DETERMINATION OF THE INELASTIC PROPERTIES
OF TiC-TiNi HARD ALLOYS BY THE ULTRASONIC
PULSED METHOD

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Modern technology requires the development of new alloys whose properties are equal to or higher than those of the standard hard alloys based on tungsten carbide which is in short supply because the reserves of tungsten ore are limited. In many cases, vibrations of various type are prevented by the use of alloys with high internal friction or damping. These alloys are characterized by a high relative degree of energy dissipation in loading. The main role in the damping alloys is played by the amplitude-dependent internal friction. The free oscillations in the components made of the damping alloys rapidly attenuate, greatly reduce the amplitude of the forced resonance oscillations and the stress of shock loading, and reduce the sensitivity of the material to crack propagation.

The damping theory explaining the mechanism of energy dissipation in the alloys and metals in cyclic loading in a relatively wide frequency range is still in the development stage. The nature of damping in the cermet materials has been studied insufficiently. Therefore, examination of the damping properties of these materials should be regarded as one of the most important tasks. The present work is concerned with the determination of the coefficient of attenuation of ultrasonic waves in a TiC-TiNi damping alloy.

It is well known that the propagation of waves in materials is accompanied by absorption and dissipation of energy determined by internal friction, by heat conductivity, and by the transformation of the individual waves in these materials during encounters with inhomogeneities [1-3]. In this case, the amplitude of the waves decreases and this relationship is indicated by the attenuation factor \( \alpha \) [4]: 

\[
\alpha = \frac{1}{\ln(A_0/A_n)},
\]

where \( A_0 \) and \( A_n \) are the amplitudes at the start and end of the path with length \( a \) (cm) passed by the wave. Therefore the attenuation factor may be regarded as a characteristic of the damping properties of the materials. There are a number of methods of determining the attenuation factor in materials in pulsed measurements [1, 2, 5-7]. We used the reduction method [6] whose principle may be described as follows. Using a calibrated attenuator, the amplitude of ultrasonic oscillations after passage through the specimen is reduced to the value established in the position of gages brought into contact through a thin foil. The thin foil generates two compact layers. The DUK-66 ultrasonic flaw detector makes it possible to vary attenuation in steps of 1 dB. The degree of attenuation is determined with the accuracy of 0.5 dB by visual interpolation on an oscillogram. The volume attenuation factor was determined from the equation 

\[
\alpha_v = (N_0 - N)/l
\]

where \( N_0 \) and \( N \) are the degrees of attenuation for the transducers and after passage of a pulse through the specimen at which the amplitudes on the electron-beam tube were identical; \( l \) is the measurement length (the length of the specimen). The time factor of attenuation was evaluated by the compensation method [7] which makes it possible to combine the calibrated exponent with the detected envelopes of the series of the reflected pulses. The measurements were taken in a DUK-20 ultrasonic flaw detector. The inspected acoustic contact between the specimen and the transducer was generated using machine oil and a load of 0.5 kg.

The specimens were prepared by the method of powder metallurgy from titanium carbide and TiNi intermetallic compound. The powders with an acetone addition were thoroughly mixed and the prepared mixture was dried in a cabinet and then used to produce compacts in the form of cylinders 18 mm in diameter and 8-10
Fig. 1. Dependence of the attenuation factor of ultrasound on the volume content of the intermetallic compound in the TiC-TiNi hard alloy. $\gamma_T = 0.6$ (1), 1.25 (2), 2.5 (3), and 5 (4) MHz. The measurements were taken in DUK-66 electronic device.

Fig. 2. Amplitude of ultrasonic oscillations recorded from the electron beam tube of the device without the specimen (1) and after passage through the specimen (2). $\gamma_T = 5$ MHz.

Fig. 3. Dependences of volume and time attenuation factors on the content of the intermetallic compound in the TiC-TiNi hard alloy ($\gamma_T = 5$ MHz). Measurements taken on DUK-66 and DUK-20 devices.

Fig. 4. Dependence of the attenuation factor of ultrasound on the volume content of boron in the TiC-TiNi alloy. Symbols as in Fig. 1.

mm high at a pressure of 200 MPa. Sintering was carried out in a vacuum of 6.65 kPa at a temperature of 1250-1280°C for 1 h with subsequent slow cooling. The density of the sintered material was determined by hydrostatic weighing. The phase composition of the alloys was inspected in DRON-3.0 x-ray equipment with filtered copper radiation [9]. The porosity of the specimens varied from 1 to 6%. The coefficient of attenuation of the ultrasonic oscillations was examined on the specimens whose edges deviated from the parallel direction by no more than $10^{-3}$ rad and the surface finish was not lower than the seventh grade of surface finish. The energy losses associated with the transfer of ultrasound through the contact layer, the conversion of mechanical energy into electric energy, and with reflection from the receiver were assumed to be identical for the closed transducer and after passage of the pulse through the specimen and were not taken into account. The tests were conducted on five specimens for each composition with the transducers with resonance frequencies of 0.6, 1.25, 2.5, and 5 MHz.

The attenuation factor in the TiC-TiNi alloy at the third amplitude of the ultrasonic oscillations depends on the resonance frequency of the transducers and the volume content of the intermetallic compound (Fig. 1). The maximum energy was recorded at the third amplitude. The volume attenuation factor increases with an increase of the resonance frequency of the transducers at the constant TiNi content of the alloy. This form of the $\alpha_v(\gamma_T)$ dependence is typical of all the examined compositions. The volume attenuation factor increases.