PARAMETERS OF SHOCK COMPRESSION IN STEEL CYLINDERS

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The study of the physico-chemical transformations of materials shock-compressed in steel containers has a number of advantages associated with the preservation of the material and the possibility of determining new and sufficiently stable properties [1, 2]. In this case reliable determination of the thermodynamic parameters in the container is a prime requirement. However, suitable methods are still lacking. Measurements show that after an explosion virtually the only change in clyinders with a sufficiently large L/D ratio is in the diameter. Thus, in experiments based on the method of [1], after the explosion of 100 g RDX the inside diameter of a steel cylinder changed on the average by from 5 to 3.5 mm, and the length hardly at all.

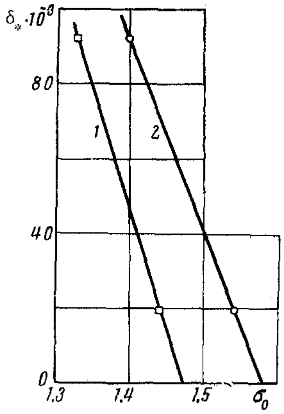

Fig. 1

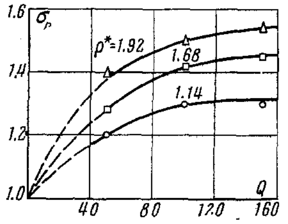

Fig. 2

However, measuring the residual deformation of the cylinder does not give an idea of the true volume at the moment when the shock wave converges in the neighborhood of the cylinder axis, since during the unloading period the cylinder partially recovers its original dimensions.

Experiments show that discs of sufficiently plastic material, placed at right angles to the cylinder axis, have a much greater residual deformation than the cylinder itself, which is in agreement with the data of [3] (pp. 418–419). In these circumstances, a probable factor is friction between the plates and the surrounding material.

For a cylinder with large L/D in radial compression, at the center section end effects will not be very significant, and a perfectly plastic indicator will record the maximum compression of the cylinder walls. By conducting experiments with indicators of different plasticity (copper and steel), one can construct the $\sigma(\delta_*)$ characteristic, where σ is the degree of compression and δ_* the dynamic yield point (N/cm^2) [3] (p. 127, Table 8). Figure 1 shows such data for two experiments. Extrapolating to $\delta_* = 0$, we identify the value obtained with the true maximum compression. It was found that this value exceeds by only 2% the degree of compression determined from the change in the diameter of a copper plate. Figure 2 shows the dependence of σ_0 on the weight Q(g) of the explosive charge for values of $\rho^* = 1.92$, 1.68, 1.14 g/cm^3. There is a well-expressed plateau, i.e., other things being equal a further increase in the charge does not lead to much change in its effect on the cylinder. Figure 3 shows the dependence of σ_0 on the relative packing density $\sigma^* = 1 - \varphi$, where φ is the porosity, for values of Q = 50, 100, 150 g. Clearly, for a saturated explosive charge the relation $\sigma_0(1-\varphi)$ becomes almost linear.

The table presents results of experiments on the shock compression of NaCl in steel cylinders with an inside diameter D_0 = 5 mm and wall thickness Δ_0 = 2.5 mm. The density of the single crystal ρ_{00} = 2.165 g/cm^3, $\sigma_0 = \rho_{max}/\rho_{00}$; the degree of compression σ was registered by copper indicators; σ_0 is the degree of compression reduced to the density of the single crystal, and $\delta_* = 0$; T_0 = 300°K, p and T have been computed correct to the second significant figure.

Since the shock adiabatic for NaCl is known [4–6], the maximum pressure averaged over the cross section is determined from the maximum degree of compression.

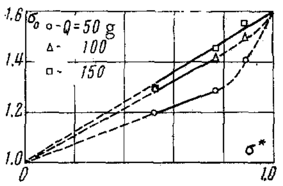

Fig. 3

The temperature was estimated from the known formula [7]

$$T \approx T_0\sigma^2.$$

In this case the degree of porosity has its normal effect, i.e., an increase in porosity is associated with an increase in the shock-compression temperature [8].

ρ^*, g/cm^3	Q, g	σ	σ_0	p, kbar	T, °C
1.14	50	2.28	1.20	240	1330
	100	2.50	1.30	500	1650
	150	2.50	1.30	500	1650
1.68	50	1.67	1.29	170	570
	100	1.83	1.42	330	730
	150	1.87	1.45	370	800
1.92	50	1.60	1.41	250	400
	100	1.69	1.50	360	610
	150	1.74	1.55	420	660

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