

CORROSION ANALYSIS OF METALLIC COMPONENTS IN ETECSA TELECOMMUNICATIONS INFRASTRUCTURE: ROLE OF COASTAL ATMOSPHERE IN CIEGO DE AVILA, CUBA

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Abstract

The atmospheric corrosion of metals is a discontinuous electrochemical process that occurs when metal surfaces are exposed to moisture from weather phenomena such as rain, condensation, and fog. The presence of certain pollutants in the atmosphere significantly enhances the magnitude of atmospheric corrosion. In particular, studies conducted by various authors have demonstrated that metals exposed to coastal atmospheres experience accelerated corrosion compared to other types of atmospheres. NaCl, originating from the sea, has been identified as one of the most aggressive atmospheric pollutants that contributes to corrosion. The presence of circulating liquid media within structures, especially at medium temperatures and with different chemical compositions further exacerbates the corrosive effects. Island territories such as the Caribbean are particularly susceptible to this phenomenon due to climate change, which has led to increased sea penetrations, stronger winds, and more frequent rainfall. This research aims to investigate the corrosion behavior of metals in the Caribbean region, focusing on the effects of coastal atmospheres and the presence of NaCl as a corrosive agent. The study will involve experimental measurements of corrosion rates, as well as the characterization of corrosion products formed on metal surfaces. Various metals with different chemical compositions will be exposed to simulated coastal atmospheres in a controlled laboratory environment. Corrosion tests will be conducted under different temperature and humidity conditions to simulate realistic environmental factors. The results will be analyzed to determine the corrosion kinetics, identify the predominant corrosion mechanisms, and assess the influence of NaCl on the corrosion process. This research is expected to provide valuable insights into the corrosion behavior of metals in coastal environments, particularly in island

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territories like the Caribbean. The findings will contribute to the development of effective corrosion prevention strategies and the selection of suitable materials for infrastructure exposed to such aggressive atmospheric condition

1. INTRODUCTION

It is known that the atmospheric corrosion of metals is an electrochemistry discontinuous process, which occurs only when the metal surface is wet or damp with various weather phenomena such as rain, condensation, fog and other, although the magnitude of atmospheric corrosion would be relatively low, were it not for the presence of certain pollutants in the atmosphere [1]. Authors dedicated to the study of corrosion [2-8] demonstrated that different metals exposed to coastal atmosphere increases the speed of this process much more than if they were influenced by another type of atmosphere; NaCl was identified as an atmospheric pollutant of the most aggressive for corrosion to occur. This salt is incorporated from the sea being its profound effects near the shore, where air transports large amounts and produces a continuous water spray [9] It was, noted further, that the presence of circulating liquid media do through structures, mainly at medium temperatures and different chemical compositions, resulting also highly corrosive under these conditions [2].

This phenomenon is accentuated in island territories such as the Caribbean where, motivated by climate change, there is a trend towards greater aggressiveness in terms of sea penetrations, increased winds and the frequency of rainfall.



Figure (1): Effects of the coastal atmosphere on the corrosion of components in metal structures

In the particular case of Cuba, the climate is characterized by having more than half the year average temperatures above 25°C and average relative humidity of around 80% [9] which, together with the configuration and geographical location of the country, allows the influence of marine spray to reach almost the entire national territory. These conditions notably favor the deterioration of different materials, especially metallic ones [10]. Figure (1) shows the effects of coastal atmosphere corrosion on the components of the metal structures located in northern of Ciego Avila province.

In ETECSA conditions, no study has been carried out of the effect of the atmosphere, particularly the coastal one, on the corrosion of metal structures and their components located in areas that correspond to that context, which may constitute an aspect negative in the implementation of the maintenance system established by the organization.

This lack led to the realization of this work with the aim of to make a preliminary study of the effect of the coastal atmosphere corrosion of components in the metal structures of ETECSA in Ciego de Ávila.

2. MATERIAL AND METHODS.

This work was carried out in ETECSA Ciego de Ávila division, taking as samples certain components of the structures of the AT-60 model, the most widespread in the province, and of the Najasa model, for having this model a large structure that also assumes the important function of supporting main nodes; both structures located

in coastal atmosphere at north of Ciego de Avila province. To observe the damage caused by corrosion, the samples were subjected to a metallographic analysis (micro level) in a NOVEL eye microscope (Figure 2) from which the corresponding images were obtained.



Figure (2): NOVEL brand metallographic microscope or electronic tweeter

For analysis to macro level two plates equalizers of the same type only corresponding to the AT-60 model were taken, one of them unaffected and the other subjected to corrosion in coastal atmosphere for one year. The element for this study was selected due to the importance of its function, since it is responsible for attaching the anchors to the tensions of the different levels of winds or braces to maintain the verticality of the structure. In the plates were determined the mass loss (g) and the thickness loss (mm) of the metal, plus the hole diameter (mm) existing. The obtained values were expressed in percent.

The thickness of the plates and the diameter of the perforations was measured with caliper and mass with a digital scale model L4501 BEL with a maximum weighing 4 500 g.

The calculations made for the determination of the losses in thickness and mass of the plates were as follow:

$$\text{Loss of metal thickness (\%)} = (E_1 - E_2 / E_1) / 100 \quad (1.1)$$

E_1 : Initial thickness E_2 : Thickness of the corroded part (one year later).

$$\text{Loss of metal mass (\%)} = (m_1 - m_2 / m_1) / 100 \quad (1.2) \quad m_1: \text{Initial mass } m_2:$$

Mass of corroded plate (one year later)

3. ANALYSES OF DATA

3.1 Analysis at the micro level

The microstructure of the galvanized coatings was observed in both models, with the objective of examining the morphology of the phases and inters metallic layers formed during the galvanizing.

In Figure (3) it is shown the image corresponding to elements of a circular profile in the AT-60 structure, which reveals the loss in the metal of the paint layer and the appearance of pitting corrosion. Although the objective of this work was focused on the study of the phenomenon in a coastal atmosphere, it was considered important to present the comparison with another type to highlight the impact caused in the sample submitted to the marine environment. Denote of observation that the mark on the sample taken in coastal atmosphere

Pitting

was greater in size and depth to taken in urban atmosphere.



(a) Urban (b) Coastal

Figure (3): Cross section of circular profile elements in structures AT-60 model

In the sample of Najasa model (Figure 4) the loss of the galvanized layer, the lack of protection of the metal with the consequent metallic luster and the onset of the formation of urine (oxide layer) detected by the reddish black color were observed. This phenomena shown on the iron surface is due to humidity or air.

Importantly that in both models was detected coexistence in loss of a portion of the plating layer with the start of pitting corrosion.

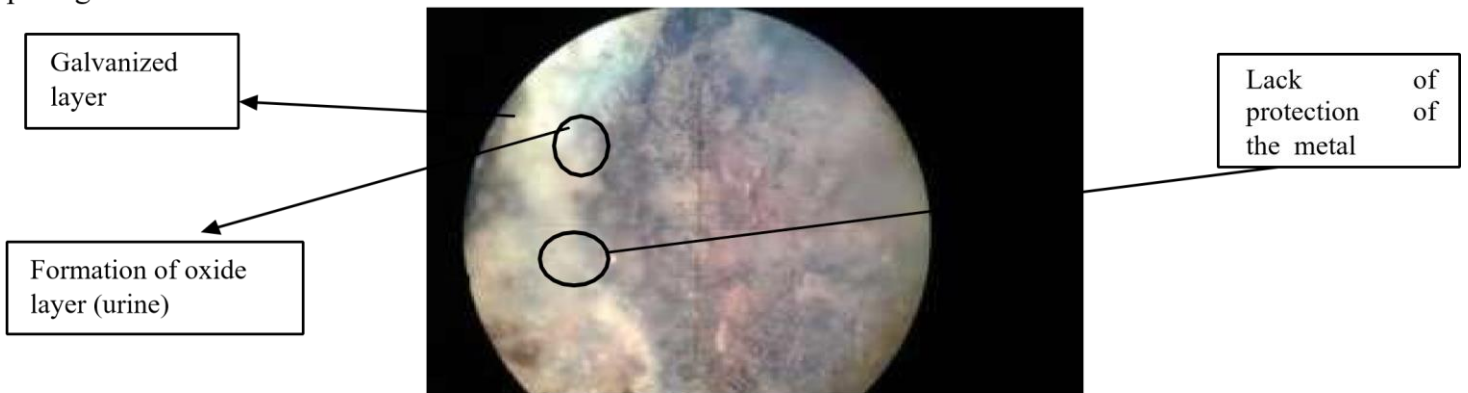


Figure (4): Surface of the part of an element of angular profile in structure of the Najasa model.

3.2 Analysis at the macro level

At the macro level, an equalizing plate supported on a model AT-60 structure was analyzed, applying the gravimetric analysis method to determine the loss of thickness (mm) and mass (g) and the diameter of the perforations (mm) existing.



(a) Corrosion-free part



(b) Corroded part

Figure (5): Structure equalizing plate AT-60

For the loss of thickness of the piece, the measurements were made in different places of the piece, since the corrosion does not behave in the same way in all the sections.

Initial thickness: 6 mm Final thickness varies from 0 to 3 mm depending on the affected section. When the final thickness was 3 mm, the loss corresponded to 50% When the final thickness was 2.5 mm, the loss corresponded to 58%.

When the final thickness was zero, the loss corresponded to 100%, therefore, it was complete.

The different perforations pitting existing, which are observed in Figure (5b), reached diameters of 9, 12.5, 13 and 17 mm

For the loss of the mass the following results were obtained:

Initial mass: 1,395 g Final mass: 1,140 g.

Mass loss: 255 g which corresponded to 18.3 % of the initial mass.

4. DISCUSSION OF RESULTS

The coexistence detected in loss of a portion of the plating layer with the start of pitting corrosion provided an interesting result since although this appearance has much to do with the resistance of steel to corrosion phenomenon [11-13]. Different authors have determined an increasing in the speed of corrosion if the metal is also exposed to a pollutant aggressive as NaCl [14,15], predominant in coastal atmospheres as it happens in the case of the metallic structures studied.

In this regard also [16], had evaluated the corrosion behavior of different galvanized steel products with and without coating, for a humid tropical climate condition in the marine-coastal area of Cojimar in north of Havana, Cuba. The results evidenced the presence of corrosion being exposed to the atmosphere coastal regardless of whether or not they were protected. Authors [9, 17] when performed microscopic analyzes of the assembly components, in high-voltage transmission towers evaluated in areas with an atmosphere similar to that studied, found an association between the loss thick and the presence of Cl and S, as predominant pollutants; both form soluble corrosion products in the presence of rain to the continuous dissolving generate a loss of thickness and thus mass. These authors also point out that the situation is aggravated by the direction of the winds, which exert an erosive effect due to the dragging of sand (SiO₂) from the beaches. The results of evaluations to the components of the structure AT-60, corroborates this hypothesis. In the case of ETECSA, for which there is no specific maintenance program, where the conditions of the different types of atmosphere in general and of the coastal area in particular are taken into account [18]; it is urgent to carry out the necessary transformations in that sense, which surely benefit the company in terms of a decrease in expenses caused for losses and an increase in the effectiveness of the organization with the consequent rise in the quality of services. Is therefore a challenge for design engineers and corrosion experts, the constant study of the engineering structures metals and proposed sustainable of actions corrosion protection for them. The results arrived at could constitute a basis to be taken into account for this.

5. CONCLUSIONS

Analysis at the micro level allowed determining that the coastal atmosphere influenced a greater corrosive wear of the components in the metallic structures of the AT-60 and Najasa models, beginning the process with the loss of the paint layer and the onset of pitting corrosion. Macro level analysis showed that after one year of exposure to the coastal atmosphere of a component in the AT- 60 structure, the thickness of the metal decreased between 50% and 100% (complete loss) and perforations were found due to pitting corrosion that reached diameters between 9 and 17 mm, causing a total loss of mass in the metal of 255g corresponding to 18.3% of the initial mass. The results in both types of analysis justify a need to implement maintenance actions immediately the loss of the paint layer is observed, especially in areas where the coastal atmosphere is predominant, which should be considered in management maintenance program.

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