Therefore this is a simple and quite accurate method of repeated determination of the value of the critical stress concentration factor $K_{IC}$ of brittle nonmetallic materials on flat samples of arbitrary configuration and dimensions.*

**LITERATURE CITED**


*This investigation was made in a plan for the development of the work of G. S. Pisarenko and V. P. Naumenko on method of crack control in fracture toughness tests.

**EXPERIMENTAL INVESTIGATION OF THE SUPPORTING SURFACE OF Kh STEEL AT NORMAL AND LOW TEMPERATURES**

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The development of new areas of technology, as well as the existing tendency toward more economical parts design, leads to the fact that the material of many design elements separates under nonsteady temperature conditions at stresses significantly exceeding the yield strength. A change in temperature during elasto-plastic deformation may have a substantial effect on the supporting capacity of thermally stressed design elements. If the temperature is low or the loading processes are short-term ones so that the creep deformations may be neglected, then the stress-strain state of the material of such elements may be analyzed with the help of the theory of plasticity, which takes into consideration the nonisothermal character of loading.

The determining equations of the theory of yield for the case of nonisothermal loading may be obtained using the concept of supporting surface in the form [1]

$$f(\sigma_{ij}, T, \varepsilon_{ij}^p, \chi_i, k_i) = 0,$$

where $\sigma_{ij}$ are the components of the stress tensor, $T$ is temperature, $\varepsilon_{ij}^p$ are the components of the tensor of plastic deformation, $\chi_i$ are the work-hardening parameters, and $k_i$ are the material constants.

An experimental determination of the work-hardening rule characterizing the change in loading surface during yield is important.

At present a large quantity of work on investigation of the supporting surface in isothermal loading [in Eq. (1) $T = \text{const}$] is known. In particular, it has been established for many constructional materials that a change in the position and form of the supporting surface is satisfactorily described by the hypothesis of isotropic-kinematic work hardening. There has been practically no study of work hardening under nonsteady temperature conditions.

This experimental investigation was made for the purpose of studying the rules of work hardening for certain particular cases of nonisothermal loading under conditions of normal and low temperatures by determining the subsequent limiting yield curves of a previously deformed material.
The samples were deformed to the specified level of plastic deformation at room temperature in uniaxial tension, the load was removed, they were cooled to a uniform temperature, and then they were tested in the plane stressed state at various (fixed for each test) ratios of the main stresses.

The investigations were made on thin-walled tubular samples (Fig. 1) prepared from 40-mm-diam. bars of hot-rolled Kh chrome steel, which has a chemical composition of C 1.1%, Cr 1.4%, Mn < 0.40%, Si < 0.35%, Ni < 0.25%, S < 0.03%, and P < 0.03%. The samples were in the as-received condition.

The samples were tested on an SNT-5PM machine [2] equipped with a system for automatic control and treatment of the experimental data based on a "Dnepr-1" computer.

The plane stressed state was accomplished by loading the samples with an axial force and internal pressure. To create the internal pressure ethyl alcohol and isopentane were used as the working medium. The low-temperature tests were made in a vacuum chamber. The samples were cooled using a circulating type cooler located in the internal cavity of the sample. The sample temperature was measured with copper-constantan thermocouples and maintained at the specified level with the help of an automatic system controlling the flow of cooling nitrogen through the cooler.

The axial $\varepsilon_\varphi$ and tangential $\varepsilon_\theta$ deformations of the sample were measured with an EMT-3 electromechanical strain gauge [2]. The radial deformation was determined from the equation

$$\varepsilon_r = \frac{\sigma_r + \sigma_\varphi}{E} (1 - 2\mu) - (\varepsilon_\varphi + \varepsilon_\theta),$$

assuming that the volume of material changes elastically.

The preliminary loading at room temperature was done to three levels of plastic deformation: $\varepsilon^p = 2$, 4, and 6%. Repeated tests were made at temperatures of $+20$ and $-100^\circ C$ under conditions of uniaxial tension in axial and tangential stresses, biaxial tension ($K = \sigma_\varphi/\sigma_\theta = 0.5$, 1, and 2), pure shear ($K = -1$), and axial compression.

The nominal yield strength in the complex stress state was found from a generalized $\sigma_1 \sim \varepsilon_1$ curve as the stress corresponding to 0.2% residual deformation.

In order to quantitatively establish the effect of the history of preliminary loading on the deformation work-hardening of the steel, limiting yield curves of this steel were presented as $S_1$ vs $S_2$ curves in a five-dimensional space $\Sigma_5$ [3]. The values of $S_1$ and $S_2$ are related to the main stresses $\sigma_\varphi$ and $\sigma_\theta$ by the relationships

$$S_1 = \sqrt{\frac{2}{3} \left( \sigma_\varphi - \frac{1}{2} \sigma_\theta \right)^2}, \text{ and } S_2 = \sqrt{\frac{2}{3} \sigma_\theta^2}.$$