CORROSION RESISTANCE OF TITANIUM ALLOY

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Abstract. The paper examines the influence of the corrosive effect on the change of microstructure of titanium alloys, which are often used as a replacement material for the human body. These alloys are generally among the corrosion resistant alloys, but the requirements for their resilience in case of implants are still extreme. The corrosion tests were carried out using standard corrosion tests in salt spray environment. The aim was to evaluate the corrosion resistance of titanium alloy, and compare the changes in the structure of the material depending on the length of exposure to corrosion.

Keywords: titanium alloy, corrosion resistance, microstructure.

Introduction

The effect of stress, thermal and chemical effects has resulted in changes in the structure of materials and then the changes of their properties. These changes often lead to permanent degradation of the material components, which often means a threat to the safety and reliability in extreme cases, failure to complete their function. Titanium and its alloys are among the chemically active metals with high corrosion resistance, because the surface creates a passive-resistant coating of TiO_2. Thanks to the rust layer in the atmosphere, in fresh water and in the human body. The chemical composition of the alloy determines the resulting structure at room temperature, which can be: pure α-structure, pseudo-α, α / β, pseudo-β, and pure β-structure. The most common structures for the implants are β-alloys high-alloy β-stabilizing elements [1]. Corrosion resistance of the implant material to the environment of the human body is among the main conditions for long-term and proper functioning of the implant. This requires careful selection of Ti alloys. During the corrosion process, the implant may lose its integrity; corrosion products may cause adverse reactions, which can have disastrous consequences for humans.

The paper deals with the evaluation of the influence of microstructure on the corrosion load titanium alloy VT6, which is often used as material compatible implants (artificial joints, prosthesis, etc.) into the human organism. Evaluation of the corrosion resistance was carried out using standardized tests in a corrosive environment, corrosive salt spray and the subsequent evaluation of the microstructure in the surface layers depending on the length of the corrosion effect on a confocal microscope Olympus LEXT OLS 3100 [2].

Materials and methods

As the experimental material titanium alloy Ti-6Al-4V chemical composition is shown in Table 1.

Table 1

Chemical composition of Ti-6Al-4V alloy

Ti , %	Al, %	V, %	Impurities, %							
			Fe	Si	C	O	N	H	∑ of other	Cr
100 % - ∑ of all elements	5.3-6.8	3.5-5.3	0.30	0.10	0.10	0.20	0.05	0.015	0.30	0.30

Surface samples from the corrosive loading were metallographically prepared in the usual procedure. To test application the salt spray corrosion chamber Liebisch S 400 MTR was used in accordance with [3]. The test solution was 5 % salt solution in demineralised water (concentration of $50 \pm 5\ g \cdot l^{-1}$ sodium chloride should not contain more than 0.1 % of sodium iodide and more than 0.5 % total impurities in terms of pure salt). The time effects of corrosion load were set at 30, 40, 50, 88, 125 and 214 days.

Microstructural analysis

Microscopic evaluation of the samples was analysed by the confocal laser microscope OLYMPUS LEXT OLS 3100. It is a titanium alloy composed $\alpha + \beta$ phase. It is a typical "basket" structure, where the size of plates is different in some places.

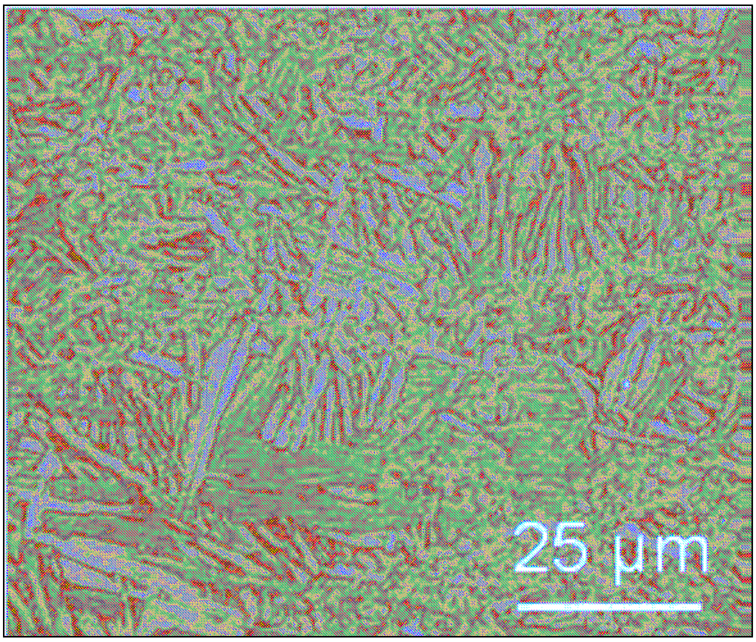

Fig.1 **Initial structure of Ti-alloy, without corrosion load**

Sample No. 1, after 30 days of the load (Fig. 2), was only partially oxidized surface. The size of the plates was unchanged. Sample No. 3, removed from the corrosion chamber after 40 days (Fig. 3), plates remain in good condition; there are no visible locations with corrosive attack.

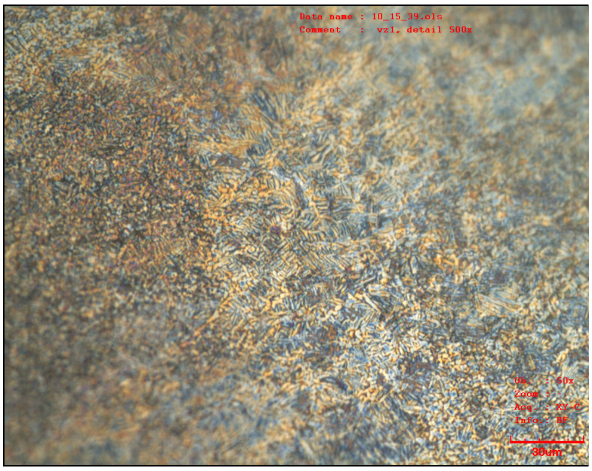

Fig. 2 **Sample No. 1, 30 days of corrosion exposure**

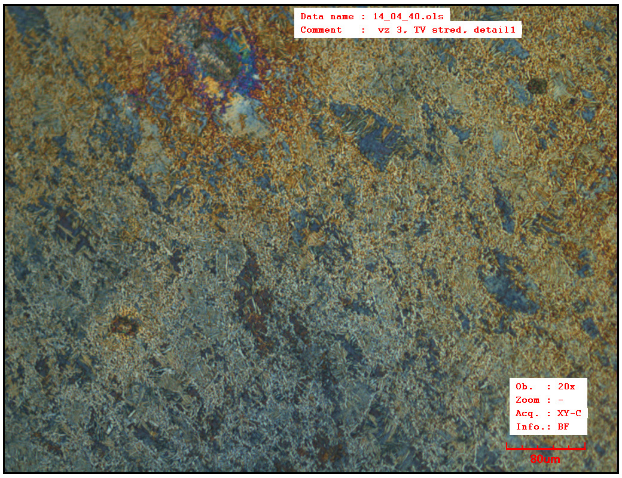

Fig. 3 **Sample No. 3, 40 days of corrosion exposure**

Sample No. 2, removed from the corrosion chamber after 50 days, the characteristic points, which was falling off of intermediate phases (Fig. 4). Sample No. 4, after 60 days, characterized by their uniform corrosion points over the sample surface area (Fig. 5).

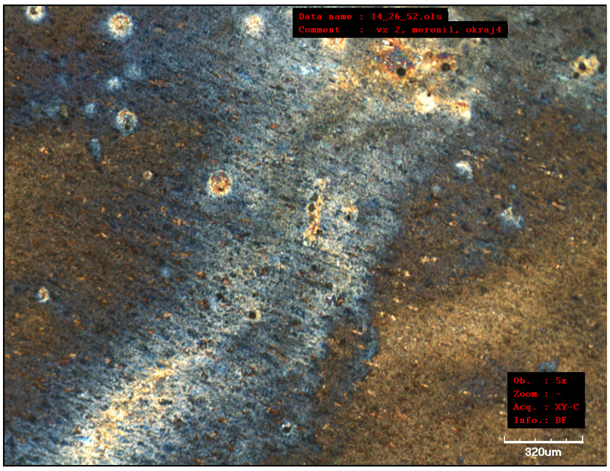

Fig. 4 **Sample No. 2, 50 days of corrosion exposure**

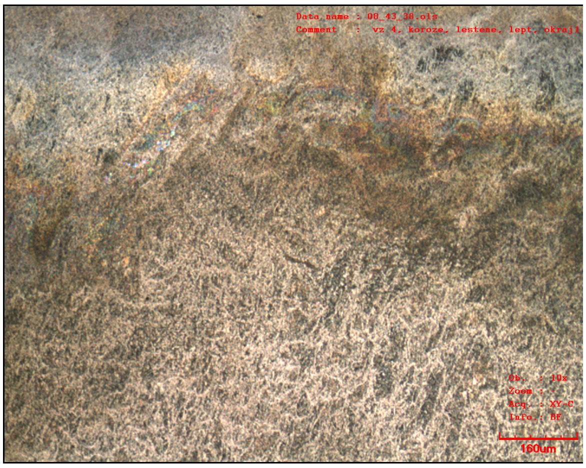

Fig. 5 **Sample No. 4, 60 days of corrosion exposure**

Sample No. 5, the loading time of 88 days of corrosion, contained some areas of more or less corrosion-attacked, Fig. 6. It can be assumed that it reflected the influence of different sizes of blades in the monitored areas. Detailed examination of the microstructure, Fig. 7, confirmed the apparent differences in the size of the plates of the phases α and β.

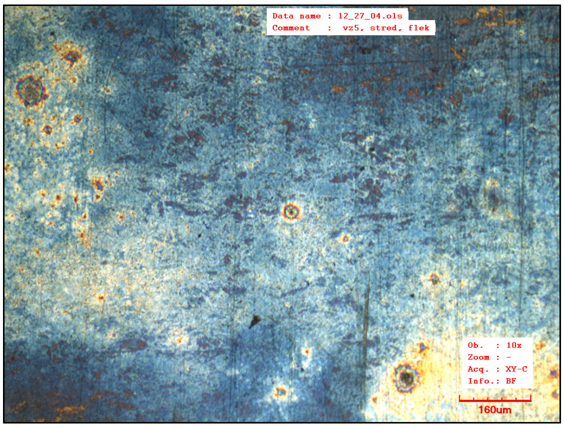

Fig. 6 **Sample No. 5, 88 days of corrosion exposure**

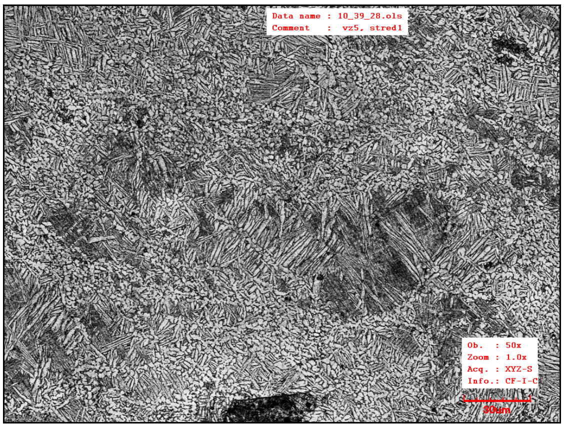

Fig. 7 **Sample No. 5, detail, confocal mode**

Sample No. 6, after 125 days of corrosion exposure in the corrosion chamber (Fig. 8) was typical of that to highlight and differentiate the areas with increased corrosive attack on contrast to the areas with less intense oxidation. Based on the study sample surfaces after corrosion exposure it is possible to characterize the process of degradation of the surface of titanium alloy Ti-6Al-4V as diverse.

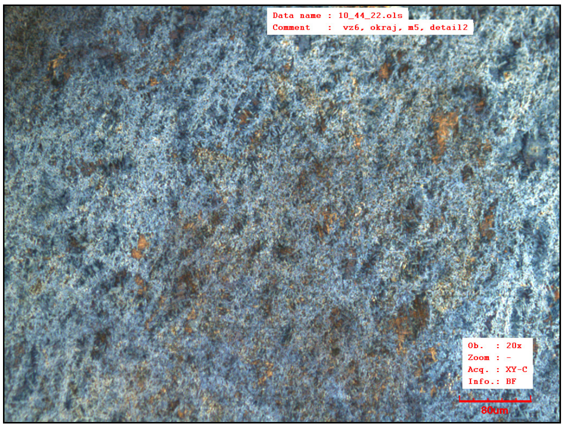

Fig. 8 **Sample No. 6, 125 days of corrosion exposure**

Conclusions

Due to the fact that Ti alloys are currently used mainly as joint replacements or dental implants, it is important to find as many aspects of the behaviour of the surface during the lifetime of the implant in the body. The reference alloy with respect to these appears inadequate. Not only changes in the microstructure occurred, but the inclusions were localized, thereby reducing the quality that is critical for the production of implants and dentures. The experiments will be extended to the measurement of the thickness of the surface layer, electron microscope evaluation, which describes in detail the impact loading on the corrosion degradation of the surface and microstructure of titanium alloys.

References

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