

RABOTNOV, YU. N.

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IL'YUSHIN, A. A., RABOTNOV, YU. N., IMZHENERNYY. SBORNIK. (OTV. RED. A. A. IL'YUSHIN, YU. N. RABOTNOV). M., IZD. VO AKAD. NAUCH SSSR, 1954, 26 SM. (AKAD. NAUK. SSSR. OTD. NIYE TEKHN. NAUK. IN. T MAKHNIKI). T. 20 184 S. S. ILL. 2.500 EKZ. 90 R. 80 K. --BIBLIOGR: V KONTSE STATEY. -- (55.943 ZH)

SO: KNIZHNAYA LETOPIS* VOL. 7, 1955.

USSR/Engineering - Metallurgy

FD-1125

Card 1/1 Pub. 41-6/17

Author : Rabotnov, Yu. N., Moscow

Title : A possible mechanism of breakdown of metal in a corrosive medium

Periodical : Izv. AN SSSR. Otd. tekhn. nauk 6, 53-56, Jun 1954

Abstract : Presents a hypothetical explanation of spread of crack in metal subjected to mechanical loads and located in a corrosive medium. Graph. One reference.

Institution :

Submitted : August 2, 1954

USSR/Engineering - Machine Study

FD-1456

Card 1/1 : Pub. 41-10/17

Author : Rabotnov, Yu. N., Moscow

Title : ~~Small plastic deformations as a problem of mechanics~~
Small plastic deformations as a problem of mechanics

Periodical : Izv. AN SSSR. Otd. tekhn. nauk 7, 97-104 -1954

Abstract : For the purpose of clarifying questions linked with the external aspect of the occurrence of plastic deformation in metals at normal temperature (temperature at which life of organisms is possible) and at relatively small speeds of deformation such as are realizable on ordinary machines for static tests, discusses laws of the theory of plasticity and their reliability as indicated by experimental findings. Graphs. Seven references.

Institution :

Submitted : August 2, 1954

ZHUKOV, A.M.; RABOTNOV, Yu.N. (Moscow)

Investigation of plastic deformations in steel in complex loading.
Inzh.sbor. 18:105-112 '54. (MLRA 7:5)
(Deformations (Mechanics))

RABOTNOV, Yu.N.

Mechanics and mathematics faculty. Nauka i shisn' 21 no.1:13 Ja '54.
(MLRA 7:1)

1. Chlen-korrespondent Akademii nauk SSSR. 2. Dekan mekhaniko-
matematicheskogo fakul'teta Moskovskogo gosudarstvennogo uni-
versiteta. (Mechanics)

USSR/Engineering - Metallurgy

FD-2745

Card 1/1

Pub 41 - 6/16

Author : Danilovskaya, V. I., Ivanova, G. M., Rabotnov, Yu. N.,
Moscow

Title : Creep and relaxation of chromium-molybdenum steel.

Periodical : Izv. AN SSSR, Otd. Tekh. Nauk 5, 102-108, May 1955

Abstract : Describes experiments performed to determine the amount of permanent deformation which takes place through creep, when a 30 KhMA steel is subjected to elastic deformation at 500° C for a 100 hour period. Relaxation is discussed, and it is noted what effect creep, relaxation and deformation have on the tensile strength and the aging of steel, as well as on each other. Graphs and formulae. Five references, 3 USSR.

Institution : Institute of Mechanics, Academy of Sciences USSR.

Submitted : March 31, 1955

24-5-3/25

AUTHOR: Rabotnov, Yu. N. (Moscow)

TITLE: On some possible descriptions of unsteady creep with an application to the study of creep of rotors.
(O nekotorykh vozmozhnostyakh opisaniya neustanovivsheysya polzuchesti s prilozheniyem k issledovaniyu polzuchesti rotorov).

PERIODICAL: "Izvestiya Akademii Nauk, Otdeleniye Tekhnicheskikh Nauk"
(Bulletin of the Ac. Sc., Technical Sciences Section),
1957, No.5, pp. 30 - 41 (U.S.S.R.)

ABSTRACT: It is assumed that there exists a functional relation between tension, plastic deformation, speed of plastic deformation and temperature, for creep metals in a uniaxial tensile state. This may be written in the form:

$$\Phi(p, \dot{p}, \sigma, T) = 0$$

Card 1/7 For the treatment of experimental data the following relation is recommended:

$$\dot{p} p^a = K \exp\left(\frac{|\sigma|}{A}\right) \tag{1.1}$$

where

$$p = \left| \epsilon - \frac{\sigma}{E} \right|$$

On some possible descriptions of unsteady creep with an application to the study of creep of rotors. (Cont.)
 here p is the absolute magnitude of plastic deformation (cf. refs. 2 - 4). The constants K , α and A depend on temperature. The table on p.31 gives experimental values of these parameters for a number of materials and temperatures. Eq. (1.1) may be put into another form by the substitutions:

$$\bar{\sigma} = \frac{\sigma}{A}, \quad \bar{\epsilon} = \frac{E\epsilon}{A}, \quad \bar{p} = \frac{Ep}{A}, \quad \tau = K \left(\frac{E}{A} \right)^{1+\alpha} t \quad (1.2)$$

so that

$$\dot{p} p^\alpha = \exp \sigma$$

The region of small tensions is excluded and eq.(1.2) applies only when $\dot{p} p^\alpha > 1$. The equation is applied to the case of creep under constant load, so that

$$p = \left[\frac{\tau}{m} \exp \sigma \right]^m \quad \left(m = \frac{1}{1+\alpha} \right) \quad (1.3)$$

For $\epsilon = \epsilon_0 = \text{constant}$, i.e. in the case of relaxation

$$\sigma = \epsilon_0 - \chi^{-1} \left[\chi(p_0) + \tau \exp \epsilon_0 \right] \quad (1.4)$$

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Here

$$\chi(u) = \int_u^u u^\alpha \exp u du$$

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If relaxation takes place after instantaneous extension in the elastic region, the formula (1.4) can be simplified and takes the form

$$\sigma = \sigma_0 - \chi^{-1} (\tau \exp \sigma_0) \quad (1.5)$$

Two problems are considered in the case of uniaxial tensional state:

(a) A specimen connected to a spring in which relaxation does not take place. Here the relation between tension and plastic deformation can be written in the (linear) form

$$\sigma = \sigma_0 - \gamma P$$

(σ_0, γ are constants depending on the nature of the elastic connection and initial conditions). Substituting this into (1.2) and integrating:

$$\sigma = \sigma_0 - \chi^{-1} [\tau \gamma^{1+\alpha} \exp \sigma_0] \quad (2.1)$$

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(b) The case when the load changes with time thus:

$$\sigma = \sigma_0 + \sigma'_0 \sin \tau$$

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Hence
$$p = \left[\frac{\tau}{m} \exp (\sigma_0 + \sigma_0'') \right]^m \quad (2.2)$$

where

$$\sigma_0'' = \lg \left[\sum_0^{\infty} \frac{1}{(2n)!} \frac{1}{2^{2n}} \binom{2n}{n} \sigma_0'^{2n} \right]$$

In formula (2.2) periodic numbers are omitted; only that part which continuously increases with time is retained. It follows that, under these conditions, the creep under the action of a load changing within the range $\sigma_0' - \sigma_0 \rightarrow \sigma_0 + \sigma_0'$ takes place as if there was a constant tension $\sigma_0 + \sigma_0''$. $\sigma_0 - \sigma_0'$ must, of course, be large enough for (1.1) to hold. It has been shown (5) that

$$K = K_0 \exp \left(- \frac{\Delta H}{kT} \right)$$

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where k = Boltzmann's constant and ΔH is the activation energy which is constant for a given metal. Hence, instead of (1.2) we have

On some possible descriptions of unsteady creep with an application to the study of creep of rotors. (Cont.) 24-5-3/25
 (1.6)

$$\dot{p} p^{\alpha} = \exp(\sigma - \beta)$$

$$(\beta = \frac{\Delta H}{kt})$$

The theory of uniform creep, expressed in eq.(1.6) does not take into account various secondary effects, e.g. inverse creep, by which is meant a partial restitution of deformation after unloading. Generalisations of the relations established for uniaxial tensile states to the general 3-dimensional case are very difficult. To begin with it is assumed that the speed of creep has a potential so that

$$\dot{p}_{ij} = \frac{\partial f}{\partial \sigma_{ij}} \quad (4.1)$$

The function f depends on plastic deformations as well as σ_{ij} . It is also assumed that f depends on two invariants: the stress tensor and the tensor of speeds of plastic deformation e.g.

$$\sigma_i = \left(\frac{3}{2} \sigma_{ij}^* \sigma_{ij}^* \right) \quad (\text{stars indicate deviator of the tensor) and$$

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$$p = \int_0^t \left(\frac{2}{3} \dot{p}_{ij} \dot{p}_{ij} \right)^{1/2} dt \quad (4.2)$$

Assuming $f = f(\sigma_i, p)$, then from (4.1) one has

$$\dot{p}_{ij} = \epsilon_{ij} - \frac{1}{2G} \dot{\sigma}_{ij}^* = \frac{2}{3} \frac{\partial f}{\partial \sigma_i} \frac{\sigma_{ij}}{\sigma_i}$$

In order to obtain (1.2) in the case of simple stress one puts

$$\frac{2}{3} \frac{\partial f}{\partial \sigma_i} = K p^{-a} \exp \frac{\sigma_i}{A}$$

It follows that

$$\dot{p}_{ij} = \frac{3}{2} K p^{-a} \left(\exp \frac{\sigma_i}{A} \right) \frac{\sigma_{ij}}{\sigma_i} \quad (4.3)$$

If $\sigma_1 > \sigma_2 > \sigma_3$, $s = \sigma_1 - \sigma_3$, $2p = p_1 - p_3$, then it follows from (4.1) that $\dot{p}_1 = -\dot{p}_3 = \dot{p}$, $\dot{p}_2 = 0$ and instead of (4.3) one has

$$\dot{p} = K p^{-a} \exp \frac{s}{A} \quad (4.4)$$

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On some possible descriptions of unsteady creep with an application to the study of creep of rotors. (Cont.)

The theory is applied to the following cases: ^{24-5-3/25} bending of shafts, radial and peripheral deformation of discs, rotating cylinder and related cases.

There are 5 figures and ten references, 6 of which are Slavic.

SUBMITTED: February 6, 1957.

AVAILABLE:

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24-11-1/31

AUTHORS: Blagonravov, A.A. and Rabotnov, Yu. N.

TITLE: The Technical Sciences Division on the Occasion of the Fortieth Anniversary of the Great Socialist October Revolution. (Otdeleniye Tekhnicheskikh Nauk k 40-letiyu Velikoy Oktyabr'skoy sotsialisticheskoy revolyutsii).

PERIODICAL: Izvestiya Akademii Nauk SSSR, Otdeleniye Tekhnicheskikh Nauk, 1957, No.11, pp.5-9 (USSR)

ABSTRACT: The Technical Sciences Division of the Ac.Sc. consisted at first of the following five groups: power engineering; engineering physics; engineering chemistry; engineering mechanics and mining. Furthermore, it controlled the Power Research Institute (Energeticheskiy Institut), the Institute of Mined Fuels (Institut Goryuchikh Iskopayemykh) and the Commission on Engineering Terminology (Komissiya po Tekhnicheskoy Terminologii). The volume of scientific activity of the Technical Sciences Division increased appreciably in 1939 when fifteen new Academicians and twenty-nine Corresponding Members were elected. In the same year the following were incorporated into this section: The Institute of Mining (Institut Gornogo Dela); Institute of Metallurgy (Institut Metallurgii); Institute of Mechanics (Institut Mekhaniki);

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Institute of Mechanical Engineering (Institut Mashinovedeniya);
Institute of Automation and Telemechanics (Institut
Avtomatiki i Telemekhaniki) and a number of others.

At present, the Division has twenty-nine Academicians and seventy-four Corresponding Members, it comprises eleven research institutes, seven independent laboratories, one "section" and one committee and publishes four journals.

Over 7000 people work in the establishments of the Division; of these 2800 are scientific personnel including twenty-three Academicians, fifty-seven Corresponding Members, two hundred Doctors of Science and 352 Candidates of Science. Only a few of the most important results obtained in the Scientific Establishments of the Technical Sciences Division of the Ac.Sc. are dealt with here.

Metals. In the field of investigation of metallurgical processes a theory of blast furnace smelting under pressure was evolved which permits justification of the practical application of the method. New theoretical conceptions on the processes of coke combustion in the hearth of blast furnaces enabled development of technological methods of

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entire characteristic of the blast furnace process. Methods of granulation (pelletizing) of ore-coal mixtures were developed. Important theoretical investigations were carried out relating to the interaction of metals and the kinetics of phase transformations; a number of new high strength and special alloys were developed. Much work has been carried out for the purpose of obtaining purer titanium and of studying the properties, the diagram of state of titanium-based alloys and of the influence of alloying elements on the properties of titanium alloys, particularly the heat resistance. Work is in progress on developing new semi-conductor materials based on germanium-silicon-chemical elements of the third group with elements of the fifth group, compounds of chalcopyrite and others. Oil. Of the new high molecular compounds, most attention is paid to polypropylene; systematic study is being carried out at the Oil Research Institute (Institut Nefti), as a result of which crystalline polypropylene was obtained from which the first specimens of this new fibre have been produced. A process of high speed cracking was developed which enabled reduction of the production costs

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by about 50% and of the specific first costs by 40 to 60%. A new synthesis was developed of high fatty alcohols by direct oxidation of paraffin hydrocarbons omitting the stage of hydrating of liquid acids obtained by oxidation of paraffin. The obtained alcohols are used as a raw material for producing fine washing media (detergents), which is of great importance from the point of view of saving edible fats. Great strides forward were also made in turbo-drilling; over 83% of the total drillings (in terms of the combined total of the drilling depths) is at present effected by turbo-drilling.

Solid Fuel. The Institute of Mined Fuel jointly with the Ministry of Ferrous Metallurgy (Ministerstvo Chernoy Metallurgii) developed scientific principles of continuous coking, a process which is about five times as intensive as current methods and enables obtaining high quality metallurgical coke from coal with bad coking properties. 50 to 70% of the coal from the Donets, the Kuznets and Karaganda deposits and up to 100% of the coal reserves of the Irkutsk, Minusinsk and the Bureinsk Basin consist of such coal. A new process of centrifugal desulphuring

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and de-ashing was developed which permits increasing appreciably the productivity of blast furnaces and to reduce the coke consumption; the resulting economy in the Donets Basin alone is about 600 million Roubles in capital costs. The Power Research Institute developed a process of combined power-technological utilisation of solid fuels, i.e. coal, peat and shale.

Mining. Highly efficient variants were developed of underground working, breaking up of the ore by means of deep explosive charges and using a new design of the bottom of the chamber which permits intensification of the removal of the broken-up ore. Compared to existing systems, this method enables speeding up the mining to double the conventional value and to increase the productivity of labour 2.5 to 3 fold, to reduce the silicosis danger, to improve the conditions of work and the safety. Investigations are in progress relating to the theory of beneficiation processes, i.e. flotation of coal and ores.

Power. One of the major complex problems in this field is
Card 5/11 the "evolving of scientific bases of the development of

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power systems and integrating it into a single power system". A large number of establishments of the Ac.Sc. and of other institutes are working on this problem under the general direction of the Power Institute imeni G. M. Krzhizhanovskiy (Energeticheskiy Institut im. G. M. Krzhizhanovskiy). Investigations in this field comprise a large number of problems: power generation generally, electric power generation, thermal power, hydraulic power. A unified power system of the European part of the Soviet Union is being put into effect in the Sixth Five Year Plan period. At present research and development are directed towards the creation of a unified power system covering the entire territory of the Soviet Union. In this respect the Academy has carried out a large number of investigations, including determination of the behaviour of super-long distance transmission lines of the order of 2000 km and longer operating with voltages of 400 kV and higher and powers of the order of two million kW. Creation of a unified power system of the European part of the Soviet Union is likely to result in an annual economy of 400 million Roubles and the additional cost

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involved in constructing the necessary power transmission system will be recuperated in less than ten years. As a result of further investigations, the installed power of the system of hydraulic power stations along the Volga and the Kama Rivers will be increased by two million kW compared to the originally scheduled capacities.

Mechanics. The Institute of Mechanics of the Technical Sciences Section claims a number of achievements. The most important one in the field of the theory of elasticity and plasticity is the evolution of a theory of strength, stability and vibrations of thin elastic shells and thin walled three-dimensional systems; this theory was developed as a result of analysis of accurate equations as well as by evolving approximate engineering calculation methods. As regards the theory of plasticity, the theory of limit equilibrium was evolved and also the "theory of small elastic-plastic deformations"; by means of the latter a number of concrete problems were solved. Much attention has been paid in recent years to applying the theory of plastic flow of metals to shaping by means of pressure.

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Experimental and theoretical investigations were carried

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out of creep of metals at elevated temperatures and methods of creep calculation were evolved. General methods were evolved and concrete problems were solved using the theory of limit equilibrium of loose media. In the field of general mechanics important results are claimed relating to the theory of stability of motion. A general theorem of instability was evolved and effective methods were developed for analysing the stability of non-steady state movements. Much work was devoted to the theory of stability of movement, to the investigation of the stability of aircraft and the spin movement of artillery shells. In the field of hydromechanics effective methods were evolved of calculating the steady state and the non-steady state of seepage of liquid through porous media and on the basis of these methods numerous problems were solved relating to oil well operation, seepage of water under the foundations of hydraulic structures etc.

Mechanical Engineering. In the Institute of Mechanical Engineering, methods were evolved for investigating the stresses and strains and calculating the carrying capacity of large size structures as applicable to large hydraulic turbines and large hydraulic presses. These methods were utilised in designing new hydraulic turbines, including

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the turbines of the Kuybyshev and the Bratska hydraulic power stations; to ensure reliable operation of large turbo-generators (100 000 kW and higher) oscillatory phenomena were investigated in the system rotor-stator under steady state and transient conditions. Analysis of the stress conditions of the individual elements of the structure has revealed the analogy laws for the case of fatigue fractures; this enabled design improvements resulting in an increase of the fatigue strength of the rotors. Friction and wear were investigated and a new material was developed for highly stressed engine bearings and also a new friction material for brakes.

Automation and telemechnics. New principles and methods were evolved of analogue computers and analogues have been built, the design of which is being improved continuously. An "aggregate" unified system of automatic control and regulation is being developed which consists of a small number of standardised blocks and differing combinations of such blocks permits obtaining an extreme variety of apparatus and circuits ensuring the control

Card 9/11 of complex automatic production processes. A system of

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automatic regulation of compressor operated oil wells has been evolved which is successfully applied in production; in the Baku area about 95% of the entire quantity of compression operated wells are automated and this enables increasing the oil extraction, economy of electric power and reduction of the operating personnel. Radio-active isotopes and radiations. A radiometric method was evolved for distinguishing oil bearing rocks from water bearing ones, new data were obtained on the distribution of alloying elements in light alloys in dependence of various pertinent factors and the process of diffusion of iron in solid iron base alloys was studied. A radiographic method was used for determining the real area of contact between mating metallic components, which is of importance from the point of view of wear studies. Radio-active methods were also used for studying the solubility of various substances in steam. In this brief article only some examples could be enumerated and they do not represent an exhaustive survey of the research progress. Numerous Academicians carry out their

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Scientists of the Ac.Sc. have played an important role in the development of Soviet aviation. Many achievements in this field are linked with the theoretical work of S. A. Chaplygin, L. S. Leybenzon, N. Ye. Kochin, A. I. Nekrasov and numerous others.

AVAILABLE: Library of Congress.

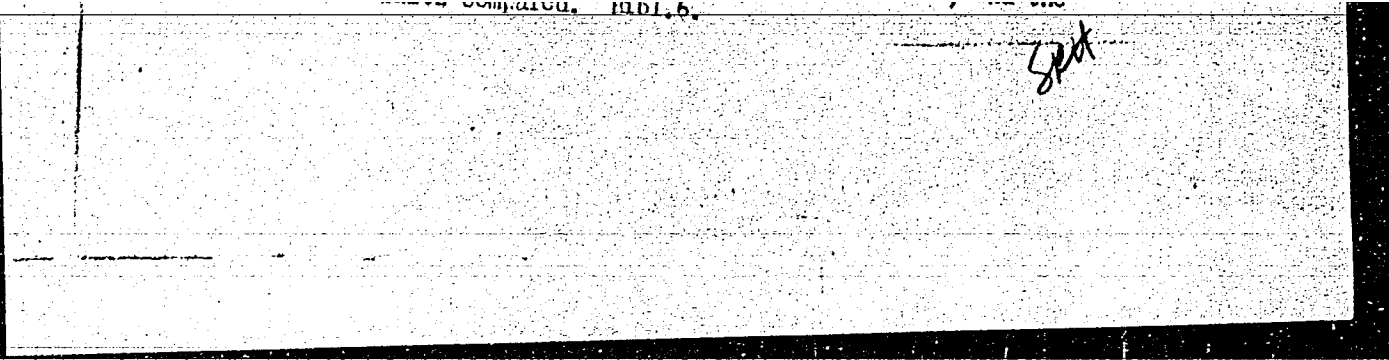
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Rabotnov, Yu. N.

221/14/2 624.071.3 : 624.073.1 : 539.434 8
Stability of Rods and Plates Prikl. Mat. Mekh.
under Creep 21(3), 406-412
1957
Yu. N. Rabotnov, S. A. Shesterikov U.S.S.R.
An attempt is made to analyze the loss of stability of
either a rod or a plate in its pure state, i.e. apart from

"APPROVED FOR RELEASE: Tuesday, August 01, 2000

CIA-RDP86-00513R001343



APPROVED FOR RELEASE: Tuesday, August 01, 2000

CIA-RDP86-00513R0013438

Yu. N. Rabotnov

AUTHORS: Odintsov, I.A., and Tulyakov, G. A. (Moscow). 24-1-1/26

TITLE: Creep of austenitic steel in the case of complicated stress states. (Polzuchest' austenitnoy stali pri slozhno-napryazhennom sostoyanii).

PERIODICAL: Izvestiya Akademii Nauk SSSR, Otdeleniye Tekhnicheskikh Nauk, 1958, No.1, pp. 3-10 (USSR).

ABSTRACT: Most of the theories of creep in the case of complex stress states are essentially extensions of the theory of plasticity. N. M. Belyayev (Ref.1) and Yu. N. Rabotnov (Ref.2) proposed using the theory of small elastic-plastic deformations. In the case of steady state creep the analytical expression for the speed of creep, which is not limited to a single axis, can be expressed by the following equation:

$$v_1 = \frac{A}{2} \tau_1^{\frac{n-1}{2}} \tau_1^{n-1} [(\sigma_1 - \sigma_2) - (\sigma_3 - \sigma_1)] \quad (123) \quad (1)$$

where A and n are constant coefficients and depend on $v = A\sigma^n$ which are determined by means of tensile creep tests, whilst the symbol (123) denotes that the formulae for v_2 and v_3 are obtained by suitably changing the indices in rotation. Similar relations are obtained by

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means of the theory of creep which represents a further development of the theory of flow of Il'yushin, A.A. (Ref.3), Malinin, N. N. (Ref.4) and also of the theories of Soderberg, C.R. (Ref.5), Marin, J. (Ref.6) and Odquist, F. (Ref.7). On the basis of a number of special experiments, Bailey, R.W. (Ref.8) recommends a different formula for calculating three-dimensional creep, whilst Johnson, A. E. (Refs.9 and 10) recommends another formula. Eq.(1) contains only two constants A and n, which can be determined from creep tests in tension. The formula of Bailey contains a larger number of constants, which have to be determined from creep tests at a different stress state, whilst the equations of Johnson are more cumbersome and less convenient for practical calculations. Creep tests, carried out by Bailey and Johnson (Refs.8-10), in tension and in torsion on thin walled tubular specimens fundamentally confirm the here expressed views. However, the duration of these tests was only 150 hours which is not long enough. In this paper the results are described of long duration creep tests under complex stress

Card 2/6 conditions at a temperature of 600°C. The experiments

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were effected in a special test rig described in earlier work (Ref.11) in which 32/20 tubes (as shown in Fig.1) of current industrial manufacture were subject to the effect of a constant tension and a constant torsion moment. The specimens were made of austenitic steel with the following composition: 0.09% C, 0.78% Mn, 0.36% Si, 0.010% S, 0.018% P, 17.18% Cr, 10.68% Ni, 0.47% Ti. The heat treatment consisted of annealing for thirty minutes at 1100°C followed by cooling in air (austenisation), each specimen was subjected solely to a single experiment with a constant ratio of the tensile stresses, σ , to the torsion stresses, τ . The following τ to σ ratios were chosen: $\tau/\sigma = \infty, 2.0, 1.0, 0.6, 0.5, 0.4, 0.3, 0$; for each τ to σ ratio at least two specimens were tested. The duration of a single test depended on the magnitude of the applied stresses; in each case the experiments were continued until the steady state second section of the creep curve was reached. Most experiments lasted 1500 to 2000 hours during which usually a constant creep speed became established. This duration is also adequate from the point of view of overcoming the period of most intensive ageing. Some experiments lasted less

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1. The experimental results confirm the applicability of the creep theory which is based on the theory of plastic flow for describing the process of steady state creep for durations up to 2000 hours.
2. The stress calculations for components operating under creep conditions with a complex stress state can be effected on the basis of creep test results in tension but it is necessary to improve the accuracy of the experimentally determined calculation coefficients for each group of materials under consideration.
3. A material which is under creep stress conditions in tension and torsion generally complies with the criterion

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of plastic flow of Hankey. However, the relation $v_i = F(\tau_i)$ is not entirely fulfilled since the tension and torsion curves are not identical in octahedric coordinates.

4. In the case of low creep speeds, the most accurate and theoretically the most justified is an exponential dependence between the speed of creep and the stress. This relation is correct for all the investigated types of stress states. The speed of steady state three-dimensional creep should be calculated in accordance with Eq.(6), p.5.

5. For the tested austenitic steel 1X18H9T, the power dependence between the creep speed and the stress for a temperature of 600°C approximates satisfactorily the exponential dependence for a wide range of creep speeds (from 10⁻⁴%/hr and higher) and, therefore, the exponential dependence can be used for practical calculations since it is simpler and more convenient.

6. Creep tests of the austenitic steel 1X18H9T in tension and torsion did not confirm the assumption of coincidence of the directions of the main stresses and the main axes of the deformation speeds over long periods. In the

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case of non-uniaxial stress states, a redistribution of the main creep speeds is observed whereby the creep speeds in the main directions v_1 and v_2 are equalised and the creep speed in the third main direction, v_3 , tends to become zero.

7. Under conditions of long duration tests, the creep theory, which is based on the assumption of isotropic behaviour of real commercial alloys, requires corrections which can be established by studying the physical nature of creep in the case of complicated stress states. There are 2 tables, 8 figures and 12 references - 6 Russian, 6 English.

SUBMITTED: March 6, 1957.

AVAILABLE: Library of Congress.

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RABOTNIKOV, I. N.
P. D.

PHASE I BOOK EXPLOITATION

SOV/3416

Akademiya nauk SSSR. Institut mashinovedeniya

Voprosy prochnosti materialov i konstruktsiy (Problems of Strength of Materials and Structures) Moscow, 1959. 399 p. Errata slip inserted. 3,200 copies printed.

Resp. Ed.: D. N. Reshetov, Professor, Doctor of Technical Sciences;
Ed. of Publishing House: G. B. Gorshkov; Tech. Ed.: S. T. Shikin.

PURPOSE: This book is intended for engineers and scientists concerned with the problems of the strength of materials and construction.

COVERAGE: The book contains 28 articles on the strength of materials in general and of machine construction in particular. This collection was prepared under the direction of the Institute of Mechanical Engineering of the AS USSR in honor of Sergey Vladimirovich Serensen, one of the founders and directors of the national school of strength of materials, who recently completed 30 years of scientific activity. The preface gives a short sketch of his life and professional activities. The collection is divided into two parts. The first part contains 13 articles on general problems of strength and the strength of machine construction materials.

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Problems of Strength (Cont.)

SOV/3416

The second part contains 15 articles on dynamics and calculation of strength and rigidity. There are references at the end of each article.

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Ra Botnov, Yu. N

SOV/24-58-4-3/19

AUTHOR: Ivlev, D.D.

TITLE: Conference on Sustained Static Strength of Turbine Components Working at High Temperatures (Soveshtaniye po dlitel'noy staticheskoy prochnosti detalei turbotzashin, rabotayushchikh pri vysokoy temperature)

PERIODICAL: Izvestiya Akademii Nauk SSSR, Otdeleniye Tekhnicheskikh Nauk, 1958, Nr 4, pp 149 - 150 (USSR)

ABSTRACT: The Commission on the Strength of Gas Turbines from the Institut Mekhaniki AN SSSR (Institute of Mechanics of the Ac.Sc.USSR) (Chairman - Yu.N. Rabotnov) and the Strength Section of the Leningrad Technical Committee on Turbine Construction (Chairman - V.K. Naumov) held a conference during November 20-22, 1957 on the sustained static strength of turbine components working at high temperature.

SOV/24-58-4-3/19

Conference on Sustained Static Strength of Turbine Components Working at High Temperatures

G.A. Tulyakov (ASWITMASH) described the results of an experimental investigation of creep in the boiler steel 1st St (Walt) under complex stress conditions.

M.K. Kats (IzKI in Polzunov) gave a paper on "Investigation of Deformation and Sustained Strength of Tubes" containing results on the study of creep under complex stress conditions.

A.M. Grubin (Vyssheye Voenno-morskoye uchilishche in Dzerzhinskogo "Advanced Naval School in Dzerzhinsk) read a paper on "Calculation of the 'fir-tree' Roots of Blades of Gas Turbines in the Creep Deformation Region."

V.K. Naumov (Leningradskiy gosudarstvennyy universitet - Leningrad State University and IzKI in Polzunov) dealt with calculating the deformation of turbine rotors and to calculate the deformation of turbine rotors and to calculate the deformation of turbine rotors.

Yu.K. Babitskiy (Moscow State University, Institut mekhaniki AN SSSR - Institute of Mechanics of the Ac.Sc.USSR) described the results of theoretical and experimental investigations in unsteady creep under complex stress conditions. He remarked that there now exists a theory, agreeing satisfactorily with experimental data, which permits the calculation of the stress and deformation state in turbine disks and rotors at high temperatures. In addition he has designed constructed apparatus for investigating sustained strength and creep of heat resisting alloys under complex stress conditions and a number of valuable results have been obtained with this apparatus.

A.P. Spolin (IzKI in Polzunov) discussed the choice of the nature of loading of components working at high temperatures.

M.V. Gerasimov (TALAN) gave a paper "On Constructional Factors of Sustained Static Strength" which described results obtained on low-power turbine equipment.

The paper of M.K. Kalinovsky dealt with the bearing capacity of turbine rotors.

Many participants remarked on the increasing need for extensive coordination of work in the field of strength of gas turbines.

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24(5)
AUTHORS:

SOV/179-59-4-12/40
Rabotnov, Yu. N., Rabinovich, V. P. (Moscow)

TITLE:

On the Strength of Disks in Creep

PERIODICAL:

Izvestiya Akademii nauk SSSR. Otdeleniye tekhnicheskikh nauk.
Mekhanika i mashinostroyeniye, 1959, Nr 4, pp 93-100 (USSR)

ABSTRACT:

The results of the experiments for the strength test of disks in creeping are put forward. The problem of strength of a turbine wheel disk subjected to creep conditions consists of 2 tasks: 1) Determination of strains and deformation, and 2) determination of the conditions causing the destruction. The investigations described had primarily the purpose of checking the correct determination of stresses and deformation by experiment. Second, the conditions were checked under which the wheel disks are destroyed in creep. The usual calculation method is based on the assumption that the maximum creep strength of the material is equal to the maximum standard stress calculated according to the simplest aging theory (Ref 1). It is shown here that this calculation method ensures a satisfactory accuracy in the forecast of disk life, and, therefore may be used as a basis in the choice of admissible

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On the Strength of Disks in Creep

SOV/179-59-4-12/40

stress. It is shown that the properties of the material influence the strength of wheel disks. The investigations were carried out with 4 different materials used in turbine construction: perlite steel R-3, austenite steel EI-405 and EI-572, and nickel alloy EI-437b. The experiments were made at the creep tester of the TsNIITMASH (Central Scientific Research Institute of Technology and Machinery). The computations were carried out on the "Strela-3" electron computer by means of the program developed at the Institut im. Baranova (Institute imeni Baranov) by A. V. Amel'yanchik (Ref 4) for the elasticity- and plasticity calculation of disks. - The experimental results show that the strength of disk depends on the creep strength and on the ability of the material of redistributing the stresses. The latter ability is characterized by the value m . The diagram of the influence of a central boring on the disk strength is shown in figure 6. It is shown that this influence does not only depend on the share of the boring on the disk surface, but also on m . The experiments showed that in the case of good material properties, the stresses are also redistributed in flat disks if there is a creeping, i.e. that the principle of "equal strength" can be

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On the Strength of Disks in Creep

SOV/179-59-4-12/40

ensured, to a certain extent, not by the shape of the disk but by the material. There are 6 figures, 1 table, and 8 references, 6 of which are Soviet.

SUBMITTED: March 20, 1959

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RABOTNOV, Yu.N. (Moskva)

Model illustrating certain properties of plastic bodies with reinforcement. Prikl. mat. i mekh. 23 no.1:164-169 Ja-Y '59. (MIRA 12:2)

(Plasticity)

RA BO TROU, Y. U. N.

Report presented at the 1st All-Union Congress of Theoretical and Applied Mechanics, Moscow, 27 Jan - 3 Feb '60.

- 234. G. I. Piontseva (Moscow): Large deflections of reinforced shells of cylindrical shells.
- 235. V. I. Babitskiy (Moscow), V. A. Babitskiy (Kirovograd): Creep through of hollow shafts.
- 236. A. I. Babitskiy (Moscow): Creep and consolidation of sands under the action of average forces.
- 237. Yu. I. Babitskiy (Kirovograd): Creep.
- 238. B. M. Bogoyavlitskiy (Leningrad): Some problems in the theory of elasticity concerning the design of rock foundations.
- 239. B. M. Bogoyavlitskiy (Leningrad): Some difference equations of structural mechanics.
- 240. B. A. Babitskiy (Moscow): On the propagation of elastic plastic waves in a half-space.
- 241. B. A. Babitskiy (Moscow): Propagation of disturbances in continuous media.
- 242. V. F. Belik (Novosibirsk): Barye processes on flexible retaining walls.
- 243. V. G. Prityay (Chelabinsk): On the pressure of a punch on an elastic half-space.
- 244. V. G. Prityay (Moscow): Types of high molecular and fiber-reinforced structures and their anisotropy in mechanical properties.
- 245. B. I. Buzdakov (Leningrad): On the influence of the maximum principal stress on the fatigue strength.
- 246. V. G. Prityay (Moscow): The application of the method of homoclinic trajectories to some two-dimensional problems of the theory of elasticity.
- 247. A. I. Babitskiy (Moscow): Some three-dimensional problems of fluid equilibrium in rigid, plastic shells.
- 248. B. I. Buzdakov (Leningrad): On the application of the Galerkin-Bubnov method to Aronov's creep theory of composites.
- 249. B. I. Buzdakov (Leningrad): Some problems of the integral operator theory of creep.
- 250. A. G. Babitskiy (Leningrad): Design of elastic-plastic truss for bending and torsion deformations.
- 251. B. I. Buzdakov (Leningrad): The determination of the deformation of rock foundations by the method of successive approximations.
- 252. B. I. Buzdakov (Leningrad): The determination of the deformation of rock foundations by the method of successive approximations.
- 253. B. I. Buzdakov (Leningrad): The design of a double punch in a half space.
- 254. B. I. Buzdakov (Leningrad): The design of a double punch in a half space.
- 255. B. I. Buzdakov (Leningrad): The use of anisotropy considerations in determining the convergence in the design of shells by successive approximations.
- 256. B. I. Buzdakov (Leningrad): Stability of cellular structures built on rock ground.
- 257. B. I. Buzdakov (Leningrad): Stability of thin kirpicholom tubes supported by an elastic layer of finite thickness.
- 258. B. I. Buzdakov (Leningrad): Plastic bending of plates into cylindrical shells.
- 259. B. I. Buzdakov (Leningrad): A beam on a two-layer half space beyond the elastic limit.
- 260. B. I. Buzdakov (Leningrad): Some problems of creep and consolidation of activated soils.
- 261. B. I. Buzdakov (Leningrad): Investigation of the natural frequencies of plates of constant and variable thickness.
- 262. B. I. Buzdakov (Leningrad): Dynamic problems of the design of retaining walls and soil foundations under impact loads.
- 263. B. I. Buzdakov (Leningrad): Solution of some dynamic problems of retaining walls and soil foundations by the method of finite differences.
- 264. B. I. Buzdakov (Leningrad): On some problems of the theory of stability and soil consolidation.
- 265. B. I. Buzdakov (Leningrad): On a class of solutions of the problem of stability of plates.
- 266. B. I. Buzdakov (Leningrad): The effect of internal friction on the stresses in beams and plates under impulsive loading.
- 267. B. I. Buzdakov (Leningrad): Stresses in cylindrical shells subjected to internal pressure.

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24.4200 1327 2607

AUTHOR: Rabotnov, Yu. N.
TITLE: Creep of metals and its computation

PERIODICAL: Rozprawy inzynierskie, v. 8, no. 3, 1960, 349-394

TEXT: After describing in detail the creep of metals and its representation on strain-temperature graphs, the importance of the exact evaluation of creep is stressed for designing machine elements made of heat-resisting alloys for which small deformations take place at high temperatures. The relationship between the creep strain, stress and time of loading is discussed for the following creep theories: (A) The theory of aging-- (2.1)

(B) The theory of flaw--

$$\epsilon = f(\sigma, t)$$

(2.1)

$$\epsilon = \frac{\sigma}{E} + f_1(\sigma, t)$$

(2.2)

X

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Creep of metals...

(C) N. M. Belyayev's theory--

$$\epsilon = \sigma \left[\frac{1}{E} + \int_0^t \frac{f_1(\sigma, t)}{\sigma} dt \right] \quad (2.3)$$

(Ref. 2: Izvestiya AN SSSR, OTN no. 7, 1943); (D) The theory of strain hardening based on the hypothesis of the equation of state--

$$\Phi(\dot{\rho}, \rho, \sigma, T) = 0 \quad (2.4)$$

where $\rho = \epsilon - \psi(\sigma)$ - plastic deformation, σ - stress $\psi(\sigma)$ - instantaneous deformation; (E) The theory of plastic inheritance due to Volterry. The comparison of these theories and their suitability for various applications is discussed, and the obtained results are studied for their verifications with the experimental data and the simplicity in various practical calculations. The conditions are analyzed for the steady-state creep introduced, in which the stresses are unknown and the strain rates are not constant. Relaxation as a phenomenon allied to creep is defined, and the equations for the steady-state creep and for relaxation are given, from

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Creep of metals...

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which the distinction between the instantaneous plastic deformation and that due to creep is apparent. The experiments carried out at the Institut mekhaniki (Institute of Mechanics) AS USSR by G. M. Ivanova, (Ref. 13: Izv. AN SSSR, OTN, no. 4, 1959) are described in order to find the relationship between the influence of the temperature changes and creep deformation. The mechanism of the failure's origin and the crack propagation leading to destruction of test specimens under creep is analyzed by summation methods for variable loading. The equations representing the creep for complex stresses are derived from the theory of elasticity and the notion of plastic potential is introduced. Recommendations are given for the scheme for calculating relaxation. Various experiments and research work are described for a number of machine design problems, from which it follows that the most simple methods of computation lead to sufficiently accurate results and provide the basis for stress determination. The author gives some computation methods for solving rotating disc problems on the basis of the theory of strain-hardening, taking the stress-distribution into consideration, which is particularly important for analysis of non-steady states. The stability problems under conditions of creep are considered for bars

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Creep of metals...

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D265/D305

and sections of thin-walls, and several analytical approaches are considered for finding the criteria of stability. There are 14 figures, 1 table and 34 references: 27 Soviet-bloc and 7 non-Soviet-bloc. The 4 most recent references to English-language publications read as follows: G. Gerard, A Creep Buckling Hypothesis, J. Aeronaut Sci. 9, 23 (1956); F. H. Turner, K. E. Blumquist, A Study of the Applicability of Rabotnov's Creep Parameter for Aluminum Alloy, J. Aeronaut Sci. 12, 23, (1956); N. I. Hoff, Creep Buckling, Aeronaut Quart. 7 (1956); A. E. Johnson and N. E. Frost, Notes on the Fracture under Complex Stress Creep Conditions for 0.5% Molybdenum Steel at 550° and a Commercially Pure Copper at 250° C, NPL, 2, 31 (1954).

ASSOCIATION: Institut gidrodinamiki, Novosibirsk, AN SSSR (Institute of Hydrodynamics, Novosibirsk, AS USSR)

SUBMITTED: March 4, 1960

Card 4/4

AUTHORS: Rabotnov, Yu. N., Sokolov, B. P.S/032/60/036/03/054/064
B010/B117TITLE: A Device for Testing Materials in Complex State of StressPERIODICAL: Zavodskaya laboratoriya, 1960, Vol ²⁶ ~~25~~, Nr 3, pp 374-375 (USSR)

TEXT: A simple, small-size device (Fig) has been designed which permits the establishment of any state of stress in tubular samples, and makes it possible to investigate the behavior of materials under the conditions of a state of stress in a plane. In the housing of the device described, there is an upper and a lower piston as well as a casing. The thin-walled, tubular sample is attached to the upper part of the housing while the lower part of the sample is fixed either to the piston or to the cylinder. If the sample has been fixed to the piston, an axial elongation stress can be attained by means of a pressure fluid (highly viscous liquids being recommended) and of the piston with a step-by-step action. An additional axial compressive stress is attained by the attachment of the lower part of the sample to the casing, and by the pressure liquid. By applying pistons or casings with different diameters, different states of stress in a wide interval can be reached. Experiments performed with steel and plastics samples gave satisfactory results. There is 1 figure.

~~cont'd~~ *Inst. Hydrodynamics, Siberian Dept AS USSR.*

BITSADZE, A.V., red.; VEKUA, I.N., red.; KUDRYAVTSEV, L.D., red.;
MIGIRENKO, G.S., red.; RABOTNOV, Yu.N., red.; KHRISTIANOVICH,
S.A., red.; ALEKSANDROVSKIY, B.M., red.; NAZARYANTS, T.M.,
red.; VYALYKH, A.M., tekhn. red.; LOKSHINA, O.A., tekhn. red.

[Some problems in mathematics and mechanics] Nekotorye pro-
blemy matematiki i mekhaniki. Novosibirsk, Izd-vo Sibirskogo
otd-nie AN SSSR, 1961. 265 p. (MIRA 15:2)

1. Akademiya nauk SSSR. Sibirskoye otdeleniye.
(Mathematics) (Mechanics)

NAMESTINIKOV, V.S. (Novosibirsk); RABOTNOV, Yu.N. (Novosibirsk)

Hypothesis of the equation of state in the case of creep. PMTF
no.3:101-102 S-0 '61. (MIRA 14:8)
(Equation of state) (Creep of materials)

S/207/61/000/004/011/012
E032/E514

AUTHORS: Namestnikov, V.S. and Rabotnov, Yu. N. (Novosibirsk)

TITLE: Hereditary theories of creep

PERIODICAL: Akademii nauk SSSR. Siberskoye otdeleniye.
Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki.
no.4, 1961, 148-150

TEXT: This is a continuation of previous work (Ref.5: Vestn. MGU, 1948, No.10; Ref.9: PMFF, 1960, No.4). A review is given of the stress-strain relations in the form of integral equations which are suitable for describing the creep properties of materials. Experimental results for the creep of the $D-16T$ (D-16T) alloy subjected to constant and step loading at 200 and 150°C, and the stress relaxation at 150°C are compared with the theoretical curves calculated from the equations of the second of the present authors (Ref.5) and of N. Kh.Arutyunyan (Ref.3: "Some problems in the theory of creep". GTTI, 1951) and M. I. Rozovskiy (Ref.6: ZhTF, 1951, v.21, No.11). Although the general trend of the experimental results is reproduced by the theoretical curves, the overall numerical agreement is not good. There are 4 figures and
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Hereditary theories of creep

S/207/61/000/004/011/012
E052/E514

9 references: 5 Soviet-bloc and 4 non-Soviet-bloc. The English-language references read as follows: Ref.4: Lee E.H., Viscoelastic stress analysis. Structural mechanics, Pergamon Press, 1960; Ref.7: Turner F.H., Blumquist K.E. A study of the applicability of Rabotnov's creep parameter for aluminium alloy; J.Aeronaut.Sci., 1956, 12, 23. ✓

SUBMITTED: March 31, 1961

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Рабoтнoй, Yu. N.
Transactions of the All-Union Congress (Cont.)

SOV/6201

(25)

PURPOSE: This book is intended for scientific and engineering personnel who are interested in recent work in theoretical and applied mechanics.

COVERAGE: The articles included in these transactions are arranged by general subject matter under the following heads: general and applied mechanics (5 papers), fluid mechanics (10 papers), and the mechanics of rigid bodies (8 papers). Besides the organizational personnel of the congress, no personalities are mentioned. Six of the papers in the present collection have no references; the remaining 17 contain approximately 1400 references in Russian, Ukrainian, English, German, Czechoslovak, Rumanian, French, Italian, and Dutch.

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PHASE I BOOK EXPLOITATION SOV/6201 29

Vsesoyuznyy s"yezd po teoreticheskoy i prikladnoy mekhanike. 1st, Moscow, 1960.

Trudy Vsesoyuznogo s"yezda po teoreticheskoy i prikladnoy mekhanike, 27 yanvarya -- 3 fevralya 1960 g. Obzornyye doklady (Transactions of the All-Union Congress on Theoretical and Applied Mechanics, 27 January to 3 February 1960. Summary Reports). Moscow, Izd-vo AN SSSR, 1962. 467 p. 3000 copies printed.

Sponsoring Agency: Akademiya nauk SSSR. Natsional'nyy komitet SSSR po teoreticheskoy i prikladnoy mekhanike.

Editorial Board: L. I. Sedov, Chairman; V. V. Sokolovskiy, Deputy Chairman; G. S. Shapiro, Scientific Secretary; G. Yu. Dzhanelidze, S. V. Kalinin, L. G. Loytsyanskiy, A. I. Lur'ye, G. K. Mikhaylov, G. I. Petrov, and V. V. Rumyantsev; Resp. Ed.: L. I. Sedov; Ed. of Publishing House: A. G. Chakhirev; Tech. Ed.: R. A. Zamarayeva.

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AVAILABLE: Library of Congress

SUBJECT: Physics

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IS/dmp/mas
2-13-62

BRONSKIY, A.P.; KLYUSHNIKOV, V.D.; MAZING, R.I.; RABOTNOV, Yu.N.;
SHESTERIKOV, S.A.

Dynamic strength of building materials at medium deformation
rates. PMTF no.1:118-130 Ja-F '62. (MIRA 15:4)
(Deformations (Mechanics)) (Strength of materials)

S/030/62/000/001/005/011
B104/B102

AUTHOR: Rabotnov, Yu. N., Academician

TITLE: Cold resistance of machines and constructions

PERIODICAL: Akademiya nauk SSSR. Vestnik, no. 1, 1962, 53 - 55

TEXT: Cold brittleness occurs in low-alloy carbon steels at such temperatures as exist in the northern regions of the Soviet Union. Austenite steel alloys do not get brittle. But for economic reasons it is impossible to use them. Small admixture of nickel lower the characteristic temperature below which cold brittleness occurs; the same is attained by hardening or normalizing. At the Laboratoriya matallovedeniya Vostochno-Sibirskogo filiala Sibirskogo otdeleniya Akademii nauk SSSR (Laboratory of Metallography of the East Siberian Branch of the Siberian Department of the Academy of Sciences USSR) in Angarsk, methods are investigated for improving the cold resistance of machines and metal constructions. A small group is working at an independent laboratory in Yakutsk. A nauchno-tehnicheskii sovet po khladnostoykosti (Scientific and Technical Council for Cold Resistance) was established with scientists from Moscow, Card 1/2

Cold resistance of ...

S/030/62/000/001/005/011
B104/B102

Leningrad, Novosibirsk, Irkutsk, Kiyev, and chairmen of proyektnyye instituty (Design and Planning Institutes), sovnarkhozy, and enterprises of the heavy industry of Yakutsk, Noril'sk, Magadan, and other towns. Methods for improving the cold resistance, and the elaboration of new steel grades are planned. ГОСТ (GOST) standards should be modified or completed. Improving the cold resistance is regarded as important to national economy. ✓

Cat: 2/2

S/179/62/000/002/001/012
E191/E435

AUTHOR: Rabotnov, Yu.N. (Novosibirsk)

TITLE: The mechanics of solids and the trends in its development

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye tekhnicheskikh nauk. Mekhanika i mashinostroyeniye, no.2, 1962, 3-10

TEXT: The traditional and modern relations between engineering stress analysis, the theories of elasticity and plasticity and the mechanics of continuous media in its most general form are discussed, including some conceptions of crystal physics such as the theory of dislocations. The author claims no more than the presentation of selected observations stimulated by the current knowledge in the mechanics of solids. The range of mechanical models underlying fully developed mathematical theories is greatly limited, for example in the theory of elasticity by the linear relation of stress and strain. The great discrepancy between the accuracy of the methods of elastic theory and the Card 1/4

S/179/62/000/002/001/012
E191/E435

The mechanics of solids ...

rough approximations by which the local strength criteria are established is highly unsatisfactory. Even elementary treatment contains some formulations of "global" failure. The mechanical model chosen assists in the overall formulation of failure, for example the classical model of elastic instability. The most important discovery in elastic theory during the last ten years was that of the loss of "macroscopic" stability in shells. The linear theory gave excessive critical loads compared with experiment. Equilibrium shapes exist, different from the initial, and separated from it by a certain potential barrier. These shapes can be formulated mathematically only with the help of non-linear theory, taking finite deflections into account. Accidental circumstances cause crossing the barrier or "snapping over". Another example of a theory concerned with overall failure is the theory of ideal plasticity. The material can flow without limit insofar as is kinematically possible. The usual problem is that of determining the loads under which the plastic region develops to the extent that further increase of the external loads becomes impossible. An example is the extension

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S/179/62/000/002/001/012
E191/E435

The mechanics of solids ...

of a notched bar. When the plastic region developing at the bottom of the notch extends over the entire cross-section, a further increase in tension becomes impossible. The theory of plasticity of strain hardening materials is also being developed. So far, reliable results have been obtained only for the case of proportional loading, namely when the components of the stress tensor (or its deviator) grow proportionally with a single parameter, i.e. preserving constant ratios between the components. Attempts to create new theories of plasticity, more realistic in terms of polycrystalline materials have so far only clarified the nature of the difficulties; some of these are discussed and reference is made to the author's earlier analysis of flexure in an elasto-plastic body (Prikladnaya matematika i mekhanika, v.23, no.1, 1959). These theories have received much attention recently. Many more problems are amenable to solution but very little knowledge has been gained on the criteria of failure under plastic conditions. Some attempts have been made to formulate the conditions of local failure, such as the tearing strength, but this does not necessarily yield the full strength.

Card 3/4

S/179/62/000/002/001/012
E191/E435

The mechanics of solids ...

reserve, since some cracks can cease to propagate after reaching certain dimensions. Some of the crack growth theories in Russian and non-Russian literature are discussed. However, the origin of cracks is not yet clarified or brought into agreement with observed phenomena. In this sense, the physical strength of real plastic materials has not yet been explored. In the theory of creep, the large scatter between test results has made attempts of refinement fruitless. Moreover, for the main object in which work on creep analysis has been concentrated, the rotating turbine disc, several theories give similar results. The only difference between theories concerns the actual process and its time history and not the final results. The field of fatigue, in spite of fairly reliable methods of engineering prediction, is still outside theoretical mechanics. There are 2 figures.

SUBMITTED: January 27, 1962

Card 4/4

S/032/62/028/004/022/026
B124/B101

AUTHORS: Bayev, L. V., Malinin, N. I., Rabotnov, Yu. N., and Shubin, I. A.

TITLE: Device for creep and relaxation testing of plastics

PERIODICAL: Zavodskaya laboratoriya, v. 28, no. 4, 1962, 498 - 500

TEXT: A testing device based on the loading of a lever is described. The size of the plastic specimens is 55 - 100 mm length, 1 - 10 mm thickness. The load of the lever can be changed between 0 to 200 or 500 kg. An improved model of the device for breaking load up to 1500 kg was tested. The loading limits are changed by replacing the lever with 1:10 arm ratio by a lever with ratio 1:4. For relaxation tests the loading is replaced by a spring. The device can be adjusted for constant temperature. No compensation for dynamometer deformation during the relaxation test is provided. Tests of KAKT-3 (KAST-V) glass-reinforced plastic show low creep (0.5% at 10 kg/cm²) along the warp, and higher creep (3% at 7 kg/cm²) at an angle of 45° to the warp. There are 3 figures. ✓

Card 1/2

Device for creep ...

S/032/62/028/004/022/026
B124/B101

ASSOCIATION: Institut obshchey i neorganicheskoy khimii Akademii nauk USSR
(Institute of General and Inorganic Chemistry of the Academy
of Sciences UkrSSR)

Card 2/2

✓

RABOTNOV, Yu.N., akademik

Cold resistance of machinery and metal constructions. Vest. AN SSSR
32 no.1:53-55 Ja '62. (MIRA 15:1)
(Metals at low temperatures)

RABOTNOV, Yu.N., akademik, otv. red.; MALININ, N.I., kand.
tekhn. nauk, otv. red.; NAZARYANTS, T.M., red.

[Creep and lasting strength; transactions] Polzuchest'
i dlitel'naya prochnost'; trudy. Novosibirsk, Izd-vo
Sibirskogo otd-niia AN SSSR, 1963. 198 p.

(MIRA 18:2)

1. Vsesoyuznoye soveshchaniye po teorii raschetov na
polzuchest' i dlitel'nuyu prochnost', Novosibirsk, 1962.

RAHOTNOV, Yuriy, N.

"On the equation of state of creep."

Report to be submitted for the Joint International Conference on
Creep, New York, 25-29 Aug 63.

RABOTNOV, Yu.N., akademik, otv. red.; MALININ, N.I., kand. tekhn.
naúk, otv. red.; NAZARYANTS, T.M., red.

[Creep and stress-rupture strength] Polzuchest' i dlitel'-
naia prochnost': 'rudy. Novosibirsk, Izd-vo Sibirakogo otd-
niia AN SSSR, 1963. 198 p. (MIRA 17:7)

1. Vsesoyuznoye soveshchaniye po teorii raschetov na polzu-
chest' i dlitel'nyu prochnost'. Novosibirsk, 1962.

RABOTNOV, YU.N., NEMIROVSKIY, YU.V.

On limit state of ribbed plates and shells

Report to be submitted for the Shell Structures, International
Association for (IASS) Symposium on Non-Classical Shell Problems
Warsaw, Poland, 2-5 Sept 63

IVANOV, G.V. (Novosibirsk); NEMIROVSKIY, Yu.V. (Novosibirsk);
RABOTNOV, Yu.M. (Novosibirsk)

Dynamics of a rigidly plastic system of cross bracings. Isv.
AN SSSR Otd. tekhn. nauk. Mekh. i mashinostr. no.2:51-57
Mr-Apr '63. (MIRA 16:6)

(Structural frames)

AID Nr. 985-3 7 June

THEORY OF CREEP RUPTURE (USSR)

Rabotnov, Yu. N. Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 2,
Mar-Apr 1963, 113-123. S/207/63/000/002/013/025

The present state of the theory of creep rupture is analyzed with regard to tertiary creep, and formulas describing the creep behavior and giving the rupture-test time of specimens under tension are derived for each type of rupture. Ductile rupture (with necking) is discussed with a constant creep rate and logarithmic strain assumed. Brittle rupture (without visible necking) is analyzed by introducing a parameter (ω) related to the structure of the material and associated with the crack-forming mechanism. It is used as a measure of embrittlement (in initial state $\omega = 0$; the rupture occurs when $\omega = 1$). Intermediate (ductile-brittle) rupture, where ω is used as a determining parameter in the creep function, is examined, and the dependence of strain on the degree of embrittlement is established and used as a criterion of failure. The formulas derived are applied also to the examination of short-time (with duration of the order of tens to hundreds of seconds) and complex-stress creep processes. A

Card 1/2

AID Nr. 985-3 7 June

THEORY OF CREEP RUPTURE [Cont'd]

S/207/63/000/002/013/025

sample calculation of the rupture time under a complex state of stress of a rotating disk with a central hole is carried out by applying the concept of intermediate creep rupture. The stress distribution in the disk is determined, and a system of equations for determining the rupture time is obtained from which, by putting $\omega = 1$, the instant of the failure can be predicted. A method for an approximate estimate of the rupture time is also given. The creep behavior of thin-walled tubes under the combined action of tension and torsion is discussed from the viewpoint of the theory outlined above.

[VK]

Card 2/2

NEMIROVSKIY, Yu.V. (Novosibirsk); RABOTNOV, Yu.N. (Novosibirsk)

Ultimate equilibrium of reinforced cylindrical shells. Izv. AN
SSSR. Otd. tekhn. nauk. Mekh. i mashinostr. no. 3:83-94 My-Je '63.
(MIRA 16:8)

(Elastic plates and shells)

DANILOV, N.S. (Novosibirsk); KUPRIYENKO, P.L. (Novosibirsk);
MALININ, N.I. (Novosibirsk); RABOTNOV, Yu.N. (Novosibirsk);
SHUBIN, I.A. (Novosibirsk)

Program-controlled machine for investigating deformations
of plastics under complexly stressed state conditions. Izv.
AN SSSR. Mekh. i mashinostr. no.6:20-24 N-D '63.
(MIRA 17:1)

RABOTNOV, YU. N. (Novosibirsk)

"Creep of metals"

Report presented at the 2nd All-Union Congress on Theoretical and Applied Mechanics, Moscow 29 Jan - 5 Feb 64.

RABOTNOV, Yu. N.

"Creep of shells."

report submitted for 11th Intl Cong of Theoretical & Applied Mechanics & General Assembly, Munich, 30 Aug-5 Sep 64.

ACCESSION NR: AP4013736

S/0030/64/000/001/0059/0062

AUTHOR: Rabotnov, Yu. N. (Academician)

TITLE: Nonclassical problems in the theory of thin shells (Symposium in Warsaw)

SOURCE: AN SSSR. Vestnik, no. 1, 1964, 59-62

TOPIC TAGS: thin shell, reinforced concrete, nonclassical thin shell problems, span, thin shell theory, elasticity theory, safety factor, thin shell use

ABSTRACT: A symposium on nonclassical problems in the theory of thin shells was held in Warsaw September 2-5, 1963. Instead of reading individual reports, the main speaker in each of the five sections presented a review of all works submitted. The section on thermoelasticity was presented by V. Novacki (Poland), on cohesion and creep by Yu. N. Rabotnov (USSR), on plasticity by E. Onat (USA), on the state of reinforced concrete shells by K. Johansen (Denmark), and on construction problems by F. Levi (Italy). Though a strictly theoretical approach to the problems was attempted, the numerically predominant group of engineers made it necessary to divide the context into three sections of theoretical considerations and two dedicated to the actual problems arising in reinforced concrete structures.

Card 1/3

ACCESSION NR: AP4013736

Matters related to thermoelasticity may have been relegated to the realm of the classical theory but were included in the program, possibly because of the great interest displayed in this subject by the Polish scientists. Exact equations of thermodynamics, dealing simultaneously with the thermal influences on deformations and with the influences of elastic deformations on the temperature field were not presented. Problems on dynamics (related to fast and intensive heating) were well exemplified in the work of Ch. Hsiu and P. Nagdi (USA), dealing with the distribution of thermoelastic waves in a conical shell. Problems of linear cohesion occupied the section on cohesion and creep. Theory of equilibrium in shells made of plastic materials has a tendency of passing into the realm of the classics and is undergoing a gradual development. It was well illustrated in the work of J. Rykhlevski (Poland), dealing with the state of helicoidal shells. It was noted that the theory of shells is based on some kinematic hypotheses on the one hand and on the theory of plasticity and elasticity on the other. The symposium proved the present need for developing nonclassical tendencies in the mechanics of solid state. The greatest efforts in this direction are being undertaken in the USA, which sent a large delegation. The SSSR is also attacking the problem along a broad front, and our publications on the theories of equilibrium and of creep are steadily growing in number.

Card 2/3

ACCESSION NR: AP4013736

ASSOCIATION: none

SUBMITTED: 00

DATE ACQ: 03Mar64

ENCL: 00

SUB CODE: AP, MA

NO REF SOV: 000

OTHER: 000

Card 3/3

LAVRENT'YEV, A.M., akademik; RABOTNOV, Yu.N., akademik; RZHANOV, A.V.;
VOROB'YEV, A.A., prof.; KUZNETSOV, Yu.A.; SOKOLOV, V.A., prof.

Vladimir Dmitrievich Kuznetsov, 1887-1963; an obituary.

Izv. SO AN SSSR no.2. Ser. tekhn. nauk no.1:142-143 '64.

(MIRA 17:8)

1. Chleny-korrespondenty AN SSSR (for Rzhhanov, Kuznetsov).

L 24202-65 ENT(d)/ENT(m)/ENP(w)/ENA(d)/ENP(v)/T/ENP(t)/ENP(k)/ENP(b)/ENA(h)

ACCESSION NR: AP5000274 Pf-h/Peb EM/JD S/0040/64/028/006/1040/1047

AUTHOR: Rabotnov, Yu. N. (Novosibirsk)

TITLE: Axisymmetrical creep problems of circular cylindrical shells ^B

SOURCE: Prikladnaya matematika i mekhanika, v. 28, no. 6, 1964, 1040-1047 ²⁶

TOPIC TAGS: cylindrical shell, circular cylindrical shell creep

ABSTRACT: Extending earlier work on the prediction of creep to cylindrical shells with double walls of equal thickness, and assuming the rate of deformation to be constant through the walls. so that pressure will be evenly distributed.

...ing equation by application of the step law of creep:

$$h = \left(\frac{n}{1 + 2n} \right)^{n / (n+1)} H$$

where H = radius of the cylinder and h = half the distance between the two walls. Expanding this operation for circular cylindrical shells, applying Euler's criterion for simplification, and solving for the cases of fulfillment of either Lagrange's or Castiglione's functions, relating the moment of flexure to the dimensions or rate of change in curvature,

Card 1/2

L 21202-65

ACCESSION NR: AP5000274

respectively, permits derivation of an expression in terms of α and β , two characteristic quantities which were evaluated for different values of n from 1 to 6. As n varies from 1 to 6, α varies from 1.000 to 0.646, and β varies from 1.000 to 0.540. Further investigation shows β to have definite relationships to other parameters in the equation for $n > 1$. Orig. art. has: 38 formulas.

ASSOCIATION: none

SUBMITTED: 14Aug64

ENCL: 00

SUB CODE: AS

NO REF SOV: 002

OTHER: 002

Card 2/2

L 62490-65 EPF(c), EWP(j)/EWP(k)/EWA(h)/EWT(d)/EWT(m)/T/EWA(d)/EWP(w)/EWP(v)

ACCESSION NR: AP5018613

EM/RM/WW

UR/0030/65/000/007/0033/0038

AUTHOR: Rabotnov, Yu. N. (Academician)

TITLE: Mechanics of solid bodies and polymer materials

SOURCE: AN SSSR. Vestnik, no. 7, 1965, 33-38

TOPIC TAGS: polymer, deformation rate, continuum mechanics, fatigue strength, creep mechanism, shell theory, elastic plastic theory

ABSTRACT: The various aspects of continuum mechanics as applied to solid bodies and polymers are reviewed. Two trends are observed in the investigation of solid body mechanics: the investigation of deformation

Card 1/2

L 67490-65

ACCESSION NR: AP5018613

3

A special effort in recent years has centered around plastic flow on microscopic levels, leading to the formulation of various dislocation schemes in solid bodies.
A third subdivision under study of solid bodies.

ASSOCIATION: none

SUBMITTED: 00

ENCL: 00

SUB CODE: MT, ME

NO REF SOV: 000

OTHER: 000

Card ^{mp} 2/2

RABOTNOV, Yu.N. (Novosibirsk); STANKEVICH, O.F. (Novosibirsk)

Experimental disclosure of plastic zones on models made from
a titanium alloy. Izv. AN SSSR, Mekh. no.2:108-109 Mr-Apr '65.
(MIRA 18:6)

RABOTNOV, Yu.N., akademik

Mechanics of solids and polymers. Vest. AN SSSR 35 no.7:33-38 J1 '55.
(MIRA 18:3)

L 24008-66 EWT(m)/EWP(w)/T/EWP(t) JD/HW

ACC NR: AP6014948

SOURCE CODE: UR/0207/65/000/001/0141/0159

AUTHOR: Rabotnov, Yu. N. (Novosibirsk)

ORG: none

TITLE: Experimental data on creep of engineering alloys and phenomenological theories of creep (review) 18

SOURCE: Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 1, 1965, 141-159

TOPIC TAGS: creep, heat resistant alloy, material deformation

ABSTRACT: The article is a review of the experimental data available, including that produced by the author, on the problem of creep and creep failure in engineering alloys. Almost all the experimental material available is in the form of curves showing deformation as a function of time at constant load. These curves have three sections: an unstabilized creep section at the beginning, a stabilized creep section with constant rate, and an accelerated creep section which precedes failure. In the development of a creep theory applicable to building technology a conventional creep limit, the greatest stress for which the creep does not exceed a preset value, must be used. Since modern heat-resistant alloys may fail at deformations of less than 1%, this limit must be low. Three types of creep, corresponding to the three portions of the curves mentioned above, must be contended with. Creep varies in a complex manner with temperature. The two principle ways of dealing with unstabilized

Card 1/2

46
45
B

L 24008-66

ACC NR: AP6014948

initial creep, of interest for aviation applications, are the elastic heredity theory--an integral replacement for Hooke's law--and state or strengthening hypothesis equation applications. Attempts to include viscous failure in creep theory are described. Orig. art. has: 14 figures, 5 formulas, and 1 table. JPRS

SUB CODE: 11, 20 / SUBM DATE: 26Aug64 / ORIG REF: 033 / OTH REF: 024

Heat Resistant Alloys , 8

Card 2/2 *pla*

L 29693-66 EWP(k)/EWT(d)/EWI(m)/I/EWP(w)/EWP(v)/EWP(t)/EII IJP(c) EM/WW/JD

ACC NR: AP6015606

SOURCE CODE: UR/0020/66/168/002/0300/0303

AUTHOR: Rabotnov, Yu. N. (Academician)

66
B

ORG: State Scientific Research Institute of Machine Sciences (Gosudarstvennyy nauchno-issledovatel'skiy institut mashinovedeniya)

TITLE: Variation equation of steady state creep in shells ² ₆

SOURCE: AN SSSR. Doklady, v. 168, no. 2, 1966, ¹⁶ 300-303

TOPIC TAGS: variational method, shell theory, creep, elastic stress, deformation rate, *shell structure, cylindric shell structure*

ABSTRACT: Variational principles are applied to the theory of steady-state creep in shell structures. The given creep equations are written as

$$\begin{aligned} \sigma_{ij,j} + F_i &= 0; \\ \sigma_{ij} &= \partial U / \partial \epsilon_{ij}; \\ \epsilon_{ij} &= 1/2(v_{i,j} + v_{j,i}), \quad v_i = \dot{u}_i \end{aligned}$$

and then expressed by the functional, after the manner of Reissner,

Card 1/2

L 29693-66

ACC NR: AP6015606

0

$$I = I_{00} = \int_V [-\sigma_{ij}v_{i,j} + \Phi(\sigma_{ij}) + F_i v_i] dV + \int_{\Sigma_T} \bar{T}_i v_i d\Sigma + \int_{\Sigma_0} \sigma_{ij} v_j (v_i - \bar{v}_i) d\Sigma$$

The corresponding expression for a shell under a normal pressure q and normal velocity component on the surface v_n is given by

$$I = \int \left[-\frac{4}{\sqrt{3}} (\tau_1 s_1 + \tau_2 s_2 + m_1 x_1) + \varphi\left(\frac{s^2}{a_0}\right) + \varphi\left(\frac{r^2}{a_0}\right) + \frac{q v_n}{\sigma_0} \right] dS$$

A variation on this functional along m_2 and τ_2 leads to the results

$$\tau_2 \pm m_2 = \frac{1}{2} (\tau_1 \pm m_1) + \frac{\sqrt{3}}{2} \frac{s_2}{\sigma_0^2}$$

and

$$\frac{1}{\sigma_0^2} v^2 (w^\pm) = s^2 + (m \pm \tau)^2 (w^\pm)^2$$

The same technique is applied to a semi-zero-moment cylindrical shell where it is shown that this variational principle can lead to a stability analysis for the shell. Orig. art. has: 19 equations.

SUB CODE: 20/ SUBM DATE: 27Jan66/ ORIG REF: 005/ OTH REF: 003

Card 2/2 CC

ACC NR: AP7003635

SOURCE CODE: UR/0380/67/000/001/0098/0101

AUTHORS: Rabotnov, Yu. N. (Moscow); Sinayskiy, V. M. (Moscow); Stepanychev, Ye. I. (Moscow)
ORG: none

TITLE: . A study of kinetics of the disintegration process of glass-reinforced plastic

SOURCE: Mashinovedeniye, no. 1, 1967, 98-101

TOPIC TAGS: ^{GLASS FIBER,} solid kinetics, reinforced plastic, resin, tube, film, lens objective, photoapparatus, polyester plastic, plastic deformation, performance test / No. 21 resin, PN-3 polyester, Zenit photoapparatus, Industar 22 lens objective, BSV-2 radiation tube, RT-5 x-ray film

ABSTRACT: Kinetics of the disintegration process of glass-reinforced plastics based on resin No. 21 and on unsaturated polyester PN-3 (cold set) has been studied using transmitted light photography and absorption microroentgenography. The specimens (30-mm wide rectangular strips) were cut from a sheet (0.6 mm thick) prepared from a single layer of fiber. The first study method, employing photoapparatus "Zenit" with objective "Industar 22," was used to investigate the development of cracks in the binder. The photographs were taken of specimens stretched at known load increments. X-ray diffraction study of the same specimen after removal of the load was conducted in the characteristic radiation of a copper anode at 8--9 kv issuing

UDC: 666.678.023

Card 1/2

ACC NR: AP7003635

from a BSV-2 tube, using domestic fine-grain x-ray film RT-5. It was established that, while increased load causes the appearance of a whole system of cracks (mainly perpendicular to the direction of the stretching) the microstructure of the filler is hardly affected by stretching up to the point of actual destruction of the specimen. The specimens of the materials were obtained from R. Ya. Ivanova (Leningrad). Orig. art. has: 3 figures.

SUB CODE: 11/

SUBM DATE: none

Card 2/2

PROCESSING AND PRIORITIES INDEX

11C

ca

Is *Rhizobium* capable of nitrogen fixation in pure cultures? I. L. Kabanova. *Microbiology* (U. S. S. R.) 7, No. 6, 873-82; *Khim. Referat. Zhur.* 1939, No. 7, 43. - The results of Verner and Kovalev (*C. A.* 31, 2028) were not confirmed for *R. radicum*. There was even a small decrease of N. Under the same conditions the N bacteria assimilated up to 4.5 mg. of N in 100 cc. of the medium.
W. R. Henn

A S S - S L A METALLURGICAL LITERATURE CLASSIFICATION

MATERIALS INDEX

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1ST AND 2ND ORDER

PROCESSES AND PROPERTIES INDEX

Van Niel's investigations of sulfur-purple bacteria. I. L. Rabotnova. *Microbiology (U. S. S. R.)* 8, No. 6, 657-7 (1939); *Khim. Referat. Zhur.* 1939, No. 12, 30-7. Under anaerobic conditions and in direct light CO₂ is reduced without evolution of O₂. Donors of H are the sulfides, sulfites, S and thiosulfates as well as such org. substances as yeast exts., lactate, pyrotartaric acid and malic acid. Not more than 1 quantum of red light is used for the photoreduction of each mol. of CO₂ in S bacteria. The purple pigment, a carotenoid, enables the bacteria to activate H. W. R. Henn

11 C

COMMON ELEMENTS

WATERMATS INDEX

450.354 METALLURGICAL LITERATURE CLASSIFICATION

3RD AND 4TH ORDER

2ND LETTER

1ST AND 2ND LETTER

GROUP

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1ST AND 2ND LETTER

3RD AND 4TH LETTER

1ST AND 2ND ORDERS

PROCESSES AND PROPERTIES INDEX

3RD AND 4TH ORDERS

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OPEN MATERIAL INDEX

ASB-SLA METALLURGICAL LITERATURE CLASSIFICATION

RECENT PHYSIOLOGICAL INVESTIGATIONS OF ROOT-NODULE BACTERIA. I. I. Rabotnova. *Microbiology (U. S. S. R.)* 9, 195-220(1949). - A review. 143 references. T. I.

11C

1ST AND 2ND ORDERS	PROCESSES AND PROPERTIES INDEX	3RD AND 4TH ORDERS
COMMON ELEMENTS	COMMON VARIANTS INDEX	OPEN MATERIAL INDEX
ASB-SLA METALLURGICAL LITERATURE CLASSIFICATION	RECENT PHYSIOLOGICAL INVESTIGATIONS OF ROOT-NODULE BACTERIA. I. I. Rabotnova. <i>Microbiology (U. S. S. R.)</i> 9, 195-220(1949). - A review. 143 references. T. I.	11C

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PROCESSED AND REPRODUCED FROM

CA

16

Effect of environment on AcOH fermentation. I. I. Malukova; *Mikrobiologiya* (U.S.S.R.) 13, 125-34 (in English, 1955) (1944); cf. Ierusalimskii and Mantel'el, *C.A.* 37, 719. — Must cultures of "rapid method" bacteria, somewhat different from *B. curvum* and *B. schutzenbachi* (W. Henneberg, 1946), were used in a continuous fermentation app. of special design. The culture was introduced into a generator contg. beechwood shavings or short sections of porcelain tubing impregnated with the nutritive medium. After standing 1-2 days the app. is fed the substrate continuously, under aeration, at 28-30°. Usually the bacteria spread rapidly on the shavings and acidification of alc. begins in 3-4 days. On porcelain the process begins after 40 days. The substrate contained (NH₄)₂SO₄, MgSO₄, K₂HPO₄, 0.1 g. each, (NH₄)₂HPO₄, 0.2 g., AcOH 51-55 g., alc. 45 cc., must 10% 20 cc., and tap water 1 l. Calcd. on maltose the sugar content was 0.3-0.5%. Abrupt change in aeration inhibits bacterial activity for several days, and the bacteria are swept off the shavings into the receiver. They do not adhere to the porcelain under any conditions. When substrate is added at the rate of 60-70 cc. per 24 hrs. (corresponds to 40 l. in an industrial set-up) the optimal concn. of alc. is 5% and that of AcOH is 6%. Addn. of sucrose greatly increases bacterial activity. The bacteria utilize 5-20 mg. sucrose to produce 1 g. of AcOH, which corresponds to 7-8 kg. of AcOH under industrial conditions. Must has no advantages over glucose when NH₄ salts are present. Abrupt changes in the concn. of must do not affect activity. The bacteria in the generator disacc. into R and S forms, but these do not show any essential differences in acid production.

T. Laurus

A 13-55A METALLURGICAL LITERATURE

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RABOTKOVA, I. L. (1976)

"New Data on the Nitrogen Assimilation by Microorganisms" (p.444) by Rabotkova, I. L.

SO: Advances in Modern Biology (Uspekhi Sovremennoi Biologii) Vol. XXI, No. 3, p. 444