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EFFECT OF HEATING ON THE SPALL FRACTURE OF A COMPOSITE BASED ON SKTN RUBBER

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Elastomeric composites are often used in structures subject to the combined action of intense dynamic loads and elevated temperatures during operation. There are no experimental data on spall strength of these materials under such loading conditions, which are necessary for the calculations of dynamic strength. However, it has been shown [1] that certain polymeric composites have a tendency to increase the spall strength as the test temperature increases.

The aim of the present paper is to determine the effect of heating temperature on the spall strength of high-filled composites based on SKTN rubber. The composite being tested contained as a filler 80 % by wt. of a finely divided mixture of oxides of several metals. The sizes of filler particles ranged within 1.5–30 μm. The specimens for dynamic tests were in the form of disks 30 mm in diameter and 3 mm thick. Before the tests the specimens were attached to aluminum shields 80 mm in diameter and 8 mm thick. The specimens were loaded by a 4-mm-thick aluminum plate impinging on the shield with the required velocity w produced by sliding detonation of a thin layer of explosive. Heating to the necessary temperature T, monitored with a Chromel–Copel thermocouple, was performed through the shield using an electric heater.

After the tests, visual examination of the specimens was made. When no separation of spall layer was found visually, the specimen was cut and its longitudinal diametric section was examined for the presence or absence of spall cracks. Conditions and results of dynamic tests are shown in Table 1, where h_s is the thickness of a spall layer and l is the length of a crack. The external view of two specimens tested at normal temperature is shown in Fig. 1 (a — $w = 136$ m/sec, b — $w = 154$ m/sec). The pressure P in loading compression pulses was estimated numerically. The value $h_s = 0.9$ mm, which was stable under normal test temperature, allowed for estimation of the wave velocity for the composite under consideration, $c_c = c_a(h_s/h_p)$. Taking the wave velocity for aluminum as $c_c = 5.3$ km/sec and the thickness of the striker plate as $h_p = 4$ mm, we have $c_c = 1.2$ km/sec. To determine the pressure in loading pulses we used the formula $P = \rho_c c_c w/(1 + \rho_c c_c/\rho_a c_a)$, where the values 2.7 and 3.0 g/cm^3 were used for density of aluminum ρ_a and composite ρ_c, respectively. The characteristic time of loading in the present arrangement of the tests $\tau = 2h_p/c_a$ is 1.5 μsec.

The experimental results point to the substantial and nontrivial effect of elevated temperatures on the spall strength of the composite. Thus, if at normal test temperature its characteristic value is 300 MPa, then heating up to 150 °C increases it to 380 MPa, and further heating up to 250 °C returns it to the value characteristic of normal temperature. It is noteworthy that an analogous tendency for growth of the spall strength was also observed for composites based on phenol-formaldehyde resins with fabric fillers when heated up to 130 °C [1]. An increase of spall strength due to heating was also noticed for two polymer materials: Plexiglas and fluoroplastic [2]. The value of 300 MPa obtained for the spall strength of the composite tested under normal test temperature corresponds to one-dimensional strain $\varepsilon = P/\rho_c c_c^2$, which is 7 %. For comparison it should be noted that under static conditions of uniaxial tension the fracture of the composite is characterized by a limiting tensile stress of 2 MPa and an appropriate limiting strain of 60 %.

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TABLE 1

T, °C	w, m/sec	P, MPa	State of specimen
~ 0	103	297	Absence of fracture
	116	334	Two small cracks, $l = 1$ mm, $h_s = 0.9$ mm
	136	392	Several cracks, $l_{max} = 5$ mm, $h_s = 0.9$ mm
	154	444	Separation of spall layer, $h_s = 0.9$ mm
	195	562	The same
150	131	377	Absence of fracture
	141	406	One small crack, $l = 1.5$ mm, $h_s = 0.9$ mm
	152	438	Absence of fracture
	164	472	One crack, $l = 10$ mm, $h_s = 1.4$ mm
	180	518	Separation of spall layer at a half of section, $h_s = 1.1$ mm
250	116	334	One small crack, $l = 1.5$ mm, $h_s = 0.8$ mm
	164	472	Separation of spall layer, $h_s = 0.9$ mm

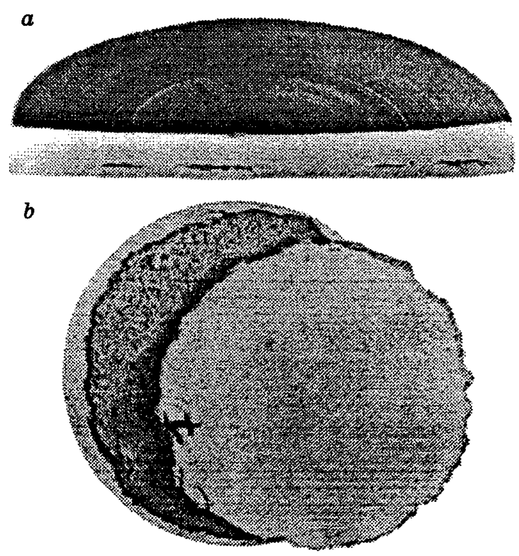

Fig. 1

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