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On Degradation of Cast Iron Surface- -Protective Paint Coat Joint

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Abstract

The paper is a presentation of a study on issues concerning degradation of protective paint coat having an adverse impact on aesthetic qualities of thin-walled cast-iron castings fabricated in furan resin sand. Microscopic examination and microanalyses of chemistry indicated that under the coat of paint covering the surface of a thin-walled casting, layers of oxides could be found presence of which can be most probably attributed to careless cleaning of the casting surface before the paint application process, as well as corrosion pits evidencing existence of damp residues under the paint layers contributing to creation of corrosion micro-cells

Keywords: Thin-wall casting, Flake-graphite grey cast iron, Corrosion, Paint coat

1. Introduction

Corrosion processes, occurring in most cases on surfaces of metals and alloys, result in occurrence of characteristic reaction products in the form of oxides, rust, scale, and corrosion pits [1]. One of the main types of corrosion processes is the electrochemical (galvanic) corrosion. The phenomenon consist in electrochemical reactions between metallic substrate and electrolyte, as a result of which local corrosion micro-cells occur [2–5].

Protective measures used to inhibit corrosion processes include application of paint or varnish coats on properly prepared surfaces of castings [5, 6]. The coats separate the cast part surfaces from exposure to moisture and oxygen.

Protection of casting surfaces against corrosion is a matter of great economic significance. However, in many applications, aesthetic qualities are also essential. This is particularly important in case of fittings made of cast iron surfaces of which, after suitable preparation, are coated with several layers of paint. However, careless preparation of substrate [7], wrong selection of painting materials, or incorrectly conducted painting process can

be the cause of developing corrosion centres deteriorating aesthetic qualities of thin-walled cast-iron castings.

In view of the above, a study was undertaken to establish possible causes of degradation of the cast iron surface- protective paint coat joint.

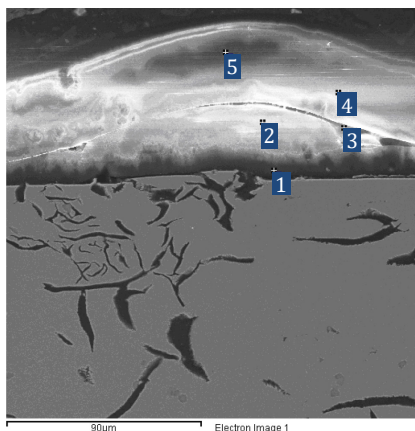
2. The test material

The material used for the study was a thin-walled casting made of cast iron with flake graphite and ferritic-pearlitic matrix, containing 3.08% C, 3.36% Si, 0.65% Mn, 0.45% P, 0.12% S, 0.07% Cr, 0.02% Mo, 0.03% Ni, 0.08% Cu, and Fe to balance, with a coat of paint applied on its surface and traces of corrosion visible under the coat.

The study was carried out on metallographic sections cut-out in the plane perpendicular to surface of the casting covered with a coat of paint. Sections were examined with the use of VEGA XMH scanning electron microscope (TESCAN), equipped with INCA x-act adapter for chemistry microanalysis (Oxford Instruments).

3. Research results

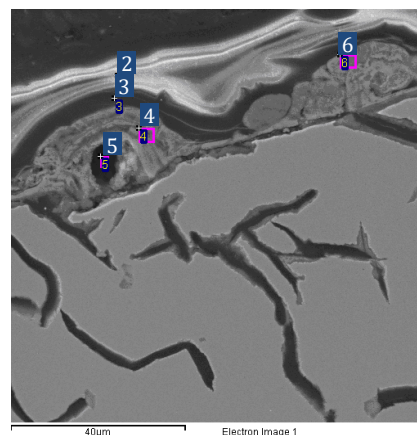
Metallographic analysis of specimens cut out in the plane perpendicular to the painted surface allowed to conclude that two paint coats were applied in the production process. The coat differed from each other in chemical composition, and in particular in chlorine content. Example results of metallographic examination of the paint coat are presented in Fig. 1. The first coat was rich in chlorine (above 17% Cl), while the second revealed low chlorine content (0.44–1.89% Cl, Fig. 1).



Spectrum No.	Element content, % wt.		
	C	O	Cl
1	71.14	10.95	17.92
2	66.87	16.13	17.00
3	75.79	19.61	4.59
4	84.36	15.20	0.44
5	89.22	8.89	1.89

Fig. 1. An example specimen microstructure in transverse section with two layers of paint. Note a discontinuous chlorine-rich paint layer (point 2) and continuous layer of paint with low chlorine content (points 4 and 5)

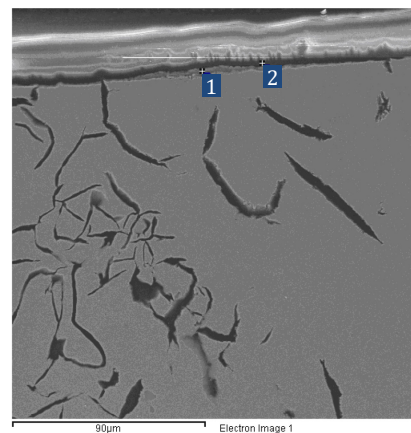
Results of microscopic examination indicate presence of corrosion traces passed over in the surface cleaning process in the form of convex oxide particles adhering to the casting surface (Fig. 2). This is evidenced by presence of a thin paint layer over the areas where oxide particles are found. Observed were also oxide layers adhering to casting surface and covered with a paint coat of normal thickness (Figs. 3, 4). Moreover, discontinuities of the paint coat could be visible with layers of oxides adhering locally to the substrate (Figs. 5, 6) and corrosion pits emerging on the casting surface, filled with oxides and covered with a layer of paint (Figs. 7, 8). This suggests that the paint could be applied onto a surface of casting some areas which were dampened. In presence of moisture, already under the paint layer, the corrosion process could develop penetrating then the casting material. It turned out that easy corrosion paths run through separation surfaces between flake graphite precipitates and the matrix. The corrosion process was intensified by presence of chlorine which most likely came from the paint used to coat the product.



Spectrum No.	Element content, % wt.				
	C	O	Si	Cl	Fe
2	77.24	22.33	0.00	0.43	0.00
3	68.23	15.74	0.25	7.52	8.25
4	6.78	37.31	1.92	0.00	53.31
5	0.00	0.00	0.00	1.52	98.48
6	12.71	34.70	0.00	2.01	50.58

Fig. 2. An example specimen microstructure in transverse section.

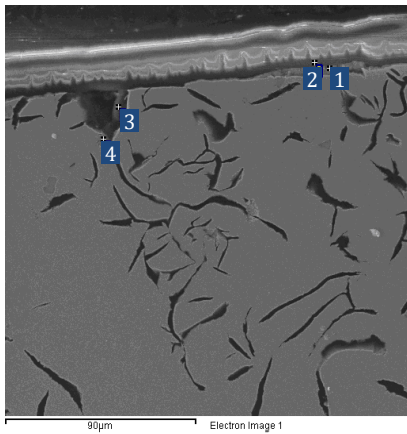
Note oxide particles with convex shapes adhering locally to casting surface and covered with thinned coat poor in chlorine



Spectrum No.	Element content, % wt.					
	C	O	Si	P	Cl	Fe
1	15.51	35.71	1.69	1.28	1.16	44.65
2	67.68	16.22	0.00	0.00	12.12	3.97

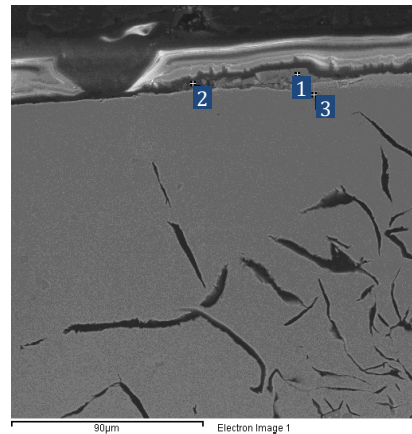
Fig. 3. An example specimen microstructure in transverse section.

Note a layer of oxides adhered locally to the casting surface and covered with a layer of paint with similar thickness



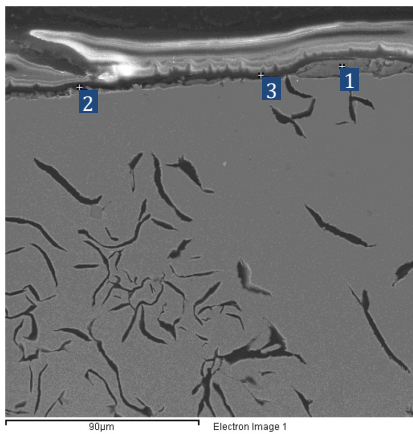
Spectrum No.	Element content, % wt.				
	C	O	Si	Cl	Fe
1	19.51	28.50	1.23	2.44	48.33
2	70.12	15.30	0.00	11.33	3.26
3	99.09	0.00	0.00	0.00	0.91
4	53.60	0.00	1.54	0.00	44.86

Fig. 4. An example specimen microstructure in transverse section. Note a layer of oxides adhered locally to the casting surface and covered with a layer of paint with similar thickness



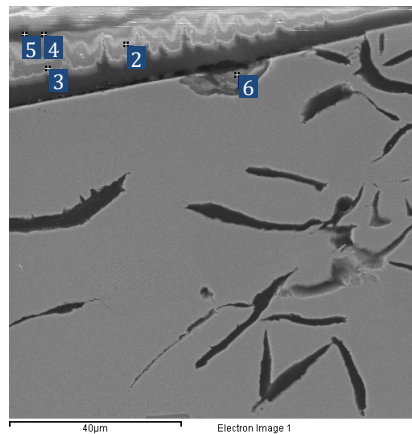
Spectrum No.	Element content, % wt.							
	C	O	Si	S	Cl	Ti	Mn	Fe
1	9.08	35.08	1.10	0.00	0.68	0.00	0.00	54.06
2	64.12	16.91	0.00	0.00	12.65	0.00	0.00	6.32
3	11.79	0.00	0.00	30.80	0.00	2.74	52.45	2.22

Fig. 6. An example specimen microstructure in transverse section. Note a layer of oxides adhered locally to the casting surface covered with a layer of paint with diversified thickness and flat face. Note also discontinuities of the paint coat



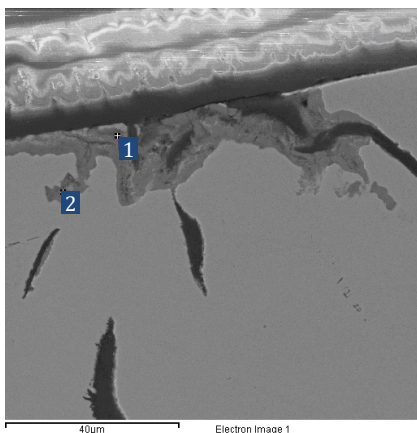
Spectrum No.	Element content, % wt.				
	C	O	Si	Cl	Fe
1	7.15	36.73	2.19	1.34	52.58
2	39.61	33.61	1.34	2.74	22.71
3	68.21	16.45	0.00	11.31	4.03

Fig. 5. An example specimen microstructure in transverse section. Note a layer of oxides adhered locally to the casting surface covered with a layer of paint and discontinuities of the paint coat



Spectrum No.	Element content, % wt.							
	C	O	Si	P	Cl	Ca	Fe	
2	75.50	23.90	0.00	0.00	0.60	0.00	0.00	
3	76.77	20.05	0.00	0.00	3.19	0.00	0.00	
4	80.11	19.42	0.00	0.00	0.47	0.00	0.00	
5	81.04	18.35	0.00	0.00	0.61	0.00	0.00	
6	12.10	44.71	6.88	0.50	0.82	1.21	33.78	

Fig. 7. An example specimen microstructure in transverse section. Note a corrosion pit on casting surface filled with oxides (point 6), covered with a layer of paint in which the first coat is characterised with low chlorine content (points 2 through 5)



Spectrum No.	Element content, % wt.						
	C	O	Na	Si	P	Cl	Fe
1	7.95	40.50	0.66	6.65	0.56	1.00	42.67
2	5.46	37.79	1.16	5.06	0.00	0.89	49.64

Fig. 8. An example specimen microstructure in transverse section.

Note a corrosion pit on casting surface filled with oxides at presence of chlorine (points 1 and 2), covered with paint coat

4. Analysis of results

The obtained results show that the painting process comprised application of two coats of paint differing in their chemical composition, and in particular in chlorine content. The paint with high chlorine content was used locally to apply the first discontinuous coat.

Location of oxides found on the substrate surface onto which the paint coat was applied suggest two main causes of their presence. The first is the failure to remove oxides from metal surface. This is evidenced by presence of oxides adhering to the casting surface and the paint coat covering them being thinner than in the areas free from oxides. The second cause consists in the casting surface retaining locally some moisture which, in presence of chlorine coming most likely from the paint, became an electrolyte contributing to creation of micro-cells. In such cases, corrosion penetrated deep into the casting wall.

Graphite precipitates turn out to be easy corrosion paths. The process takes place after application of the paint coat which is evidenced by similar coat thickness on both corrosion centres and corrosion-free areas.

5. Conclusions

- To ensure that surfaces of painted cast-iron castings will maintain high aesthetic qualities, it is necessary that the substrate will be thoroughly cleansed of any traces of corrosion and made free of micro-residual damp.
- The used paint should not contain chlorine, as presence of the element in areas with micro-residual damp results in occurrence of corrosion micro-cells, creating conditions for penetration of corrosion deep into the casting material.
- The paint coat should have no discontinuities exposing surface of the casting, because in conditions of free access of damp, in particular in atmospheres typical for maritime regions, local corrosion centres can be created.

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