the creep processes of these materials occur practically without the work hardening stage (on the creep curves there are practically no "surges" after the changes in load). On the creep curve the titanium alloy studied by us has a clearly expressed work hardening stage.

Under service temperature and load conditions in power stations the processes of creep normally occur in constructional materials with a work hardening stage. On the other hand, at moments of starting and stopping the stressed condition in design elements may differ substantially from the stressed condition under non-steady conditions, i.e., there will be turning of the vector of stresses and a change in its modulus.

**LITERATURE CITED**


**AN INVESTIGATION OF THE EFFECT OF CREEP ON THE RESISTANCE TO DEFORMATION AND LOW-CYCLE FATIGUE OF CAST 20KhML STEEL IN PURE SHEAR**

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The material of parts of power and transportation equipment for which thermal fatigue failure is characteristic as a rule operates with alternating elastoplastic deformations (start-stop conditions) and creep (stationary conditions). The sequence of these processes occurs in different ways under actual conditions [1]. One of the typical cases of deformation is the cycle shown in Fig. 1a. In the first start-up on the heated surface of the part there occur compressive stresses (process OA) and then after complete heating there occur

![Fig. 1. Plans of deformation of a material.](image)


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residual stresses $\sigma_R$, which in stable operation relax (process BC). In the case of slow stopping the point C will represent the condition of the material before the next stop, which occurs on the curve CA. In calculating the life of parts operating under such conditions a number of difficulties arise.

The curve of cyclic deformation (Fig. 1a), strictly speaking, is open (unsteady) and changes from cycle to cycle (even with a constant range of deformation $\Delta \varepsilon$). This is related both to the unsteadiness of the processes of short-time plastic deformation (without creep) (Fig. 1b) and to the unsteadiness of the relaxation process.

The majority of mechanical engineering materials under the actual limits of $\Delta \varepsilon$ in practice are cyclically stabilized. In those cases where the unit portion of the transitional process in the total life is small, it is acceptable to assume the material to be ideally stable with a curve of cyclic deformation for a stabilized curve.

In calculating the process of the first load it is necessary to take not the deformation curve for the first load, but some fictitious curve [2] obtained from the cyclic means of using the known principle of Mazing. However, the use of such an approach for a cycle with relaxation (Fig. 1a) requires an experimental basis since in this case the creep process may change the cyclic deformation curve. A few investigations of the cyclic relaxation process [3] show that in this case there is cyclic stabilization.

Calculation of the process of the second load CA is difficult because of the indefiniteness in the start of the point of calculation for this process.

It is impossible to consider as sufficiently clear the question of totalling the damages from fatigue and creep. Linear totalling [1] is quite frequently used in calculations but it is apparently true only for certain materials and certain deformation cycles [4]. However, in making practical calculations in the majority of cases the rule of linear totalling provides satisfactory accuracy [1] and, what is very important, does not require tests with complex cycles for obtaining the additional constants of the material.

In this article these questions are considered using as an example cast 20KhML steel, which is widely used for turbine parts.

The Material and Method of the Experiments. The test samples were made from $300 \times 150 \times 35$-mm plates cast and heat treated together with a steam turbine casing. The steel had the following chemical composition (%): 0.24 C, 0.32 Si, 0.6 Mn, 0.02 S, 0.021 P, 0.58 Cr, 0.5 Mo, remainder Fe. Based on the data of control tests its mechanical properties at 20°C were $\sigma_{0.2} = 30$ kgf/mm$^2$, $\sigma_b = 55$ kgf/mm$^2$, $\varepsilon_b = 21\%$, $\psi = 45.5\%$, $a = 900$ kJ/m$^2$, BHN = 143.

The basic purpose of the work was an investigation of the effect of alternating processes of short-time plastic deformation and relaxation on the rules of deformation and failure under conditions of pure shear at a constant temperature of 560°C using the cycle shown in Fig. 1c.

In the tests the range of deformation $\Delta \gamma$ varied within the limits of 0.88-2.0% and the hold time $t_h$ was 1, 10, and 95 min, as a result of which there was a change in the degree of relaxation of the stresses $\Delta \tau_R$.

For an analysis of the results obtained low-cycle fatigue ($t_h = 0$) and short-term creep tests were made on the same experimental unit [5].