



UNIT IV FERROUS AND NON FERROUS METALS

Titanium (Ti) Alloys

Engineering Materials and Metallurgy

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TITANIUM AND ITS ALLOYS

Titanium is named after the *Titans*, the powerful sons of the earth in Greek mythology.

- Titanium is the *forth abundant metal* on earth crust (~ 0.86%) after aluminium, iron and magnesium.
- Not found in its free, pure metal form in nature but as *oxides*, i.e., ilmenite ($FeTiO_3$) and rutile (TiO_2).
- Found only in small amount in Thailand.



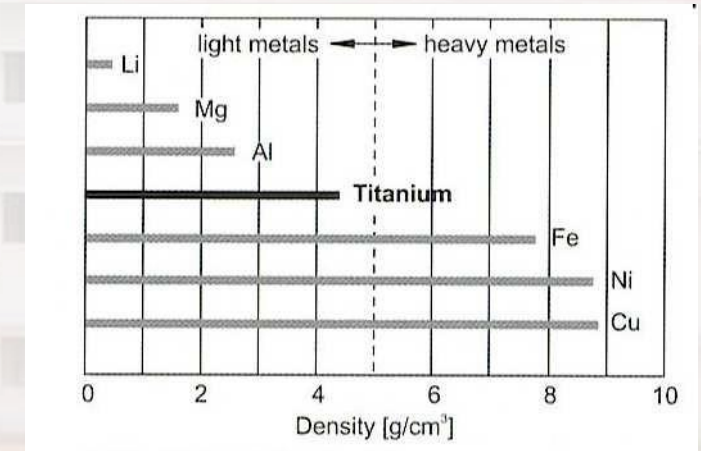
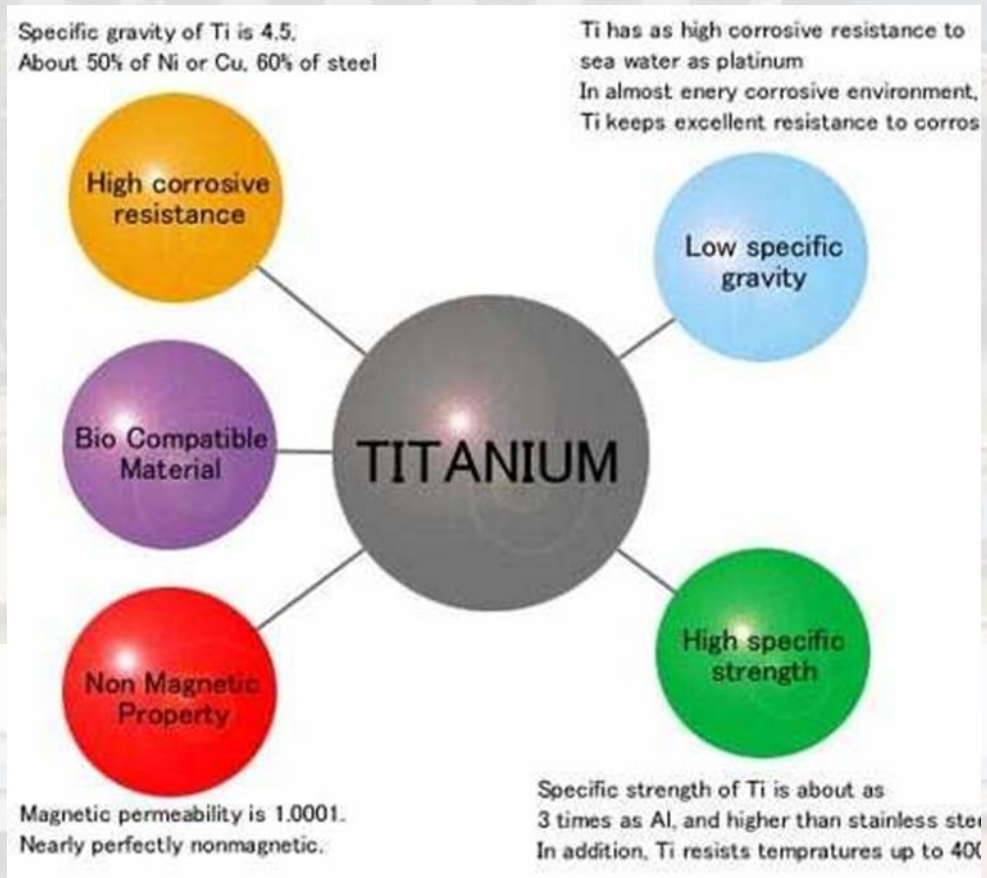
Atlas, c. 460 BC. Photo © Maicar Förlag - GML

- Have similar *strength as steel* but with a *weight nearly half of steel*.

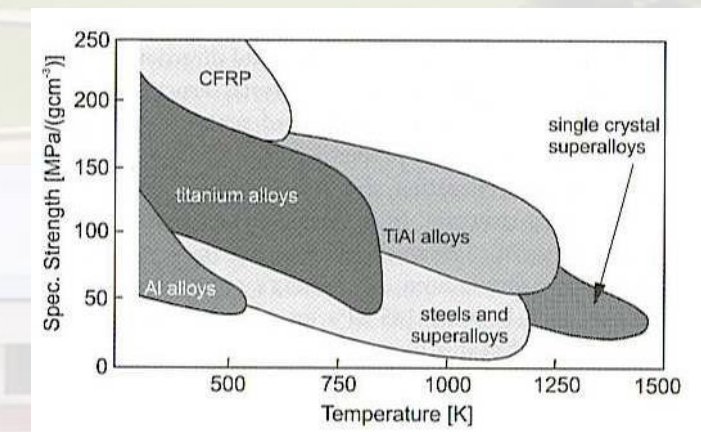




ADVANTAGES OF TITANIUM ALLOYS



Density of selected metals



Specific strength vs temperature



APPLICATIONS OF TITANIUM ALLOYS



- Used mainly in aerospace, marine, chemical, biomedical applications and sports.



Turbine blades



National science centre, Scotland



Titanium clad Guggenheim Bilbao museum, Spain at sunset.



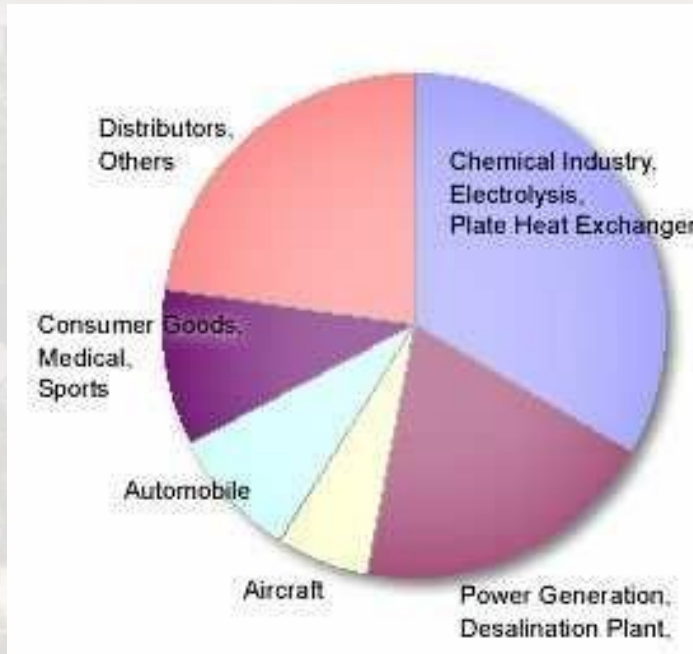
Hip-joint component



Shape memory alloy



Applications of Titanium alloys



AEROSPACE

- Civil
- Military
- Space

MEDICAL

- Orthopaedic Implants
- Bone Screws
- Trauma Plates
- Dental Fixtures
- Surgical Instruments

INDUSTRIAL

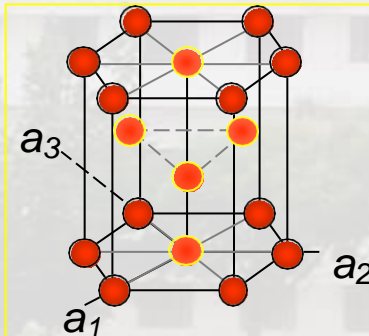
- Petrochemical
- Offshore
- Subsea
- Metal Finishing
- Pulp & Paper
- General Engineering

SPECIALIST

- Body Jewellery
- Ultrasonic Welding
- Motor Racing Components
- Marine
- Bicycle
- Sports Equipment

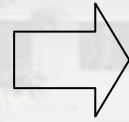


ALLOYING SYSTEM OF TITANIUM ALLOYS

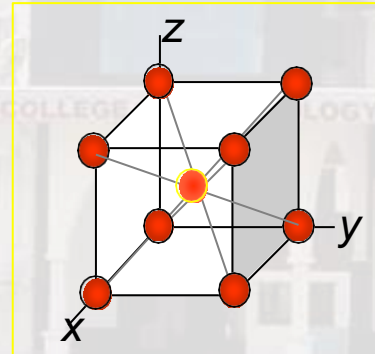


α phase
HCP structure

Allotropic
transformation



882.3 °C



β phase
BCC structure

Alloying elements

- Alpha stabilisers

Al, O, N

- Beta stabilisers

Isomorphous: Mo, V,
W, Nb, Ta.

Eutectoid: Fe, Cr,
Cu, Ni, Co, Mn.

- Neutral

Zr, Si, Sn



Classification of titanium alloys

- Commercially pure (CP) titanium alpha and near alpha titanium alloys
 - Generally non-heat treatable and weldable
 - Medium strength, good creep strength, good corrosion resistance
- Alpha-beta titanium alloys
 - Heat treatable, good forming properties
 - Medium to high strength, good creep strength
- Beta titanium alloys
 - Heat treatable and readily formable
 - Very high strength, low ductility



COMMERCIALY PURE (CP) TITANIUM AND ALPHA/NEAR ALPHA ALLOYS



Microstructure contains *HCP* \square phase and can be divided into;

- *Commercially pure titanium alloys*
- *Alpha titanium alloys*
- *Near alpha titanium alloys*

Characteristics:

- Non-heat treatable
- Weldable.
- Medium strength
- Good notch toughness
- Good creep resistance at high temperature.

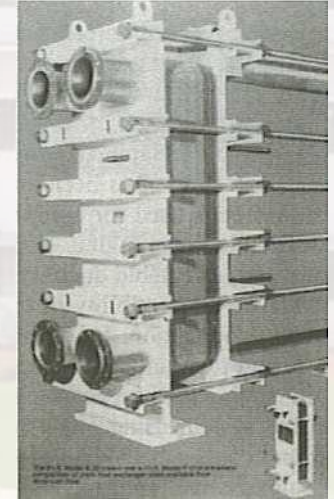


PROPERTIES AND TYPICAL APPLICATIONS OF COMMERCIAL PURE (CP) TITANIUM ALLOYS

Properties

- Lower strength, depending on contents of O , N .
- Corrosion resistance to nitric acid, moist chlorine.
- 0.2% Pd addition improves corrosion resistance in HCl , H_2SO_4 , H_3PO_4 .
- Less expensive

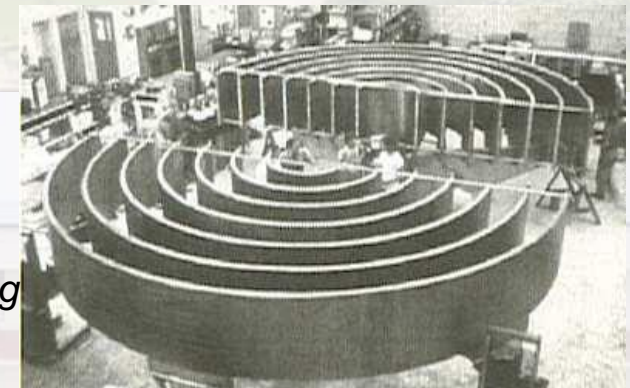
Plate and frame heat exchanger



Applications:

- Airframes, heat exchangers, chemicals, marine, surgical implants.

Large structure used in bleaching section of pulp and paper

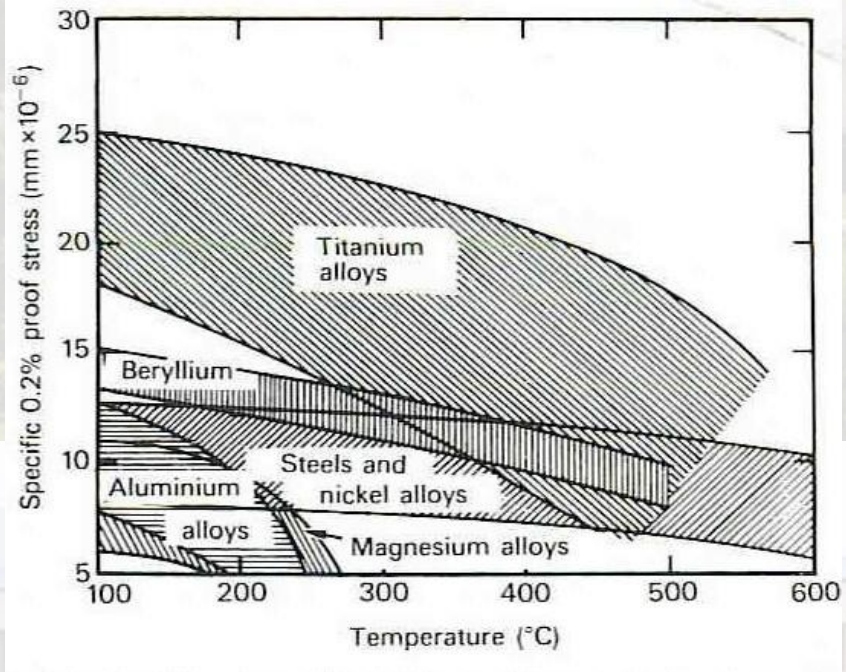




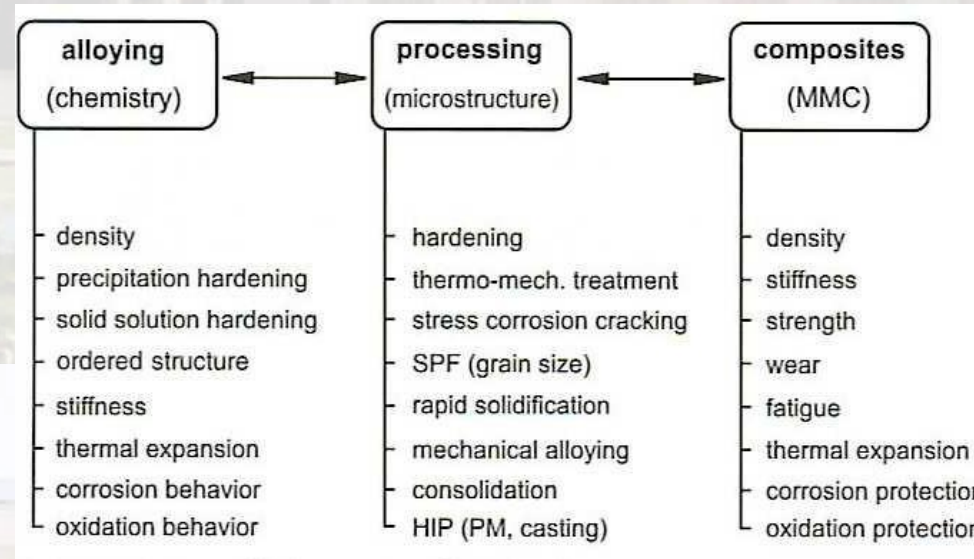
PROPERTIES OF TITANIUM ALLOYS

Material strength, creep resistance and fatigue properties are the main properties usually required for applications of titanium alloys.

- Titanium alloys provide superior specific yield strength (high strength to weight ratio) than other alloys.



Specific proof stress of various materials



Approaches to modify the properties of titanium alloys



THANK YOU