ТЕЗИСЫ ДОКЛАДОВ

INTERNATIONAL WORKSHOP

«Multiscale Biomechanics and Tribology of Inorganic and Organic Systems»

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

«Перспективные материалы с иерархической структурой для новых технологий и надежных конструкций»

VIII ВСЕРОССИЙСКАЯ НАУЧНО-ПРАКТИЧЕСКАЯ КОНФЕРЕНЦИЯ С МЕЖДУНАРОДНЫМ УЧАСТИЕМ, ПОСВЯЩЕННАЯ 50-ЛЕТИЮ ОСНОВАНИЯ ИНСТИТУТА ХИМИИ НЕФТИ

«Добыча, подготовка, транспорт нефти и газа»

Томск
Издательский Дом ТГУ
2019

DOI: 10.17223/9785946218412/100

AUTOWAVE AND ACOUSTIC CHARACTERISTICS OF LOW-CARBON STEEL 1008 AT LOADING

Orlova D., Lunev A., Zuev L.
Institute of Strength Physics and Materials Science,
Siberian Branch, Russian Academy of Sciences, Tomsk, Russia
dvo@ispms.tsc.ru, agl@ispms.tsc.ru, lbz@ispms.tsc.ru

Owing to the synergetic approach that describes the self-organization of highly nonequilibrium systems, a two-component model of localized plastic flow was proposed in the strength physics laboratory [1, 2]. This model is based on the connection of two subsystems of deformable solids: dynamic (responsible for plastic shaping) and informative (acoustic emission pulses). It was established that the specific distribution of deformation sites — the pattern of localized plastic flow — is spontaneously generated in materials at any stage of deformation . The type of such patterns is determined by the strain hardening law.

The key factor in the change of ultrasound velocity is that the elastic properties of the material become anisotropic in regions of local stress concentration due to structural defects (including dislocation pile-ups) [3]. At the present time, a comprehensive framework, which combines analysis of macro-scale localized plasticity patterns with measurements of ultrasound rate variation is only beginning to develop for real materials with complex structure. Thus, the goal of this paper is to investigate the dependence of surface wave velocity on plastic deformation behavior in low-carbon steel 1008, and to analyze the possibility of using the autowave model to formulate criteria for the structural strength of materials and elastic-plastic transition.

The investigation was performed on specimens of low-carbon steel 1008 (C – 0.05–0.11%; Mn – 0.35–0.65%; Si – 0.05–0.17%) cut from hot rolled steel in the form of dog-bone-shape with gage section dimensions 2×10×50 mm and annealed in vacuum at a temperature of 900 °C for 1 hour. The specimens were subjected to uniaxial loading at a constant rate of 6.67×10^{-5} s^{-1} at room temperature in the grips of a universal LFM-125 testing machine. Double exposure speckle photography [4, 5] was used to study in real time the stress-strain state of the specimens, and to visualize localized deformation and fracture zones. The acoustic informative parameter was the velocity of ultrasonic Rayleigh waves at a frequency of 5 MHz. The Rayleigh wave velocity was measured using a probe that consisted of a transmitting and receiving piezoelectric transducers.

A joint description of the evolution of localized plastic flow autowaves and ultrasonic Rayleigh waves was studied in deformed low-carbon steel 1008. Thus, specimen deformation affects both the ultrasound velocity increase and the evolution of autowave patterns. Changes in the kinetics of the both processes correspond to the critical points (kinks) on the material condition. The first kink corresponds to the elastic-plastic transition and the formation of switching autowave. The second kink and collapse of the localized deformation autowave correspond to material fracture. The kinetic characteristics of the autowave collapse at the prefracture stage can be established experimentally and may help to predict the time and place of fracture long before the appearance of its external signs. These features can be used in the development of metal forming technology and in diagnostic testing of parts and structures.

The work was carried out within the framework of the Program of Fundamental Scientific Research Russian State academies of sciences for 2013–2020, III.23.1.2.

1. L.B. Zuev, Metallofiz.Noveishie Tekhnol. **38**, 1335-1349 (2016).
2. L.B. Zuev, Ann. Phys. **16**, 286–310 (2007).
3. M. Kobayashi, Int. J. Plasticity **26**, 107-125 (2010).
4. L.B. Zuev, V.I. Danilov, Philos. Mag. **79**, 43-57 (1999).
5. R. Jones, C. Wykes, *Holographic and Speckle Interferometry* (Cambridge Univ. Press., Cambridge, 1983).