INVESTIGATION OF SHOCK WAVE COMPRESSIBILITY OF TEXTOLITE FOR EXPERIMENTS AT PRIOR

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1. Introduction

Using a laser interferometer VISAR with nanosecond time resolution, the experiments on developing of targets, investigation of the shock wave structure and spall strength and also the determination of Hugoniot data were carried out with samples of textolite with longitudinal and transverse direction of the fibers. The goal of this study is development of targets for experiments at a novel diagnostic system proton microscope (PRIOR) at the TU Darmstadt. Textolite is a composite anisotropic material with a low specific weight, consisting of interwoven fabric fibers and a binder - epoxy resin. The density of the investigated material is 1.265 g/cm^3. The thickness of the samples in the experiments varied from 3 to 10 mm, the diameter from 25 to 50 mm. The measured sound speed along the fibers is C_l = 7.1 km/s, transverse - C_l = 2.45 km/s.

2. Scheme of experiments

To study the shock wave compressibility of textolite under high pressure, the explosive propellant charges were used to provide a flat throw of aluminum flyer plates with diameter of 70-100 mm and thickness of 2-10 mm. Their velocity W varied from 0.7 to 2.5 km/s. The scheme of experiments is shown in Figure 1. Shock waves in the investigated samples (3) were created by the collision of an aluminum flyer plate (1) with the metal plate (2). The velocity of the sample-water (4) boundary was recorded by VISAR interferometer. To determine the absolute value of the velocity, two interferometers with velocity fringe constants of 280 m/s and 1280 m/s were used simultaneously. A laser beam was reflected from an aluminum foil which was glued onto the sample (5). In each experiment, the piezoelectric gauge (6) recorded the entry time into the sample of the shock wave, which allowed us to determine the average value of the shock wave velocity *D* using interferometric data.

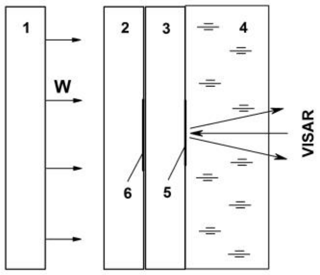

Figure 1: Scheme of experiments.

3. Experimental results

Particle velocity profiles on the textolite/water boundary at high pressure are shown in Fig. 2. The experimental setup parameters are indicated in the figure descriptions. On the velocity profile for a textolite with transverse direction of the fibers, after the shock jump, oscillations are observed due to the porosity of the investigated material (Fig. 2, left). Unlike the textolite with transverse orientation of the fibers, in the case when a shock wave propagates along the fibers (Fig. 2, right), a two-wave configuration is recorded (precursor and shock wave), which is due to the anisotropic structure of material. The amplitude of the precursor is about 150 m/s. The velocity of the perturbations propagation along the fibers can be several times higher than the shock wave velocity, what results in the formation of the precursor. Since the amplitude of forward-running perturbations attenuates, the front of the first wave degenerates into a sound pulse, so its propagation velocity is close to 7.1 km/s, measured by the ultrasonic method.

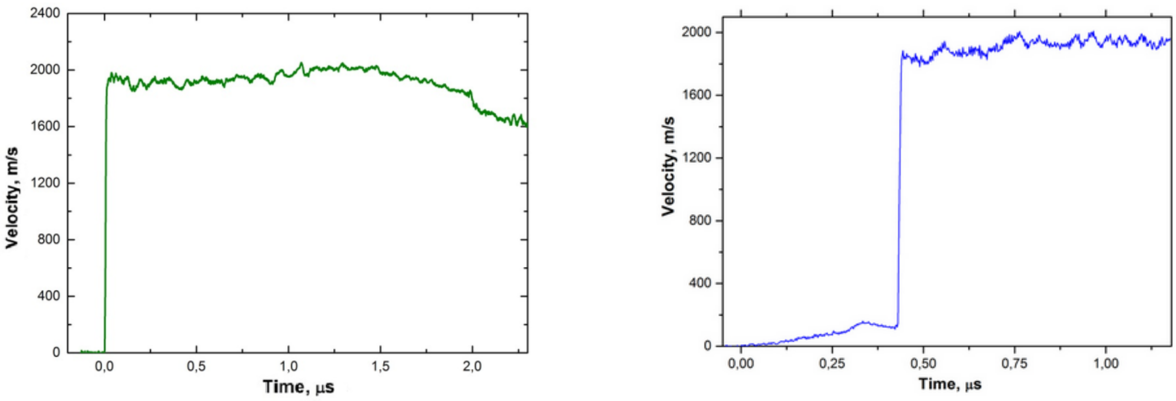

Figure 2. Particle velocity profiles on the textolite/water boundary. Aluminum projectile of 10 mm, W=2.5 km/s; aluminum plate of 4 mm: left - transverse orientation of the fibers, right – parallel.

As a result of the processing of the experimental data, Hugoniot parameters of textolite in the coordinates of shock wave D – particle velocity u were plotted (Fig. 3) at the wave propagation along (red filled circles) and across the fibers (black filled circles). The solid lines represent a linear approximation of the experimental data: $D = 1.50 + 2.00*u$, km/s for parallel orientation of the fibers, $D = 2.17 + 1.45*u$, km/s – for transverse.

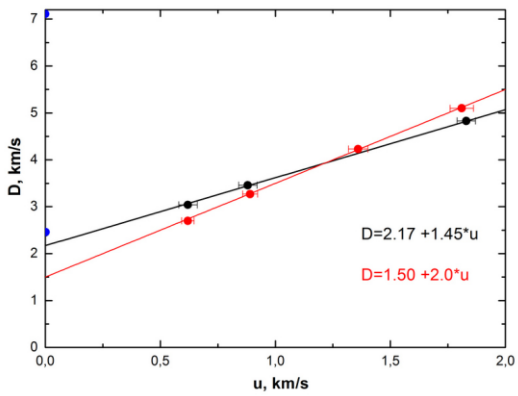

Figure 3. Hugoniot parameters of textolite.

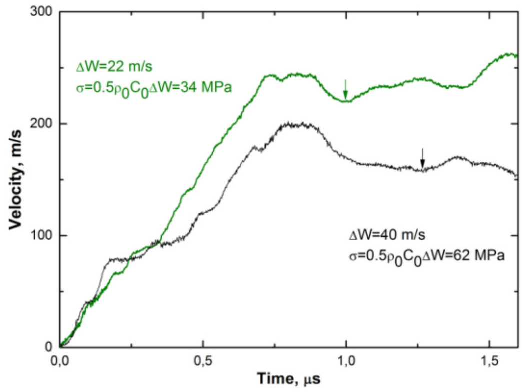

Figure 4. Particle velocity profiles of free surface for textolite.

Also a study of spall strength for textolite was conducted. The measured particle velocity profiles of free surface of textolite for parallel (black profile) and perpendicular (green profile) orientation of the fibers are shown in fig.4. The exit of the shock wave on the free surface causes an increase in the velocity of the surface up to the maximum value. A rarefaction wave propagates inside the sample, which, interacting with the incident unloading wave, results in an internal fracture - a spall. The spall strength σ, which characterizes the maximum tensile stress in the sample, is determined by the equation: $\sigma=0.5\ \rho_0 C_0\ \Delta W$, where ΔW - the velocity difference between its maximum and value at the moment of arrival of spall pulse (shown by arrow), C_0 – the sound speed at zero pressure, ρ_0 – the initial density of the sample.
It was found that the spall strength value of textolite with parallel orientation of the fibers is almost twice higher than that for perpendicular orientation.
Thus, it was found that shock wave properties of textolite were strongly dependent on the fibers orientation.

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