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МИКРОСТРУКТУРА И МЕХАНИЧЕСКИЕ СВОЙСТВА СПЛАВА ВТ6, ИСПОЛЬЗУЕМОГО В МЕДИЦИНЕ

В работе были исследованы титановые сплавы ВТ6, обладающие различной микроструктурой. Все сплавы были сформированы методом дугового переплава в инертной атмосфере аргона. Максимальное значение микротвердости (415 $HV_{0,05}$) соответствовало материалу после закалки.
Ключевые слова: биоматериалы, титановые сплавы, микроструктура.

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MICROSTRUCTURE AND MECHANICAL PROPERTIES OF SUCTION CAST AND QUENCHED BIOMEDICAL Ti-6Al-4V

Two Ti–6Al–4V samples have been researched. One samples was received by quenching the commercial master alloy, the other alloy was received by melting and casting the commercial master alloy into a water-cooled cooper crucible. The quenched sample showed a microhardness of 415 $HV_{0,05}$.
Key words: Ti alloys, metallic biomaterial, microstructure.

In the human body bone related degeneration or disease of bones, joints or tooth occur frequently. Patients may suffer from pain caused by full or partial loss of the functionality. To relieve pain a replacement of diseased tooth, bone or even the complete joint by artificial biomaterial is often required in orthopedic surgeries. To fulfil the requirements caused by an expanded life time artificial biomaterial should not only avoid short-term rejection caused by infection, they also should provide a high long-term biocompatibility and overcome long-term limitations. Ti-based alloys show excellent biocompatibility, low density and excellent corrosion resistance and were therefore used as biomaterials since the early years of the 1950`s [1, 2, 3, 4]. Within titanium alloys for application in medicine Ti–6Al–4V is the most frequently used alloy for biomedical application. The applications cover dental implants, joint replacement parts for hip, knee, shoulder, spine or as housing material for pacemakers [5]. The aim of this paper is to investigate the difference in microstructure and mechanical properties between suction cast and quenched Ti–6Al–4V.

For the study two samples of Ti–6Al–4V were investigated. The first sample was prepared by remelting an Ti–6Al–4V (VT6) ingot in a BUHLER arc melter. The melting chamber was evacuated and flushed three times with argon prior to melting and throughout melting an argon atmosphere was maintained. The received button shaped alloy was remelted and suction cast into a cylindrical water-cooled copper crucible with a diameter of 5 mm. The weight loss of the samples was evaluated by measuring the initial material and the sample after casting. The second sample was received by heating the Ti–6Al–4V sample to 1000 °C and fast quenching into oil. The samples were etched with Kroll`s solution consisting of vol. % HF, 6 vol. % HNO_3 and 92 vol. % distilled water. Microstructural analysis was conducted using a Carl Zeiss AxioObserver Z1m microscope for optical microscopy (OM). The Vickers hardness test was used to evaluate the mechanical properties. At least 30 measurements with a load of 50 g and a dwell time of 10 s were done with a WOLPERT Group 402 MVD Vickers hardness tester to achieve a significant average.

The weight loss of the suction cast samples was found to be 0,35 % which indicates that the remelting process of initial Ti–6Al–4V does not cause a change in composition. The weight loss as well as the microhardness are shown in table 1.

Table 1

Sample notation, weight loss and microhardness of Ti–6Al–4V samples

Alloy code	Weight loss, %	Microhardness, $HV_{0,05}$
Ti–6Al–4V_SC	0,35	334 ± 5
Ti–6Al–4V_Q	–	415 ± 5

Fig. 1 shows, that the suction cast samples exhibit a typical α + β duplex microstructure. The more or less equiaxed grains of primary α and transformed β. When β transforms to α the morphology of the transformation α is very different to the that of primary α. Prior β grains transform to co-oriented α lamellae, also known as transformation α. These transformation α is separated by ribs of retained β. Large colonies of co-oriented α lamellae are present within β grains and grain boundary α is delineating the prior β grains. Since it is proposed that the cooling rate in suction casting is very high the α are thin and show a relatively small length. The microstructure of the sample in quenched state is shown in fig. 1, *b*. The microstructure consists of lamellae of transformed α and β. The ribs of grain boundary α are thicker compared to the suction cast sample. The microhardness of quenched and suction cast samples is shown in table 1 and the maximum value of 415 $HV_{0,05}$ correspond to the quenched sample. The suction cast sample showed a microhardness of 334 $HV_{0,05}$. It is proposed that the high microhardness for the sample in quenched state is due to the presence of metastable ω phase. A high cooling rate supports the formation of ω phase in alloys with sufficient high β stabilised Ti-based alloys.

a *b*

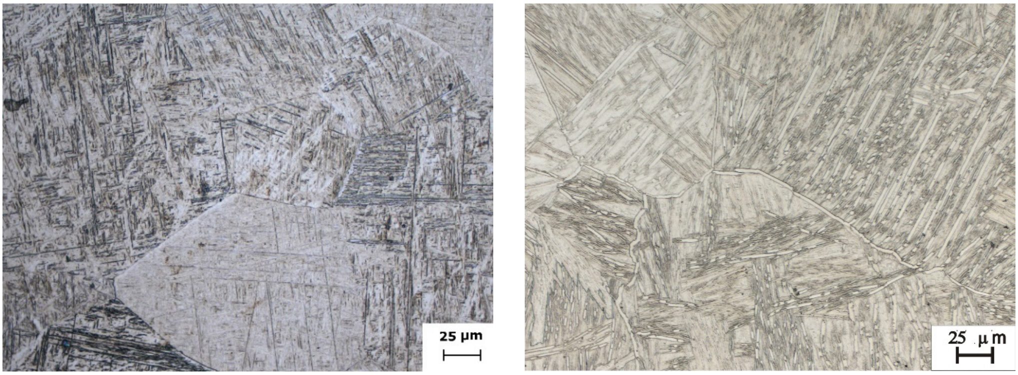

Fig. 1. Micrographs of the Ti–6Al–4V samples in (*a*) suction cast state and (*b*) quenched state

Experimental results indicated that both the microstructure and the mechanical properties strongly depend on the heat treatment. After suction casting the sample showed a microhardness of 334 $HV_{0,05}$. The microhardness of the sample containing metastable ω phase reached a maximum microhardness of 415 $HV_{0,05}$.

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