metal with various stresses and service durations. Then, the reserve strength until failure C will equal

$$K_c = \frac{C}{C'} \quad (4)$$

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If the work of a single dislocation is expressed by $r$, a stress $\sigma$ will produce $e^{\beta\sigma}$ dislocations in the avalanche. The total number of avalanches required for the metal to fail will be

$$t = \frac{C}{kr \exp(\beta\sigma)} \qquad (8)$$

At present no data are available which would permit establishing accurately the work until failure $C$ during creep. However, it is shown in the paper that, assuming that the work until failure is a constant value, the line of equal damage of a given alloy is equidistant to the line of failure. Experimental results reproduced in the graph, Fig.3, for several steels and some other alloys indicate that in all cases the lines of proneness to damage are parallel to the lines of failure. Thereby, as the proneness to damage the authors assume that point on the creep curve which corresponds to the beginning of the third section, 18 the section of the curve with increasing creep speed. The theoretically established fact that all the lines of proneness to damage are parallel to the failure lines have been confirmed

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experimentally. Therefore, a very simple method is proposed of determining the coefficient of reserve working ability of the metal $K_c$, which can be expressed as the reserve service life for a given stress and can also provide a possibility of calculating the strength reserve from the reserve of service life. Structures in which the metal has an equal proneness to damage will possess equal strength reserve values. The distance between the lines of equal proneness to damage from the failure lines will differ for various metals, depending on the intensity of accumulation of damage. The proneness to damage of the metal can be expressed as the ratio of the past service time at a given stress to its service life until failure at the same stress. The here proposed method is more justified than the current method of calculating the coefficient of strength reserve, which is based on a constant stress reserve for any given service life. There are 3 figures and 9 references: 8 Soviet and 1 English.

SUBMITTED: July 6, 1960

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18.8200

AUTHOR: Ivanova, V. S.

TITLE: Accelerated Method for the Determination of the Fatigue Limit From the Critical Fatigue Stresses

PERIODICAL: Zavodskaya laboratoriya, 1960, Vol. 26, No. 5, pp. 593-598

TEXT: At cyclic tensile loads the test material passes 3 phases up to the fracture. Elastic deformations in the crystal lattice develop during the initial phase, submicroscopic cracks during the second phase (beginning of the fracture, fatigue period II - period of loosening) and only during the third phase the fracture itself (fatigue period III). These periods can be illustrated in a generalized fatigue diagram (Fig. 1). New fatigue criteria are calculated in the case in question on the basis of this diagram. These criteria are connected with the physical constants of the metal in the following two equations:

$$\alpha = \tau_c - \tau_w = \beta\sqrt{\frac{L_{melt}}{C_p \cdot T_S}} \cdot \frac{G}{E} \quad (1)$$

($\alpha$ = cyclic fracture constant,

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Accelerated Method for the Determination of the Fatigue Limit From the Critical Fatigue Stresses

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$\tau_c$ = critical stress, $\tau_w$ = stress corresponding to the fatigue limit, $L_{melt}$ = latent melting heat, $C_p$ mean specific heat of the metal, $T_S$ = = absolute melting temperature, G = modulus of rigidity, E = modulus of elasticity, $\beta$ = constant of the metals = 8.5 kg/mm$^2$ (Ref. 2)) and $N_c = C_p \cdot T_S \cdot E \cdot \gamma \cdot A \cdot \frac{1}{\beta^2}$ (2) ($N_c$ = critical number of cycles, A = mechanical heat-equivalent, $\gamma$ = specific weight). The values calculated for $N_c$ and $\alpha$ are given in Table 1 for 18 pure metals. A study of 70 experimentally obtained fatigue curves mentioned in publications showed that the calculated $N_c$ and $\alpha$ values agree well with the experimental data. By using the new fatigue criteria $N_c$ and $\alpha$, the duration of the fatigue test can be reduced to one hundredth compared with the usual method. Some test samples only must be brought to fracture at a lower number of cycles than $N_c$ and at a somewhat higher number of cycles than $N_c$, in order to be able to record the dependence diagram $\sigma$, lnN and to interpolate the value $\sigma_c$ ($\sigma_c$ = critical fatigue stress). The applicability

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of the method described is illustrated on examples of fatigue tests on copper and aluminum-magnesium alloys, as well as aluminum alloys of type V95, test data by S. V. Serensen et al (Ref. 5) having been applied in the last case. The fatigue tests on copper were carried out by S. Ye. Gurevich at the Institute of the author. The values of the fatigue criteria for copper (Table 2) as well as for aluminum-magnesium alloys (Table 3, of type AMg6T, AMg, AMg5V, and AMg3) are given. It was established that the values for $N_c$ and $\alpha$ at samples with a diameter of up to about 20 mm do not depend on the dimension of the sample, and samples of a diameter of up to 20 mm are therefore to be used in order to obtain reliable results according to the method described. If there is no physical fatigue limit, the method described cannot be applied. There are 4 figures, 3 tables, and 8 references, 6 of which are Soviet.

ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR (Institute of Metallurgy imeni A. A. Baykov of the Academy of Sciences, USSR)

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18.8200

03305

S/032/60/026/010/016/035
B016/B054

AUTHOR: Ivanova, V. S.

TITLE: Determination of the Line of Damage of Metals in Fatigue

PERIODICAL: Zavodskaya laboratoriya, 1960, Vol. 26, No. 10, pp. 1136-1139

TEXT: The author criticizes the widely used method of determining the line of damage (liniya povrezhdayemosti) by H. I. French (Ref. 1) and H. F. Moor (Ref. 2). In the author's opinion, it would be more correct to estimate the mentioned line on the basis of stress values and the corresponding number of cycles at which submicroscopic cracks begin to form. It is known that irreversible metal damages are due to these processes. Submicroscopic cracks are formed in the metal not immediately after the application of a cyclic stress but only after attaining a certain number of cycles. This number is the larger, the smaller the stress (Refs. 5-7). Submicroscopic cracks may develop into micro- and macrocracks after attaining a certain number of cycles, if the stress applied is higher than the fatigue limit. Otherwise, submicroscopic cracks are formed which, however, do not develop into microcracks so that no destruction occurs. The line of formation of submicroscopic cracks, or the line cor-

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responding to the beginning of shearing processes is the line of the beginning of metal damages. It is parallel to the line of destruction (Refs. 6, 7). If a metal is subjected to cyclic overstress at a certain stress level and with a number of cycles not exceeding the limit, this type of overstress is not dangerous. In this case, submicroscopic cracks have not sufficient time to form. The author explains the determination of the fatigue diagram, taking account of the rules governing the fatigue process which were found on the basis of the hypothesis of energetic similarity of destruction by fatigue and of melting. This hypothesis permitted an analytical relationship to be determined between fatigue limit and physical constants of metals. The theoretical analysis and experimental investigations (Ref. 9) proved that the difference ($\alpha$) between the critical fatigue stress, expressed in tangential stresses, has a constant value for all metals. It is 3 kg/mm$^2$ for ferrous metals, and 3.5 kg/mm$^2$ for nonferrous metals. Taking account of the fact that the curve for the beginning of formation of submicroscopic cracks is similar to the curve for destruction (Refs. 6, 7), it is possible to determine the line of damage for the respective metals without any additional experiment. There are 3 figures and 12 references: 6 Soviet, 4 US, 1 French, and

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ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR (Institute of Metallurgy imeni A. A. Baykov of the Academy of Sciences, USSR)

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89635

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S/509/60/000/004/013/024
E193/E183

AUTHOR: Ivanova, V.S.

TITLE: Localization of Plastic Deformation of the I-st and II-nd Type in Polycrystalline Metals

PERIODICAL: Akademiya nauk SSSR. Institut metallurgii. Trudy, No.4, 1960. Metallurgiya, metallovedeniye, fiziko-khimicheskiye metody issledovaniya, pp.158-169

TEXT: Although the problem of non-uniformity of plastic deformation in polycrystalline metals has been extensively studied, few attempts have been made to investigate this effect quantitatively. No method of measuring the degree of non-uniformity has been developed, and it is not yet possible to correlate quantitatively non-uniformity of plastic deformation in microvolumes of a metal with the process of plastic flow and strength of metals. For this reason the present investigation was undertaken, its object being to study localization of plastic deformation of the I-st and II-nd type. The localization of plastic deformation of the I-st type is defined as that which occurs during the initial stage of plastic deformation when all

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the microvolumes of metal are not deformed simultaneously, plastic deformation spreading across the metal in jumps. Metal deforms plastically in this manner until the degree of deformation in all microvolumes has reached a critical level, after which plastic deformation takes place simultaneously in all microvolumes, although the degree of deformation attained in the various microvolumes is different. This effect is defined as localization of plastic deformation of the II-nd type. The fact that the deformation of a metal within the yield ledge proceeds in jumps has been established by the present author (Refs.9, 10), who studied this process on flat, polished specimens of Armco iron, extended at normal rates of strain (0.02 mm/sec). On reaching the yield point, the movement of the Chernov--Luders' lines was studied with the aid of a cine-camera, operated at a speed of 16 frames/sec. The results are reproduced in Fig.1, where the displacement of the deformation front ($\Delta \ell$, mm) is plotted against number of frames for specimens in which deformation proceeded (a) from one end only

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and (b) from both ends. It will be seen that the Lüders' lines moved in jumps of 0.7 mm at a speed which exceeded 11 mm/sec. This effect has been confirmed by other workers (Refs.12, 14, 15, 16). The discontinuous nature of the plastic deformation of the I-st type having thus been established, the next problem was to determine the degree of deformation in the microvolumes deformed in this manner. This has also been done by the present author (Refs.9, 10) with the aid of the following technique: the gauge lengths (60 mm) of flat, polished Armco iron specimens were marked at approximately 10 mm intervals, so that each gauge length was divided into six equal parts. The specimens were then extended to produce various residual strains, and the displacement of the markers on the test piece after each test was measured with the aid of a horizontal comparator. The results are reproduced in Fig.2, which, on the left, shows a stress ($\sigma$, kg/mm$^2$)-strain ($\varepsilon$, %) diagram of the material tested, and on the right, the distribution of plastic deformation in five specimens which have

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been stressed to give the following mean residual strain: I - 0.1%; II - 1.6%; III - 2.0%; IV - 2.5%; V - 3.9%. The unshaded and shaded areas relate to the elastically and plastically strained parts of the gauge length, the figures by each microvolume of the specimen giving the magnitude of residual strain in that microvolume. The moment at which the stress was removed from each specimen is indicated by points I-V on the stress-strain diagram. The results reproduced in Fig.2 prove conclusively that the deformation of metal within the yield ledge of the stress-strain curve is invariably of localized and discontinuous nature. A metal, stressed beyond the yield point, deforms in this fashion until all microvolumes of the specimen attain the critical degree of deformation whose magnitude depends on the same factors which determine the length of the yield ledge, i.e. on the grain size, previous heat treatment, rate of strain employed, etc: in specimens to which the results shown in Fig.2 relate, this critical degree of deformation amounted to 2.5%.

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The specific features of plastic deformation discussed above are associated with the fact that in metals, characterized by a well-defined yield ledge, the initial stage of plastic deformation consists mainly in relative movement of the individual grains, whereas slip within the grains plays a predominant part only if all microvolumes have attained the critical degree of deformation. This view is supported by the results obtained by the present author (Refs.9, 10) who has found that microhardness of Armco iron stressed to attain the critical degree of deformation (2.5%) was hardly affected by this treatment, the average microhardness number in the interior and at the periphery of the grains being, respectively, 102.8 and 100 before, and 108.6 and 109.0 after deformation. Since deformation by slip is always accompanied by work-hardening, this proved that a different mechanism of deformation was operating. On the other hand, it has been found that hardness, measured at the periphery of the grains in specimens deformed to the critical degree of deformation, increase

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after ageing, being 120 and 132 after 1 and 5 hours ageing, respectively, the corresponding figures for the interior of the grains being 108.6 and 102.8. Since age-hardening should take place in the region of maximum distortion of the crystal lattice, the data quoted in the previous paragraph indicate the presence of lattice distortions in the peripheral regions of the grains, and prove again that relative movement of the grains is the dominant mode of plastic deformation in the initial stages of this process. The interesting fact is that the localization of plastic deformation of the I-st type is a characteristic common for all metals, irrespective of whether or not the yield ledge is shown by the stress-strain diagram of a given metal. However, in the absence of the yield ledge, the critical degree of deformation is relatively low, amounting to about 0.2%. Examples of localized deformation of the I-st type are given in Figs. 3 and 4, which show the distribution of plastic deformation on specimens of steels ЭЯ -1Т (EYa-1T) and ЭИ -454 (EI-454) respectively.

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Localization of Plastic Deformation of the I-st and II-nd Type in Polycrystalline Metals

In this case, the gauge length (50 mm in the former and 200 mm in the latter steel) was also divided into equal parts approximately 10 mm long and the degree of plastic deformation (ε, %) of each part is shown on the respective graphs. The unshaded and shaded blocks in Fig.3 relate, respectively, to specimens stressed to attain the mean residual strain of 0.16 and 0.21%. The mean residual strain in specimens of steel EI-454 (Fig.4) was 0.05%; it will be seen that in the case of this steel, parts 2, 4, 5, 6, 10, 12, 14, and 15 of the gauge lengths did not deform plastically at all. The presence or absence of the yield ledge on the strain-stress diagram depends on the ratio of the resistance to shear in the interior of the grains to that in their peripheral regions. If the resistance to shear near the grain boundaries is less than that in the interior of the grains, the I-st stage of plastic deformation is associated with the movement of grains relative to each other. If the interior of the grains has lower resistance to shear, the initial stage of deformation is associated with both

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relative movement of the grains and slip within the grains, the latter mode of deformation causing work-hardening of the metal. Consequently, metals which work-harden readily will have low critical degree of deformation and vice versa, which means that there is a definite relationship between these two properties. This postulate was confirmed by constructing an experimental graph D' versus $\varepsilon_{crit}$, where $\varepsilon_{crit}$ is the critical degree of deformation (%), and D' is the relative modulus of work-hardening defined as the $\sigma_{0.4}/\sigma_t$, $\sigma_t$ and $\sigma_{0.4}$ denoting the yield point and the stress corresponding to mean residual strain of 0.4%, respectively. The graph is reproduced in Fig.5, the experimental points (from left to right) relating to steels EI-454, EYa-1T, EI-395, AK-4, 30, 20, and Armco iron. The degree of localization of plastic deformation of the II-nd type was studied in the following way. The gauge length of a test piece (10 mm in diameter, 200 mm long) was marked at equal intervals (10 mm) by diamond pyramid indentations, the test piece was then stressed in

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tension, and the distance between the markers was periodically measured after removing the test piece from the testing machine. Fig.6 shows the distribution of deformation ($\varepsilon$, %) across the gauge length of a test piece of steel EI-454, extended at room temperature. The numbers under the horizontal axis indicate the numbers of the segments of the gauge length, the height of the blocks giving the magnitude of $\varepsilon$, and blocks 1-7 relating to specimens stressed to attain mean residual strain of 0.21%, 1.0%, 1.78%, 1.87%, 2.4%, 3.28% and 4.2% respectively. The distribution of deformation in a specimen of the same steel tested at 625 °C is shown in a similar way in Fig.7, and it will be seen that at the elevated temperatures the localization of deformation of the II-nd type is much more pronounced. Regarding the degree of localization of deformation of the II-nd type, it can be expressed either by $\ell_{cp} = \varepsilon_{max}/\varepsilon_{cp}$, where $\varepsilon_{max}$ is the maximum local deformation and $\varepsilon_{cp}$ is the mean residual strain of the whole specimen, or by $\ell_{max} = \varepsilon_{max}/\varepsilon_{min}$, where $\varepsilon_{max}$

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Localization of Plastic Deformation of the I-st and II-nd Type in Polycrystalline Metals

and $\varepsilon_{min}$ are the maximum and minimum local deformations, measured on a given specimen. $\rho_{cp}$ characterizes the degree of homogeneity of the plastic properties of the material ($\rho_{cp} = 1$, corresponding to material perfectly homogeneous in this respect), whereas $\rho_{max}$ indicates to what extent the plasticity of the metal has, owing to some reason or other, been reduced in a micro-volume of the metal. In other words, $\rho_{max}$ is a criterion of the quality of the metal, i.e. an indication whether or not imperfections are present in the material. $\rho_{cp}$, on the other hand, gives the measure of the non-uniformity of the plastic properties of a component regarded as a whole, making it possible for the designer to predict to what extent the performance of the components in service will be affected by imperfections in the metal. Analysis of the numerical values of [illegible] max and $\rho_{cp}$ for various metals has shown that in some metals (Armco iron, steel EYa-1T), $\rho_{cp}$ decreases with increasing $\varepsilon_{cp}$, whereas in others (steel EI-454) $\rho_{cp}$ is independent of $\varepsilon_{cp}$ and remains

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S/509/60/000/004/013/024
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Localization of Plastic Deformation of the I-st and II-nd Type in Polycrystalline Metals

constant until necking begins to take place. In the case of Armco iron and steel EYa-1T, $\ell_{max}$ also decreases with increasing $\varepsilon_{cp}$, but in a more irregular manner; (for specimens of this steel deformed to $\varepsilon_{cp} = 1\%$, $\ell_{max}$ can vary between 5 and 10, whereas at higher values of $\varepsilon_{cp}$, $\ell_{max} = 2.4-1.2$). The magnitude of $\ell_{cp}$ and $\ell_{max}$ can also be used to assess the quality of a metal. If, for instance, a metal has been subjected to incorrect heat treatment which has caused large variation in the grain size, both $\ell_{cp}$ and $\ell_{max}$ sharply increase. The results of the present investigation indicate that mean degree of deformation (i.e. elongation determined by the standard tensile test) is not a true criterion of the plastic properties of microvolumes of the metal, and that these properties can be fully determined only by determining $\ell_{cp}$ and $\ell_{max}$ whose magnitude may be considerably affected by the conditions of testing.
There are 8 figures, 2 tables and 19 references: 17 Soviet and 2 English.

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Localization of Plastic .....

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E193/E183

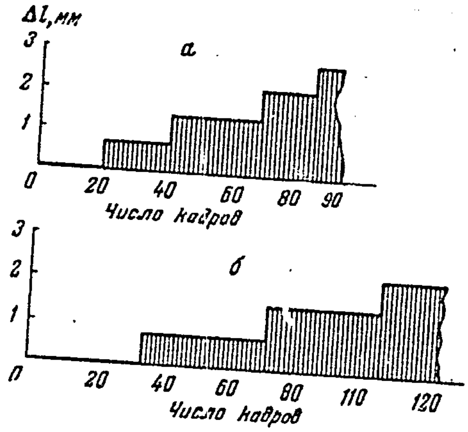


Рис. 1. Скачки пластической деформации

Fig. 1

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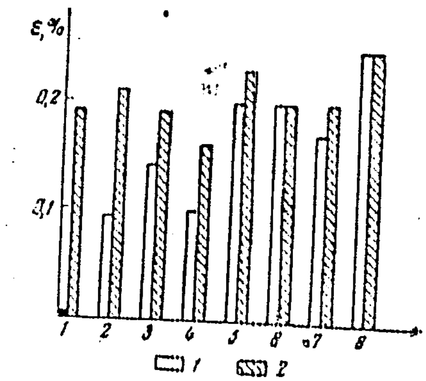


Fig. 3

Localization of Plastic .....

S/509/60/000/004/013/024
E193/E183

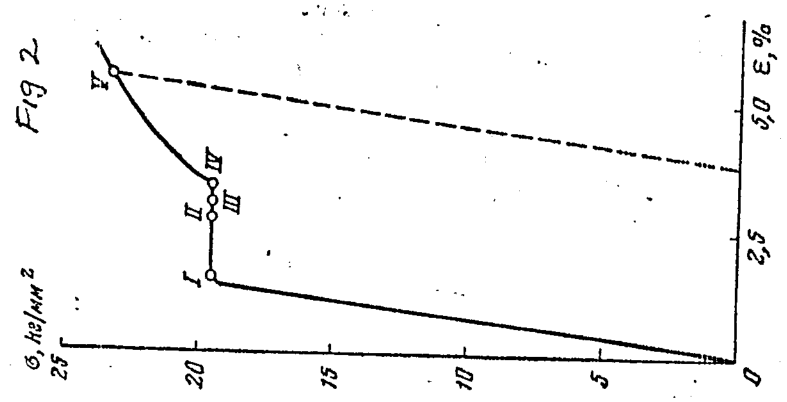


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Fig.2

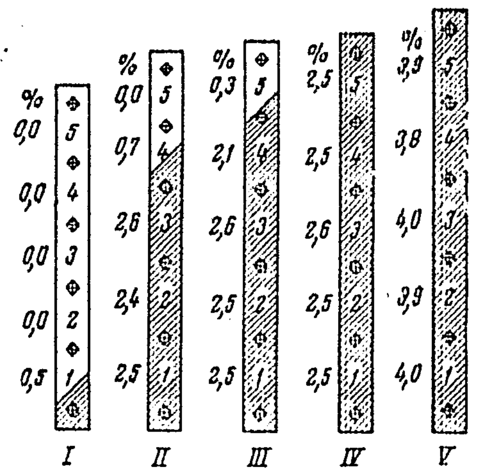


Fig. 2 continued.

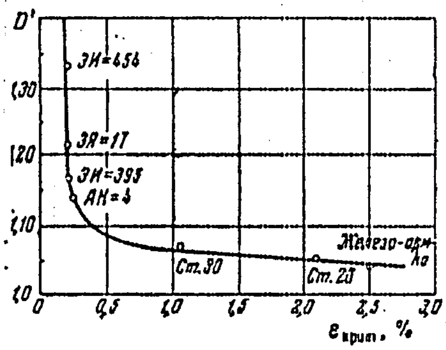


Рис. 5. Зависимость степени упрочнения

Fig. 5

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Localization of Plastic ..... S/509/60/000/004/013/024
E193/E183

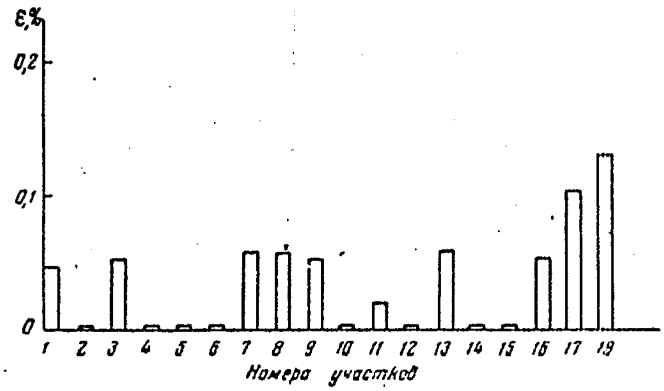


Fig. 4

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Localization of Plastic .....

S/509/60/000/004/013/024
E193/E183

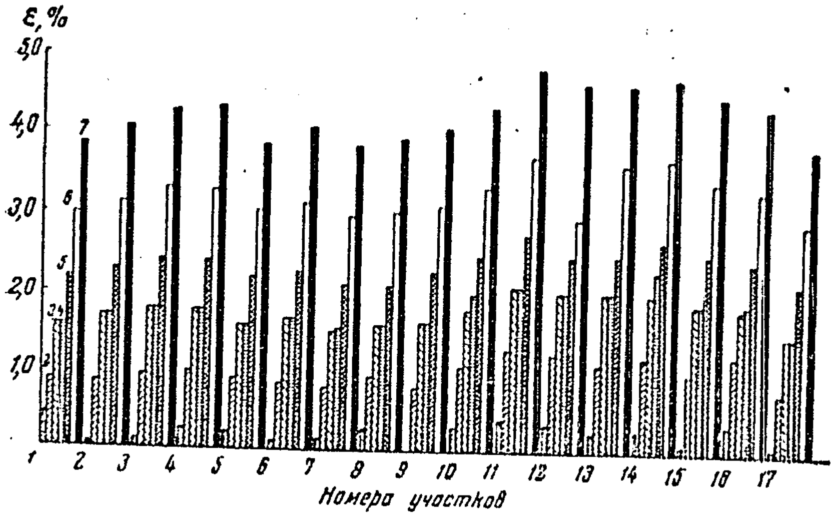


Fig. 6

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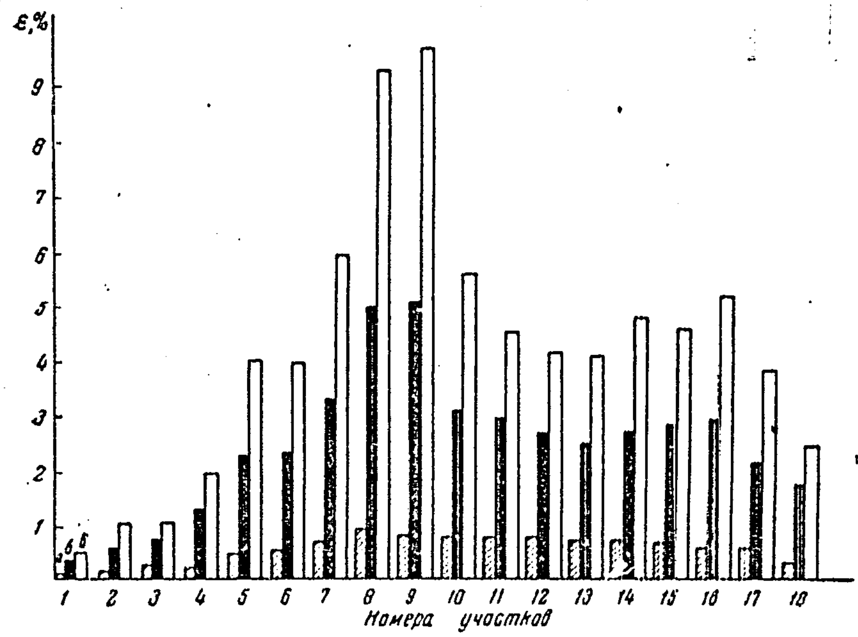
Localization of Plastic ......

S/509/60/000/004/013/024
E193/E183

Fig.7




Card 18/18

IVANOVA, V. S.

Doc Tech Sci - (diss) "Structural-energy theory of metal fatigue." Moscow, 1961. 30 pp with diagrams; (State Committee of the Council of Ministers USSR for Automation and Machine-Building, Central Scientific Research Inst of Technology and Machine-Building "TsNIITMASh", ONTI); 170 copies; price not given; list of author's works at end of text (14 entries); (KL, 6-61 sup, 211)

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10.9220 also 4016,1418,1045

S/180/61/000/003/009/012
E073/E535

AUTHOR: Ivanova, V.S. (Moscow)

TITLE: On the Mechanism of Formation of Fatigue Cracks in Metals

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1961, No.3, pp.77-81

TEXT: A. H. Cottrell and D. Hull (Ref.11: Proc. Soc. A, 1957 2, 42, No.1229) interpreted the mechanism of extrusion and intrusion as being the result of the alternating effect of intersecting slip systems, whereby during the first half-cycle sources of dislocation act which are located in one of the slip systems, whilst in the other half-cycle the action is by sources of dislocation associated with the other slip system intersecting the first. On repeating the cycle, extrusion and intrusion occurs. In this paper microscopic and electron microscopic investigations are described which were carried out for the purpose of verifying the Cottrell-Hull hypothesis and also the conditions are analysed under which it is possible to detect the two mechanisms of formation of fatigue cracks. According to Cottrell and Hull, extrusion and intrusion should occur only in metals for which slip

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On the Mechanism of Formation of ... S/180/61/000/003/009/012
E073/E535

in the grains during cyclic stresses can occur only along mutually intersecting planes. For verifying this assumption two differing metals were chosen: an austenitic steel ЭЯ-1Т (EYa-1T) (which is prone to develop active mutually intersecting slip planes during cyclic loading) and carbon steel 10, for which the displacement of the grains is only along a single slip system (within the limits of one grain). Prior to the fatigue tests the steel EYa-1T was water quenched from 1200°C and then stabilized at 650°C; the carbon steel 10 was annealed at 900°C. The fatigue tests were made on 1 x 10 mm specimens (polished and etched to reveal the structure) with symmetrical bending by means of an electromagnetic system. The structure was studied by means of a metallographic microscope and the electron microscopes ЭМ-3 (EM-3) (resolution 50 Å) and Jem-5 Y (resolution 10 Å) using colloidal replicas with chromium shading. The microstructure of the steel EYa-1T showed that for this steel displacement along active intersecting slip systems is characteristic. The intersecting angle of the slip planes is approximately 120°. For the steel 10 the slip is only along a single slip system. The electron microscopes enabled detailed

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study of the structure of the slip bands of these steels. In the steel EYa-1T the boundary of the slip bands is in the form of circular patterns similar to those described by P.J.E. Forsyth (Ref.6: The Basic Mechanism of Fatigue and its Dependence on the Initial State of a Material. International Conference of Fatigue of Metals 10th-14th September, 1956. The Inst. of Mechanical Engineers, London). No extrusion phenomena could be detected for the steel 10. In this steel intensive loosening of the metal in the slip bands was observed on account of large bands of sub-microscopic cracks oriented along the slip bands. In a number of cases spherical sub-microscopic pores were observed at the boundaries of the deformed layer. The sub-microscopic cracks were partly extended chains of pores. Such a loosening of the metal subjected to deformation was not observed for the steel EYa-1T. The obtained data lead to the conclusion that extrusion is characteristic only for those metals in which the slip processes develop along active intersecting slip bands, which is a necessary but insufficient condition. A further necessary condition is that the stresses should alternate. In the case of

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active tension or in tests with repeated loading, extrusion and intrusion was not observed. This is illustrated by the example of the manganese-austenite steel Г-13Л (G-13L) (1% C, 12% Mn, 0.1-0.3% Cr, 0.08% P, 0.01% S), which was subjected to fatigue tests with repeated loading for a duration of 120 000 cycles (the tests were carried out by N. V. Baranova at NATI). In this steel intersecting sliding systems are activated but no extrusion phenomena were observed. The fatigue cracks were distributed at the points of intersection of the active slip planes. Under such conditions the mechanism of formation of fatigue cracks is associated with the coagulation of vacancies and annihilation of dislocations during interaction of dislocations which move in intersecting slip systems. Thus, for extrusions and intrusions to develop, the existence of active intersecting slip systems and a change in sign of the acting stress are necessary. Only in this case will the mechanism of extrusion and intrusion of Cottrell and Hull be correct. The carried out investigations also show that under certain conditions processes of coagulation of vacancies may be of decisive importance in the formation of fatigue cracks.

A number of authors express the view that the vacancies may play an important role in metal failures during high temperature operation. As regards fatigue conditions, the role of vacancies was investigated for the first time by Oding. However, the vacancy mechanism manifests itself only under certain conditions. Thus, at low temperatures when the diffusion processes are braked, it cannot be anticipated that the vacancies will play an important role. The same conclusion can be arrived at as regards low plasticity metals. Apparently in these the process of annihilation of dislocations and the effect of super-position of the force fields of dislocations during accumulation of dislocations at barriers should play an important role in the formation of fatigue cracks. Thus, the conclusion is arrived at that whether one or another mechanism of formation of fatigue cracks manifests itself depends on the nature of the metal and on the test conditions. There are 4 figures and 19 references: 9 Soviet-bloc and 10 non-Soviet-bloc.

ASSOCIATION: Institut metallurgii AN SSSR (Institute of Metallurgy AS USSR)

SUBMITTED: October 27, 1960

[Abstractor's Note: Condensed translation.]

SHTEFAN NEDESHAN [Ştefan Nădăşan], prof.; KHOROVITS, Bernard [Horoviţ, Bernard] dotsent; USOV, A.M.; IVANOVA, V.S.

Rapid method for determining the fatiuge limit from critical fatigue stresses. Zav.lab. 27 no.11:1430-1435 '61. (MIRA 14:10)

1. Filial AN Rumynskoy Narodnoy Respubliki, Timishoara (for Stefan Nadasan, Horoviţ, Bernard). 2. TSentral'nyy nauchno-issledovatel'skiy institut Ministerstva putey soobshcheniya (for Usov). 3. Institut metallurgii imeni A.A.Baykova AN SSSR (for Ivanova).
(Metals--Fatigue)

S/137/62/000/012/026/085
A006/A101

AUTHOR: Ivanova, V. S.

TITLE: The structure-energy theory of metal fatigue

PERIODICAL: Referativnyy zhurnal, Metallurgiya, no. 12, 1962, 47 - 48, abstract 12I284 (In collection: "Tsiklich. prochnost' metallov", Moscow, AN SSSR, 1962, 11 - 23)

TEXT: The author proposes a structure-energy theory of fatigue, which takes into account both structural changes occurring in the metal, and energy values required for the processes during different fatigue periods. The theory is based on the concept of the independence of the breakdown energy upon the method of supplying the energy; thus it was possible to compare the specific energy of breakdown with the latent heat of metal melting. A detailed description is given of the mechanism of accumulating elastic distortions of the crystal lattice, and breakdown of the material during fatigue. It is shown that the specific energy consumed in the fatigue process from the moment of applying the load and until full failure, is composed of two parts: 1) the specific

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S/137/62/000/012/050/085
A006/A101

AUTHORS: Ivanova, V. S., Gurevich, S. Ye.

TITLE: The experimental verification of the accelerated method for determining the fatigue limit

PERIODICAL: Referativnyy zhurnal, Metallurgiya, no. 12, 1962, 103, abstract 12I634 (In collection: "Tsiklich. prochnost' metallov", Moscow, AN SSSR, 1962, 110 - 122)

TEXT: Results are presented from the experimental checking of the accelerated determination of $\sigma_w$ (RZhMet, 1960, no. 1, 27635). To use this method for finding $\sigma_w$, it is necessary to determine experimentally the stress $\sigma_{cr}$ which causes the specimen failure at a critical number of cycles, $N_{cr}$. The subsequent calculation was carried out, using formula $\sigma_w = \sigma_{cr} - \alpha_\sigma$ where $\alpha_\sigma$ is the cyclic fatigue constant, equal to 6 kg/mm$^2$ for ferrous metals and 7 kg/mm$^2$ for non-ferrous metals. The magnitude of $N_{cr}$ may be calculated either from the known physical constant of metal or be determined from one of the fatigue curves (e.g. obtained under bending condition). The number of specimens required for the

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reliable determination of critical stress, $\sigma_{cr}$, depends upon the scatter of experimental data on the cyclic strength of the given material. An analysis shows that in case of a slight scatter of fatigue test data, the value $\sigma_{cr}$ can be determined, with sufficient accuracy for practical use ($\pm 1$ kg/mm$^2$), from data of tests made with four or five specimens. If the scatter of experimental data is high, the number of specimens should be increased to 8 - 10. However, in this case the duration of tests is considerably reduced, since there is no need to carry out the tests at low stress, close to $\sigma_w$, which is 50 - 70% of the total fatigue test duration. The accelerated method was checked on Cu, grade 3.5, 15, 20, and 50 steel, 20XHH (20KhN), 40XH (40KhN) steel, and B-95 (V-95) Al-alloy with the use of the following 2 methods: 1. Special tests were made with a limited number of specimens, at stresses causing the failure at a number of cycles, both below and above $N_{cr}$; furthermore the interpolated $\sigma_{cr}$ value was defined, from which the rated $\sigma_w$ value was determined. Subsequently, check-specimens were tested to establish the correctness of the calculated $\sigma_w$. 2. $\sigma_{cr}$ was determined from the inclined section of the available Weller curve; the value obtained for $\sigma_{cr}$ was used to determine the rated $\sigma_w$, which was then compared with experimental data. It is shown that in all cases $\sigma_w$ can be calculated with an accuracy sufficient for practical use from $\sigma_{cr}$, determined from data of fatigue tests made with a limited number of specimens (5 - 8). There are 8 references.

L. Gordiyenko

[Abstracter's note: Complete translation]

S/277/63/000/003/001/002
A052/A126

AUTHORS: Ivanova, V. S., Gal'perin, M. Ya.

TITLE: An analysis of the possibility of using new criteria for an accelerated fatigue limit determination

PERIODICAL: Referativnyy zhurnal, Otdel'nyy vypusk. 48. Mashinostroitel'nyye materialy, konstruktsii i raschet detaley mashin, no. 3, 1963, 33, abstract 3.48.237 (In collection: Tsikl.ch. prochnost' metallov. M., AN SSSR, 1962, 134 - 140)

TEXT: The possibility is analyzed of using the fatigue criterion proposed by V. S. Ivanova for the fatigue limit determination under conditions of fatigue tests with rotational bending and symmetric bending in one plane. It is shown that the critical number of cycles $N_k$ can be determined experimentally by one of the fatigue curves, and the fatigue limit can be computed by the formula

$$\sigma_{-1} = \sigma_{k'} - \alpha_{c},$$

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where $\sigma_k$ is the stress causing breakdown in $N_k$ cycles and $\alpha_5$ is a cyclic constant. In the presence of sharp stress concentrators the $N_k$ value increases as compared with that for flat samples.

[Abstracter's note: Complete translation]

IVANOVA, V. S. (Moskva)

Investigating the role of grain boundaries on the development of the fatigue process. Izv. AN SSSR. Otd. tekh. nauk. Met. i topl. no.6:90-97 N-D '62. (MIRA 16:1)

(Metals--Fatigue) (Dislocations in metals)

S/032/62/028/009/008/009
B104/B102

AUTHORS: Oding, I. A., Ivanova, V. S., Gordiyenko, L. K., and Stepanov, V. N.

TITLE: An electromagnetic apparatus for fatigue tests on flat specimens bent in alternate directions

PERIODICAL: Zavodskaya laboratoriya, v. 28, no. 9, 1962, 1126 - 1128

TEXT: This device described (Fig. 1) provides for the fatigue testing of flat specimens in vacuo ($10^{-5}$ mm Hg) or in various gases. The specimen is clamped in a holder (5) surrounded by the glass tube (4) and mounted on a brass head (1). Thus the space around the specimen is hermetically sealed by the sample holder, glass tube and observation window (17). The tube (9) serves for evacuation. Bending vibrations are excited in the specimen at its natural frequency by the electromagnet (16) with the aid of the special plate (18). The device is reliable and gives very accurate results. There are 3 figures.

ASSOCIATION: Institut metallurgii im. A. A. Baykova (Institute of Metallurgy imeni A. A. Baykov)

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IVANOVA, Vera Semenovna. Prinimal uchastiye GORDIYENKO, L.K., kand. tekhn. nauk; SHKOL'NIK, L.M., kand.tekhn.nauk, red.; GORDON, L.M., red.izd-va; MIKHAYLOVA, V.V., tekhn.red.

[Fatigue failure of metals] Ustalostnoe razrushenie metallov. Moskva, Metallurgizdat, 1963. 272 p. (MIRA 16:12)
(Metals—Fatigue)

ODING, I. A.; IVANOVA, V. S.

Mechanism of the fatigue failure of metals. Trudy Inst. met. no.13:3-28 '63. (MIRA 16:4)

(Metals--Fatigue)
(Dislocations in metals)

ACCESSION NR: AT4014043 S/3073/63/000/000/0014/0022

AUTHOR: Ivanova, V. S.

TITLE: Change in the dislocation structure of metals under cyclic loads

SOURCE: Prochnost' metallov pri peremenny*kh nagruzkakh; materialy* tret'yego soveshchaniya po ustalosti metallov, 1962 g. Moscow, Izd-vo AN SSSR, 1963, 14-22

TOPIC TAGS: fatigue, dislocation density, etching, chemical etching, iron alloy, steel alloy, reagent, austenite steel, austenitic steel, heat treatment, annealing, stress cyclic stress, grain, load, grain skidding

ABSTRACT: The study of the formation of fatigue cracks in metal shows that these cracks develop where the critical density of dislocations is attained. Changes in dislocation structure during fatigue were studied by chemical etching of iron containing 4% Si and of certain brands of steel. A reagent consisting of a 50% solution of $CrO_3$ in water was used to reveal both the annealed and fresh dislocations. The reagents L-3 (100 cc methyl alcohol and 1 g $FeCl_3$) and L-1 (100 cc methyl alcohol, 2.5 cc HCl and 1 g $FeCl_3$) were used to reveal the fresh dislocations on iron and austenitic steels, respectively. The annealed dislocations were due to mechanical and thermal treatment of metal and the fresh dis-

ACCESSION NR: AT4014043

locations were due to plastic deformation when a cyclic load was applied. When high cyclic stresses ($\pm$ 31.4 kg/mm$^2$) were applied, the etching pits of high density revealed that the dislocations were observed close to the grain boundaries and that these dislocations led to inter-grain destruction and crack formation. At lower cyclic loads (26 kg/mm$^2$) the dislocation accumulation was observed in the areas of grain skidding. "Laboratory technicians I. D. Russavskaya and N. S. Sabitova participated in the work." Orig. art. has: 12 figures, 4 formulas and 1 table.

ASSOCIATION: Institut metallurgii im. A. A. Baykova (Institute of Metallurgy)

SUBMITTED: 00 DATE ACQ: 20Feb64 ENCL: 00

SUB CODE: MM NO REF SOV: 006 OTHER: 003

Card 2/2

AM4016864 BOOK EXPLOITATION S/

Ivanova, Vera Semenova

Fatigue failure of metals (Ustalostnoye razrusheniye metallov) Moscow, Metallurgizdat, 1963. 272 p. illus., biblio. 3350 copies printed. Editor: L. M. Shkol'nik; Publishing house editor: L. M. Gordon; Technical editor: V. V. Mikhaylova; Cover artist: P. P. Perevalova.

TOPIC TAGS: fatigue, fatigue failure, cyclic strength, fatigue limit, damageability curve, strength of metals, critical stress, strain hardening, cyclic loading, scale factor, dislocation structure, static strength, brittle strength, internal friction

PURPOSE AND COVERAGE: This book is intended for scientific and also engineering-technical personnel studying problems of fatigue and the design strength of machine parts; it may be useful also for students in metallurgical and machine-

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AM4016864

building vuzes. The results of experimental and theoretical studies of the nature of fatigue failure are generalized. Physical theories of fatigue, the micromechanism of fatigue failure, the change in structure and properties in fatigue, and the influence of various factors on the cyclic strength of metals are analyzed. Furthermore, experimental and analytical methods of determining the fatigue limit are outlined and new accelerated methods of determining the fatigue limit by utilizing the energy criteria of fatigue and the method of plotting the curve of damageability from the fatigue curve are described. The author thanks I. A. Oding for help with the manuscript, and L. K. Gordiyenko for help with Chapter IV and L. M. Shkol'nik for editorial help.

TABLE OF CONTENTS (abridged):

AM4016864



SUB CODE: AP SUBMITTED: 18Jul63 NR REF SOV: 235

OTHER: 241 DATE ACQ: 09Jan64

Card 3/3

IVANOVA, V. S.; GORDIYENKO, L. K.

Changes in the physical properties of metals under the effect of cyclic stress. Trudy Inst. met. no.13:29-63 '63.
(MIRA 16:4)

(Metals--Testing)
(Strains and stresses)

IVANOVA, V.S.; SABITOVA, N.S.; RUSSAVSKAYA, I.D.

Methods of exposing dislocations in deformed metals. Zav.lab. 29 no.2:193-197 '63. (MIRA 16:5)

1. Institut metallurgii imeni A.A.Baykova.
(Dislocations in crystals) (Dislocations in metals)

L 12624-63 BDS/EWP(q)/EWT(m) AFFTC/ASD JD/EH-2

ACCESSION NR: AP3003511 S/0020/63/151/001/0092/0095

AUTHORS: Oding, I. A. (Corr. mem. AS SSSR); Ivanova, V. S.; Liberov, Yu. P.

TITLE: Basic assumptions for a correlation between the criteria for static and cyclic strength of metals

SOURCE: AN SSR. Doklady, v. 151, no. 1, 1963, 92-95

TOPIC TAGS: metal fatigue strength, static strength, static-fatigue strength, correlation metallurgy, elasticity theory, nickel, armco iron

ABSTRACT: In their attempt at establishing a correlation between the static and cyclic strength, the authors use parameters which are indicative of equivalence of the energy state of metals subjected to mechanical stress under different loading conditions. They determine the conditions for cyclic rupture, which are equivalent to the static increase of stress, by using the diagram of fatigue rupture together with the damage curve, introduced earlier by Ivanova (DAN, 119, no. 1, 1958, 71), which gives the formation of the first submicroscopic cracks. Thus it becomes possible to predict the fatigue rupture on the basis of static data. There is good agreement between the theoretical and experimental values

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L 12624-63

ACCESSION NR: AP3003511

obtained by the authors with nickel and armco iron. Orig. art. has: 2 formulas and 3 figures.

ASSOCIATION: Institut metallurgii im. A. A. Baykova (Institute of Metallurgy).

SUBMITTED: 23Feb63 DATE ACQ: 30Jul63 ENCL: 00

SUB CODE: PH, ML NO REF SOV: 009 OTHER: 001

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S/0279/64/000/001/0095/0107

ACCESSION NR: AP4019811

AUTHORS: Ivanova, V. S. (Moscow); Gordiyenko, L. K. (Moscow)

TITLE: The nature of metal strengthening by thermomechanical treatment

SOURCE: AN SSSR. Izv. Metallurgiya i gornoye delo, no. 1, 1964, 95-107

TOPIC TAGS: metal strength, thermomechanical treatment, metal structure, dislocation control, dislocation distribution, high temperature phase, polymorphic transformation

ABSTRACT: The strength of metal can be increased in two basic ways: 1) by imparting to it a desired crystalline structure; 2) by producing the structure with a large number of dislocations distributed in a proper way through the material. The second method is more practical. It involves a complex interaction between plastic deformation and temperature effects. An analytical study of this method is presented and the results obtained are shown graphically in Figures 1 and 2 on the Enclosures. The thermomechanical (TM) treatment involved in the process produces an intense deformation at high temperature followed by cooling (in the course of cooling the high temperature phase of the metal should undergo a polymorphic transformation, and only the materials capable of such transformation can be processed

ACCESSION NR: AP4019811

by this method). Because the state of metal obtained in this manner is metastable, only the increase in the static strength of steel was observed, while several of its other properties at high temperature and after prolonged working remained unchanged. Its resistance to creep and stress relaxation were improved by the mechanical-thermal (MT) treatment. This process involved producing preliminary metal deformation at temperatures below those necessary for the beginning of crystallization, and a subsequent rest at the same temperature (it did not involve polymorphic transformations). The MT and TM products were found to differ in structure because the increase in dislocation densities is considerably smaller due to the low degree of metal deformation in the MT process. Orig. art. has: 2 figures and 11 formulas.

ASSOCIATION: none

SUBMITTED: 08Jun63 DATE ACQ: 31Mar64 ENCL: 02

SUB CODE: ML NO REF SOV: 022 OTHER: 009

Card 2/4

ENCLOSURE:01

ACCESSION NR: AP4019811

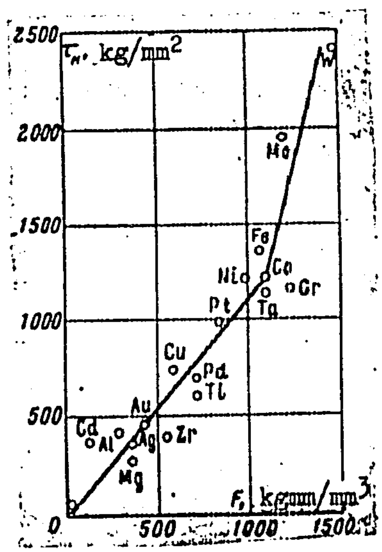


Fig. 1. Relation between the critical resistance to shear and the specific energy capacity $F = \int_{T_n}^{T_s} C_p\, dT + L$ of different metals.

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ACCESSION NR: AP4019811

ENCLOSURE: 02

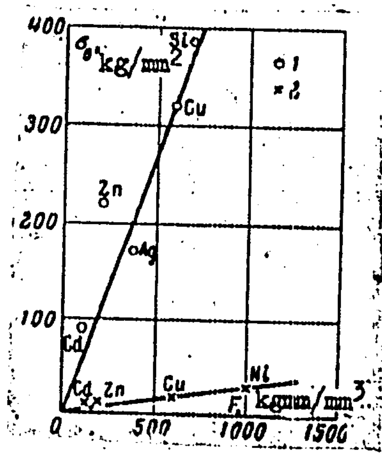


Fig. 2. Relation between the ultimate strength and F for perfect crystals (1) and for annealed polycrystalline metals (2).

Card 4/4

IVANOVA, Vera Semenovna; GORDIYENKO, Lev Kimovich; ODING, I.A., otv. red.

[New ways of increasing the strength of metals] Novye puti povysheniia prochnosti metallov. Moskva, Izd-vo "Nauka," 1964. 116 p. (MIRA 17:6)

1. Chlen-korrespondent AN SSSR (for Oding).