8. *Кац Ш. Н.* Исследование длительной прочности углеродистых труб // Теплоэнергетика. 1955. № 11. С. 37–40.

Creep and Long-Term Strength Modeling for Thick-Walled Tubes under Combined Loading with Axial Force, Torsional Moment and Internal Pressure

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We have developed a method for solving the boundary-value problem of rheological deformation and creep rupture of thick-walled tube under combined loading with axial force, torsional moment and internal pressure. Energetic variant of the theory of creep and long-term strength is used to describe creep process. Experimental verification of proposed method has been performed using known test data for creep and long-term strength of thick-walled tubes made of D16T alloy and Steel 20. Calculated dependencies for total axial strain and torsion angle on time are obtained. The results of calculation and estimated deviations for long-term strength are given. It is shown that the calculation data fit to experimental values as well as calculation data obtained by other scientists in third-party sources.

Key words: boundary-value problem, creep, long-term strength, thick-walled tube, tension, torsion, internal pressure.

References

1. Lokoshchenko A. M. *Polzuchest' i dlitel'naia prochnost' metallov* [Creep and long-term strength of metals]. Moscow, Fizmatlit, 2016. 504 p. (in Russian).

2. Golub V. P., Regul'skiy M. N., Rusinov A. A. Dlitel'naia prochnost' tonkostennyh trub pri dvuhosnom staticheskom nagruzhenii [Long-term strength of thin-walled tubes under biaxial loading]. *Vestn. NTUU "KPI". Ser. Mashinostroenie*, 2008, no. 52, pp. 61–67 (in Russian).

3. Golubovskiy E. R. Dlitel'naia prochnost' i kriteriy razrusheniya pri slozhnom napryazhonnom sostoyanii splava EI698VD [Long-term strength and damage criterion for complex stress state of EI698VD alloy]. *Strength of Materials*, 1984, no. 8, pp. 11–17 (in Russian).

4. Lokoshchenko A. M., Platonov D. O. Long-term strength of nickel alloy EI437BU-WD at the complex stress state. *Mashinostroenie i ingenernoe obrazovanie*, 2010, no. 2, pp. 15–24 (in Russian).

5. Radchenko V. P., Eremin Yu. A. *Reologicheskoe deformirovanie i razrushenie materialov i elementov konstruktsiy* [Rheological Deformation and Fracture of Materials and Structural Elements]. Moscow, Mashinostroenie-1, 2004. 264 p. (in Russian).

6. Radchenko V. P., Tsvetkov V. V. The stress-strain state of cylindrical sample from alloy D16T under axial tension and torsion creep. *Vestn. Samar. Gos. Tekhn. Univ. Ser. Fiz.-Mat. Nauki* [J. Samara State Tech. Univ., Ser. Phys. Math. Sci.], 2013, no. 3 (32), pp. 77–86 (in Russian). DOI: https://doi.org/10.14498/vsgtu1277

7. Sosnin O. V., Gorev B. V., Nikitenko A. F. *Energeticheskii variant teorii polzuchesti* [Energetic variant of the creep theory], Novosibirsk, Institute of Hydrodynamics, USSR Acad. of Sci., 1986. 95 p. (in Russian).

8. Kats Sh. N. Issledovanie dlitel'noy prochnosti uglerodistyh trub [Investigation of long-term strength of carbon tubes]. *Teploenergetika*, 1955, no. 11, pp. 37–40 (in Russian).