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KATA PENGANTAR

Assalamu'alaikum Wr. Wb.

Syukur Alhamdulillah dengan Rahmat dan Karunia Allah SWT telah terbit Buletin Teknologi FT-UISU Vol. 4 No.1 Januari 2000, yang menyangkut bidang science dan keteknikan. Baik itu merupakan tulisan hasil Penelitian maupun karya Ilmiah Populer yang dilakukan oleh Staff Pengajar .

Kami mengharapkan untuk terbitan bulan berikutnya Staff Pengajar dapat meningkatkan kualitas maupun mutu dari tulisan, sehingga memungkinkan sebagai bahan rujukan dalam melakukan kegiatan penelitian atau karya ilmiah lainnya.

Hal ini juga tidak menutup kemungkinan bagi mahasiswa yang telah melakukan kegiatan penelitian atau kegiatan ilmiah untuk dapat berperan serta dalam mengirimkan tulisannya pada redaksi.

Pada kesempatan ini Redaksi juga mengucapkan Selamat Hari Raya Idul Fitri 1420 H ***"Minal Aidin Walfa Izin Mohon Maaf Lahir dan Bathin"***.

Wabillahi Taufiq Walhidayah
Wassalamu'alaikum Wr. Wb.

Redaksi

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"THE EFFECT OF HEAT TREATMENT ON MICROSTRUCTURE AND ON TENSILE PROPERTIES OF Ti-29Nb-13Ta-4.6Zr Alloy"

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ABSTRACT

The usefulness of β Type titanium alloy in light weight structures is enhanced by the slow rate of transformation of β phase that enables mechanical processing in β state and control of subsequent strengthening processes by phase transformation.

The structural and mechanical property changes in the β type titanium alloy, Ti-29Nb-13Ta-4.6Zr, after cold rolled, solution treatment and then aging were investigated. The alloys conducted with some heat treatments offer suitable tensile properties as implant materials. The tensile strength and elongation of designed alloys in this study are equivalent or greater comparing with reported values reported as implant materials.

Key Word : *Titanium Alloys, Cold Working, Solution Treatment and aging, Microstructure and Mechanical Properties.*

INTRODUCTION

Titanium and it's alloys have high corrosion resistance, good mechanical properties, high strength and low densities compared to steel. Therefore they are excellent candidates for high performance application. Until recently the titanium market has been limited to high tech/high price market segments such as military, medical and chemical industry [1].

They are used for aerospace applications such as steam-turbine blades, hydrogen storage media, desalination, etc.; biological applications such as dental, implant material, etc. Which apparently provide them to be a third largest of commercial alloys in the word. Based upon the present phases, they can be divided into 3 major class ; α, α + β and β alloys. In further details, near α (lean β) type alloys exist between α and α + β type alloys, and near β (β-rich) type alloys between α + β type alloys [1,2].

The possibility to substitute the hard tissue instrumentations like artificial bone, artificial teeth and dental implants for functionally disordered hard tissues like bone and teeth is growing recently with increasing the population of over 65 years old person and bedridden old person. In general, α + β type titanium alloys such as Ti-6Al-4V ELI, Ti-6Al-7Nb and Ti-5Al-2.5Fe alloy have been widly used as surgical implant materials. Becouse of their excellent combination of biocompatibility, corrosion resistance and mechanical properties.

Howefer, toxicity of alloying elements and high moduli of elasticity compared with bone of these alloys have been point out.

From point of view of modulus of elaticity, β type titanium alloys with low modulus of elasticity have a greater advantage.

New β type titanium alloys composed of non-toxic elements such as Nb, Ta and Zr [3] with lower modulus of elasticity, greater strength and greater corrosion resistance were designed in this study.

The designed alloys were melted by tri-arc furnace in the laboratory in this study. The tensile test were conducted at room temperature in order to investigate the basic mechanical properties of the designed alloys [4,5,6].

The purpose of this paper is to present results of the investigation of the effect solution treatment and ware aging on microstructures and the resulting effect on tensile properties of Ti-29Nb-13Ta-4.6Zr.

EXPERIMENTAL PROCEDURES

Alloy Processing

The designed alloy button shaped ingot with 45 gr were melted using a tri-arc furnace from appropriate mixtures of sponge Ti and alloying elements such as Nb, Ta and Zr. Nb, Ta and Zr are non-toxic element [3]. There are some difficulties to produce homogeneous ingots of designed alloys becouse Ta, Nb, and Zr are higher melting point elements, and their density is greater than that of titanium. Therefor, the firstly melted button-shape ingots were cut into four pieces, and then they were remelted. The button-shape ingots with 45 gr were homogenized at 1273 K for 21.6 ks, and were then cold rolled by a reduction of 75 % heat treatment process of designed alloys in this study are shown in Fig.1.

The designed alloy was solutionized at 1117 K for 1.8 ks after homogenization, and then was aged at 673, 723 and 773 K for 10.8 ks, respectively. Heating and cooling process were carried out in argon atmosphere.

Tensile Test and Microstructure Observation

Several tensile test specimens with the size of 56 mm x 12 mm x 1.5 mm were machined from ingot sample of designed alloys geometry of the tensile test speciment is shown in Fig.2. Each tensile test speciment was finished using a op-s solution before testing. The tensile tests were conducted at room temperature using an Instron type mechined at a cross head speed of 8.33×10^{-6} ms^{-1} in order to investigate the basic mechanical properties of designed alloys. Ultimate tensile strength, 0.2 % yield strength, and elongation were determined .

After evaluation of mechanical properties the specimen were eched with a solution containing hydrofluoric acid : HF (3 - 2 cm^3), nitric acid : HNO_3 (20 cm^3) and H_2O (77-78 cm^3) to reveal the microstructure of designed alloy was characterized using a light microscope. Moduli of elasticity of designed alloys were measured using a piezoelectric composite-bar method.

RESULTS AND DISCUSSION

Aging curves of Ti-29Nb-13Ta-4.6Zr alloys aged at 673, 723 and 773 K are shown in Fig. 3. Vickers hardness of Ti-29Nb-13Ta-4.6Zr alloys aged at 673 K is greater comparing with that of other aging temperature.

After aging vickers harness of Ti-29Nb-13Ta-4.6Zr alloys were decreasing aging temperature. It has been reported that the aging characteristics of β type titanium alloys can be divided in to 3 types. Kawabe has been reported that the aging characteristics can be divided by stabilization of β phase. The stabilization of β phase can be evaluated by Mo equival (equation 1). Vickers hardness of low β stabilization alloy (Mo equival is 5 ~10%) such as Ti-10V-2Fe-3Al is increase at 573~673K. Middle β stabilization alloy (Mo equival is about 12%) such as Ti-15Mo-5Zr has two aging peak (573~673K and 673~773K).

Vickers hardness of high β stabilization alloy (Mo equival is about 16%) such as Ti-3Al-8V-6Cr-4Mo-4Zr is increase in high temperature region and need long time to hardning.

In general, it is known that ω phase precipitates at lower temperature aging in β type titanium alloys with low and middle β stabilization. ω phase is more brittle phase. Hardness is increase with increasing ω phase precipitation. Mo equival of Ti-29Nb-13Ta-4.6Zr alloy is about 11 %. Ti-29Nb-13Ta-4.6Zr alloy is, middle β stabilization alloy. Therefore, the precipitation of ω phase will causes an increase in vikers hardness of Ti-29Nb-13Ta-4.6Zr alloy at low aging temperature is shown in Fig. 3. In high aging temperature, Vickers hardness maybe increase with increasing aging time.

Tensile strength, 0,2 % proof stress, elongation and modulus of elasticity are shown in Fig.4. Tensile strength and 0.2 % proof stress aged at 673 K for 10.8 ks are greater comparing with those of other aging condition. Tensile strength and 0.2 % proof stress are, however, decrease with increasing aging temperature. While, elongation is increase with increasing aging temperature. In aged condition, the precipitation of ω phase will causes an increase in tensile strength and decrease in elongation of Ti-29Nb-13Ta-4.6Zr alloy at low aging temperature. The tensile strength and elongation of Ti-29Nb-13Ta-4.6Zr alloy are in particular, equivalent or greater comparing with those of existing titanium alloys for implant materials.

Light micrograph of Ti-29Nb-13Ta-4.6Zr after solution treatment is shown in Figure 5. Average β grain size is about 23 μ m. Precipitation of α phase is decreace with increasing aging temperature, After aging at 773 K for 10.8 ks, α phase precipitated in to β grain boundary. Therefore, tensile strength is lower comparing with that of other aging temperature.

CONCLUTION

1. Tensile strength and elongation of Ti-29Nb-13Ta-4.6Zr alloy are equivalent or greater comparing with those of typical conventional titanium alloys for implant materials.
2. Young's moduli of the designed alloys are much lower comparing with that of Ti-6Al-4V ELI which has been, in general, used for an implant materials.
3. β type titanium alloys, Ti-Nb-Ta-Zr, Ti-Nb-Ta-Mo and Ti-Nb-Ta-Sn system alloys designed in this study are expected to have greater performance for implant materials.
4. Tensile ductility is strongly dependent upon the grain size and the aged structure.

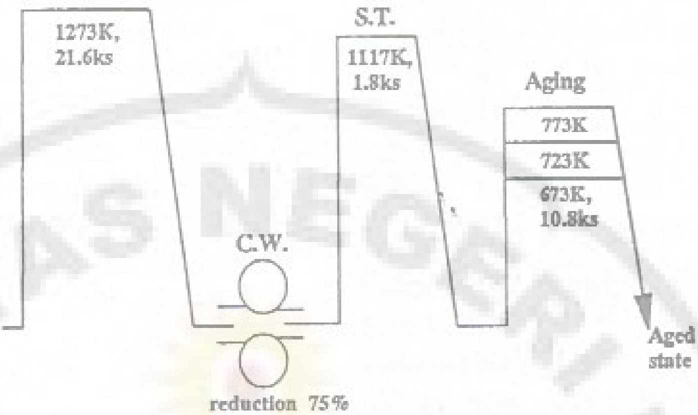

Fig.1 Schematic drawing of heat treatment process in designed alloys.
S.T.:solution-treatment , C.W. : cold-working

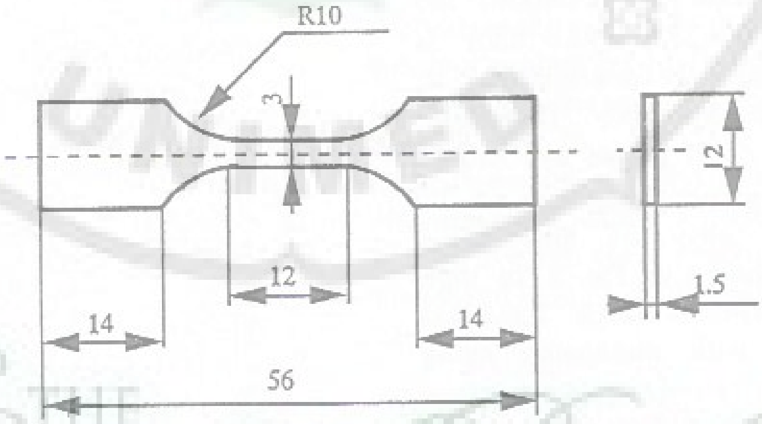

Fig.2 Geometry of tensile specimen in mm.

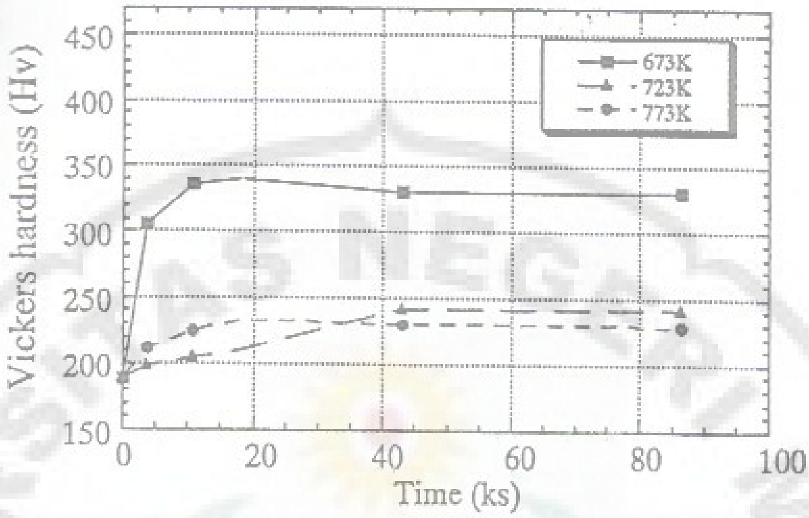

Fig.3 Hardness curve of Ti-29Nb-13Ta-4.6Zr alloy solutionized at 1117K for 1.8Ks and aged at 673,723 or 773K.

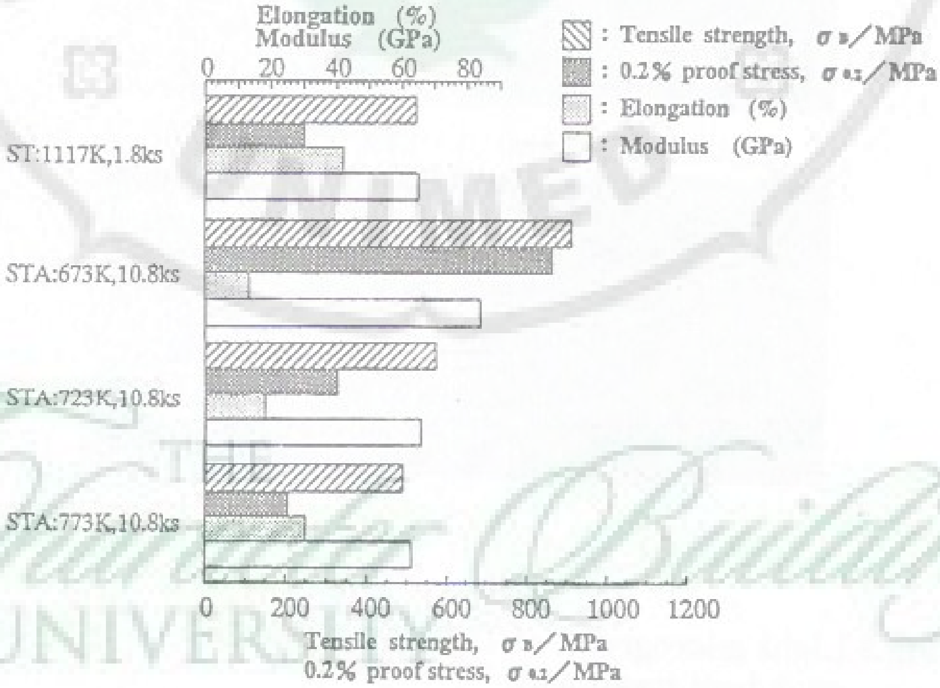

Fig.4 Comparision of the mechanical properties in Ti-29Nb-13Ta-4.6Zr alloy.

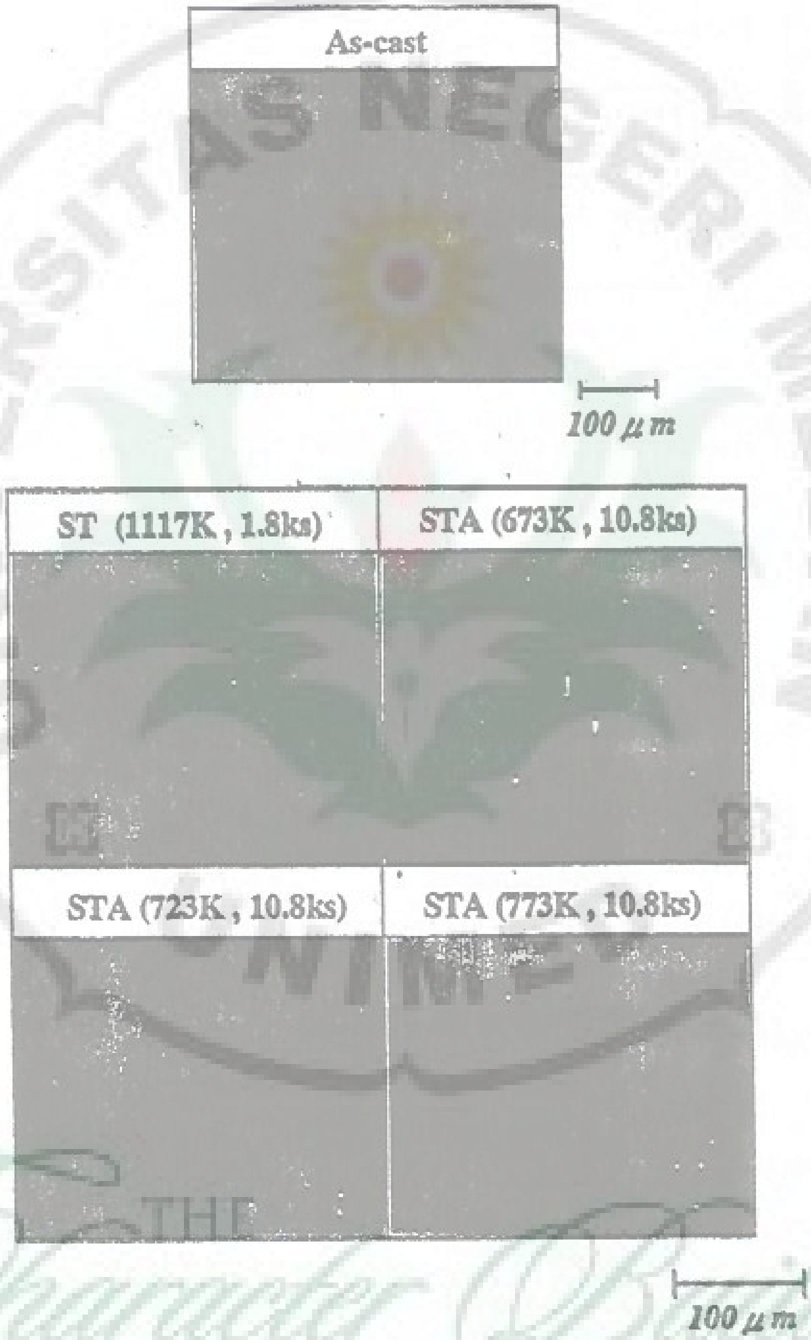

Fig.5 Light micrograph of Ti-29Nb-13Ta-4.6Zr alloy after each heat treatment.

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