CREEP STABILITY OF CYLINDRICAL SHELLS

N. M. Matchenko

Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Vol. 7, No. 4, pp. 165–166, 1966

ABSTRACT: The methods of stability at small elastoplastic strains [1] are extended to an investigation of the creep stability of shells. Experimental data are presented, and the calculated and experimental results are compared.

1. In considering the stability of a cylindrical shell in compression at the end faces we will assume that the creep properties of the material at loss of stability depend only on the stresses of the basic state, which are related to the strains by the expressions

$$\varepsilon_{mn} = \frac{3}{2}\frac{\varepsilon_i}{\sigma_i}S_{mn}, \qquad \frac{\sigma_i}{\varepsilon_i} = \frac{\sigma_0}{\varphi(\sigma_0) + \psi(\sigma_0)\,\omega(t)},$$
$$\frac{d\sigma_i}{d\varepsilon_i} = \frac{1}{\varphi'(\sigma_0) + \Psi'(\sigma_0)\,\omega(t)}. \tag{1.1}$$

Here ε_{mn} and S_{mn} are the stress and strain deviators, σ_i and ε_i are the stress and strain intensities at an arbitrary point of the shell, σ_0 is the stress intensity of the basic state, and $\omega(t)$ is a function of time. Then the calculation reduces to replacing the secant and tangent moduli in the formula for computing the critical load [2] with new generalized moduli depending on time. For determining the buckling time we obtain the expression

$$\psi\psi'\omega^2 + (\varphi\psi' + \varphi'\psi)\omega + \varphi\varphi' - \frac{4}{9}\frac{h^2}{R^2\sigma_0} = 0,$$
$$\varphi = \varphi(\sigma_0), \qquad \psi = \psi(\sigma_0), \qquad \omega = \omega(t). \tag{1.2}$$

2. To check solution (1.2) at room temperature we conducted two series of stability tests on cylindrical lead shells 40 mm long, 2 and 1.4 mm thick, and with a radius of 24 mm. The properties of the load were such that

$$\varepsilon = (2.93\cdot 10^{-8} + 2.79\cdot 10^{-10}\,t)\sigma^8, \tag{2.1}$$

where σ is measured in kg/cm^2 and t in minutes.

The shells were loaded with the help of a special centering device. The buckled shells were characterized by continuous annular bulges; sudden collapse was not observed.

The critical time was taken as the moment at which the shell began to buckle. In the first series of tests (R/h = 12) the beginning of bulging was determined from the change in the nature of the axial strain, which was measured with dial-type indicators graduated in 0.01 mm, and in the second series from the change in the nature of the resistance of resistance strain gauges bonded to the inside and outside of the shell.

In Figs. 1 and 2 the axial strain and the change in resistance are plotted as functions of time, the critical buckling time being denoted by a broken line.

The data thus obtained from tests on 24 shells are presented in Figs. 3 and 4, where the continuous curves were constructed in accordance with solution (1.2).

REFERENCES

1. A. A. Il'yushin, Plasticity [in Russian], Gostekhizdat, 1948.
2. A. S. Vol'mir, Stability of Elastic Systems [in Russian], Fizmatgiz, 1963.

22 May 1965 Tula

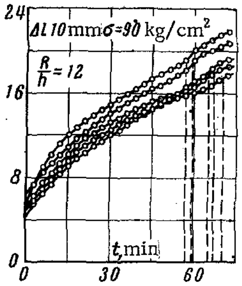

Fig. 1

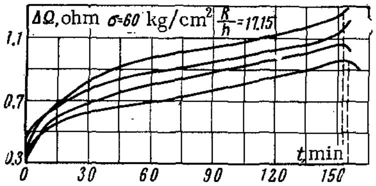

Fig. 2

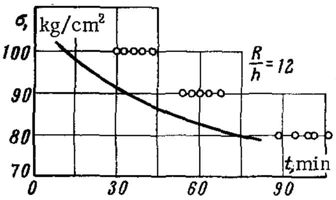

Fig. 3

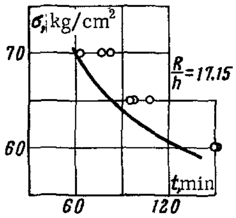

Fig. 4