Abstracts

Matveev V. V. and Onishchenko E. A. **Analysis of Vibrodiagnostic Parameters of the Presence of a Breathing Surface Crack of Different Configurations in a Round Bar** // Problems of Strength. – 2017. – No. 6. – P. 5–20.

The authors discuss a method of approximate calculation of possible values of vibrodiagnostic parameters of the presence of a breathing crack of different crack front configurations (semi-elliptical, semi-circular, or straight one) in a round bar under super- and subharmonic resonances in a natural bending mode. The calculation of the vibrodiagnostic parameters due to the presence of a crack has been performed through the example of a cantilever bar in the case of the resonance in the first normal mode under force and kinematic excitations. The vibrodiagnostic parameters have been found as a function of the place of the exciting force application, crack location, relative depth and relative area, for different ellipse semi-axes ratios and for cracks with straight or semi-circular fronts. A comparison is made between the calculated results and the finite-element numerical solution data.

Shul'zhenko N. G., *Zaitsev B. F.*, *Asaenok A. V.*, *and Protasova T. V.* **Deformation and Vibration Induced Stress Intensity of a High-Temperature Turbine Rotor with a Breathing Transverse Crack** // Problems of Strength. – 2017. – No. 6. – P. 21–30.

The vibrations of a double-seat weighty rotor of the steam turbine with a breathing transverse crack are examined in the field of operating environment temperatures. The 3D vibration model for the rotor with a breathing transverse crock is applied. The variable two-dimensional temperature field is found from the solution of nonstationary heat transfer problem. Its effect on the contact of crack edges on rotor vibrations was evaluated. The distribution of stress intensity factors along the crack front was established for different rotor positions. Fatigue crack extension modes are assessed.

Ignatovich S. R. and Krasnopol'skii V. S. **Probabilistic Distribution of Crack Length in the Case of Multiple Fracture** // Problems of Strength. – 2017. – No. 6. – P. 31–42.

A model describing crack length distribution is proposed on basis of experimental laws governing the formulation and growth of fatigue cracks in a flat specimen with multiple stress raisers. The density of this distribution corresponds to Pareto distribution and can be used to describe the accumulation of scattered defects in a wide range of cracking scale. The critical value of Pareto distribution exponents, which correspond to the limit states of the multiple fracture of solid bodies, have been substantiated.

Gulyaev V. I. and Glazunov S. N. **Stability and Vibrations of a Rotating Drill String in the Horizontal Borehole** // Problems of Strength. – 2017. – No. 6. – P. 43–52.

The development of new production technologies of hydrocarbon fuels from shale rocks in the oil and gas industries make very topical the tasks of horizontal and inclined borehole drilling. The specific features of drilling such wells are strongly manifested contact and frictional forces acting between the borehole and drill string walls. The respective problem of bifurcation buckling and small-scale bending vibrations of the drill string rotating in the horizontal borehole is tackled in this study. With account of frictional forces and complementary binding responses, the differential equations are derived, and the solutions for the natural vibrations of strings with finite and infinite length are obtained.

Andreykiv O. E., *Shtajura N. S.*, *and Yarema R. Ya.* **Energy Approach to the Evaluation of the Short Fatigue Cracks Growth Rate in Plates** // Problems of Strength. – 2017. – No. 6. – P. 53–63.

The paper describes the energy approach, which is employed for the development of the calculation model to determine the period of the subcritical growth of short fatigue cracks in the elastic-plastic plates using the specific energy components. The authors propose the formula for the approximate

determination of the short cracks tip opening displacement via the relative level of loading of the plate and the stress intensity factor. The obtained results are compared with the known experimental data. From the proposed model and comparison of the obtained results with the experimental ones it follows that the crack growth rate can be different at similar stress intensity factors at various relative levels of loading of the plates with a short crack. However, the proposed model retains the dependence of the short crack growth rate on the specific work of plastic deformations in the zone of pre-fracture, or on the crack tip opening displacement with the unchanged averaged stresses.

Pokrovskii V. V., *Ezhov V. N.*, *and Sidyachenko V. G.* **Thermomechanical Preloading-Governed Temperature Dependence of Crack Resistance on Mixed I–III Modes** // Problems of Strength. – 2017. – No. 6. – P. 64–72.

Results of experimental investigations and assessment of theoretical backgrounds of the thermomechanical preloading effect on the static crack resistance characteristics of heat-resistant 15Kh2NMFA steel are presented. The longitudinal shear component is established to decrease a "positive effect" of an increase in crack resistance. A decrease of crack resistance in longitudinal shear as compared to that in normal fracture is also observed above the critical brittleness temperature of the material, which should be considered in equipment service life calculations by crack resistance criteria.

Lepikhin P. P., *Romashchenko V. A.*, *and Beiner O. S.* **A Numerical Study of 3D Dynamics and Strength of Metal-Composite Cylinders under Internal Explosion Loading** // Problems of Strength. – 2017. – No. 6. – P. 73–89.

The 3D dynamics and strength of metal-composite finite-length cylinders under non-axisymmetric internal explosion loading have been studied by a numerical-analytical method. The strength verification has been performed using three fracture criteria for a transtropic material: the maximum-stress criterion, the maximum-strain criterion, and the generalized Mises criterion. The influence of the explosive charge shift along the radius and axis with respect to the shell's center of symmetry on the stress-strain state and strength of the cylinder has been investigated. The reinforced composites with low ultimate tensile strengths perpendicular to the reinforcement filaments have been found ineffective for such shells.

Kravchuk A. V., *Kondryakov E. O.*, *Panasenko O. V.*, *and Kharchenko V. V.* **Determination of Temperature Dependences of Fracture Energy Constituents for Bending Impact Test Specimens of Different Types** // Problems of Strength. – 2017. – No. 6. – P. 90–98.

Impact tests of standard Charpy, small-scale, and notched specimens at different temperatures were conducted. The temperature dependences of the total deformation and fracture energies, as well as their constituents, were constructed for all types of the tested specimens. The fractography analysis has revealed the ductile component of specimen fracture surface an d the first critical temperature of brittleness $T_{50\%}$.

Shvabyuk V. I., *Mikulich O. A.*, *and Shvabyuk V. V.* **Stress State of Foam Media with Tunnel Openings under Non-Stationary Dynamic Loading** // Problems of Strength. – 2017. – No. 6. – P. 99–110.

The dynamic stress state of the bodies considering the couple stresses using the Fourier transformation and method of integral equations has been investigated. The obtained results are in the agreement with the basic concepts of wave mechanics. The developed procedure allows one to investigate the non-stationary dynamic processes in synthetic materials with openings of the virtually free section. The opening geometry effect on the distribution of dynamic loads in foam media has been studied.

Dzyuba A. P., *Prokopalo E. F.*, *and Dzyuba P. A.* **Experimental Investigation on the Torsional Stability of Cylindrical Shells Weakened by Circular Holes** // Problems of Strength. – 2017. – No. 6. – P. 111–121.

This paper presents the results of experimental investigation on the stability of orthotropic cylindrical shells of different lengths weakened by regular circular holes located in one zone along the guide cell under torque loading. The buckling modes of shells are described. The critical buckling loads as a function of the number of holes are analyzed.

Degtyarev V. A. **Influence of High-Frequency Mechanical Peening on the Residual Life of Butt-Welded Joints** // Problems of Strength. – 2017. – No. 6. – P. 122–134.

The efficiency of hardening of St3sp steel butt-welded joints by high-frequency mechanical peening is shown. The paper investigates the regularities of variation in their residual life and fatigue crack growth rate with changes in the high-frequency peening conditions for specimens hardened both in the initial state and after previously accumulated fatigue damages.

Ismail Ali A. and Al Tamimi A. **Optimum Constant-Stress Partially Accelerated Life Test Plans Using Type-I Censored Data from the Inverse Weibull Distribution** // Problems of Strength. – 2017. – No. 6. – P. 135–145.

In this paper, a constant stress partially accelerated life test (CSPALT) model is presented and analyzed using type-I censored data from the inverse Weibull distribution. The maximum likelihood estimates (point and interval) of the distribution parameters and the acceleration factor are obtained. CSPALT plans are developed. The proportion of test units that should be allocated to run under accelerated condition is optimally determined. To demonstrate the theoretical results, simulation studies are made.

Rizov V. I. **Analysis of Longitudinal Cracks in Multilayered Beams with Account of the Material Nonlinearity** // Problems of Strength. – 2017. – No. 6. – P. 146–156.

The present paper reports a theoretical study of longitudinal fracture in multilayered beams with taking into account the material non-linearity. The study was performed in terms of the strain energy release rate by using the classical beam theory. The analysis developed holds for cracked beams whose layers may have different thickness. Besides, the mechanical behaviour of each layer may be described by different non-linear stress-strain relations. Also, the crack may be located arbitrary along the beam height. The strain energy release rate was expressed in a function of the bending moments and axial loads in the cross-sections ahead and behind the crack front. In this way, non-linear fracture analyses of multilayered beams can be carried-out in a closed analytical form. It was shown that the analysis developed is a useful tool for the understanding of non-linear longitudinal fracture in multilayered beam configurations.

Wang Z. Q., *Yu Z. W.*, *Sun X. Y.*, *Li H.*, *and Wang Y. J.* **Effect of Double-Atom Vacancy Defects on the Elastic Properties of Single-Layered Graphene Sheets** // Problems of Strength. – 2017. – No. 6. – P. 157–164.

A molecular structural mechanics approach is used to study the effect of double-atom vacancy defects (DAVD) on the elastic properties of zigzag and armchair single-layered graphene sheets (SLGS). To this end, the space frame structure is also adopted to model the interatomic forces of the C–C bonds. The numerical simulation results obtained via the finite element method strongly suggest that double-atom vacancy defects reduce the elastic module of SLGS, which effect weakens with graphene size. Finally, the elastic modulus and Poisson's ratio of SLGS are found to decrease with the number of DAVDS.

Dong Z., *Wang X.*, *Lou W.*, *Huang Y.*, *Zhong M.*, *Fan H.*, *and Peng L.* **Simulation of the Spindle Coupled Multi-Axial Loading Fatigue Test of a Rear Axle** // Problems of Strength. – 2017. – No. 6. – P. 165–192.

This study aims to establish a practical method for simulating the spindle coupled multi-axis loading fatigue test of a rear axle. A dynamic finite-element model of the rear axle was constructed and validated using a static calibration test. Based on the theory and methodology of the Schenck ITFC

system, a simulation process was devised which includes system identification, calculation of the input loading signals for the finite-element model, calculation of the response stress signals based on this model, calculation of the response strain signals from the corresponding stress signals, and finally, a comparison of the desired and achieved signals. The corresponding data processing programs were made using Matlab, ensuring their easy reproducibility. The desired signals were measured on the Hainan proving ground for a duration of 2441.216 s, using strain gauges and rosettes placed in important stress-prone locations of the rear axle. The results indicate that the desired signals can be reproduced comparatively accurately, ensuring that the strain distribution of the rear axle in the field can be reasonably predicted.