MAXIMUM AMPLITUDE OF ELASTIC PRECURSORS

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The yield point of solid bodies increases as the pressure increases, and one can usually adopt

$$Y(p) = Y_0 + \alpha p \tag{1}$$

in the first approximation, where Y_0 is the yield point for pure shear when $p = 0$, p is the pressure, and α is a constant characterizing the properties of the material. The presence of the dependence (1) is expressed in the experimental results even when the external pressure is equal to zero if the spherical part of the stress tensor is different from zero. It is well known, for example, that the dependence (1) results in a discrepancy between experimentally measured yield points in the case of uniaxial tension and compression (the SD effect, i.e., strength-differential [1-3])

$$Y^+ = \sqrt{3}Y_0/(\sqrt{3} + \alpha),\ Y^- = \sqrt{3}Y_0/(\sqrt{3} - \alpha)$$

(the superscript "+" refers to tension, and "—" refers to compression). However, the size of the effect is small in this case. Actually, the ratio of the yield points upon tension—compression is equal to the ratio

$$Y^+/Y^- = (\sqrt{3} - \alpha)/(\sqrt{3} + \alpha).$$

Experimental data on the values of the coefficient α are sufficiently numerous but unsystematic, and the values of α given by various authors for the very same material can differ by up to a factor of two and more. Typical values are $\alpha = 0.025$–0.1, which leads to a difference in the yield points of 3-12% in all. Very high values of α are specified for some materials. Thus, titanium has $\alpha = 0.25$–0.33 [4], lithium 0.25, and some carbides about 0.4, and finally for steels at very high pressures $\alpha \to 0.5$ [5, 6]. However, by virtue of what has been said above, it is not possible to consider these data as final, and with rare exceptions the SD effect is not taken into consideration in practice.

The effect of dependence (1) on the structure of elastoplastic waves is more substantial in those situations where it is necessary to deal with uniaxial strains rather than with a uniaxial stress state. In a plane wave the normal stress σ_{xx} (the x axis coincides with the propagation direction of the wave) is related to the principal tangential stress τ by the relationship

$$\tau = \sigma_{xx}(1 - 2\nu)/2(1 - \nu), \tag{2}$$

where ν is the Poisson coefficient. In the elastic precursor of a plastic wave, τ reaches a maximum value equal to the dynamic deformation stress for a given strain rate. Restricting ourselves to an estimate of the pure effect (1) and neglecting therefore the viscous component of the stress, we will identify τ with Y from (1). Then it follows from (1) and (2) that the amplitude of the elastic precursor is equal to

$$\sigma_{xx} = 6(1 - \nu)Y_0/[3(1 - 2\nu) - 2\alpha(1 + \nu)]. \tag{3}$$

The correction to α in (3) is not taken into account in explicit form in the literature on strong compression waves in rigid bodies [7]. But already for such a not-too-sensitive material as high-strength steel at pressures of ~10 kbar $\alpha \approx 0.078$ [3], and the correction in (3) should amount to about 20%.

The influence of the effect under discussion is sharply intensified as α increases. It is interesting to note that when

$$\alpha \geqslant (3/2)(1 - 2\nu)/(1 + \nu) \approx 0.25\text{—}0.6 \tag{4}$$

we formally have $\tau \leqslant Y$ for any p, i.e., a compression wave of any amplitude turns out to be elastic. Of course, the amplitude of an elastic precursor can not exceed the value determined

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through (2) by the theoretical strength of the material. However, one should bear in mind that the theoretical strength is then raised as the pressure increases, and for material with α satisfying (4) the amplitude of the precursor is determined by the intersection point of the pressure dependence of the theoretical strength with the dependence (1), if such a point exists in general. Another factor limiting the amplitude of the precursor is heating and melting of the material in a strong compression wave [8]. The contemporary state of the experimental data does not permit judging whether or not the situation (4) can be realized in some specified material or other having well-expressed plastic properties. The formulation of special experiments on a number of materials having suspiciously high values of α is necessary for the solution of this problem.

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DYNAMIC FRACTURING OF GLASS RODS

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Many literature sources remark that the tensile strength of rigid bodies upon dynamic loading differs from the strength under static conditions. For example, we encounter in [1] the values 2.1 and 1.4 kbar (10^3 kg/cm^2), respectively, for glass, and the dynamic value is found as a result of numerical interference of the incident measured and reflected pulses.

One can explain the discrepancy in the values of the limit in different ways, e.g., as follows. Static loading is characteristically slow in comparison with the propagation velocity of sound waves c_0 and the change in the stress state. In this case the entire rod proves to be loaded, and its strength is determined by the strength of the weakest link σ_0. In the case of dynamic action one should not discuss the entire sample but only the part of it which is entrapped, e.g., by the tension phase of a wave $\lambda = c_0T$, where T is the duration of the tension phase. It is completely natural to expect that in this part, which shifts around the sample, "its own" weakest link for λ with characteristic $\sigma_0^* \geqslant \sigma_0$ may not turn out to be the weakest link with strength σ_0 but the strongest. As λ decreases (an increase in the rate of increase), the probability of the appearance in λ of a link with strength σ_0 decreases. This may lead to an increase in the strength.

The dependence of the limiting values on loading (increase in the loading rate, decrease in the action time; e.g., see [2]) has been discussed earlier; cases are noted of the fracture of a material not in the section where active tension is increasing but where it is decreasing [2], as has been the possibility of fracture of a material not upon the first but upon the

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