SUMMARY

The main purpose of this doctoral dissertation was to evaluate the effect of an aqueous solution of sodium chloride (brine) on the operational properties of epoxy coatings.

Epoxy coatings were obtained from environmentally friendly powder paints, which were applied to a steel substrate by electrostatic spraying.

Samples of two-layer epoxy coatings consisting of a topcoat (blue) and the base layer (grey) were aged by immersing them in an aqueous solution of sodium chloride (brine) at a concentration of 25%, which corresponded to the actual concentration of brine used in winter road maintenance. The maximum ageing period of the coating samples was 70 days (1680 h).

To evaluate the operational properties of the tested epoxy coatings, the following criteria were adopted: thickness, surface topography and roughness, hardness (according to Buchholz and pencil), gloss, contact angle (with water and diiodomethane), surface free energy, water absorption (assessed on the basis of mass change), strength of the adhesive connection of the coating with the substrate (tested by the peel-off method and on the basis of a cross-cut test), resistance to scratching and impact. The ageing changes in the chemical structure of epoxy coatings (caused by the effect of brine) were assessed on the basis of the results of tests using: FTIR infrared spectroscopy and DSC differential scanning calorimetry and X-ray examinations.

FTIR tests showed a progressive development of the epoxy oxidation processes (documented by an increase in the content of CO and OH functional groups), contributing to an increase in the brittleness of the top layer of coatings. The increased brittleness of aged coatings favoured the evolution of their destruction. The obtained test results proved that the long-term effect of the brine resulted in the appearance and development of the symptoms of coating destruction in the form of: craters, cracks, silver cracks and in the form of pits resulting from the loss of coating fragments from the surface layer. These defects contributed to the escalation of the surface roughness of the coatings (assessed using the Ra, Rz, Rmax parameters) and to a significant change in the surface topography.

A reduction in the hardness (according to Buchholz) of the coatings was also found, which resulted in a reduction in their mechanical properties, including resistance to scratching and impact.

The contact of epoxy coatings with brine also contributed to an decrease in the contact angle of the coating surfaces with water, resulting in an increase in their water absorption.

The increase in water absorption was also favoured by the increase in porosity of the coatings, caused by cracking of chemical bonds in the epoxy material of the topcoat, documented in FTIR tests by increasing the content of CH_3 functional groups. The penetration of brine into the pores formed in the structure of the topcoat resulted in an increase in its thickness and mass.

A decrease in the temperature of the onset of thermal decomposition of the epoxy film-forming material was also observed, which proved a decrease in the heat resistance of aged coatings, which was demonstrated by tests with the use of differential scanning calorimetry.

The base coats containing zinc filler in their composition showed high tightness, because their ageing with brine did not reduce the strength of the adhesive connection between the coating and the steel substrate, assessed using the peel-off method and on the basis of the surface condition of the cut grid made on the coating with a circular knife.

It should be emphasised that the aged topcoats have retained their decorative qualities, because the influence of the brine only slightly decreased their gloss and colour, probably due to the content of nanoparticles of titanium dioxide in the surface layer.

The obtained results of testing the operational properties of epoxy coatings can be used to improve their recipe in order to increase the resistance of coatings to brine. The developed methodology for testing epoxy coatings exposed to brine has the features of a universal methodology and can be used in the assessment of operational properties of various types of polymer coatings under the influence of a selected aggressive medium.

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