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RESEARCH OF IMPACT VISCOSITY OF COMPOSITE MATERIALS

The intensive development of transportation, energy, chemical and atomic engineering, shipbuilding, and aerospace technology imposes new requirements on structural materials. The quality of materials is ensured through thermal and thermomechanical treatments, alloying, and the application of protective coatings [1]. One of the promising ways to address the problem of improving the reliability and durability of machine structures and components operating under complex loading conditions could be the development of new layered metal composite materials (LMCMs), which allow for the formation of a structure with interlayer boundaries and provide properties in accordance with the operating conditions of the components [2]. LMCMs are produced by rolling and pressing, thermodiffusion welding, casting, deposition on one or several components' surfaces, etc. One of the methods characterized by high technological efficiency and cost-effectiveness is the production of LMCMs using explosion welding [3].

The aim of the work: To investigate the dependence of impact viscosity of layered composite materials on shock-wave loading.

Composite material is a material consisting of two or more components and possessing new properties that differ from the sum of the properties of the constituent elements [2].

The following materials were chosen as starting materials for the production of layered composite materials: alloyed steel 12X18H10T and carbon steel 20 [4]-[5]. The steels had different structures (austenitic in steel 12X18H10T and ferrite-perlite in steel 20), as well as varying levels of strength and plasticity.

Layered composite materials 12X18H10T + 20 were obtained by explosion welding under different welding parameters: plate velocity, contact point motion speed, collision angle, and pressure at the interface. LMCMs were obtained using welding modes No. 1, 2, and 3.

As a result of explosion welding, all composite materials had wave-shaped interlayer boundaries. The length and amplitude of the waves were measured in the LMCMs. The variation among the measured values was within 10%.

The properties and performance of composite products are largely determined by the compositionally heterogeneous interlayer bonding zone, the structure and properties of which are formed due to the melting of surface layers, their mixing, and diffusion of elements. In the bonding zone of materials obtained under welding mode 1, regular waves were formed. In the bonding zone of materials obtained under welding mode 2, regular waves were formed with slight vortexing at the crests. In the bonding zone of materials obtained under welding mode 3, large waves with pronounced vortexing at the crests were formed, and in certain areas, cast structure zones appeared.

Explosion welding was accompanied by significant strengthening of the metals in the bonding zone. The degree of strengthening was calculated as the ratio of microhardness after explosion welding to the initial microhardness. The degree of strengthening of steel 12X18H10T was 1.5 (welding mode No. 1), 1.6 (welding mode No. 2), and 1.7 (welding mode No. 3). For steel 20, the degree of strengthening was 1.6 (welding mode No. 1), 1.9 (welding mode No. 2), and 2.1 (welding mode No. 3).

Impact viscosity is an important material characteristic that largely determines its susceptibility to brittle fracture.

Impact bending tests of layered samples with dimensions 10x10x55 mm and a Menagé notch ($r = 0.25$ mm) were conducted at a temperature of 20°C in accordance with DSTU ISO 148-1:2022 on a pendulum impact testing machine with a maximum impact energy of 300 J [6]. In the composite materials, the notch was made in steel 12X18H10T. The bottom of the notch was located 4 mm away from the interlayer boundary. The fracture plane of the samples was perpendicular to the metal layer bonding plane. The test results are presented in Table 1.

Table 1

Impact viscosity of layered composites steel 12X18H10T + steel 20	
Material	KCV, J/cm ²
Steel 12X18H10T	215,0
Steel 20	55,0
Steel 12X18H10T + steel 20, welding mode 1	138,0...142,0
Steel 12X18H10T + steel 20, welding mode 2	110,0...111,0
Steel 12X18H10T + steel 20, welding mode 3	100,0

As a result of the microhardness study in the joints of steel 12X18H10T + steel 20 welded under different modes, it was found that an increase in pressure at the detonation wave front leads to an increase in the degree of strengthening of the welded metals and the width of the hardened zone.

The results of testing the composite materials 12X18H10T + 20, obtained by explosion welding, showed that the impact toughness of the bilayer composite materials occupies an intermediate position between the impact toughness values of steels 12X18H10T and 20.

With an increase in explosion welding parameters, the impact toughness of the composite materials decreases. The composite materials welded under the 2nd and 3rd modes had impact toughness values 21% and 29% lower, respectively, compared to the composites welded under the 1st mode.

References:

1. Холявко В. В., Владимирський І. А. Механічні властивості та конструкційна міцність матеріалів : підручник. Київ : КПІ ім. Ігоря Сікорського, 2023. 270 с. URL: <https://ela.kpi.ua/handle/123456789/62087> (дата звернення: 18.03.2025).
2. Буренніков Ю. А., Сивак І. О., Сухоруков С. І. Нові матеріали та композити : навч. посіб. Вінниця : ВНТУ, 2020. Ч. 1. 135 с. URL: https://bmi.vntu.edu.ua/bioart/program/NM_lect.pdf (дата звернення: 19.03.2025).
3. Кривцун І. В., Квасницький В. В., Максимов С. Ю., Єрмолаєв Г. В. Спеціальні способи зварювання : підручник / За заг. ред. Б. Є. Патона. Миколаїв : НУК, 2017. 346 с. URL: https://www.researchgate.net/profile/Gennadii-Yermolaiev/publication/321796647_SPECIALNI_SPOSOBI_ZVARUVANNA/links/5a32349b458515afb6555f62/SPECIALNI-SPOSOBI-ZVARUVANNA.pdf (дата звернення: 18.03.2025).
4. ДСТУ 9029:2020. Сталь аустенітна. Методи визначення вмісту феритної фази в прутках. Чинний від 2021-01-01. Київ: ДП «УкрНДНЦ», 2021.
5. ДСТУ 7809:2015. Прокат сортовим, каліброваним зі спеціальним обробленням поверхні з вуглецевої якісної конструкційної сталі. Загальні технічні умови. Чинний від 2016-04-01. Київ: ДП «УкрНДНЦ», 2016. 25 с.
6. ДСТУ ISO 148-1:2022. Металеві матеріали. Випробування на ударний вигин за Шарпі на маятниковому копрі. Частина 1. Метод випробування (ISO 148-1:2016, IDT). Чинний від 2022-10-01. Київ : ДП «УкрНДНЦ», 2022. 28 с.