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A METHOD FOR CALCULATION OF HARDENING OF METAL PARTICLES AT HIGH VELOCITY IMPACT WITH A TARGET

At high-speed collision of metallic particles with a solid surface, breaking (fragmentation) of grains occurs up to the formation of nanoscale structures, which results in increased strength of the material. In this paper, physical and mathematical model of the deformation, formation of fragments and dissipation of impact energy is considered. It is assumed that the material conforms to the model of linear hardening of the ductile body, and at high compressive stresses characteristic to high-speed impact, the stress dependence of local plastic deformation is similar to Hooke's law. A method of calculation of fragmentation, deformation and strengthening of metal particles at impact with a target is developed on the basis of the energy conservation equation $\frac{mu^2}{2}+U+A_f=\frac{mu_0^2}{2}$. Here m, u_0, u are mass, impact velocity, current velocity; U, A_f are energies of plastic deformation and fragmentation of particle. The expressions for calculation of these components were obtained. An estimation of dissipative energy demonstrated that it is small in the impact range characteristic to technological processes of hardening. It is shown that there is a minimal impact velocity below which the fragmentation is absent throughout the whole particle volume. Algebraic equations for determination of such characteristics as maximal stress on contact, maximal deformation, minimum and average size of fragments and maximum and average modulus of linear hardening in dependence on impact velocity and material properties were derived. Calculation examples are given. Empirical coefficient used for calculation of subgrain size may significantly vary depending on the type of material, the method of production and processing. Therefore this work pursues a methodological purpose, and not to obtain quantitative results.

Keywords: three-dimensional nanomaterials, high-impact, plastic deformation, fragmentation of grains of metallic materials, modulus of linear hardening, dissipation of mechanical work

Fig. 1. Model of grain fragmentation under deforming strain

Fig. 2. Effect of impact velocity and the coefficient K on the volume average of hardening modulus (*a*) and the size of grain fragments (*б*) in aluminum particle with D = 10 μm: *1* – K = 20, *2* – 40, *3* – 60, *4* – 100