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Kinetics of evolution of radiation induced micro-damage in ductile materials subjected to time-dependent stresses

Aneta Ustrzycka[1], Błażej Skoczeń[2]

Cracow University of Technology, Poland

e-mail: [1]anetaustrzycka@mech.pk.edu.pl, [2]blazej.skoczen@pk.edu.pl

This paper is concerned with the estimate of the lifetime of the solids, subjected to combination of irradiation and mechanical loads beyond the yield stress (in the plastic flow range). The damage mechanism is present at both atomic and meso-scale levels including the effect of partial recombination of Frenkel pairs [4].

A multiscale constitutive model comprising the evolution of radiation induced damage under mechanical loads has been formulated [1]. The model has been developed in the framework of continuum damage mechanics and contains strong physical background related to the mechanism of generation of clusters of voids in the irradiated solids.

Two kinetic laws describing the evolution of porosity in the materials were taken into account: the Rice & Tracey model and the Gurson model [2]. The Rice & Tracey model predicts the evolution of radius of spherical void as a function of triaxiality and the accumulated plastic strain. The Rice & Tracey model is expressed in the form of differential equation and has therefore implicit character. On the other hand, the Gurson model is based on the definition of the porosity parameter. The porosity parameter can be directly recalculated to obtain the classical damage parameter in the sense of CDM. Analytical solutions for the uniaxial stress state were obtained. The results of analytical solutions were used to calibrate the numerical algorithms. The numerical procedures were used for the analysis of selected components.

As an application, the estimate of lifetime of coaxial target – detector configuration, subjected to combination of the irradiation and the mechanical loads, has been carried out [3]. The lifetime prediction, expressed in terms of number of beam cycles as a function of maximum *dpa* (displacements per atom) on cycle, is presented.

References

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