TENSILE DEFORMATION CHARACTERISTICS OF Ti-6Al-4V (ELI GRADE) AND EFFECT OF INTERSTITIAL CONTENT

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ABSTRACT

Anisotropy in tensile deformation of the Ti-6Al-4V (Ti-31) and Ti-6Al-4V extra low interstitials (ELI grade) was investigated and effect of interstitial on tensile deformation was discussed. Also reported in brief the details of chemical composition, microstructure of Ti-6Al-4V (ELI grade). The study reveals the tensile strength is more in circumferential direction than radial direction for Ti-6Al-4V (ELI grade) and due low extra interstitials the strength of alloy decreases.

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1. INTRODUCTION

Ti-6Al-4V is the most widely used alloy of all the $\alpha + \beta$ titanium compositions. The aluminum stabilizes and strengthens the alpha phase, so raising the β – transus temperature as well as reducing the density of alloy. The vanadium is β stabilizer, which leads to a greater amount of the more ductile β phase during hot working. It may be heat treated to a range of strength levels and in its fully aged condition, is successfully used in highly stressed welded structures. However, in the maximum strength conditions, careful attention must be given to the fracture toughness in a design of highly stressed parts. Harden ability is limited and fracture toughness is

poor at low temperatures. Low temperature applications should employ the extra low interstitial (ELI) grades. The alloy exhibits some susceptibility to environment – assisted cracking in halide containing aqueous environments and in hydrogen. Improved properties are obtained by using ELI grade. Titanium alloy Ti-6Al-4V (ELI grade) material is selected for its fabrication due to high strength to weight ratio, high corrosion resistance, and good fracture toughness to yield strength ratio and well established welding technology for this material. Ti-6Al-4V ELI grade is similar to Ti-6Al-4V, except that Ti-6Al-4V ELI grade contains reduced levels of oxygen, nitrogen, carbon and Iron. This alloy is stable up to 400°C and at the same time having a high damage tolerance (K_{IC}) especially at cryogenic temperature. $\alpha + \beta$ alloys containing aluminum have substantially greater strength than either α alloys containing Al or aluminum free $\alpha + \beta$ alloys[2]

2. CHEMICAL COMPOSITION

Table 1 Presented the chemical composition of Ti-6Al-4V (ELI grade).

Alloying Elements	Al	V	Fe	O ₂	C	N ₂	H ₂	Others	Ti
% weight	5.57	4.07	0.05	0.026	0.045	0.012	0.0017	0.107	90.03
Table1 : Chemical composition of Ti-6Al-4V (ELI grade)									

3. MICROSTRUCTURE

Microstructure analysis for specimen prepared from forged bar is carried at magnifications 200X and 500X & shall be exhibits that structure resulting from processing within the alpha-beta field.

Figure.1 AIR COOLED 200X

Figure.2 AIR COOLED 500X

Figure.2. SALT BATH 200X

Figure.2. SALT BATH 500X

WATER QUENCHED 200X

WATER QUENCHED 500X

Equi-axed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior grain boundaries. The shapes of the primary alpha grains are a mixture of equiaxed and elongated one. Primary alpha grains with high aspect ratio are also observed at some locations. The microstructure results for Ti-6Al-4V are shown in the table.

S. No	Quenching media	Average hardness value (HV)	ASTM grain size number	Grain diameter in microns
1	Water	261.5	7.09	31.5
2	Brine	256	6.07	45
3	Oil	257.3	6.1	44.5
4	Air	247.7	6.46	53
Table.2 : Microstructure results				

3.1. Tensile Deformation Behavior

Six Nos. of Test tensile specimens (2 each for circumferential and radial) are tested for tensile properties of the alloys Ti-6Al-4V (ELI grade) and Ti-6Al-4V to study the anisotropy in tensile deformations and to compare the tensile deformation of Ti-6Al-4V (ELI grade) with Ti-6Al-4V. Tensile tests were carried out on Instron 5500-4507-200KN. The properties evaluated include the 0.2% yield stress (YS), the ultimate tensile stress (UTS), % elongation and uniform strain.

3.2. Tensile deformation Behavior of Ti-6Al-4V (ELI grade) and its Directionality

Table3 shows the tensile test results obtained for Ti-6Al-4V (ELI grade) alloy.

The Ti-6Al-4V (ELI grade) alloy exhibits the significant anisotropy in tensile properties. From the fig.9 and fig10, it is observed that the Ultimate tensile stress (UTS) and 0.2% yield stress values are more in circumferential directions than radial directions.

SAMPLE	0.2% Y.S (MPa)	UTS(MPa)	e _u	% EL
C-1	838	876	0.088	16
C-2	776	870	0.083	15
R-1	762	847	0.089	12
R-2	816	858	0.085	13

Table3: TENSILE PROPERTIES OF Ti-6Al-4V(ELI Grade)

Figure.9: Sample - Ti-6Al-4V (ELI grade)

Figure. 10: Sample Ti-6Al-4V (ELI grade)

3.3. Tensile deformation Behavior of Ti-6Al-4V (Ti-31)

Table4 shows the tensile test results obtained for Ti-6Al-4V alloy.

SAMPLE	0.2% Y.S (MPa)	UTS(MPa)	% EL
C-7	842	930	15.5
C-8	824	914	15.1
R-5	857	941	14.9
R-6	823	915	14.5
Table 4 : TENSILE PROPERTIES OF Ti-6Al-4V (Ti-31)			

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Figure. 15: SAMPLE Ti-6Al-4V (Ti-31)

Figure 16 SAMPLES - Ti-6Al-4V (Ti-31)

3.4. Comparison of Tensile Deformation of Ti-6Al-4V (ELI grade) with Ti-6Al-4V (Ti-31)

Figure.19 shows the comparison of ultimate tensile stress values of Ti-6Al-4V (ELI grade) with Ti-6Al-4V in both circumferential and radial directions. Fig.20 shows the comparison of 0.2% Yield stress of Ti-6Al-4V (ELI grade) with Ti-6Al-4V both circumferential and radial directions. Fig.21 shows the comparison of % elongation of Ti-6Al-4V (ELI grade) with Ti-6Al-4V both circumferential and radial directions. The ultimate tensile stress (UTS) and 0.2% yield stress in both the directions for Ti-6Al-4V (ELI grade) is less than the Ti-6Al-4V. Due to extra low interstitials grain size increases which leads to decrease in strength.

Figure19: Comparison UTS between Ti-6Al-4V(ELI grade) Vs. Ti-31

Figure. 20: Comparison 0.2% YS between Ti-6Al-4V(ELI grade) Vs. Ti-31

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Figure.21 % Elongation between Ti-6Al-4V (ELI grade) Vs. Ti-31

4. CONCLUSIONS

- Ti-6Al-4V (ELI grade) having the more strength in circumferential direction than the radial direction
- The strength of Ti-6Al-4V (ELI grade) contains less strength than the Ti-6Al-4V.
- It reveals that Extra low interstitials causes the decrease in strength of alloy.

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