RESEARCH ON THE CORROSION RESISTANCE, IN SALINE SOLUTION, OF STEEL SHEETS FOR INDUSTRIAL CONSTRUCTION, BY GRAVIMETRIC METHOD

Beatrice TUDOR
"Dunarea de Jos" University of Galati, Romania
e-mail: btudor@ugal.ro

ABSTRACT

In this paper, it was presented a study on corrosion in saline medium, by gravimetric method, of the steel sheets for industrial construction. The corrosion rate was estimated by gravimetric method and evaluate based on corrosion indices, such as gravimetric index, the penetration index.

KEYWORDS: corrosion index, pitting, gravimetric index

1. Introduction

Corrosion of metallic materials consists in partial or total destruction through chemical reactions, electrochemical or biochemical, after spontaneous interaction between surface and ambient corrosive environment.

Corrosion is generally defined as an attack on a material environment, attack leading to a worsening of properties to destroy material. Corrosion is not limited to the destruction of metallic materials, it affects equally plastics, ceramic, concrete and even medium with which they interact.

The metals, under natural conditions, are not thermodynamically stable.

Local corrosion can be:

• The punctuate corrosion, which locates on small surfaces (corrosion points);

• Sub-surface corrosion, which starts at the surface but extends preferably in the metal surface causing swelling and peeling metal (corrosion bags);

• Pitting that is distributed on relatively large, but their depth is small;

• Inter-crystalline corrosion, which is characterized by the selective destruction of the metal on the edge of the crystal;

• The transcristalin corrosion**,** which is a typical case of local corrosion in corrosive destruction is determined by the direction of mechanical tension stress.

Characteristic of this type of corrosion is that cracks do not propagate only at the crystal but they actually crosses them [1, 3].

The steels studied are intended to construction in the marine industry and are exposed to corrosion in saline environments.

Quantitative criteria

Rate of the corrosion process can be estimated by laboratory tests or measurements based on corrosion index, such as gravimetric index, the penetration index.

Gravimetric index

It represents the variation in mass of the test specimen as a result of corrosion per unit area and time; frequently expressed in g/m^2 day, but can use and the other units. Measuring the mass variation of test specimens to determine the gravimetric index, is the most common way, of quantitative characterization in the corrosion testing.

Gravimetric index is denoted by K, then the variation in the loss of the metal mass, obtained after removal of the reaction products on the metal surface:

$$K = \frac{m_{cor}}{S.t} \text{ [g/m}^2\text{/day]} \quad (1)$$

where:

S - surface area corroded (m^2);
t - time of corrosion (day);
m_{cor} - corrosion mass loss(g).

Penetration index

This index, characterizes the penetration corrosion, in metal mass.

In this form, who expressing the corrosion rate allows assessment of the duration of use of the equipment (pipes, columns, tanks, etc.) within a facility [2, 4].

The average depth of corrosion penetration is calculated from weight loss, the metal density and duration of exposure. The average depth of corrosive of the metal, in mm penetration per year is denoted by p (mm / year) and is calculated by the relationship:

$$I_p = \frac{K \cdot 24 \cdot 365}{1000 \cdot d} \qquad (2)$$

where:

K - is the gravimetric index, g/m^2day;

ρ - density, g/cm^3;

d is the density of the metal material, d = 7.85 [g/cm^3];

1000 represents the conversion factor.

Penetration, is most commonly expressed in mm/year, but can use the other units. Penetration index is determined by experiments, with limited time duration. It should therefore be avoided extrapolating laboratory data from longer interval of time [3].

2. Experimental research

Samples used were from steel sheet S355N and S355MC with chemical composition shown in Table 1 and 2. It was tested in 3.5% NaCl solution (Figure 1).

Table 1. *Chemical composition of S355N samples*

S355N	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Al [%]	Nb [%]	Ti [%]
P1	0.168	1.42	0.23	0.013	0.002	0.045	0.038	0.019

Table 2. *Chemical composition of S355MC samples*

S355 MC	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Al [%]	Nb [%]	Ti [%]
P2	0.098	1.18	0.34	0.011	0.005	0.031	0.019	0.015

Fig. 1. *Samples tested for corrosion in NaCl 3.5% saline solution*

To carry out the test, it was prepared, a solution of 3.5% sodium chloride. Weighing of the samples was performed at the 7, 14, 21 and at 30 days.

In order to determine the loss of mass after the attack, the samples were washed thoroughly at room temperature, first with distilled water, then with acetone and then dried. He attended weighing, Figure 2.

The variation of the corrosion rate of the steel samples is show in Fig. 3.

To evaluate the strength class of metallic materials, is used penetration index, which expresses the average decrease of the thickness of the metal material, under standard conditions [5, 6], per unit time [mm/year].

Fig. 2. *Weighing samples subjected to the corrosion test*

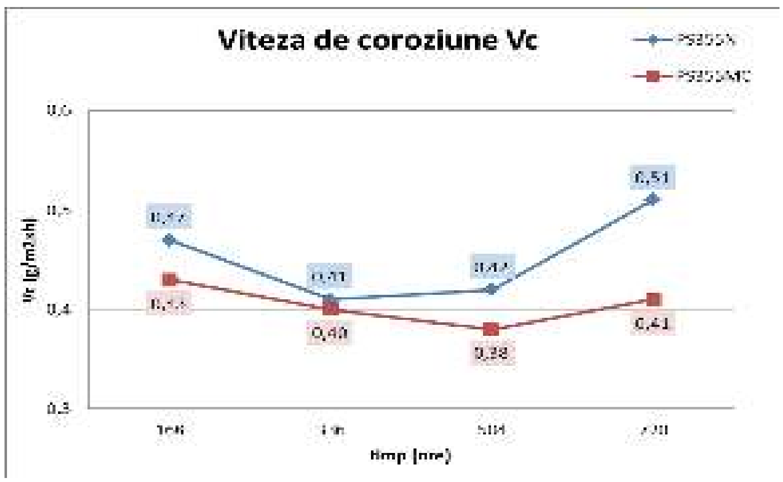


Fig. 3. *Variation of the corrosion rate of the steel samples*

Classes corrosion stability assessment used in the design are:

1. perfect stable: 1 * 10^{-3} mm year;
2. very stable 1 * 10^{-3} ÷1 * 10^{-2} mm/year;
3. stable 1 * 10^{-2} ÷1 * 10^{-1} mm/year.

Following the results obtained, the material falls into Class 3 Stability (stable).

The state of general corrosion assessment after penetration index values are given in Figure 4.

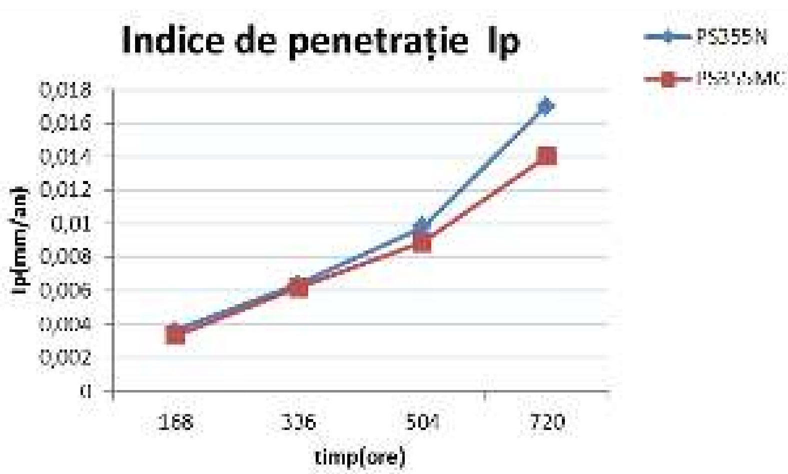
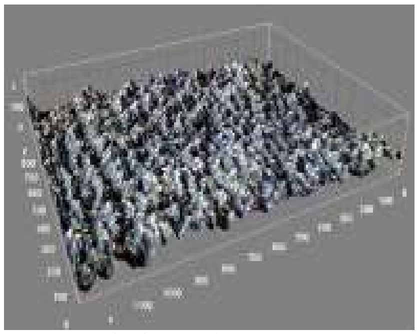


Fig. 4. *Penetration index variation*

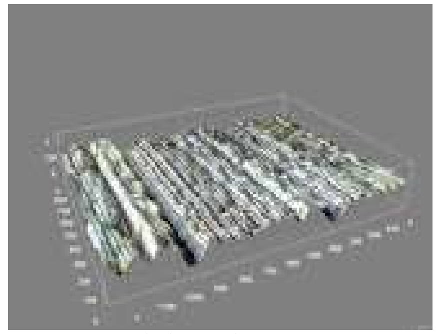
3D Imaging

Changes in the structure of steel after corrosion have been studied in the Faculty of Engineering, surface engineering laboratory microscope NEOPHOT2, using software ImageJ.

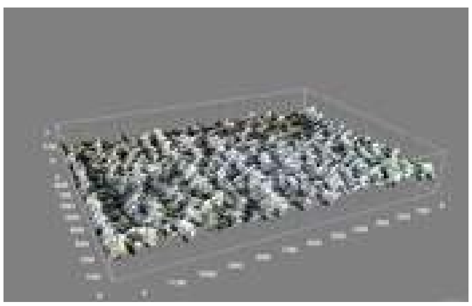
3D images of the profile surfaces subject to corrosion from the two steel grades are shown in Figure 5.



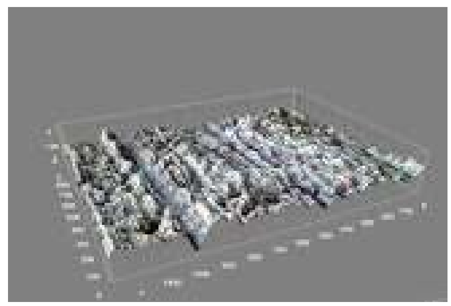
Blank sample P1 S355N



Corroded sample P1 S355MC



Blank sample P2 S355N



Corroded sample P2 S355MC

***Fig. 5.** 3D images of the samples surface profile before and after corrosion*

Darker areas of 3D images show the place where the corroded material is, and where it had lost mass at weighing.

3. Conclusion

Following research on corrosion resistance in saline solution, at the steel sheets for industrial construction, we reached the following conclusions:

After the corrosion rate, the two steel grades S355N and S355MC are stable, under 0.10 mm/year due to:

- chemical composition (steel micro-alloyed with Nb);
- fine granulation.

Because the granulation structure, of the steel mark S355MC, is much finer, and amount of perlite is smaller, this sample was less corroded.

The sample S355MC of the steel, has a greater corrosion resistance, which is due to lower carbon content and finer structure.

Acknowledgement

The author wishes to thank the student Viorica Sandu who helped me in this study.

References

[1]. Potecaşu F., Marin M., Potecaşu O., Istrate G., *The influence of heat treatment on corrosion resistance of some sintered iron alloys*, Source of the Document International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2015, 1, p. 221-226.

[2]. Potecasu F., Ciocan A., Radu T., *Sea water corrosion associated with weld for critical interface of the aluminium bronze clad steel castings*, Metalurgia International, 2009.

[3]. Alexa A., Radu T., Potecasu F., Ciocan A., *Influence of additional alloying elements on corrosion resistance of hot dip galvanised steels*, Materials Science Forum, 730-732, p. 811-816.

[4]. Danut Mihailescu, Olga Mitoseru, Viorica Musat, Emil Constantin, Aurelia Mihailescu, *Tehnologii subacvatice*, Editura Tehnica, Bucuresti, 2000.

[5]. Sanda Levcovici, *Studiul şi ingineria materialelor – note de curs*, Universitatea Dunărea de Jos, Galaţi, 2008.

[6]. Florentina Potecaşu, *Ştiinţa şi ingineria materialelor*, Editura Europlus, Galaţi, 2004.