A STUDY ON MECHANICAL PROPERTIES OF TITANIUM ALLOY THROUGH HEAT TREAMENT PROCESS

Prashanth Kumar[1], Md.Faizan Kazi[2], Rahul[3], Abhishek[4], Avinash.S[5] School of Mechanical Engineering, REVA university, Bengaluru, India : avinash.s@reva.edu.in

Abstract
In this work, an attempt was made to understand the effect of heat treatment on the mechanical properties and micro structure changes of Ti-6Al-4V alloy. This alloy was subjected to heat tretment process at the temperature of 900^0C for a duration raning from 1hr to 6hrs followed by air cooling. Room temperature tensile tests were carried out up to failure at the strain rate $1x10^3$s-1. Vickers hardness of the as-received and heat-treated Ti-6Al-4V alloy was measured using the load of 500g for the dwell time of 10sec. Microscostructure examinations were made using optical microscopy, which revealed morphological changes.

Keywords: *Ti-6Al-4V alloy, Microsturture, Mechanical Testing and Heat-Treatment.*

1. Introduction

Development of titanium aluminide (Ti-Al) based alloys has generated a huge interest for many high temperature industrial applications due to their extensive properties. Metastable β titanium alloys are widely used in the biomedical, automotive, and aerospace industry, due to their excellent corrosion resistance, fatigue strength, biocompatibility, and easy formability[1]. In literature research, it has been found that heat treatment types such as cryogenic treatment and precipitation hardening can be applied efficiently to the alloys. Titanium is an exotic metal that possesses a unique combination of mechanical, chemical, and physical properties[2]. Titanium is element number 22 on the periodic table. It is a metal that's silver in colour, found naturally on earth. Titanium alloys are alloys that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness [3]. Titanium alloy are classified as alpha titanium, beta titanium, or alpha-beta titanium. We will be conducting experiments on Ti (grade 5) and study/analyze the behavior of Titanium[4].

2. Method & Material

2.1 Material selection and sample preparation

The raw material received experimental metal was procured in the form of a plate. The dimension of the plate are 300mmx150mmx14mm. The chemical composition of the material are given in the Table1. The material used for the experiment is shown in the Fig 1. And the samples for the tensile test and compression test are cut in the dimension as shown in the Fig 2(b) & Fig 2(c) respectively.

Fig. 1. Titanium (Ti-6Al-4v);

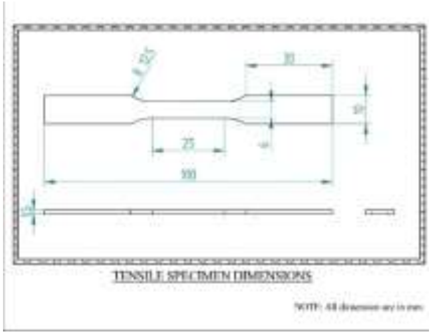

Fig 2(a). Tensile dimension

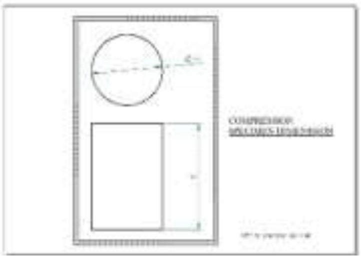

Fig 2(b). Compression dimension

Table 1. Chemical composition of Titanium alloy.

Chemical Composition	Wt. %
Titanium (Ti)	89.37
Aluminum (Al)	6.00
Vanadium (V)	4.19

2.2 Heat treatment and microstructure

Fig 3. Electric furnace

Fig 4. Metallurgical microscope

The samples were heated at the temperature of 900°C using electric furnace shown in Fig 3. And the samples were heated at different time intervals (1hr, 2hr, 4hr, and 6hr) to achieve different conditions. The microstructures are observed using olympus bx53m upright metallurgical microscope shown in Fig 4. For all the samples including as received, heat treated, and tensile samples.

2.3 Mechanical properties testing

Room temperature tensile test for the heat treated material was conducted at constant displacement using FSA M-100 universal testing machine shown in Fig 6 and the compression test of the heat treated material was conducted using the same conditions and the UTM. The Vickers hardness test of the heat treated material and the Vickers hardness test of the tensile samples were conducted at room temperature using Wilson vh1102 micro-hardness tester shown in Fig 5. The test was conducted using 500g load and the dwelling time of 10s with a spacing interval of 2mm.

Fig. 5. Micro-hardness tester

3. Results and Discussions

3.1 Microstructure observation

As mentioned above four heat treatment procedure were chosen for the material i.e., at 900°C for 1 hour, 2 hour, 4 hour, and 6 hour followed by air cooling. After the heat treatment the microstructure of the titanium alloy was observed using the Optical Metallurgical Microscope at 50 µm. comparisons of the microstructure of the material before the heat treatment and after the heat treatment were made and the microstructure of the material can be seen in the Fig 7 below.

Fig 6(a). Microstructure of as received

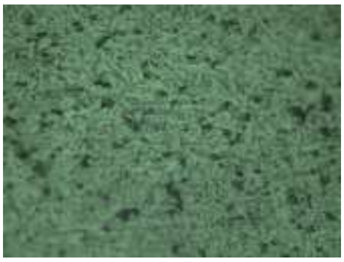

Fig 6(b). Microstructure of 1 hr

Fig 6(c). Microstructure of 2 hr

Fig. 6(d). Microstructure of 4 h

Fig 6(e). Microstructure of 6 hr

3.2 TENSILE TEST

Tensile test was carried out for all the material before and after heat treatment of the material and the results were compared. Fig 8. shows the graph of the tensile test.

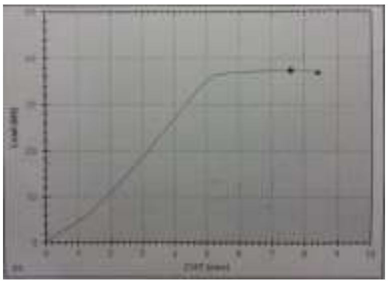

Fig. 7. Tensile strength of material

3.2 Hardness Test

Hardness test was carried out for all the material before and after heat treatment of the material and the results were compared. Fig 10. shows the graph of the hardness test.

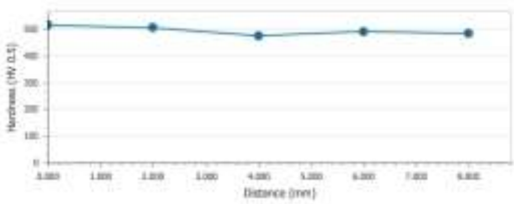

Fig. 8. Impact strength of composites

4. Conclusions

The mechanical properties of water immersed specimens were evaluated and compared with dry composite specimens. The percentage of moisture uptake increased as the fiber volume fraction increased due to the high cellulose content. The addition of fibers in the epoxy significantly increased the mechanical properties (tensile, flexural, impact, and hardness) of the specimen. However, calotropis procera fibers are hydrophilic in nature and hence have a poor resistance to water absorption. The water absorption of calotropis procera reinforced epoxy composite at room temperature was found to increase with increase in fiber content. Exposure to moisture caused a reduction in mechanical properties of the specimen. A possible explanation for this would be that bonding at the fiber-matrix interface is degraded as a result of water absorption.

References

[1] L.R. Kanyane, A.P.I Popoola, S. Pityana, M. Tlotleng, “Heat-Treatment effect on anti-corrosion behaviour and Tribological properties of LENS In-situ Synthesized Titanium Aluminide”, International Journal of Lightweight Materials and Manufacture. 15 Oct. 2021 2.

[2] D. Mpumlwana , V. Msomi, and C. J. S. Fourie “Effect of Heat Treatment on the Mechanical Properties of a 3 mm Commercially Pure Titanium Plate (CP-Ti Grade 2)”, Hindawi Journal of Engineering. 2 Dec 2020 3.

[3] Cong Li, Like Qin, Ming Li, Hui Xiao, Qi Wang, Jian Chen “Influence of deformation strain rate on the mechanical response in a metastable b titanium alloy with various microstructures”, Journal of Alloys and Compounds. 28 Apr 2019

[4] Nihal Yumak, Kubilay Aslantas, “A review on heat treatment efficiency in metastable b titanium alloys: the role of treatment process and parameters”, Journal of material research and technology 2020. 17 Jul. 2020

[5] Gurmail Singh, Niraj Bala,and Yogesh Kumar Singla (2021) Hot corrosion behavior of HVOF-sprayed carbide based composite coatings for boiler steel in Na2SO4–60 % V2O5 environment at 900 °C under cyclic conditions, 14-18.

