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RELATION BETWEEN STATIC MECHANICAL CHARACTERISTICS AND IMPULSE STRESS IN METAL RODS

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The basic difficulty in creating methods of calculation for the dynamic strength of systems and structures is the fact that the mechanical properties of the materials to be used in the construction have been insufficiently studied for dynamic loading. Existing papers [1-6] most frequently specify the value of the yield stress σ_s^{dyn}, i.e., the stress where irreversible plastic deformations begin to occur. However, the dynamic yield stress depends on the state of the material and on its static mechanical characteristics. For the purposes of investigation we took different materials as they were supplied and with different heat treatments (see Table 1).

The static mechanical characteristics were determined on a Gargarin press and an R-10 tension device in which the extension diagram was recorded.

The dynamic yield stress was determined by means of wire resistance strain gauges with a base length of 10 mm and a resistance of 100 Ω attached to the cylindrical rods (of length 150 mm and diameter 10 mm) at a distance of 120 mm from the impact end. The rod was set freely at a distance of 40 mm from the end of the shaft guides and centered accurately. The load was applied by means of a steel cylinder of length 10 mm and diameter 10 mm which was propelled with a velocity of the order of 500 m/sec. The sensor on the rod under investigation was included in an ordinary bridge circuit. The impulse corresponding to the dynamic yield stress, transmitted by the rod as a result of the blow of the cylinder-missile was recorded by means of an OK-17M oscillograph. A more detailed account of the method and the calculation of the dynamic yield stress are given in [3].

Data determined for the mechanical characteristics ($\sigma_{0.2}$ is the yield stress, σ_c is the tensile strength, S_k is the true tensile strength) and for the dynamic yield stress σ_s^{dyn} are given in Table 1.

TABLE 1

Material	$\sigma_{0,2}$	σ_c	S_k	σ_s^{dyn}	$\sigma_s^{dyn}/\sigma_{0,2}$
	kg/mm²				0,2
Aluminum (annealed at 300°C)	4,3	8,4	31,2	18	4,2
Copper (annealed at 500°C)	7,1	22,4	76,3	32	4,5
" (as supplied)	9,2	23,7	69,4	30	3,3
Nickel (annealed at 800°C)	11,5	45	215	43	3,8
Niclel (as supplied)	—	47	208	55	—
Alloy D1 (as supplied)	15,5	23,2	36,7	23	1,5
Br. A7 (as supplied)	20,3	48	122,6	51	2,5
110G-13BL (impact hardened)	86	112	125	93	1,1
St. 3 (annealed at 700°C)	20,9	40,6	96	80	3,83
Steel 45 (annealed at 700°C)	35,5	65,4	113,1	62	1,75
Steel 45 (as supplied)	41,2	74,8	117,3	82	1,99
4Kh13 (hardened + annealed at 500°C)	102	127,8	160,4	109	1,07
ShKh15 (as supplied)	44,4	71,7	131	55	1,2
ShKh15 (hardened + annealed) HR_C 35-40	163	171,7	220,2	161	0,99
ShKh15 (hardened + annealed) HR_C 45-50	174	183,5	225,4	170	0,98
ShKh15 (hardened) HR_C 60-62	195,5	211,1	224,5	194	0,99

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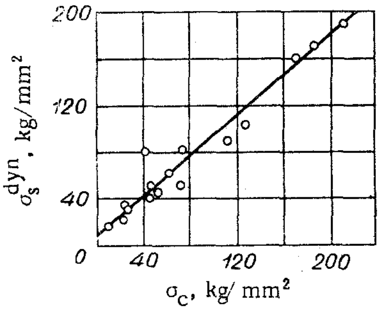

Fig. 1

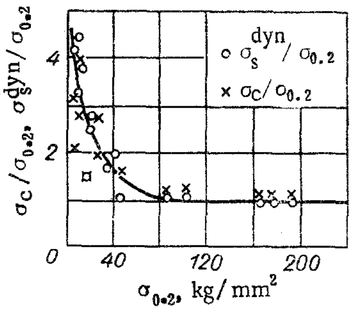

Fig. 2

Constructing the dependence of the dynamic yield stress on the static mechanical characteristics showed that the clearest dependence is that of σ_s^{dyn} on σ_c (see Fig. 1). The equation of the straight line constructed by the method of least squares can be represented in the following form in the present case:

$$\sigma_s^{dyn} = 8.8 + 0.89\sigma_c. \tag{1}$$

This dependence can be used for estimating the dynamic yield stress approximately when it cannot be determined directly, and only the value of the static tensile strength σ_c is known.

It can be proved from Eq. (1) that the maximum increase in the dynamic yield stress is limited by the static tensile strength. This is not in conflict with published data [1, 3, 5].

The dependence of the coefficient of dynamic yield stress on the static yield stress ($\sigma_s^{dyn}/\sigma_{0.2}^{st}$) is given in Fig. 2. It is clear that for materials with a static yield stress of 90–100 kg/mm² and above, the coefficient giving the dynamic quantity is approximately equal to unity. This conclusion agrees well with published data [3, 6, 7].

It should be stressed that for the majority of materials investigated the coefficient giving the dynamic quantity is approximately equal to the ratio of the static mechanical characteristics $\sigma_c/\sigma_{0.2}$ referred to arbitrarily as the plastic strength reserve (see Fig. 2). This fact confirms the relation shown in Fig. 1.

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