THE INFLUENCE OF SOME CORROSIVE ENVIRONMENTS ON THE WORKING EQUIPMENT OF THE HEAT EXCHANGERS

Lecturer PhD.Eng. Florin CIOFU, Lecturer PhD.Eng. Alin NIOAȚĂ,
Lecturer PhD.Eng. Nicoleta MIHUŢ, Lecturer PhD.Eng. Constanţa RĂDULESCU
University "Constantin Brâncuşi" of Târgu-Jiu, florin.ciofu@utgjiu.ro

Abstract: *The degradation of the structures made by steel or other metallic materials is more intense if on those structures a corrosive environment acts simultaneously with the variable mechanical stresses This process is called fatigue in corrosive environment or corrosion fatigue and has different causes and effects compared to the degradation due to the single action either of the mechanical stress, or only due to the corrosive environment. The process of degragation by a combined effect of the mechanical stresses together with a corrosive environment is intensified when the metallic structure is in contact with liquide corrosive agents., as it usually happens in cas of the equipment of the energetic industry.*

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1. GENERAL INFORMATION

The simultaneous action of the mechanical stresses and of a corrosive environment is exercised differently on metallic materials, depending on the nature of the metal - environment, resulting in substantial changes in their behavior compared to the situation in which the influence of the working environment was ignored and it was considered inert..

The action of the corrosion fatigue process is much larger than the two processes separately, and their effect is not a simple superposition of the individual effects , it is actually much more complex, having an associative character. The complex interplay of the mechanical and chemical factors is evidenced by the fact that the fatigue process in corrosive environment can occur in weak chemical active circumstances or at low levels of mechanical loads, much lower than the yield strength of the material.

The danger of such a degradation is that they can not be detected in the initiation phase , manifesting itself without visible macrodeformations without significant changes in the state of the surface layer of the part.

2. THE CURRENT STAGE OF THE RESEARCH DOMAIN

The reseqrches on domain of the degradation of the steel structures show that more than 80% of the destructions are caused by the fatigue processes. The fatigue is a process of cumulative damage and is caused by cyclic variable loadings. In the presence of an aggressive environment such a degradation is known as *the corrosion fatigue*.

The degradation by corrosion may reduce the corrosion fatigue strength of the material, as it decreases the length of the fatigue cracks initiated on the surface of the material. It was noted that the stages of initiation and propagation of fatigue cracks are much moreaffected by the corrosive action than the final destruction stage. Therefore, the knowledge of the mechanisms of initiation is very important in the study of fatigue in corrosive environment durability.

The corrosion fatigue can be defined by the consecutive steps of the interaction between the cyclic plastic deformation of the irreversible local stress concentration caused by the chemical or electrochemical reactions located in the deformation areas.

An important aspect of research on corrosion fatigue is to identify the sites of initiation of the micro- cracks and their peculiarities. These positions are responsible for the premature initiation of fatigue cracks or corrosion fatigue and reduce the alloys durability.

The environmental degradation by corrosion fatigue is cumulated when increasing the number of stress cycles. The main stages of the process of fatigue damage in the presence of a corrosive environment can be considered to be :

- Initiating pinching ;
- Pinches evolution ;
- Cracks propagation ;
- Cracks union .

The fatigue in corrosive environment is influenced by many interactive mechanical, chemical and microstructural variables, that are to be included in the experimental model. The corrosion fatigue destruction is located along the sliding strips and near the crack tips , where the high resolution observations are not generally available, so that the process must be performed by indirect measurements.

3. THE EXPERIMENTAL STUDY

The experimental studies conducted further were directed towards the analysis of the degradation mechanisms of corrosion fatigue in a steel grade used in manufacturing heating pipes of the heat carrier circuit. Taking into consideration the extension of the domain of occuring such degradations, the use of modern study methods at micro and macrostructural level are essential for the degradation analysis and modeling.

Thus, the experimental researches conducted in this paper aim at the following aspects:

-The comparative durability benchmarking of the fatigue in air and corrosive environment;

-The analysis of the electrochemical processes evolution during fatigue stresses in corrosive environment applications ;

-The study of the degradation state of the surface layer based on the analysis of the evolution of the fine structure parameters and the metallographic analysis of optical microscopy ;

Figure 1 presents some aspects of corrosion action on these facilities. In the presented figures there is a marked degradation of the layers in contact with the corrosive environment. We further show how, together with stresses to which the layers were submitted (pressure, temperature, vibration), the corrosive environment had a substantial influence on degradation. In order to determine the influence of the corrosive environment on the steel structures degradation for comparison were sampled heat exchangers installations of Rovinari power plant as well as structures that have no contact with corrosive environments.

Fig.1. *The action of the corrosive environment on steel structures*

The assay-samples are included in the pipes networks of the heat exchangers, a pipe with the diameter φ51x3,2, material 16Mo3 (fig 2) and of strength structures having no contacts with corrosive environments.

Fig.2. *The assay-samples*

The steel 16Mo3 (SR EN 10028) is assigned to the manufacture of boilers and containers under pressure presiune for high temperatures.

The steel sheet for boilers and pressure vessels for high or ambient temperature (EN 10028) are carbon steel , carbon -manganese and alloy steels in various proportions with chromium, molybdenum and other elements (vanadium , tungsten , etc.) with guarantees concerning the values of the mechanical characteristics in a wide temperature range (-20 ° C ... +640 ° C).

Also some steel grades in this class are recommended for the use in environments with hydrogen. These steels are used for both flat and tubular products delivered in normalized and tempered condition.The equipment and facilities operating under long-term pressures and high temperatures (450-530) ° C : heat exchangers, pipes and other devices or power boilers and other pressure vessels. The chemical composition was measured in the laboratory by using X -MET 3000TX apparatus (X- ray fluorescence). Table 1 presents the measured values and the values stipulated by EN 10028.

Table 1: *Chemical composition*

16Mo3	C	Mo	Mn	Ti	V	Si	Cr	Cu	Ni	P	S	N
Measured chemical composition [%]	0,20	0,30	0,50	0,20	0,10	-	-	-	-	-	-	-
Prescribed chemical composition [%]	0,12 0,20	0,25 0,35	0,40 0,90	-	-	0,35	0,03	0,30	0,30	0,02	0,01	0,01

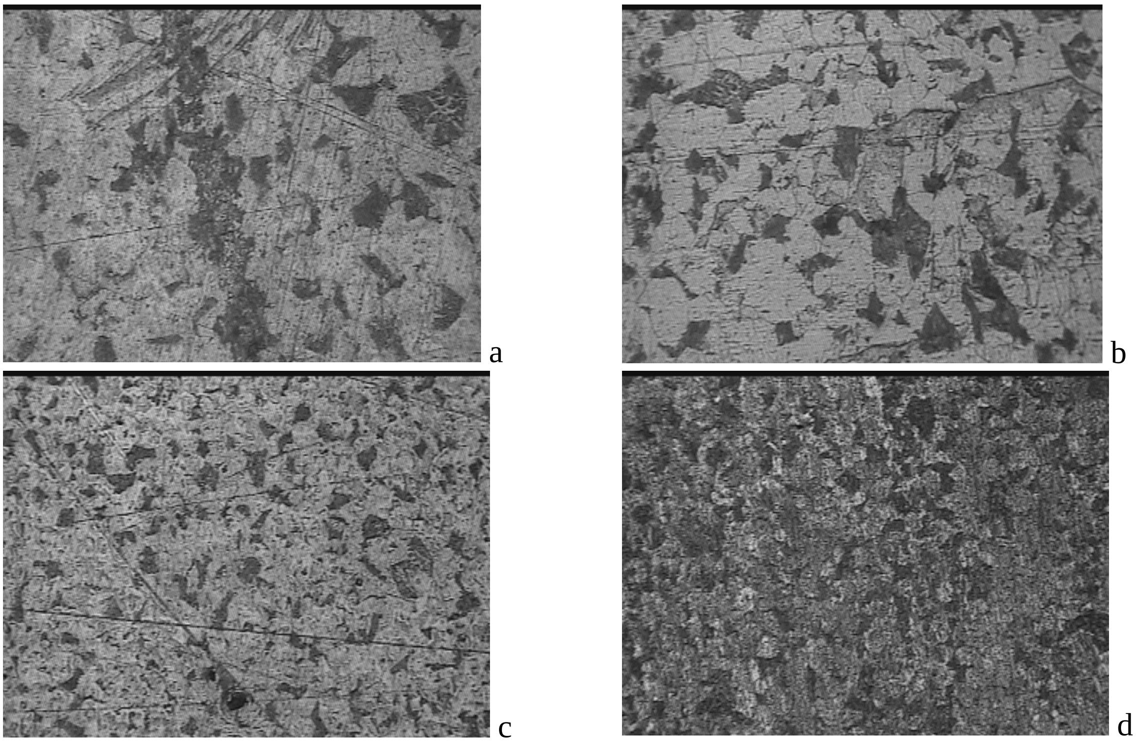

Fig.3 *The microstructure of the 16Mo3 a, b - 400x ; c, d 200x*

The metallographic samples were taken from both types of samples, then they were observed by optical metallographic microscope from the laboratory of Materials Science and Engineering of the Faculty of Engineering. The resulted microstructures are given in figure 3.

Analyzing the chemical composition it is possible to be observed structural changes caused by corrosion, by removing the alloying elements Cr , Si , Cu or Ni. In addition, in the microstructures in figure 3 is observed the influence of the corrosion by the level of the limit between the grains.

Being a hipoeutectoid steel (0.20 % C) 16Mo3, it has a Fe content of 98.70 % . For this reason as well as a low concentration of alloying elements (0.03 % Cr , 0.30 % Ni, 0.3 % Mo) the material has a low resistance to corrosion.

The influence of the alloying elements on the allotropic transformations of iron is the most important in changing the steels constitution and structure. To the Alfagene group elements belong molybdenum, tungsten , silicon, titanium , aluminum, beryllium , niobium , boron and zirconium .

The alloying elements in the steel may be in various forms such as:

a - dissolved in ferrite to form solid solution with ;

b - in combination with the carbon, forming carbides or solid solution carbide ;

c - in combination with iron or with each other , forming intermetallic compounds ;

d - in combination with various impurities , sulfur , oxygen and so on , with which it forms non-metallic inclusions such as sulfides, oxides etc . ;

e - the free state in the form of particles dispersed in the mass of an alloy steel .

4 . CONCLUSIONS

Changes in mechanical properties are due to the fact that the alloying elements, dissolving in ferrite, modifies the parameter of the iron lattice – as a cristaline network; chromium, nickel, tungsten and molybdenum increase the iron network parameter and the silicon decreases it .

Molybdenum improves the chemical stability of acids (sulfuric, hydrochloric and tartaric acids), as well as some alkaline solution of chromium-nickel austenitic stainless steels. Molybdenum steels can replace more expensive chrome-nickel steels. The concentrations of 0.25 ... 0.50 % Cu-copper improve the stability to oxidation of steels at high temperatures, but their processing by hot rolling at a temperature higher than the melting point of copper, 1083 ° C , can not be achieved because of the fragility of steel.

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