DEFORMATION LOCALIZATION AND PREFAILURE OF STEELS UNDER LOW TEMPERATURE

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ABSTRACT

Results of the measurements of the specific energy of deformation and failure at tension of cylindrical and plane notched samples are presented. It is shown that localization of deformation in the zone of a stress concentrator depends on the stressed-strained state mainly. Low temperature of the test changes sharply deformation mechanisms in the prefailure zone of steels.

KEYWORDS

Work, failure, test, energy, tension, notch, crack, localization, prefailure.

Material ability to resist to deformation and failure is defined by the process of plastic deformation in the bounded volumes of a body (Gillemot,1985). At impressed force loading of an elastic body with a stress concentrator the main work of deformation is spent in a small volume of the body adjacent to the net section.

Results of experimental measurements of the average value of specific energy of deformation and failure for cylindrical and plane samples of steels by the author's procedure (Noev et al., 1984) are presented in the paper.

Energy expenses have been determined at static tension of cylindrical samples with ring notches, made of 20-,10X2ГМ-, Y8-steels, and of plane samples with two-sided notches, made of 10X2ГМ-steel. Notches have curvature radii R=1,0; =,25 mm at the top and specially obtained fatigue cracks.

Cylindrical samples with length 210 mm, diameter Φ 15 mm have 10 mm - diameter in the net section. Plane samples with 380mm-length and 30 mm-thickness have thicknesses 8,12,15 mm. Tests have been performed under indoor and low temperature.

According to the above procedure, specific energy is determined along the length of the samples by measuring work of deformation and failure on different bases: 20,30,50,70mm. Besides, separate measurements of the shift of the notch (crack) edges have been carried out with the help of cantilever beams of the opening sensor. Beams of the sensor, as distinct from the opening measurement, indicate the shift of the notch edges independently. Work is determined by the area of the diagram "load-notch edges shift". Specific energy of deformation and failure is obtained as radio of the work for the notch edges shift to the metal volume being measured.

Distribution of the specific energy ω along the length of samples (Fig.1) depends on the sharpness of the stress concentrator.

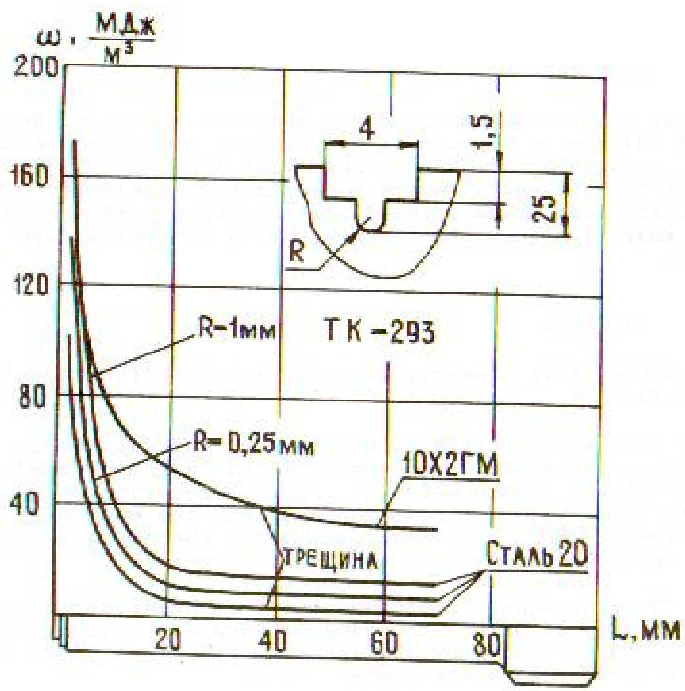

Fig.1. Distribution of the specific energy of deformation and failure along length of the cylindrical sample made of 20steel and plane sample with 15mm thickness made of 10X2ГМ at different concentrators.

With the increase of the radius of notch top rounding ω -values grow, in the zone of stress concentrator influence particularly. At tension of cylindrical samples with notches of the same depth but of different sharpness (R=1mm; 0,25; fatigue crack) curves of energy expenses for metal deformation at the distance of more than 30mm from the notch centre are practically equivalent. In the zone, adjacent to the stress concentrator, where deformation localization takes place, the influence of the notch sharpness decreases considerably. It is seen (Fig.1) that the sharp notch with the radius R=0,25mm at the top cause deformation localization different from that of a fatigue crack.

Type of the stressed-strained state has a considerable effect on the character of energy expenses at static tension of the samples with notches. Distribution of ω, obtained at tension of the plane sample (net-section is 25x15mm) shows that intensive plastic deformations cover the metal volume which is considerably larger than that of cylindrical samples.

Analysis of ω -values for cylindrical and plane samples, having known dimensions and particular section, show that structure of 10X2ГМ-steel provides higher resistance to deformation and failure. This is due to the higher strength of 10X2ГМ-steel and its better plastic properties (10X2ГМ-steel: $\sigma_{0,2}$= 462MPa, δ =67%; steel 20: $\sigma_{0,2}$ =242MPa, δ =53%).

Specific energy expenses for deformation and failure of steels 10X2ГМ and Y8 obtained at low test temperatures (Fig.2) are lower than that obtained under normal conditions. Low plasticity of Y8-steel, as compared with 10X2ГМ-steel(δ =6%, ψ = 14%), cause low level of energy expenses and weak localization of deformations in the zone of the stress concentrator.

Analysis of temperature dependence of yield point $\sigma_{0,2}$, strength σ_B and character of deformation localization for the steels considered makes it possible to point out predominant factors of the prefailure stage.

Under normal test conditions preparing acts of steel failure almost don't depend on the sharpness of the stress concentrator because this factor cause the same level of material strength due to strength and plasticity. Stressed-strained state is of considerable importance. It's slight change results in the increase of the prefailure zone and material strength due to strength properties of the steel structure.

Low test temperature causes not only reduction of the zone of deformation localization but change of the character of plastic deformation at the prefailure stage also, which is manifested by different intensity of energy expenses in the zone of the stress concentrator.

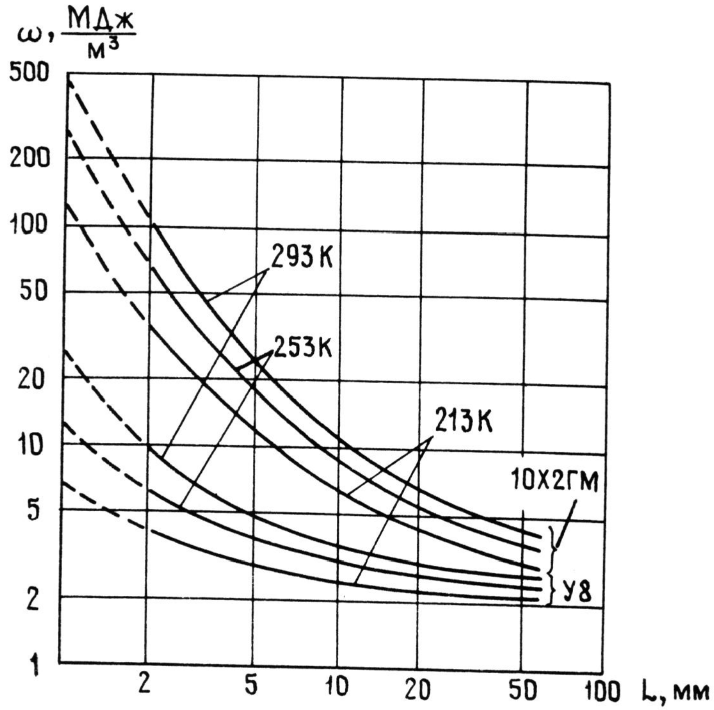

Fig.2. Specific energy of deformation and failure of steels Y8 and 10X2ГM at low test temperature of cylindrical samples with fatigue crack.

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