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Abstract

Full Text

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ON THE QUESTION OF CREEP UNDER PULSATING STRESS

1°. Modeling the high-temperature deformation of bodies by a system of two elastic and two viscous elements (Fig. 1), whose characteristics E_1, η_1, and η_2 are functions of the stress σ, makes it possible to give a simple graphical construction of the deformation-time curve (ε—t) under pulsating stress from the creep curve obtained under stress constant in time.

Let a tensile stress be applied to the specimen, pulsating as shown in Fig. 2a, its maximum value being equal to the stress at which the initial creep curve O_1K was obtained (Fig. 2b). Let us separate from the creep curve the curve of elastic aftereffect O_1h. Suppose unloading occurred at the moment t_1. The total deformation accumulated by this time is determined by the point a_1 of the curve O_1K. The deformation of elastic aftereffect accumulated up to this moment is expressed by the segment b_1e_1. The rate of recovery of the elastic-aftereffect deformation will be determined by the stress acting at the moment of unloading on the spring E_1 of the system E_1—η_1 (Fig. 1), i.e., at the moment of unloading this rate will be determined

Fig. 1
Fig. 1

Fig. 2
Fig. 2

by the angle of inclination of the tangent to the curve of elastic aftereffect at the point b_1' to the x-axis, with $b_1'e_1' = b_1e_1$. The entire recovery over the time t_1 will be represented by the segment $b_1'c_1$, and the recovery deformation will be equal to c_1d_1. Thus,

the curve c_1m_1 repeats the segment of the elastic aftereffect curve b_1c_1', and $c_1d_1 = c_1d_1'$. Under repeated loading by the stress σ_0, the increase in creep deformation and elastic aftereffect will be determined by the segment O_2a_2 of the curve O_1K, since the rate of deformation of the system η_1—E_1 at the instant of secondary loading will be determined by the stress $\sigma(2t_1) = \sigma_0 - e_1d_1''E_1$, where $B_1d_1'' = c_1d_1''$, $e_1d_1'' = e_1b_1 - b_1d_2''$, etc.

Fig. 3

Figure 3

Figure 1: Figure 3

Figure 4

Figure 2: Figure 4

It should be noted that if the time t_1 before unloading is not large, then in subsequent unloadings the rate of recovery and the magnitude of the recovery deformation may turn out to be greater than in the preceding ones, i.e. $c_2 d_2' > c_1 d_1'$.

Hence the answer is also clear to the question: how do interruptions during creep tests affect creep curves? If, for example, after unloading a specimen deformed at $\sigma = \text{const}$, it is rapidly cooled, thereby fixing the deformation of elastic aftereffect as residual, then after the next rapid heating and loading the creep curve must be restored at once, etc.

2°. **Step loading.** If at the instant t_1 the stress is rapidly increased from σ_1 to $\sigma_2 > \sigma_1$ (Fig. 3) and then the latter is maintained constant, then further deformation will proceed along the segment C_1B_1 of the creep curve obtained at the constant stress σ_2, translated parallel to the Ot axis, starting from the point C, corresponding to the same value of the elastic-aftereffect deformation.

3°. In passing, we note that in cases of an apparent, at first glance, discrepancy in the behavior of materials under creep conditions at $\sigma = \text{const}$ and stress relaxation, one cannot yet speak of a difference in the mechanisms of deformation, and one may expect satisfactory agreement between experimental and calculated data. Let, for example, the creep curves of steels A and B for identical values of the stresses σ_1, σ_2, and σ_3 be arranged as shown in Fig. 4a, respectively by solid (A) and dashed (B) lines. Then the curves expressing the dependences $\eta_2 - \sigma$ ($\eta_1(\sigma)$ and $E_1(\sigma)$, for simplicity, are omitted) for these steels will be arranged in accordance with Fig. 4b, and the stress-relaxation curve from the stress σ_1 for steel B may fall lower than for steel A (Fig. 4c), although the creep deformation of steel B at this stress is smaller than that of steel A.

Fig. 4

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Note: Figure translations are in progress. See original paper for figures.