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PROBABILISTIC APPROACH IN MODELING DYNAMIC FRACTURE PROBLEMS

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ABSTRACT

Using experimental data and numerical simulation results, it is shown, that the introduction of only one additional parameter - dispersion of the strength properties distribution, into the material model makes it possible to give a probabilistic character to the crack formation process at any scale level (macro-, meso-, microlevel), which corresponds to theoretical concepts and experimental data.

Keywords: probabilistic approach, dynamic fracture, numerical simulation.

INTRODUCTION

In many fracture problems, fragmentation is essentially a probabilistic process, which is determined by the stochastic nature of the distribution of inhomogeneities of the internal structure of material. In the paper the probabilistic approach is described, which allows to model structural heterogeneities of the material in a simple form, practically without complication of the model and additional experiments.

Distribution of materials strength characteristics (according to the selected distribution law) in the cells of the computational domain is used for initial heterogeneities and materials structure defects modeling. It is shown that the fragmentation spectra obtained using different distribution laws with the same dispersion coincide up to the probability factor, which allows to use any distribution law in the calculations.

RESULTS AND CONCLUSIONS

Expanding ring test (Diep, 2004; Lambert, 2012) is an illustrative example of the probabilistic approach. The experimental scheme provides a uniform radial velocity, so, the ring is fragmented due to the presence of internal inhomogeneities and deformations localized on the largest of materials structure defects. The final fragmentation spectrum obtained in the work (Gerasimov, 2013) using the described approach is qualitatively and quantitatively consistent with the experimental results (Diep, 2004) both in the number of fragments and in their masses (Fig. 1). It should be noted that (Diep, 2004) also come to the conclusion that the choice of the distribution law does not have a significant impact on the fragmentation spectrum.

Other example of the probabilistic approach is a petaling of a thin plate under ogive-nosed projectile impact shown in Fig. 2. The number of petals depends on the speed of the projectile and the properties of the material.

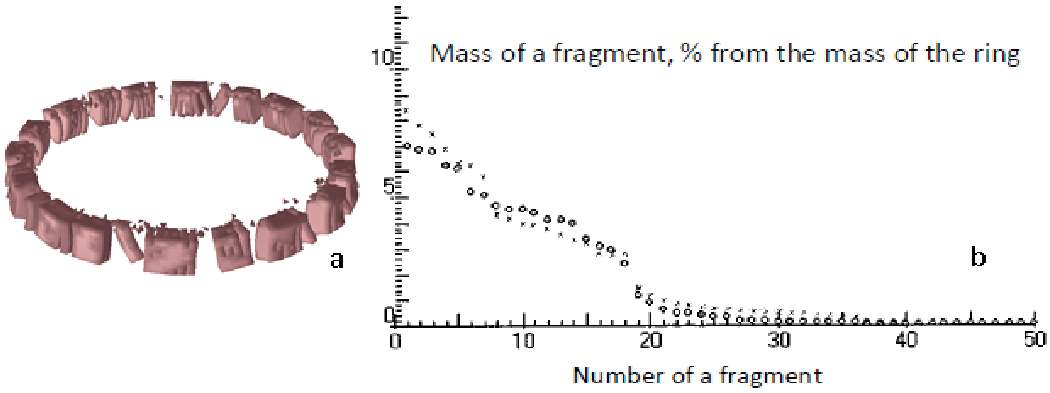

Fig. 1 - Expanding ring test: a) simulation (Gerasimov, 2013);
b) comparison of experimental data (Diep, 2004) and simulation.

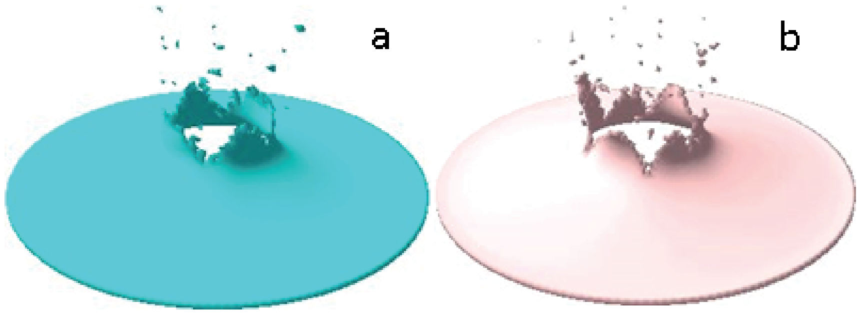

Fig. 2 – Petaling of a thin plate under ogive-nosed projectile impact:
a) copper plate, υ = 150 m/s; b) steel plate, υ = 300 m/s.

Thus, the introduction of only one additional parameter (dispersion of the strength properties distribution) into the material model makes it possible to give the process of crack formation a probabilistic character, which corresponds to the experimental data and allows to improve the accuracy of computations without preliminary study of the structure of the material. The proposed probabilistic approach can be used at any mesh step and at any level of multilevel modeling, providing the distribution of inhomogeneities of the characteristic size. This approach can be applied to any material models and fracture criteria.

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