VIBROCREEP OF POLYMERIC MATERIALS
5*. POLYURETHANES. COMPOSITE LOADING REGIME.

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An experimental comparison has been made of vibrocreep under a composite loading regime (with a periodically appearing small additional vibrational load) with static creep and with vibrocreep under the continuous action of vibration. A variant of the description of creep curves under a composite loading regime is examined. The possibility is shown of calculating creep under periodically appearing low vibrations from parameters which are found from experiments on static creep and creep under continuous action of vibration.

In a preceding study, in the case of a rigid, porous polyurethane, it was established that the application of a small additional vibrational load onto the basic static loads can lead to a considerable acceleration of relaxation processes without noticeable vibrational warming of the material. In it, the study of vibrational creep was carried out under a regime of prolonged continuous action of vibration.

It is well known that the case is very common where a small vibrational added load appears periodically. With the objective of imitating this type of loading, in the present work we have carried out tests under a composite loading regime, where a preliminarily acting constant load is periodically supplemented by a vibrational component (Fig. 1).

Tests were conducted under monoaxial compression of rigid porous polyurethane samples. The magnitude of the static stress, \(\sigma_{110}\), was taken equal to 52 kgf/cm\(^2\) (0.26 times the short-term strength). The amplitude of the dynamic stress rate under vibrational loading was 290 kgf/cm\(^2\)·sec. The experiments were conducted at 20 ± 1.5°C.

Averaged experimental data are shown by the points in Fig. 2. For comparison we give curves for static creep, vibrocreep under continuous action of vibration, and creep under a composite loading regime. The instantaneous deformations were subtracted from the total deformation. In the figure, only creep deformations are shown. It is evident that the application of vibration in part II led to a sharp acceleration of the deformation process (curve 2). After shutting off the vibration (part III), the rate of creep falls off and becomes less than the rate of static creep in the same part. Subsequent imposition of vibration (part IV) again leads to an acceleration of relaxation processes, but the absolute rise in creep deformation is considerably less, as compared with part II.

Qualitatively, this phenomenon can be explained starting from the following concepts. In the period of the first vibrational loading, the relaxation spectrum is shifted into the smaller time region, and the relaxation processes which are characterized by large relaxation times appear after a time which is commensurable with the time for observation. This also leads to a sharp increase in creep.

In part III where only a static load is acting, the material has reached a state where the rapid relaxation processes have already been finished, but the slow ones are not appreciable [2]. Thus, the preliminary

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* For communication No. 4, see [1].
† Characteristics of the material and the test method are given in [1].

action of vibrational loading in this case has led to the situation that a large part of the elements of the exponential series, with small relaxation times or relaxation times commensurate with the duration of the experiment, have practically reached the equilibrium state. The relative contribution of the elements with larger relaxation times in the total share of viscoelastic deformations is comparatively small [3]. Therefore, in subsequent applications of vibration, even though an acceleration of creep takes place, the total gain in deformation decreases with increase in repetitions of the vibrational loading. Of course, such a statement will be correct only in the case where the contribution of the damage mechanism in the development of additional vibrocreep deformations is unimportant.

And so the qualitative characteristics of the creep process under a composite loading regime are expressed in a gradual tendency to approach the vibrocreep curve under continuous action of vibration.

To describe creep under a composite loading regime, we shall make use of the relations obtained in [1]:

for static creep,

$$\varepsilon_{11}(t) = a_{1111} \sigma_{11} + (b_{11111} \sigma_{11} + b_{1111111} \sigma_{11}^2) \frac{1}{k} \sum_{h=1}^{b} \left[ 1 - \exp \left( -\frac{t}{\tau_h} \right) \right]. \tag{1}$$

for vibrocreep under continuous action of vibration,

$$\varepsilon_{11}(t) = a_{11111} \sigma_{111} + (b_{111111} \sigma_{111} + b_{1111111} \sigma_{111}^2) \frac{1}{k} \sum_{h=1}^{b} \left[ 1 - \exp \left( -\frac{t}{\tau_h} \right) \right]. \tag{2}$$

Here $a_{1111}$ is the coefficient of elastic compliance; $b_{1111}$ and $b_{11111111}$ are the coefficients of equilibrium compliances in creep; $k$ is the number of terms of the discrete series of relaxation times; $\tau_k$ are the discrete values of relaxation times in static creep; $\kappa_k (\tau_k/a \nu(\sigma_{11}))$ are the discrete values of relaxation times in vibrocreep under the regime $\sigma_{11} = \sigma_{110} + \sigma_{11a} \sin \omega t$, $\sigma_{11a} < \sigma_{110}$, and $\nu$ is the vibrational time coefficient.

Taking account of (1) and (2), and assuming by analogy with [4] that the creep process under the action of only a static load takes place with relaxation times $\tau_k$, but when vibration is applied, with relaxation time times $\kappa_k = \tau_k/a \nu(\sigma_{11a})$, for the $(s+1)^{st}$ part ($t_{s} \leq t < t_{s+1}$, see Fig. 1), we obtain the following expression:

$$\varepsilon_{11}(t) = a_{11111} \sigma_{111} + (b_{111111} \sigma_{111} + b_{11111111} \sigma_{111}^2) \frac{1}{k} \sum_{h=1}^{b} \left\{ 1 - \exp \left[ -\frac{t}{\tau_h} \right] \right\} \tag{3}$$