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THE STUDY OF STEEL PROTECTION EFFECT BY APPLICATION OF MOLTEN ACTIVE MICROALLOYED ALUMINUM AND BY COVERING THAT COMPOSITION BY ORGANIC COATING

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Abstract. *In this paper, the steel active-passive anticorrosive protection was done. Steel plates samples with dimensions 40×100×2 millimeters were used. Samples surfaces preparation was done by degreasing, then by sandblasting by pneumatic pistol. The metallising by molten metal was done by hand pistol, which worked with metal vein "Protector" (ø 3,18 millimeters) of electrochemical active anode material on the basis of microalloyed aluminum. The mentioned application was done twice and obtained layer thickness was 150-200 micrometers. After this operation, organic coating "Vinilpom", the product of Coatings Industry "Pomoravlje", was applied. Coating quality was followed by measuring of coating thickness, of dried film hardness, level of connecting with a base and of gloss. Whole composition steel - "Protector" - organic coating electrochemical study was done by measuring of galvanic team electrochemical potential change in 20% NaCl solution, during the time.*

Key words: *active-passive protection, active microalloyed aluminum, steel samples, organic coating*

INTRODUCTION

The electrochemical corrosion occurs on the iron and steel surfaces, when the products of previous corrosion process are eliminated from the metal surface and when it is exposed to water or to electrolytes watery solutions. This process is followed by one anode and by one or multi cathode processes.

Since no one technically important metal is pure; it contains other metals ingredients more electropositive and more electronegative; so the huge number of microcathodes and microanodes are located in every one metal. So large number of microgalvanic teams with local cathodes and anodes exist in iron and steel [4,5].

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Modern treatments of multilayers galvanic coatings application don't provide complete surface covering, instead of that, 0.1 % of uncovered surface exists always.

The galvanic protected iron can corrode on uncovered places; during this process, a pore presents local anode in coating and the anode process going on place, and the galvanic coating itself, presents local cathode and cathode process going on place, during the iron corrosion action. Because of that, full of holes corrosion, so called "pitting" corrosion is occurred.

It is maximally allowed that the total surface of all pores can be $7cm^2/m^2$ of surface applied by enamels or other organic coatings in passive anticorrosive protection of metals. Keeping in mind, that the pores are of very small dimensions, here is the word about huge number of pores, of order of magnitude of 10^{10}-10^{15} pores/cm^2 of surface, that is, about very big number of possible places of anode and cathode processes going on.

Therefore passive protection has limited possibility and represents incomplete protection only from atmospheric corrosion.

Scientist Davy stated basis of metals electrochemical protection during the electrolytes actions, in 1824. The electrochemical protection can be cathodic and anodic in dependence on polarization type [4,5].

Zinc and magnesium were used for metal constructions protections until the last decade of 20^{th} century. However, these protecting materials don't give good results: zinc-protective has small electrode potential, magnesium-protective has large corrosion itself. That's why; they can be used for active-passive protection [4].

Complete electrochemical protection by covering layer of metal, can be realized by application of new anode material-active microalloyed aluminum, so called "Protector" [3,4].

For the difference of other anode materials for protective action, "Protector" has important advantages. They are his good electrochemical characteristics:

- very negative electrode stationary potential;
- large output densities of protective current;
- very large ampere hour capacity;
- small velocity of corrosion itself;
- large level of protective material exploiting.

Other "Protector" advantages are his technological characteristics, because it can be obtained in different shapes: as vein, bar, thin strip or foil [3,4].

EXPERIMENTAL

The metallising process was consisted of covering metal by other metal layer by special device so called "pistol". The working principle was samples surfaces "bombarding" by thousands of fine drops of melted metal, which rushed out of pistol at speed of 100-400 m/seconds, in the shape of dispersed stream. The drops dimensions were from ten to few hundreds of micrometers [3].

Metallising process had common model of following elements:

- metal bringing to the melting place;
- metal warming up to melting point; melted metal was obtained by metal vein melting in the flame of high temperature, which appeared by burning of mixture of

ethine, propane or illuminating gas with oxygen;
- melted metal dispersion, by compressed – air under the pressure of 0.4–0.6 MPa;
- definite speed giving to metal particles by air-stream;
- stroke of particles at surface of sample, their deformity and adhesion;
- making cold of sticked particles and the whole sample surface.

Painting materials of vinyl system of protection are produced on the basis of vinyl chloride copolymers with addition of high-quality pigments, stable extenders, of inert plasticizers and modified alkyd resins. Polyvinyl chloride is exposed to copolymerization with different monomers, because of obtaining of painting materials characteristics. Products known as vinyl resins are obtained by mentioned way:
- vinyl-chloride - vinyl acetate;
- vinyl chloride – vinyl acetate – organic acid;
- vinyl chloride – vinylbutyl ether etc [1,2].

The vinyl chloride – vinylbutyl ether resin is the most important and mostly used in industries of paints and lacquers. Cited painting materials have following characteristics:
- high elasticity and toughness;
- excellent adhesion and for worse prepared surfaces;
- stability up to 80˚C;
- high resistance to acids, bases, salts and oils;
- good stability in industrial atmosphere;
- small permeability for water, gases and electrolytes;
- ease of application [1,2].

"Vinilpom" is monocomponent painting material produced on basis of vinyl chloride copolymers in combination with modified alkyd resins and stable pigments. It dries up on air, for short time. It is resisting to water and sea water, dilute solutions of acids, bases and salts, industrial atmosphere and on temperature changes from –20˚C up to +80˚C [1,2].

According to cited advantages, it has large application in protection of: steel and iron constructions, long-distance power lines, energetic plants, gas lines, oil pipelines, railroad cars, application in bridge building, in metalworking industry, chemical and pharmaceutical industries etc [1,2].

In this experiment, steel plates-samples with dimensions 40x100x2 millimeters were used. And the steel active-passive anticorrosive protection was done. It was consisted of following operations:
- samples surfaces preparation;
- metallising process;
- application of painting material;
- study of anticorrosive characteristics of obtained coatings on samples surfaces.

The first operation was done by samples surfaces degreasing by three-chloroethene, then by sandblasting by pneumatic pistol, which worked with corundum. Corundum dimension was about 1.5 millimeters. During this operation, work regime was:
- the distance between spray gun for sandblasting and samples surfaces was 80-100 mm;
- angle of corundum current to surfaces was about 50;

- compressed-air pressure in dependence on parts thicknesses was 0.1-0.2 MPa;
- apparatus production was in dependence on surfaces states and it was 5-10 m^2/h.

After sandblasting process, the profile was jagged with average height of rough spots about 50-60 micrometers.

Control of prepared surfaces quality was done by visual view, after cited operation. Corrosion traces and other impurities were not seen.

Prepared samples metallising was done by hand pistol, which worked with metal vein "Protector" Ø 3.18 mm of electrochemical active anode material produced on the basis of microalloyed aluminum. The mentioned application was done twice, obtained layer thickness was 150-200 micrometers; and its appearance was like scales.

After that, painting material "Vinilpom" the product of Industry of Painting Materials and Lacquers "Pomoravlje" was applied. It was applied by spray gun. Coating quality was followed by measuring of coating thickness, of dried film hardness, of adhesion and of gloss.

Final experimental operation was electrochemical study of whole composition steel-"Protector"-organic coating, by measuring of galvanic team electrochemical potential change in 20% NaCl solution, during the time. Potential was measured in regard to Ag/AgCl comparative electrode, whose potential was know (E=0.197 V), by voltameter.

RESULTS AND DISCUSSION

Study of characteristics of obtained organic coatings on samples surfaces gave results:

1. measured organic coatings thicknesses are shown in (Table 1.):

Table 1. Measured coatings thicknesses

Coatings thicknesses measured by apparatus "Inspector" for "Vinilpom"	
Number of sample	Average coating thickness (μm)
1	273
2	228
3	230
4	245
5	228

2. dried film hardness was 34 seconds for the dried film thickness of 30 micrometers, for all reated samples;
3. adhesion was 0 for all samples;
4. gloss was 13% for studied samples.

Measuring of potentials changes gave following values:

Table 2. Potentials changes during the time for treated samples

Time (min.)	Composition stationary potential (V)	Time (min.)	Composition stationary potential (V)
0	–0.980	19	–1.311
1	–1.220	20	–1.303
2	–1.267	21	–1.303
3	–1,289	22	–1.300
4	–1.298	23	–1.302
5	–1.307	24	–1.302
6	–1.315	25	–1.300
7	–1.313	26	–1.302
8	–1.312	27	–1.302
9	–1.317	28	–1.302
10	–1.309	29	–1.301
11	–1.303	30	–1.303
12	–1.301	31	–1.306
13	–1.305	32	–1.305
14	–1.301	33	–1.304
15	–1.309	34	–1.306
16	–1.305	35	–1.308
17	–1.307	36	–1.308
18	–1.308		

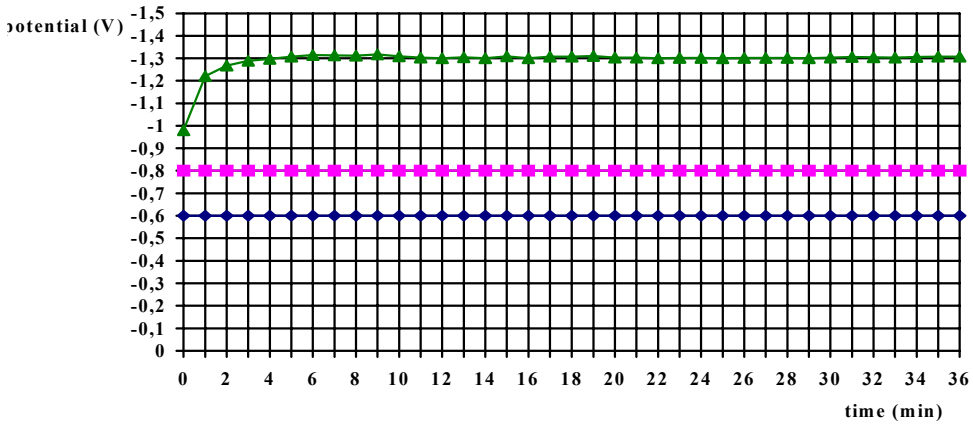

Fig. 1. Potentials changes during the time for the metallized and protected steel:
legend:
▲-▲-▲ line-mixed potential of galvanic team steel-"Protector" with "Vinilpom";
■-■-■ line- (–0.8V) protective potential of steel;
●-●-● line- (–0.6V) corrosive potential of steel;
-------- line- (–1.5V) stationary potential of "Protector".

The whole course of curved line (Fig. 1.) can be conditionally divided into two parts: a part of potential inclined change and a part of relatively stable potential, that is, potential plateau.

The plateau is result of established stationary state, when the fluxion of ions is normally established through pores in metallized and covering layers. It means the coming of reactants to the reaction place and the leaving of products from the same place.

Team potential change during the time (Table 2.) is result of porousness in metallized and covering layers.

Total team potential with the presence of "Vinilpom" is considerably more negative than the steel protective potential. The composition potential is somewhat lower (for 100-200 mV) than the "Protector" stationary potential. This is the proof that pores exist in metallized layer, that is, microgalvanic team "steel-pore" works on mentioned layer. In this team some of cathodic processes pass on steel, and of aluminum anode-dissolving process passes on aluminum, in pore. The pore expands by velocity of aluminum dissolving. The existing of metallized steel potential shows the appearance of pores in covering coat of paint layer. But, here is the word of passive protection, so the galvanic team aluminum-pore doesn' t work in covering layer.

If the pore in paint covering layer is in accordance with the pore in metallized layer, total corrosion can be occurred.

Potential inclined increase in negative part shows pores moistening by water and gradual penetration of active chloride ions. During 2-3 minutes, the whole process of pores filling in, by electrolytes, is done and the microgalvanic team starts its work.

In every case, steel is completely protected toward corrosion, because the team potential is considerably more negative (for 700-800 mV) than the steel protective potential, which is –0.8 V Ag/AgCl. Organic coating "Vinilpom" passive coating protects metallized layer of "Protector" of excessive exploitation, and of subdamaging under the covering paint layer.

CONCLUSION

- Disregarding conditions and application type of metal coatings, porousness is always present.
- Disregarding the application type of vinyl and other painting materials, the porousness can' t be avoided in that layer.
- Active-passive protection is very good method of protection toward corrosion, but on condition that minimally sufficient potential of metallized layer is provided (about 200-300 mV more negative than the steel protecting potential).
- The application of "Vinilpom" by spray gun is excellent and the adhesion to metallized layer is good.
- Passive protection and better aesthetic appearance are realized by organic coating.
- For the swimming pools, it is suggested combination of active-passive and protecting protection, by metallising with "Protector", by application of organic coating "Vinilpom" and finally by using of massive active "Protector" anode.

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ISPITIVANJE EFEKTA ZAŠTITE ČELIKA PRIMENOM AKTIVNOG MIKROLEGIRANOG ALUMINIJUMA PREKRIVANJEM KOMPOZITA ORGANSKIM PREMAZOM

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U ovom radu je izvršena aktivno-pasivna antikoroziona zaštita čelika. Korišćeni su uzorci čelika-pločice dimenzija 40×100×2 milimetara. Preprema površina uzoraka je izvršena odmašćivanjem, a zatim peskarenjem pneumatskim pištoljem. Metaliziranje tečnim metalom je urađeno ručnim pištoljem, koji je radio sa metalnom žicom "Protector"(Ø 3.18 mm) elektrohemijski aktivnog anodnog materijala na bazi mikrolegiranog aluminijuma. Pomenuti postupak je izvršen dva puta a dobijena debljina sloja je 150-200 mikrometara. Posle ove operacije, naneto je organsko premazno sredstvo "Vinilpom", proizvod Industrije boja i lakova "Pomoravlje". Kvalitet premaza je praćen merenjem debljine prevlake, tvrdoće suvog filma premaza, adhezije i sjaja. Elektrohemijsko ispitivanje celog kompozita čelik-"Protector"-organski premaz je urađeno merenjem promene elektrohemijskog potencijala galvanskog sprega u 20 % rastvoru NaCl sa vremenom.

Ključne reči: *aktivno-pasivna zaštita, aktivni mikrolegirani aluminujum, uzorci čelika, organski premaz*