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Abstract: The study focuses on resource-efficient soil tillage technologies as a means of sustainable agricultural development. It examines the limitations of traditional intensive systems and the advantages of modern approaches (no-till, strip-till, minimum tillage, subsoiling) in preserving soil structure, moisture, organic matter, and supporting soil biota. The economic benefits, including reduced fuel consumption and optimized field operations, are also highlighted. Special attention is given to the conditions in Ukraine, where the implementation of resource-saving systems enhances crop drought resistance and the resilience of agroecosystems.

Keywords: resource-efficient technologies, soil tillage, no-till, strip-till, minimum tillage, soil fertility, agroecosystems, moisture conservation, soil erosion, sustainable agriculture.

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Technological aspects of formation of composite materials and coatings based

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Abstract. The study considered the issue of increasing the durability of machine parts by increasing their resistance to wear and corrosion by using polymer composite coatings. Compositions were formed based on reactive oligomeric systems, in particular, epoxy resin ED-20 and urea-formaldehyde resin, into which dispersed modifying components were introduced - tripoli, siliceous materials, graphite and fluoroplastic. A method of forming coatings based on the technology of application using immersion was also proposed. Infrared spectroscopy and X-ray structural analysis were used to analyze the structural features of the formed layers. In addition, an evaluation of operationally important characteristics was carried out, in particular,

adhesive strength, impact strength, water absorption capacity and tribological indicators. The results obtained indicate that the introduction of fillers is not accompanied by the formation of new chemical compounds in the polymer matrix, but causes an increase in the order of its structure, which is manifested in an increase in the degree of crystallinity. It was established that the addition of fluoroplastic has a positive effect on the adhesion and impact properties of the coatings, while the use of other modifiers leads to their certain deterioration. In the process of tribological tests, a decrease in the friction coefficient to a level of about 0.2 was recorded with the introduction of siliceous components and tripolite. The practical value of the results obtained lies in the possibility of their use as an alternative to existing technologies for forming coatings on spline joints of drive shafts, which will contribute to improving their operating characteristics and increasing their resource.
Keywords: composite coatings, wear resistance, corrosion resistance, polymer materials, epoxy resin, urea-formaldehyde resin, modifiers, fluoroplastic, tribological properties, friction coefficient, adhesion.

The degradation of machine components and metallic structures is predominantly caused by wear processes and corrosion phenomena. It is estimated that natural wear contributes to nearly 70% of all failures in parts and their assemblies. At the same time, corrosion-related losses remain considerable. Statistical data indicate that in the chemical industries of CIS countries, annual losses exceed 200,000 tons of equipment and pipeline elements. In the United States, even conservative evaluations suggest that corrosion damage results in economic losses of about $70 billion per year, which corresponds to approximately 4.2% of the gross national product.

Analysis of both domestic and global engineering practices confirms that the application of protective coatings is one of the most effective approaches to improving resistance to wear and corrosion. Such coatings, formed on the working surfaces of components and structures, significantly enhance their operational reliability due to their superior functional characteristics. They act as a barrier layer, concentrating mechanical and corrosive degradation within the near-surface region and thereby preventing damage propagation into the bulk material. Depending on the required properties, coatings may be produced from materials with different compositions and structural states, as well as tailored to the substrate material. In most cases, preliminary surface preparation is also necessary [1–3].

The aim of the present study is to design a composite material system based on cross-linking oligomeric compounds and to develop a technological process for producing antifriction and wear-resistant coatings. From a practical standpoint, the task involves replacing the conventional method used in industrial practice (OJSC), where coatings on driveshaft splines are formed by immersing components into a fluidized bed of thermoplastic powders. The proposed composite and its application technique are expected to ensure economic benefits while maintaining or improving coating performance characteristics. The research methodology is described in [4–6].

As the polymer matrix for the composite systems, the following oligomeric binders were selected:

- epoxy resin ED-20 combined with an amine curing agent in a ratio of 1:10–12;
- urea-formaldehyde resin KF-Zh(M) cured with a 10% aqueous ammonium sulfate solution at a ratio of 1:20.

To enhance the properties of the matrices, various modifiers were introduced, including tripoli, flint, finely dispersed graphite, and fluoroplastic. The concentration of

modifying additives in the composites varied within the range of 0.5 to 10 wt.%. The coatings were formed on metallic substrates using a solution-based technique involving immersion of the prepared composition [7, 8].

The structural features of the obtained coatings were studied using infrared spectroscopy and X-ray diffraction analysis. The results indicate that the incorporation of modifiers into the polymer matrix does not lead to the formation of new chemical compounds. However, changes in diffraction patterns, such as the appearance of additional peaks and a reduction in the intensity of the amorphous halo, suggest an increase in the degree of structural ordering or crystallinity of the modified systems. This behavior can be explained by the absence of chemical interaction between modifiers and the polymer matrix; instead, modifiers with uncompensated surface charges likely form a network of weak physical interactions, contributing to a more ordered arrangement of polymer chains. The introduction of most modifying fillers (tripoli, silica, graphite), except for fluoroplastic, results in a decrease in adhesion strength. For epoxy-based coatings, adhesion was evaluated at 2–3 points, whereas compositions modified with fluoroplastic demonstrated improved adhesion, reaching 1 point. In the case of urea-formaldehyde matrices, the addition of the same fillers led to a reduction in adhesion strength to approximately 4 points [9, 10].

A similar trend was observed for impact resistance: the incorporation of modifiers generally reduces this property, with the exception of fluoroplastic. The addition of fluoroplastic in amounts of 0.5–10 wt.% increases the impact strength of the composites by 12–17% compared to unmodified materials. The formation of a quasi-crystalline structure within the polymer matrix also affects moisture absorption. Modified coatings exhibit a decrease in water uptake by approximately 1–4%.

Tribological testing showed that the inclusion of silica and tripoli in the base polymer matrices reduces the friction coefficient in the “coating–metal” friction pair to values around 0.2. According to the technical requirements of Belcard JSC, the friction coefficient for metal–polymer contacts in splined joints must not exceed 0.2. Therefore, further testing of such coatings was deemed unnecessary.

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Анотація. У дослідженні розглянуто питання підвищення довговічності деталей машин за рахунок зростання їх опору зношуванню та корозійному руйнуванню шляхом використання полімерних композиційних покриттів. Сформовано склади композицій на основі реакційноздатних олігомерних систем, зокрема епоксидної смоли ЕД-20 та карбамідоформальдегідної смоли, до яких введено дисперсні модифікуючі компоненти – трепел, кременисті матеріали, графіт і фторопласт. Також запропоновано спосіб формування покриттів, що базується на технології нанесення із застосуванням занурення. Для аналізу особливостей будови сформованих шарів використано методи інфрачервоної спектроскопії та рентгеноструктурного дослідження. Окрім цього, проведено оцінювання експлуатаційно важливих характеристик, зокрема адгезійної міцності, ударної в'язкості, здатності до водопоглинання та трибологічних показників. Отримані результати свідчать, що введення наповнювачів не супроводжується формуванням нових хімічних сполук у полімерній матриці, однак спричиняє підвищення впорядкованості її структури, що проявляється у зростанні ступеня кристалічності. Встановлено, що додавання фторопласту позитивно впливає на адгезійні та ударні властивості покриттів, тоді як використання інших модифікаторів призводить до їх певного погіршення. У процесі трибологічних випробувань зафіксовано зниження коефіцієнта тертя до рівня близько 0,2 при введенні кременистих компонентів і трепелу. Практична цінність одержаних результатів полягає у можливості їх використання як альтернативи існуючим технологіям формування покриттів на шліцьових з'єднаннях приводних валів, що сприятиме покращенню їх робочих характеристик та підвищенню ресурсу.

Ключові слова: композиційні покриття, зносостійкість, корозійна стійкість, полімерні матеріали, епоксидна смола, карбамідоформальдегідна смола, модифікатори, фторопласт, трибологічні властивості, коефіцієнт тертя, адгезія.

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Increasing the wear resistance of cemented carbide tools in turning of stainless steel X20CR13 (EN 1.4021) using tin coatings

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Abstract. This paper presents the results of experimental studies on the influence of wear-resistant titanium nitride (TiN) coatings on the durability of ISO K10 and ISO K20 multi-faceted, non-regrindable cemented carbide inserts during turning of stainless steel X20Cr13 (EN 1.4021). Experiments were carried out on a