

## NUMERICAL SIMULATION OF THE DISSIPATED AND STORED ENERGIES IN METALS UNDER CYCLIC LOADING

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**Key Words:** *Cyclic Loading, Stored Energy, Dissipated Energy.*

It was experimentally shown [1] that an endurance limit can be determined by using almost any thermodynamic characteristics of the process: inelastic deformation per one load cycle, irreversibly consumed energy per one load cycle, self-heating, temperature, energy dissipation rate, and energy storage rate. The analysis of the experimental studies carried out in USSR in 1970-1980 has led us to the conclusion that the obtained parameters are indirect and thus cannot be used as a basis for the development of the universal material failure criteria.

For example, it is experimentally shown that the thermal energy dissipated during the cyclic deformation of specimens made from 40X, 2X10, 25, 45 steels (Russian marking) may have very different values. In this work a value of the stored energy is used as material fracture criterion.

There is considered a cyclic loading of the steel specimen containing central crack. Numerical simulation of a crack was carried out in the finite element package Simulia Abaqus 6.13 with the application of the extended finite element method (XFEM). Stress-strain state of the sample was modeled by the original statistical thermodynamic model of the defect growth and accumulation developed in the Institute of Continuous Media Mechanics UB RAS [2] using subroutine UMAT.

Within this model two types of typical mesoscopic defects are considered: microcracks and microshears. Symmetrical second-order defect density tensor  $\tilde{\rho}$  coinciding with the deformation caused by defects is used for the description of such mesoscopic faults. The structural scaling parameter  $\delta$  is defined by two characteristic scales: mean size of the mesoscopic defects and mean distance between them. It is found that critical values of the structural scaling parameter characterize quasi-brittle, ductile and nanocrystalline responses of materials. It was defined the representation of the nonequilibrium potential – nonequilibrium free energy in the terms of  $\tilde{\rho}$  and  $\delta$ . It was allowed us to determine the kinetic equations for these parameters and to describe the defect evolutions in material.

Fracture criterion was simulated with the use of the user subroutine UDMGINI which made possible to model crack initiation and propagation on condition of an excess of an energy storage rate its critical value. The obtaining results gave distributions of the main thermomechanical characteristics of the deformation process in the crack tip.

### REFERENCES

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