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Influence of Velocities Dispersion on Spall Strength of Material

The base characteristics that can be measured in real time in the spall fracture experiments are average velocity and dispersion of the velocities on the free surface of the target. From the real and computer experiments there were found out that high level of dispersion usually leads to increase of the strength characteristics of material. In the report computer investigations of this phenomenon are presented. Molecular dynamics method is used. It is shown that increase of the initial dispersion from zero to 15–25 m/s leads to the essentially increase of the material strength. The further increase of dispersion leads to the slow decreasing of the material strength, so the strength-dispersion characteristic has maximum. This fact can help to find out the optimal parameters for the material.

1 Designations and computer experiment description

Spall process is investigated with the computer multiparticle dynamics model. Material is simulated by set of particles interacting by potential forces of attraction–repulsion type with small additional dissipation. The particles are considered as elements of mesoscopic scale level. From nature experiments it is known [1] that high level of mesoparticle velocity dispersion usually leads to increase of the strength characteristics of material. In the report computer investigations of this phenomenon are presented. Let us note that high level of dispersion is usually related with the degree of nonhomogeneity of the material.

Let the initial dispersion σ_0 be the dispersion of the particles in the whole pattern at the initial moment of time $t = 0$; the initial deviation is $\Delta v_0 = \sqrt{\sigma_0}$. The initial dispersion in the computer experiments is set by random uniform distribution of initial velocities of the particles. The aim of the experiments is to find out dependence between the initial deviation and strength characteristics of the material.

The particle model of the considered pattern is shown in the Fig. 1 (the pattern on the Fig. 1 consists of about 5000 particles). One of the main characteristics of the material strength that can be measured also in nature

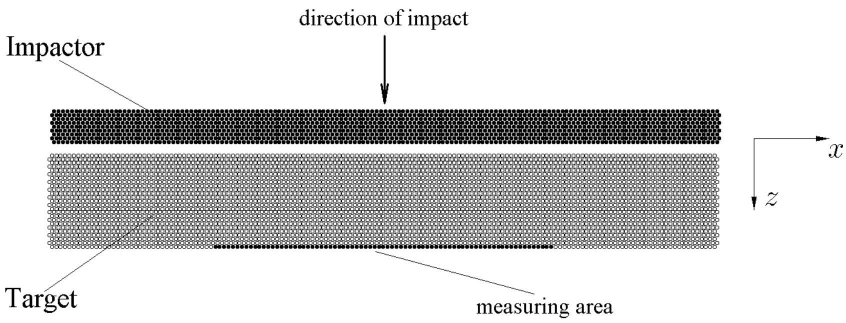

Figure 1: The initial state of the pattern.

experiments is the spall velocity W. The spall velocity can be calculated from the time relation of the average velocity on the free surface. To find out the average velocity and other characteristics on the free surface we shall use the central part of the last particles row of the target (see Fig. 1, “measuring area”).

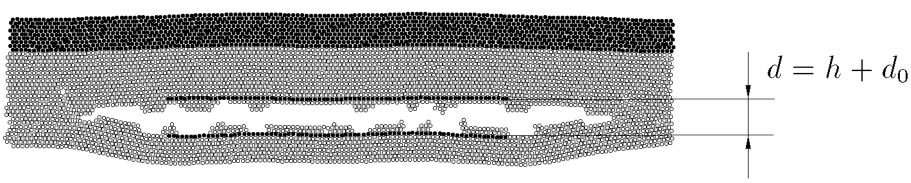

Figure 2: Measuring of the width of the spall crack.

Another characteristic that will be used to describe the strength of the material is width h of the spall crack in the impact direction — see Fig. 2. On the picture $d(t)$ denotes averaged distance between the selected rows, $d_0 \doteq d(0)$. The presented method can be used in situation, when there are a lot of small microcracks — in this case it gives the integral width of the cracks.

2 Material strength dependence of the initial deviation

Results of the computer experiments are presented on the Fig. 3. All experiments were made with the same impactor velocity — 260 m/s. The parameters of material are close to titanium. Fig. 3 (a, b) corresponds to experiments with 5000 particles and 20000 particles. The curve marked $h(4.1\,\mu\text{s})$ shows the width of the spall crack at $4.1\,\mu$s after the first contact between impactor and target. It is well to see from Fig. 3 (a) that at deviation 15–25 m/s the curve has minimum and there is no spall. For the bigger system (Fig. 3 (b)) results are same, but velocity decreasing is faster and area without spall is shifted to the left. The curve marked $h(1.4\,\mu\text{s})$ (white dots) corresponds to the time of appearance of microcracks.

The curve marked W on the Fig. 3 shows the spall velocity dependence of the initial deviation. The spall velocity W is difference between the first maximum and the first minimum on the time dependence of the free surface velocity. The spall velocity is proportional to the spall strength of the material, it is one of the main strength characteristics that we can get from the real experiments. From Fig. 3 it is well to see that W has maximum at the same place where the width of the spall crack has minimum. So the both criterions: the spall strength and the width of the spall crack give the same result.

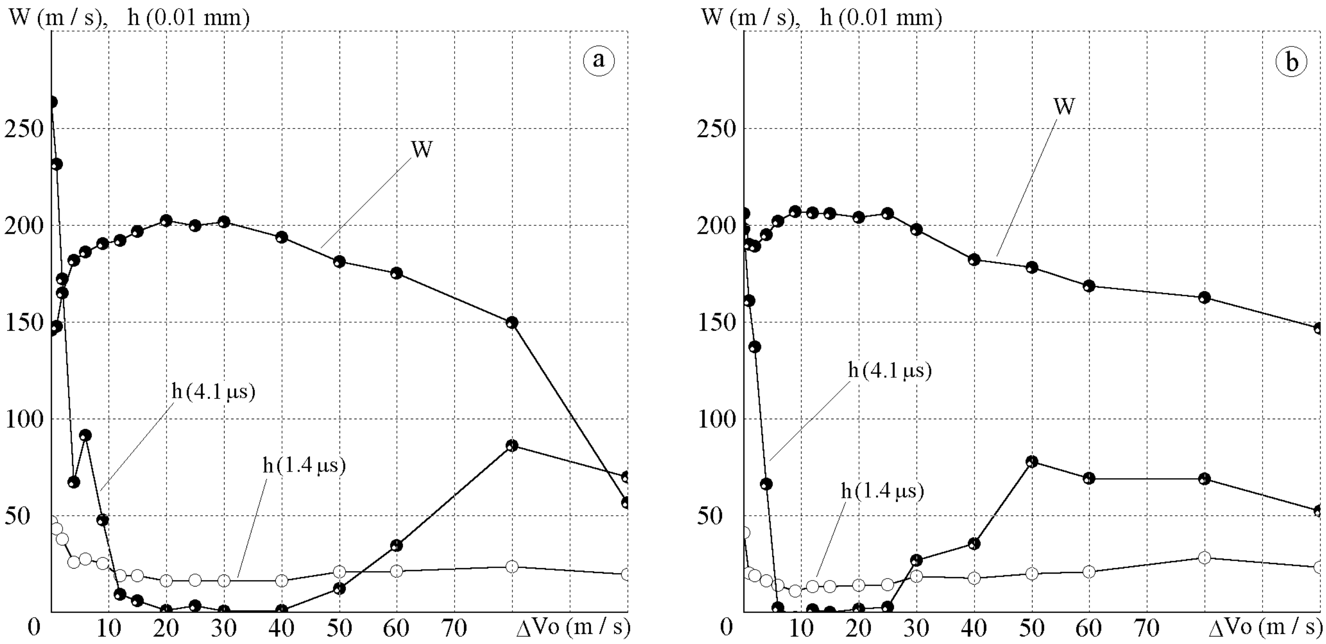

Figure 3: The spall velocity W and the crack width h dependence of the initial deviation.

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References

1 Mescheryakov Y. I., Divakov A. K.: Multiscale Kinetics of Microstructure and Strain-Rate Dependence of Materials. DYMAT J. **4** (1994). 271–287.

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