A Phenomenological Model of Solid Fracture Kinetics under Pulsed Loading

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Summary: This paper describes a phenomenological model of dynamic fracture kinetics including plastic pore growth and plastic fracture damage.

Introduction

The problem of fracture is critical for the development of structures that undergo intense pulsed loading during operation. Dynamic strain of elastoplastic materials may cause a large number of microdefects of different types. Separate numerical description of each microdefect when considering pulsed loading of a real full-size structure is quite a complex problem. The complexity of the problem is that fracture processes occur at micro-, meso- and macro-levels and are accompanied by developed plastic strain [1]. Thus, most often fracture problems as applied to pulsed loading of real structures are treated in terms of continual (or sparse) fracture.

Results and Discussion

This paper describes a phenomenological model of dynamic fracture kinetics including plastic pore growth and plastic fracture damage. Kinetics of pore formation, development and coalescence is considered in the framework of the model at tension stress, as well as material damage under plastic shear strain, and damage decrease under compression stress. Positions considered in the model have been partially developed in terms of the well-known kinetic isotropic model of ductile fracture NAG (Nucleation And Growth) [2]. The Herrmann model [3] is used for thermodynamically consistent representation of equation of state of the damaged material [3]. The considered kinetic approach allows simulation of both growth and decrease in material damage, the quantitative characteristics of which include the measure of material damage under compression and tensile stress and the measure of damage under shear strain. Equations defining the material's stress-strain state account for stress release due to micro-pore formation and due to material damage under shear strain, as well as strength properties recovery of material due to a decrease in the measure of material damage under compression stress. The model assumes that growth and interaction of different micro-damages of material can finally result in the macro-damage of solid in a local domain. Moreover, the kinetic model includes the possibility of recollection of the damaged material under compression strain.

The model was implemented in TIM-4 [4-5] intended for time-dependent continuum mechanics simulations on arbitrary unstructured Lagrangian grids. Validation of the model is provided using comparative computations with published experimental data.

References

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