STUDY OF ADHESION OF THE COATING SYSTEM TO VITREOUS ENAMEL COAT

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Abstract

The contribution deals with study of adhesion organic coating systems for the repair of a damaged vitreous enamel coat. Vitreous enamel is resulting product of the physiochemical reactions in the process of heat glass forming of the complicated chemical constitution with next components of the inorganic character and connecting nesting characteristics of the glass and ceramic with ability of the adhesion to metal. Damage of the vitreous enamel coat arises particularly during of transport the product and its handling and assembly of enamelled parts for agricultural, energy and water industry. For experimental works were used two types of coating systems on the basis epoxy concrete resin and polysiloxane. Experimental results show that the vitreous enamel coat can be repaired by the above-mentioned organic coating systems. According to the results of adhesion tests according to EN ISO 16276-1 (Pull-off Test) and EN ISO 16276-2 (Cross-cut Test), the adhesion of organic coatings on vitreous enamel coat is suitable in value in the range from 4.0 to 5.2 MPa (according to Pull-off Test) and degree classification in the range from 0 to 4 (according to Cross-cut Test and according to pre-treatment of surface vitreous enamel coat). Use of thus repaired vitreous enamel coat is limited by the properties of the organic coating in contact with aggressive corrosive environment, temperature, drinking water and food.

Keywords: Vitreous enamel coat, organic coating system, adhesion, surface treatment

1. INTRODUCTION

One of the coatings that is resistant to contact with acidic and alkaline environments, aggressive corrosive environment is a vitreous enamel coating. Besides vitreous enamel coating are known organic coating systems, also resistant to aggressive environments. Among these coatings there is a fundamental difference in terms of mechanical and physical properties as well as adhesion to the steel substrate. Vitreous enamel coat is the resultant product of physicochemical reactions in the process of heat treatment glass of complicated chemical composition with other ingredients of an inorganic character, combining the properties of glass and ceramics with the ability to adhesion to the metal. It is characterized by high resistance to compressive stress and low resistance to tensile strength and low break toughness (impact resistance). Vitreous enamel coat has to be applied to a steel substrate of a specified chemical composition suitable for enameling. Higher plasticity of paint systems makes it possible to apply them to steel substrates without chemical composition requirements and they are more resistant to impact. Enameled products and enameled segments used in agriculture, energy industry, wastewater treatment plants, etc. may be damaged during their use by impact, which is particularly characterized by cracking and consequent loss of adhesion of the coating to the metal. Therefore suitable technologies for repairing damaged surfaces are searched for (if it is not a large-dimensional damage). The paper deals with the possibility of repairing the damaged enamel coating by means of organic coating systems on the basis epoxy concrete resin and polysiloxane, which suit the corrosive environment and contact with drinking water and food.

2. EXPERIMENTAL RESULTS

For experimental works were used samples of the low carbon hot-rolled sheet steel suitable for enamelling about thickness 3 mm and dimension 100 x 75 mm. Enamel slurry containing frit, clay, water and other additives intended for application on samples of steel was applied in two layers: a base layer of gray shade and a cover layer of blue shade in a total thickness of 450 µm.

Two types of coating systems based on two-component epoxide and polysiloxane were used to study the adhesion to the damaged glass coating. The application of the organic coating was by hand-brush.

The organic coatings were applied on pre-treated vitreous enamel coat: without surface pre-treatment (high of profile 50 µm), degreased in an ecological degreaser (the resulting value of high of profile 60 µm), a finely ground surface (the resulting value of high of profile 40 µm) and impact-damaged surface (the resulting value of high of profile 73 µm). After curing the coatings, the following tests were carried out:

- Dry film thickness measurement acc. to EN ISO 2808
- Adhesion test - Pull-off test acc. to EN ISO 4624
- Adhesion test - Cross-cut test acc. to EN ISO 2409

Dry film thickness of organic coating systems: epoxy coating: 140 - 180 µm; polysiloxan coating: 130 – 150 µm.

Results of adhesion test - Pull-off test acc. to EN ISO 4624

Table 1 Pull-off test, epoxy coating

Surface pre-treatment	Sample Nr.	Pull-off test						
		Adhesive strength (MPa)	Characteristics of the fracture surface (%)					
			A	A/B	B	B/Y	Y/Z	
Degreasing	1	6.0	-	-	-	65	5	
	2	1.8	-	-	60	40	-	
	3	5.8	-	-	35	65	-	
Without surface pre-treatment	10	4.1	-	-	90	10	-	
	11	4.2	-	-	50	40	10	
	12	3.8	-	-	50	50	-	
Grinding	20	3.0	-	-	55	45	-	
	21	2.0	-	-	30	60	10	
	22	3.0	-	-	95	5	-	
Surface damage with hammer	29	5.8	2	-	70	28	-	
	30	4.4	-	5	60	35	-	
	31	4.0	25	-	35	40	-	

Table 2 Pull-off test, polysiloxane coating

Surface pre-treatment	Sample Nr.	Pull-off test						
		Adhesive strength (MPa)	Characteristics of the fracture surface (%)					
			A	A/B	B	B/Y	Y/Z	
Degreasing	1	4.8	40	-	40	20	-	
	2	5.0	10	-	25	40	25	
	3	4.1	10	-	70	20	-	
Without surface pre-treatment	10	6.0	7	-	23	70	-	
	11	5.3	15	-	40	35	10	
	12	6.2	20	-	30	45	5	
Grinding	20	5.8	5	-	30	65	-	
	21	3.8	5	10	60	25	-	
	22	4.0	40	-	45	15	-	
Surface damage with hammer	29	6.5	10	-	65	5	20	
	30	4.0	35	-	30	35	-	
	31	6.5	3	7	30	40	20	

Results of adhesion test - Cross-cut test acc. to EN ISO 2409

Table 3 Cross-cut test, epoxy coating

Surface pre-treatment	Sample Nr.	Cross-cut test
		Degree (-)
Degreasing	7	1
	8	1
	9	0
Without surface pre-treatment	16	0
	17	2
	18	1
Grinding	26	1
	27	1
	28	0
Surface damage with hammer	35	1
	36	1
	37	1

Table 4 Cross-cut test, polysiloxane coating

Surface pre-treatment	Sample Nr.	Cross-cut test
		Degree (-)
Degreasing	7	2
	8	3
	9	2
Without surface pre-treatment	16	3
	17	4
	18	3
Grinding	26	2
	27	2
	28	3
Surface damage with hammer	35	3
	36	2
	37	2

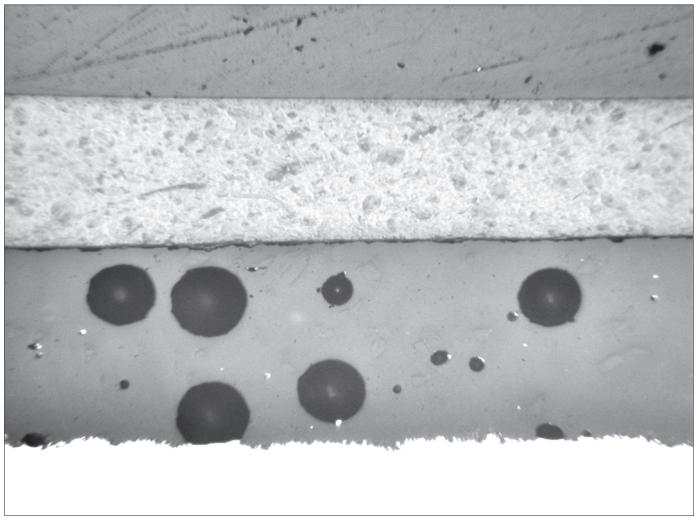

Figure 1 Cross section of sample with epoxy coating system, magnified 600 x

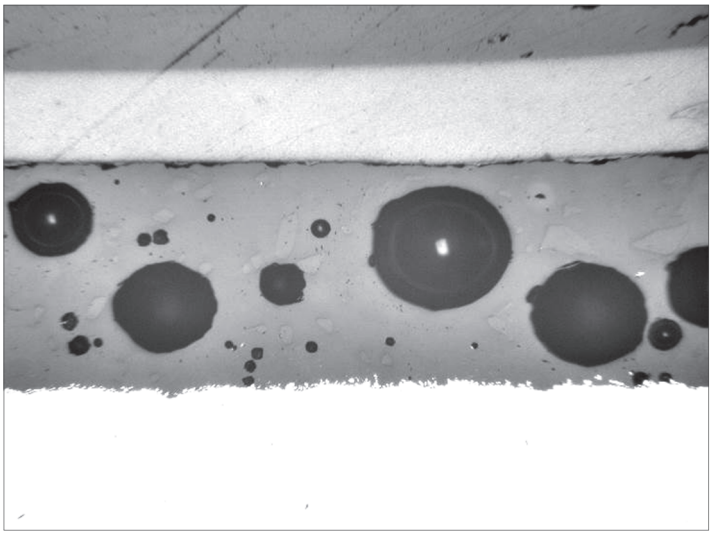

Figure 2 Cross section of sample with polysiloxane coating system, magnified 600 x

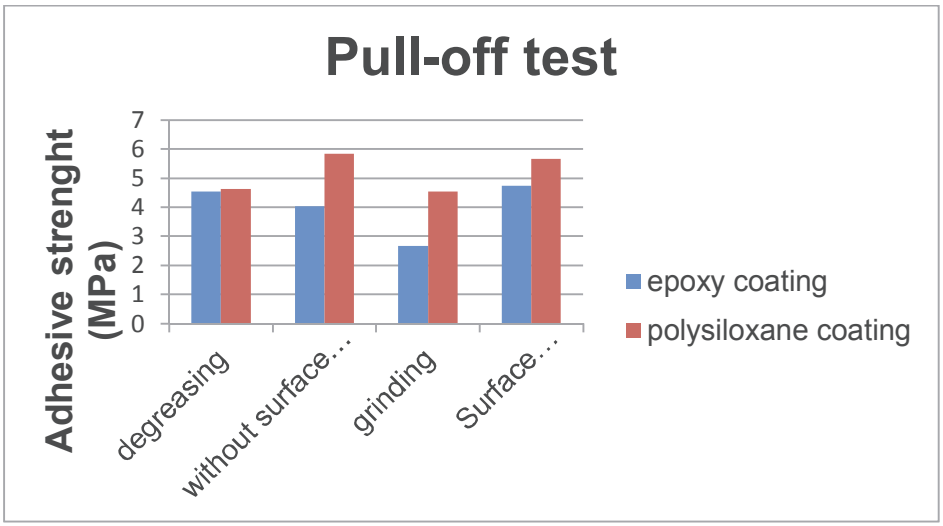

Figure 3 Results of adhesion test - Pull-off test

3. CONCLUSION

The results of the measurements show that both organic coating systems have a very good adhesion to a vitreous enamel coat in the range from 2.67 to 5.83 MPa on average, depending on the type of surface treatment of the vitreous enamel coating. Improved adhesion of the polysiloxane coating modifies the silicon content of the coating structure in reaction with the ligand of vitreous enamel coat, which also contains a silicon component. [1] The decisive result is that both types of used organic coatings have the best adhesion to the damaged surface of the vitreous enamel coat by impact, which is of great importance for the subsequent repair of the defects organic coatings. The characteristics of the fracture surface shows that the fracture mostly occurs in the organic coating. In many cases, a cohesive fracture in enamel has occurred, which confirms the excellent adhesion of used organic coatings to the enamel coating.

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