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INCREASING THE IMPACT STRENGTH OF PROTECTIVE COATINGS BY OPTIMIZING THE INGREDIENT CONTENT

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ПІДВИЩЕННЯ УДАРНОЇ В'ЯЗКОСТІ ЗАХИСНИХ ПОКРИТТІВ ШЛЯХОМ ОПТИМІЗАЦІЇ ВМІСТУ ІНГРЕДІЄНТІВ

Introduction. Due to their improved mechanical and chemical properties, epoxy coatings are widely used in various industries, including shipbuilding. One of the essential characteristics of epoxy coatings is their impact strength, which affects the material's resistance to mechanical loads and the ability to withstand impact loads without significant damage. Increasing impact strength by modifying the composition of coatings is a relevant task in materials science and coating production. Thus, it is possible to significantly expand the scope of application of new coatings based on epoxy binders. At the same time, the use of mathematical, experimental design methods allows for minimizing the number of studies (which is economically feasible when using nano additives) while maintaining high accuracy of results and effectively determining the optimal levels of components that provide the maximum effect in the form of increasing the properties under study [1-5].

To create polymer coatings intended for the protection of vehicle surfaces, the epoxy oligomer ED-20 (ISO 18280:2010) was selected as a binder, which was cured with an aliphatic hardener - polyethylene polyamine PEPA (TU 6-05-241-202-78). The following were used to increase the impact strength: nanodispersed fullerene-carbon black mixture, dispersion 30…40 nm; trimethoprim $C_{14}H_{18}N_4O_3$, dispersion 5…10 µm.

Impact strength (W) was determined by the Charpy method according to ASTM D6110–18. The deviation of the values in the impact strength studies of the developed polymer coatings was 2…5% of the nominal value.

Optimization of the content of heterogeneous fillers was carried out using the statistical data processing software package Statgraphics Centurion 19, with the definition of the Cochrane, Student, and Fisher criteria [6].

Based on the mathematical design of the experiment, taking into account the above criteria, a regression equation with coded values of factors for the impact strength of protective coatings was obtained:

$$y_1 = 40{,}67 - 1{,}65\, x_1 - 0{,}82\, x_2 - 0{,}35 x_1^2 - 3{,}45 x_2^2 + 0{,}37 x_1 x_2 \quad (1)$$

The conversion of variable parameters encoded into natural values was performed according to the method presented in [7]. As a result of mathematical transformations, the following model of impact strength increase was obtained, which takes into account the content of the ingredients of the protective coating:

$$W = 8{,}22222 + 0{,}543333 q_1 + 268{,}667 q_2 - 0{,}0253333 q_1^2 - 1{,}0 q_1 q_2 - 2613{,}33 q_2^2 \quad (2)$$

Based on the Pareto maps obtained during the analysis of data from the Statgraphics Centurion 19 application package, it can be stated that the most statistically significant effects are the factors q_{22} and q_{12}, i.e., the quadratic values of the content of the two additives.

A graphical interpretation of the results obtained in the form of main effects was also obtained (Fig. 1).

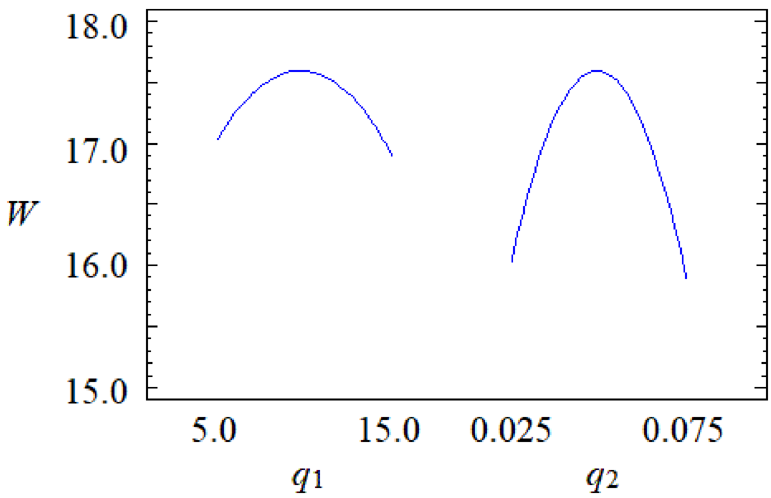

Fig. 1. Main effects of the influence of heterogeneous fillers $W = f(q_1, q_2)$

Based on the analysis of the presented graph (Fig. 1), to ensure the maximum impact strength, the optimal composition of the protective coating should contain 10.0 wt.% of trimethoprim and 0.050 wt.% of nanodispersed fullerene-carbon black mixture.

Conclusions. The content of additives of different physicochemical nature in the epoxy binder was optimized using the method of mathematical planning of the experiment using the Statgraphics software, and an increase in the value of the adhesive strength was ensured from $W = 7.0$ kJ/m^2 to $W = 17.2$ kJ/m^2.

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