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Modeling of Discontinuities in Resistance Structures due to Corrosion

The corrosion process is a process that produces significant negative effects on the resistance structures by reducing their section and by deterioration of mechanical properties of materials. In this paper are presented some notions about the corrosion process, types of corrosion encountered and types of geometric models that can be used for analytical calculation and for numerical simulation using finite element analysis programs, of the effects produced in the corrosion process on the natural frequency of the structure elements.

Keywords: *corrosion, geometric model, natural frequencies*

1. Introduction

According to SR EN ISO 8044:2000 the corrosion process means all the physical and chemical interaction between a metal and its environment that lead to changes of material properties and often to functional degradation, environment degradation or technical degradation of the system consisting from these two factors [1].

Corrosion process is irreversible and affects the technical performance of the various systems used in industry thereby causing significant economic losses and leading to dangerous situations [3].

To avoid such situations it should be taken measures for prevention of corrosion phenomena (corresponding protecting of metal surfaces) and for detection in incipient stage of this process (with different methods for damage detection).

Under corrosion process occur mass variations, changes of the mechanical properties (tensile strength, hardness and ductility), changes of the optical characteristics, electrical and magnetic properties, and of the natural frequencies for the metallic objects subjected to this process.

Currently are performed researches for the establishment of a method for damage detection (and for corroded areas) by monitoring the natural frequencies of structures elements.

The corrosion process is a very complex process that occurs under the influence of various factors such as the type of material subject to corrosion, corrosive nature, concentration, temperature and pressure of the corrosive environment, the period of contact between the material and the corrosion environment, etc.

2. Classification of the corrosion process

The corrosion process can be classified depending on the nature of the processes by which it occurs, depending on the nature of the corrosive environment and depending on the location and nature of damage caused.

Depending on the nature of the processes by which the corrosion occurs, there are the following three types of corrosion [4]:

- chemical corrosion represents the degradation of materials in general due to chemical reactions between the material and the corrosive environment during which transport of electric charges doesn't appear;
- electrochemical corrosion is the degradation of metallic materials due to chemical reactions between the material and the corrosive environment, reactions accompanied by electric charges transport;
- microbiological corrosion is caused by the action of microorganisms on metal objects.

Depending on the nature of corrosive environments, there are the following types of corrosion [3], [4]:

- atmospheric corrosion;
- corrosion in the soil;
- corrosion in gases;
- corrosion in liquids.

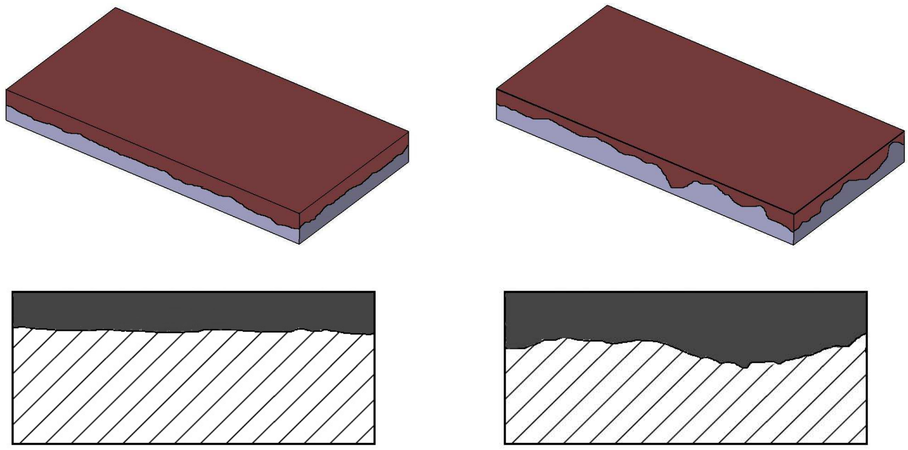
The corrosion in liquids can be of several types as follows:

- corrosion in acids (acid);
- corrosion in bases (alkaline);
- corrosion in salts;
- corrosion in sea water (marine);
- corrosion in river water;
- corrosion in oil products.

From the point of view of macroscopic and microscopic appearance of the corroded areas, several types of corrosion can be observed [3], [4]:

- surface corrosion (superficial);
- depth corrosion.

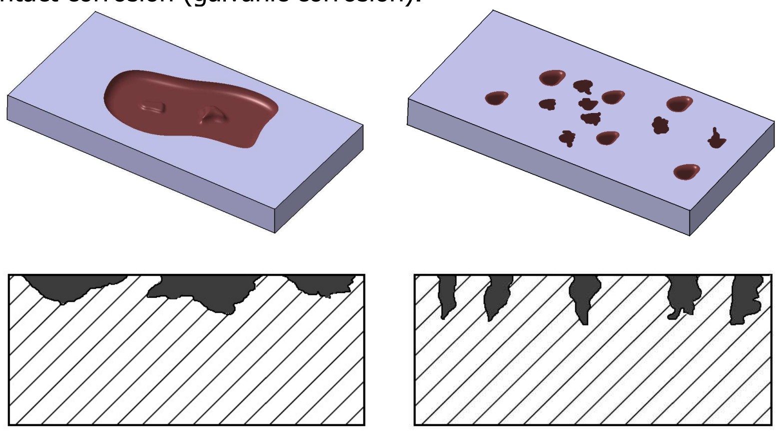
The surface corrosion can be continuous (uniform or nonuniform corrosion) or localized.



a) uniform corrosion b) nonuniform corrosion

Figure 1. Types of continous corrosion

The local corrosion can be of several types, as follows:
- corrosion in the form of spots or plagues;
- pitting corrosion;
- crevice corrosion;
- perforation corrosion;
- contact corrosion (galvanic corrosion).



a) corrosion in the form of spots or plagues b) pitting corrosion

Figure 2. Types of localized corrosion

The depth corrosion can be of different kinds as follows:
- intergranular corrosion;
- stress corrosion cracking;

- erosion corrosion;
- cavitation corrosion;
- fatigue corrosion;
- selective corrosion, etc.

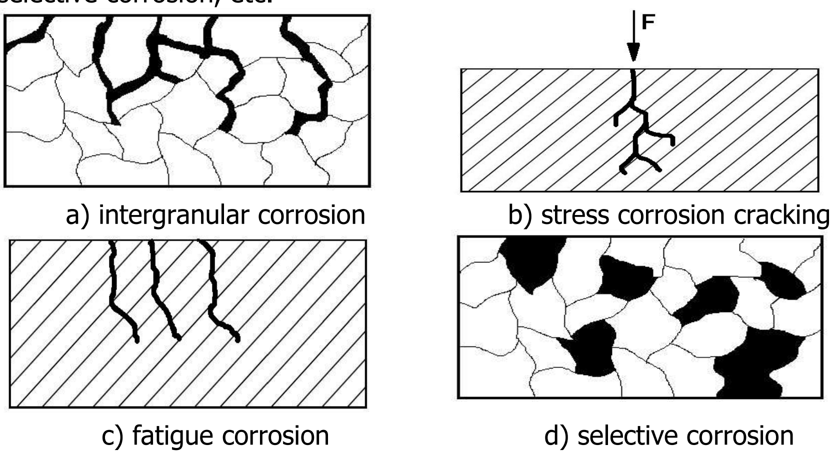


Figure 3. Different types of depth corrosion

3. Geometrical models

After the corrosive action on the various metallic objects it can be observed a change of their weight in most of the cases.

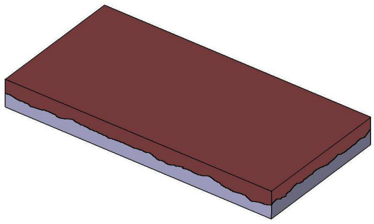
The corrosion products which occur as a result of corrosion processes can be completely soluble in the corrosive environment or can remain adherent to the metal surface in the case of atmospheric corrosion or gas corrosion [2].

There are also situations where corrosion products are partially soluble and partially adherent to the metallic objects [2].

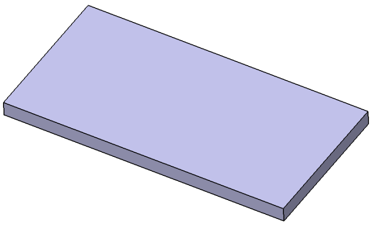
For the case of uniform surface corrosion where corrosion products form an adherent layer it can be used the model from figure 4c which is subjected to corrosive attack and in which the element has the same cross section as the item without damage.

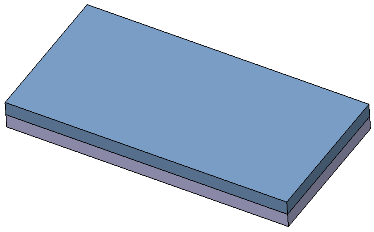
The geometrical model used consists of two different layers with different densities and different Young's modulus because in the case of surface corrosion, corrosion products may have a mass greater or less than the base material, while a decrease in the Young's modulus in the corroded layer it can be observed.

For the case of uniform surface corrosion where corrosion products are completely soluble in the corrosive environment, the corroded element shows a reduction of the cross-section and in this case it can be used the geometric model shown in figure 4b.



a) element subjected to surface corrosion

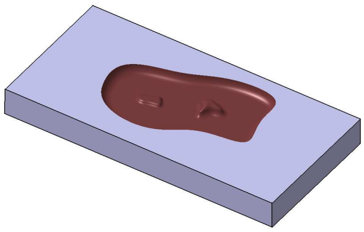




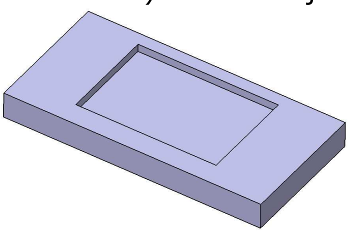
b) geometric model type 1 c) geometric model type 2

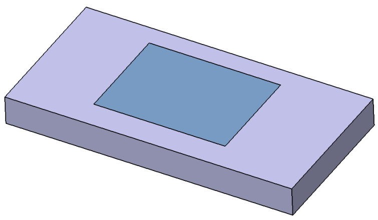
Figure 4. Geometric model used for uniform surface corrosion simulation

In figure 5 are presented the geometric models that can be used to simulate the cases of localized corrosion where the corrosion products can be also soluble in the corrosive environment or adherent to the metal surface.



a) element subjected to localized corrosion





b) geometric model type 1 c) geometric model type 2

Figure 5. Geometric model used for localized corrosion simulation

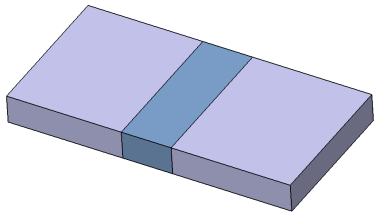


Figure 6. Geometric model used for depth corrosion simulation

In the case of depth corrosion there are changes of the mechanical properties of the material without a significant decrease in the mass of the corroded object [2]. The cases of depth corrosion are very dangerous because they are very difficult to detect. To simulate the effects of depth corrosion it can be used the geometric model from figure 6, model composed of three distinct areas with different Young's modulus.

4. Conclusion

The geometric models presented in this paper can be used in the finite element analysis programs to study the dynamic behavior of structural elements subjected to corrosive attacks, in order to establish an efficient method for detecting of corroded areas in incipient stages by monitoring the natural frequencies for different modes of vibration for these elements.

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