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QUALITY EVALUATION OF CORROSION LOADED SHEETS METAL USING THE MICROSTRUCTURAL ANALYSIS

Abstract: At present is the global trend dealing with environmental protection. This trend is mainly affected industries, which includes field of surface treatment. Study of surface treatment (surface pre-treatment and coatings) has great impact on the working and living environment. In this context it is necessary to solve the issue of hazardous organic volatile compounds, wastewater discharge, etc. The paper deals with quality evaluation of corrosion loaded sheets metal using the microstructural analysis. These steel plates were pre-treated in three different ways, when it was used a new method of surface preparation based on the nanotechnology and classic technology of ferric phosphate. The test specimens were subjected to the corrosion test chamber and after removal from the corrosive environment was performed microstructural analysis. Experimental samples were compared in terms of quality and corrosion resistance surface protection.

Key words: quality, corrosion, surface pretreatments, microstructure

12.1. Introduction

The corrosion of the metals and their alloys is the spontaneous irreversible destruction of metallic materials due to their chemical or electrochemical reaction with the surrounding aggressive environment that directs to loss of the functional opportunities of the products made from

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these materials (MICHNA, 2008). By the limiting of the corrosive effect on the metal materials and the metallic products deals the corrosion protection technology of materials. With the development of manufacturing technologies are increasing demands for machine functions and structures. Research, development and production of new ways to protect the surface of materials is accelerating and strives to produce more efficient means of active corrosion. One of these instruments is the use of nanotechnology in coatings. Since the second half of the 20th century nanotechnology recorded its rise. To the field of nanotechnology are including nanolayers and their purpose is to protect the material against to corrosion.

These nanolayers are being developed to improve existing resources to corrosion surface protection or reimbursement. Nanopassivating layers in the future may replace conventional phosphate for several reasons: technological, economic and environmental. Nanolayer ZircaSil® is a technological point of view (compared with ferric phosphate):

- applicable at lower temperatures
- less time-consuming application
- produce sewage sludge
- has universal application for pretreatment of steel, zinc and aluminum
- easier method of disposal, etc.

ZircaSil® is the zirconium nanopassivation which creates inorganic layer of the silanes base on the material surface. These very reactive silanes create chemical bond by the reaction with the base material and create highly cross linked inorganic layer on the material surface (thickness 50 – 100 nm).

The aim of this paper is the quality evaluation of the corrosion loaded sheets metal using the microstructural analysis.

12.2. Experiment Conditions

The experiment was solved with the following material and corrosion conditions.

Experimental Material

For the solving of the experiment was used base material Q-panel Fe. This material is used for laboratory purposes. This is a low carbon, unalloyed, slightly blasted steel material with chemical composition in the table 12.1.

Table 12.1. Chemical composition of the base material

Material	max. C %	max. Mn %	P %	S %
Q-panel Fe	0.12	0.60	0.045	0.045

The base material was chemically pretreated by alkaline degreasing (CC), iron phosphating (Feph) and nanopassivating product ZircaSil® (Zr). We prepared experimental material in the following groups:

Group A – CC + Zr

Group B – Feph + Zr

Group C – CC + Feph + Zr

After the chemical pretreatment was applied powder coating TIGER Drylac® Series 29 – color light gray.

Thus prepared samples was provided by cross cut, see figure 12.1. This is due to the evaluation of delamination and corrosion around the cut after corrosion test.

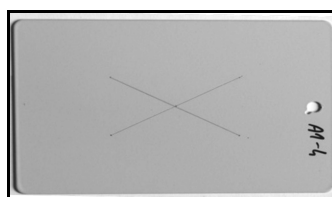


Fig. 12.1. Sample A1-4 before insert to the corrosion chamber.

Corrosion Load

Experimental samples were corrosion loaded in salt spray of corrosion diagnostic equipment LIEBISCH ®. Working conditions of corrosion chamber were set according to the standard CSN EN ISO 9227. The set parameters are shown in table 12.2.

The marking of the experimental samples is shown in the table 12.3. Within the microstructural analysis was performed evaluation of the behavior of the coating layer after corrosion load. For clarity were chosen 3 representatives each from one type of surface pretreatment.

Table 12.2. Chemical composition of the base material

Parameters of the test	Neutral salt spray
Temperature	35°C ± 2°C
The average rate of the accumulation of spray mist from a horizontal collector area 80cm ²	1,5 ml/h ± 0,5 ml/h
The concentration of sodium chloride (accumulated in the solution)	50 g/l ± 5 g/l
pH (accumulated in the solution)	6,5 to 7,2
Corrosion load time	480, 720, 1000 hours

Table 12.3. The marking of the experimental samples

Corrosion load time		
480 hours	720 hours	1000 hours
A1-1	A2-1	A3-1
B1-3	B2-3	B3-3
C1-1	C2-1	C3-1

12.3. Microstructural Analysis

Microstructural analysis was performed on the confocal laser microscope Olympus LEXT 3100. In this article is shown microstructural analysis for the

samples after 480 hours and 1000 hours corrosion load. In these times we can see the biggest differences between all chemical pretreatments.

From each sample were prepared metallographic specimens. The specimens were taken from the place where did not occur to the secession of the painted layer after delamination (a) and from the place of the cut where occurred to the partial secession or total secession of the coating (b).

Microstructural analysis after 480 hours of corrosion load

From the tested samples after 480h loading in corrosive salt spray chamber has the best results the combination of the pretreatment CC + Feph + Zr. For the sample C1-1, as it is documented in the figure 12.6., is shown a uniform unbroken paint layer. The coating adjoins well to the base material. The same it is in the case for samples A1-1 (Fig. 12.2.) and B1-3 (Fig. 12.4.) at the point of sampling without delamination (a). Significant differences can be observed in Figures samples from space (b). Significant differences we can observe in the figures 12.3., 12.5. and 12.7. For the sample A1-1 is evident almost detached coated layer and uneven corrosion and surface of the base material. For a sample B1-3 was completely coated layer secession. The sample surface is at the cutting apparent uneven corrosion depth of up to 160 μm . Surface surrounding the cut is attacked mainly by pitting corrosion. The best result, as already mentioned, has a sample C1-1. Painted layer is breached in the cutting zone. The figure 12.7. shows undercutting painted layer and although the beginning of the corrosion of the base material did not completely occur to the separation of the painted layer, such as for samples A1-1 and B1-3.

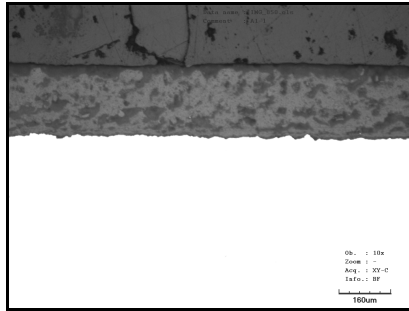


Fig. 12.2. Painted layer A1-1 (a).

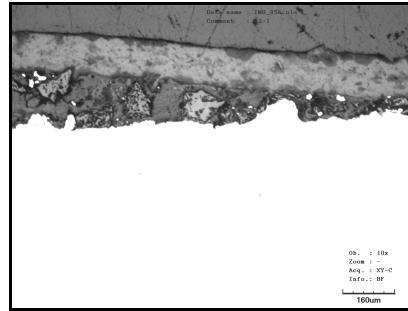


Fig. 12.3. Painted layer after delamination A1-1 (b).

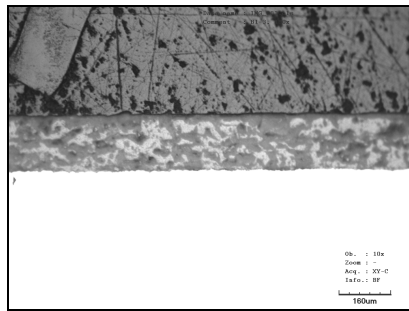


Fig. 12.4. Painted layer B1-3 (a).

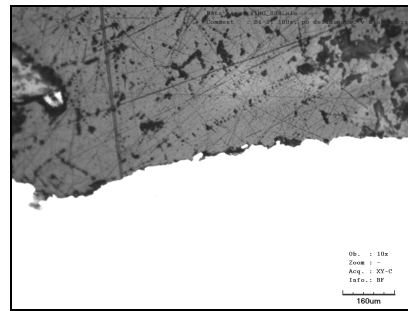


Fig. 12.5. Surface after delamination B1-3 (b).

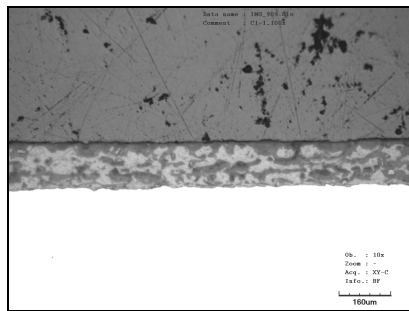


Fig. 12.6. Painted layer C1-1 (a).

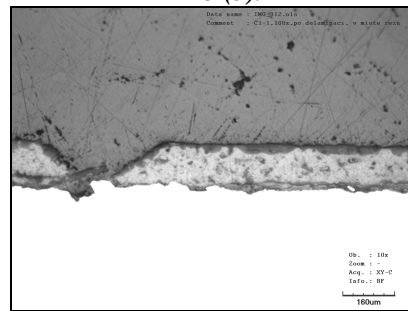


Fig. 12.7. Painted layer after delamination C1-1 (b).

Microstructural analysis after 480 hours of corrosion load

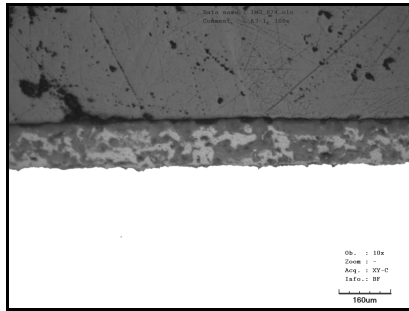


Fig. 12.8. Painted layer A3-1 (a).

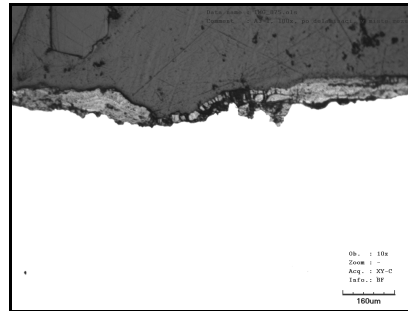


Fig. 12.9. The surface after delamination in the cut place A3-1 (b).

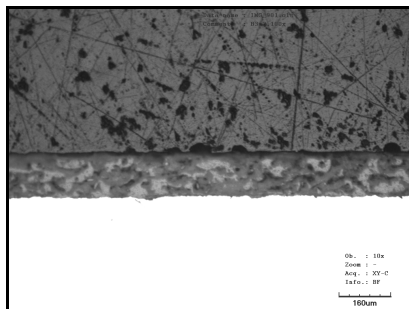


Fig. 12.10. Painted layer B3-3 (a).

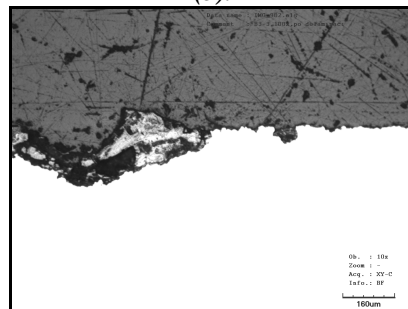


Fig. 12.11. The surface after delamination in the cut place B3-3 (b).

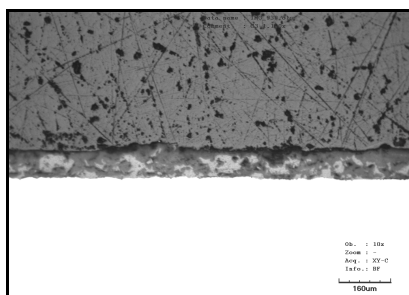


Fig. 12.12. Painted layer C3-1 (a).

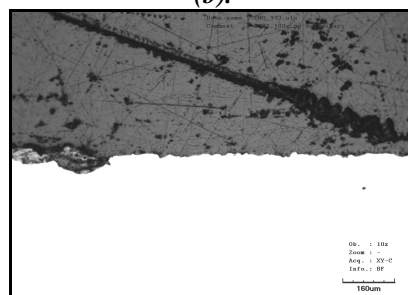


Fig. 12.13. The surface after delamination in the cut place C3-1 (b).

After corrosion load in the corrosion chamber by the salt mist after delamination it occurred to the total peel of the painted layer from the surface of the material by the all samples. The differences between particular combinations of the surface pretreatment type are in the extent of the corrosion and the amount of the corrosion products on the material surface. The surface is attacked by the pitting corrosion by the sample A3-1 (fig. 12.9.). There are evident corrosion products on the surface of the base material. The sample B3-3 is attacked by the pitting corrosion, as it is documented on the figure 12.11. The surface of the material is under corroded to the depth of 180 μm . After 1000 hours of the corrosion load is the best evaluated the sample in combination CC + Feph + Zr of the chemical pretreatment (fig. 12.13.). The corrosion product are evident only in the place of the cut. By the sample C3-1 occurred to the smallest corrosion attack on the base material surface. The samples taken from the place (a) show the excellent adhesion to the base material surface by the all samples (figures 12.8., 12.10., 12.12.).

12.4. Conclusion

In our research we deal with the testing of the new surface pretreatment based on nanotechnology. These nanolayers could replace the classical phosphating process in the firm production in the future, which are interested in the material surface pretreatment and their corrosion protection. Within the microstructural analysis was evaluated the influence of the surface pretreatment on the painted layer quality.

We can say that the best results have the triple combination of the chemical pretreatment thus alkaline degreasing + iron phosphating + nanopassivation. The second best chemical pretreatment after corrosion load is the combination of the alkaline degreasing + nanopassivation. The samples without alkaline degreasing had the worst results and we cannot to recommend this procedure as appropriate for the surface pretreatment of the painted products. What about the thickness of the painted layer we can see

from the figures that the thickness is considerably irregular. To better comparison of the results it would be suitable to achieve approximately the same thickness of the coating by all of the metal sheets. In this case we can recommend the better compliance of the technological process by the powder coating application.

We can conclude that the surface pretreatment based on the nanotechnology currently cannot replace the classical iron phosphating. The use of nanopassivation is particularly suitable as the seal up agent for phosphate. As it is known the surface of the material after the phosphate application is particularly porous and the new nanopassivation is suitable as the final surface pretreatment to the seal up of this pores. In combination with the iron phosphating the nanopassivation reaches good result as in the case of the painted layer adhesion to the base material so in the material resistance to the corrosion opposite to the next two tested surface pretreatment.

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Acknowledgments:

This paper was created with the support of the Internal student grant FVTM UJEP No. 48202 15 0004 01.