

Titanium Alloy Presentation Outline

Purpose: to inform the audience of the Ti-6Al-4V ELI titanium alloy, and the medical application.

- I. Introduction:

Of the very numerous applications, Ti 6Al-4V ELI may be considered in any biomedical application, particularly for implantable components. Some typical applications where this alloy has been used successfully include joint replacements, bone fixation devices, surgical clips, and cryogenic vessels. The product that we chose to focus on is a screw used in back surgery.
- II. Product
 - A. Medical application
 1. Back Surgery
 2. Foot correction
 - B. Background
 1. In 1970's interest in Ti-6Al-4V ELI grew due to favorable conditions
 2. Why is it used?
 - a. Corrosion resistance
 - b. Strength
 3. Other Uses
 - c. Aircraft
 - d. High temperature applications
- III. Material Properties
 - A. Mechanical Properties
 1. Tensile strength/120 ksi
 2. Modulus of Elasticity is 15.2×10^3 ksi
 3. Ultimate Bearing strength is 200-300 ksi
 4. Compressive Yield Strength 120-130 ksi
 5. Ultimate Shear Strength 70-100 ksi
 - B. Density
 1. Density- 4.43g/cm^3
 2. Important so that the screw will not break
 - C. Corrosion Resistance
 1. Ti 6Al-4V ELI
 - a. Immediately forms stable, continuous, tightly adherent oxide film upon exposure to oxygen
 - b. This alloy is highly resistant to general corrosion in most aqueous solutions, oxidizing acids, chlorides, and alkalis.
 2. Important characteristic to be in the human body
 - D. Stress Corrosion

1. Stress corrosion cracking associated with exposure to halide ions at elevated temperatures
2. General practice to avoid chlorinated solvents in processing titanium.

E. Hardness Values

1. Brinell-334
2. Knoop-363
3. R_a -68.5
4. R_c -36

IV. Chemical Composition

A. Percent composition

1. Aluminum
 - a. 6.75%
 - b. The 6.75% is the 6 in Ti-6Al-4V ELI
 - c. To give strength and provide alpha stabilizers.
2. Titanium
 - a. 91.0%
 - b. Main ingredient / solvent
3. Vanadium
 - a. 4.50%
 - b. The 4.50% is the 4 in Ti-6Al-4V
 - c. So that the product is more wear resistance
 - d. To give toughness and improved formability/ to provide beta stabilizers.
4. Impurities
 1. Do not want more than the maximum amount given.
 - a. Carbon- 0.0800% max
 - b. Hydrogen- 0.0150% max
 - c. Iron- 0.400% max
 - d. Nitrogen- 0.300% max
 - e. Oxygen- 0.200% max

B. Alpha, Beta, and Alpha/Beta

1. Alpha
 - a. Alpha stabilizers such as aluminum, tin, oxygen
 - b. All-Alpha alloys not heat treatable/only strengthened by cold working, control grain size
 - c. All- Alpha used gas turbine casings/ ELI alloys useful for high pressure cryogenic applications.
 - d. Near- Alpha alloys useful for aircraft skins
2. Beta
 - a. Thermodynamically unstable

- b. Generally high strength, toughness, and improved formability
- c. Heat treatable to very high strengths
- d. Used in high strength aircraft frames, fasteners, springs, pipes, and commercial consumer products

3. Alpha/Beta

- a. Contains 10 -50 % beta phase microstructures
- b. Can be heat treated
- c. Two types “lean” and “rich”
- d. “lean” = moderately heat treatable and weldable
- e. “rich” = most difficult to weld, great hardenability
- f. Ti-6Al-4V ELI is classified under Alpha-Beta “rich”.

V. Manufacturing Processes

A. Heat treat

- 1. Used in either mill annealed, beta annealed or re-crystallization annealed condition
- 2. Used to maximize strength for applications such as total joint replacements.
- 3. Beta annealed results in a completely transformed structure, used to maximize damage tolerance.
- 4. Intermediate/final annealing of Ti 6Al-4V ELI is performed in vacuum/inert gas atmosphere to avoid alpha case formation and associated material loss.

B. [Video] clip about Titanium manufacturing process

- 1. Goes through how titanium is made/manufacturing
- 2. Explains other applications

VI. Conclusion

There is a wide range of applications for the titanium alloy The titanium alloy Ti-6Al-4V is known as the “workhorse” of the titanium industry because it is by far the most common Ti alloy, accounting for more than 50 % of total titanium usage. It can be used to transport you across the ocean, or to help make your life healthier by correcting your back posture.