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CORROSION RESISTANCE OF THE X6CrNiTi18-10 MATERIAL EXPOSED TO A SALT SPRAY TEST

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The research was focused on testing the corrosion resistance of the X6CrNiTi18-10 material. This material exhibits good corrosion resistance in the humid atmosphere, but with the occurrence of chloride inclusion in the same atmosphere, its corrosion resistance is drastically reduced. The X6CrNiTi18-10 material is austenitic stainless steel susceptible to pitting corrosion and this can cause problems during exploitation of the construction made of this material. In order to determine the likelihood of pitting corrosion occurrence, a light microscopy was performed on test samples that were exposed to the salt spray test chamber atmosphere, i.e. sprayed with a 5% sodium chloride solution (NaCl) at different time intervals.

Key words: steel X6CrNiTi18-10, corrosion resistance, salt spray test chamber/NaCl, time interval, light microscope

INTRODUCTION

When designing mechanical constructions, it is important to consider all properties of construction material, in order to avoid problems that can occur in certain exploitation conditions, such as the appearance of corrosion. Improper selection of material, which corrosion properties are not fulfilling the exploitation requirements, may result in the decay and mass loss due to corrosion mechanisms. Consequently, this leads to the deviation in the required construction properties and shortens the service life of the construction [1,2].

In this research, the authors used the X6CrNiTi18-10 material. It was important to know the material corrosion properties in order to determine the optimal scope of material application. For example, if a particular element made of this tested material is exploited in a chloride-rich atmosphere, such as coastal atmosphere, it is necessary to be informed about the level of material corrosion resistance in that specific condition. In order to determine the durability of the material in the chloride-rich atmosphere, the experiment was carried out in a chamber where samples were sprayed with a fog of 5% sodium chloride solution in cycles at a constant temperature and pH value [3-5].

Since the X6CrNiTi18-10 material is austenitic stainless steel, which resistance to corrosion in the salty environment is not good, there is a possibility that pits will occur as a corrosion damage. Referring to the geometric classification of corrosion forms, pits or spots are certainly one of the most dangerous forms of damage, since the depth of damage at the corrosion spot can be several times greater than the width of the damage visible on the surface [6,7].

In order to determine whether pitting corrosion occurred on the tested samples, they were subjected to the salt spray test and observed by light microscope. On some samples, small corrosion pits on the material surface were visible to the naked eye, but only the recording of the corrosion-forming site at a certain magnification can confirm the extent of damage, the pit size and penetration depth [8,9].

EXPERIMENTAL PART

For the determining the corrosion resistance of the X6CrNiTi18-10 material, tests were performed on 8 samples exposed to the salt spray test chamber atmosphere at different time intervals and then subjected to microscopic recording of the surface to detect the resulting damage. The samples were cut out of the base material in the dimensions of 150 x 100 x 0,3 mm. Before being placed in the chamber, samples were cleaned of impurities and grease deposits accumulated on them in the preparation.

The tested material is characterized by good resistance properties to atmospheric corrosion resulting from moisture, oxygen, other atmospheric gases and solid particles. Moisture is a problem due to the formation of electrolyte layer on the surface, which is a prerequisite for the occurrence of the electrochemical corrosion. This would not be a major problem if there were not inclusions of chlorides, such as the coastal atmosphere in which seawater particles are transferred to a construction. It is known that the material is not resistant to these elements, but it is not known exactly to what extent. Therefore, it is necessary to examine whether the

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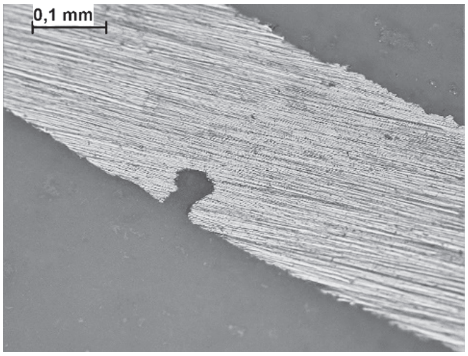

Figure 1 Example of pitting corrosion on the X6CrNiTi18-10 material

material is suitable for exploitation over a certain period of time, or its exploitation is not advisable at all. In order to present the risk of pitting corrosion on the stated material, there is the Figure 1 showing pitting corrosion on the element that was in use in the chloride atmosphere.

When magnified 200 times, it is clearly visible that corrosion penetrates into the material, thus reducing the cross-sectional area of the surface. By reducing the cross section, the required mechanical properties of the element are also reduced, which can lead to a breakdown under heavy workloads. This experiment will precisely determine the period in which mechanisms of this corrosion type shall emerge.

The tested material X6CrNiTi18-10 is characterized by good mechanical properties. As of its chemical composition, it is classified as the austenitic stainless steel [10]. Chemical composition of the material is shown in Table 1.

Table 1 **Chemical composition of the material X6CrNiTi18-10 / wt. % [11]**

C	Mn	Si	Ni	Ti	Cr
0,01	1,79	0,53	9,56	0,15	17,05

Previously cut and prepared samples were exposed to the salt spray test chamber atmosphere at different time intervals with the aim to observe the appearance of corrosion and the progress of adverse corrosion effects. Salt spray test chamber is a device that enables accelerated testing of corrosive processes on samples exposed to cyclic spraying with a 5% sodium chloride solution at a constant temperature and pH value. The tests are performed in accordance with ISO 9227, and the parameters are shown in the Table 2.

Table 2 **Parameters of the salt spray test chamber according to ISO 9227 [12]**

Temperature / °C	Concentration NaCl / %	pH value
35 ± 2	5	6,5 – 7,2

The same standard recommends the holding time of the test samples in the salt spray test chamber. Since the tested material is expected not to show corrosion damage in a short period of time after exposure to the salt spray test, one sample was kept in a chamber for 24 hours and one sample for 48 hours. Some manufacturers do not recommend this material as suitable for exploitation in the atmosphere with presence of chloride inclusion, and they do not provide specification to which extent the material shall be durable in the stated conditions. Other manufacturers state that the material could potentially withstand the exploitation in salty conditions in duration of about 100 hours. For this reason, the remaining three time intervals of 96, 168 and 240 hours were determined as duration of testing of two samples per each interval. Two samples are used for each interval so that the results could be more accurately compared. As the exact data about the durability of the tested material in the salty conditions were not available, this experiment should provide the information if and to which extent the material is applicable for exploitation under the aforementioned conditions.

After all samples rested in the salt spray test chamber over a defined time, they were ready for further examination. Since the samples contained chloride as a leftover from the chamber, it was necessary to clean them before proceeding with the testing. After that, samples were visually inspected to find the spots where the corrosion mechanism occurred. The damage was defined as a corrosive product around the opening in which pitting corrosion occurred, as shown in Figure 2. Longer exposure to the aggressive atmosphere affected the pits to become increasingly noticeable and more numerous.

It was determined that the sample 1 did not exhibit the corrosion damage, while corrosion was observed on all other samples. The longer the samples were kept in the salt spray test chamber, the greater corrosion damage occurred. After marking the spots of pitting corrosion, microscopy was performed by a light microscope Leica DM 2500M with a magnification of 100 times to determine the exact harmful effect that corrosion caused on samples.

By observing the tested samples, it was determined that the corrosion damage increased proportionally with the time spent in the salt spray test chamber. As already mentioned above, corrosion did not occur on the sample 1, while the sample 2 had noticeable spots of corrosion,

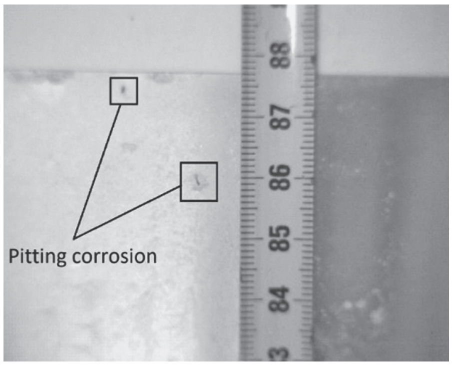

Figure 2 Spots of pitting corrosion

but since the corrosion just started, the depth of damage was not significant enough to cause greater damage or to pass completely through the material. Serious corrosion damage occurred on other samples, on which pitting corrosion was in great progress by penetrating deeper into the material surface. In addition to the greater intensity of corrosion damage, longer time of exposing samples to the salt chamber conditions caused the increase in number of corrosion pits. Table 3 shows the number of pits occurring on samples.

Table 3 **Number of corrosion pits on samples**

Sample mark	Number of corrosion pits
1	0
2	1
3	3
4	3
5	4
6	3
7	4
8	5

The following Figures 3-9 present the micro-images of tested samples, by showing the spots of pitting corrosion recorded by light microscope.

It is visible that only sample 2 had weaker corrosion damage, while all other samples had similar damages caused by corrosion. This confirms the fact that corrosion mechanisms are rapidly developing on the material. In the relatively short period of time, the corrosion becomes intense and causes great damage. Further problem occurs with the increasing number of corrosion pits, which increases proportionally with the duration of sample exposure to the salty conditions.

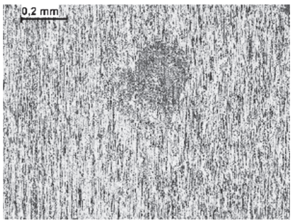

Figure 3 Sample 2 100 x

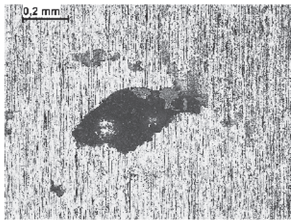

Figure 4 Sample 3 100 x

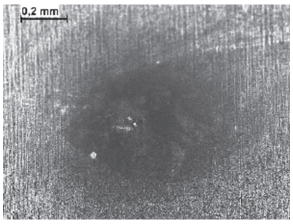

Figure 5 Sample 4 100 x

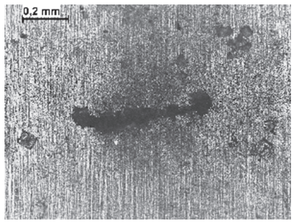

Figure 6 Sample 5 100 x

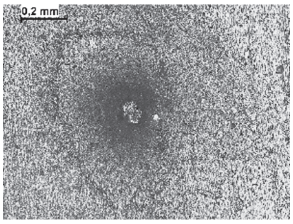

Figure 7 Sample 6 100 x

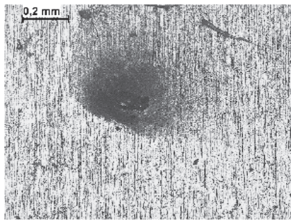

Figure 8 Sample 7 100 x

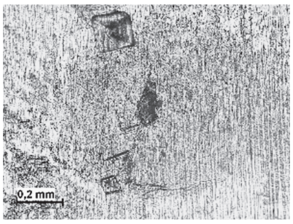

Figure 9 Sample 8 100 x

CONCLUSION

The research into corrosion resistance of X6CrNiTi18-10 material proved that the material was insufficiently resistant to corrosion in a chloride-rich atmosphere. The material is characterized by good resistance to corrosion in the humid atmosphere, but the problem arises with inclusion of chlorides. In such conditions, there is the possibility of pitting corrosion, as pits are characteristic geometric classification of corrosion processes for this material. As it is known that under these conditions the corrosion resistance is reduced, the aim of this research was to determine how long shall it take for the corrosion process to occur and whether the material can be exploited in real conditions with a certain limitations, or it should not be used at all. To determine this, the samples were placed in a salt spray test chamber and exposed to cyclic spraying with a 5% sodium chloride solution (NaCl) in different time intervals. This atmosphere imitated the real exploitation conditions present in the coastal areas. After the salt spray test chamber, samples were observed with a light microscope with 100x magnification and pitting corrosion was detected on all samples, except for the sample 1 that was kept in the chamber for 24 hours. Other samples that were kept in the chamber for 48, 96, 168 and 240 hours developed corrosion pits, which appearance and intensity increased proportionally with the time spent in the chamber atmosphere. Obtained research results proved that the investigated material exhibits almost no resistance or very low resistance to corrosion in a chloride-rich atmosphere, and for this reason, it is not suitable for exploitation under the above-described conditions.

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