ARC Centre of Excellence Design in Light Metals

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Effects of Impurity Elements on Compaction Behaviour of Commercially Pure Titanium Powders

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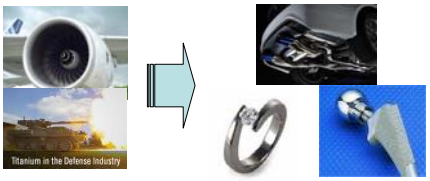
ABSTRACT

It is well known that the presence of impurity elements including oxygen, nitrogen and hydrogen in titanium bulk material affects the mechanical properties such as strength, ductility and hardness. However, the effect that these elements have on the behaviour of titanium powder has not been investigated. In this study, the compaction response of the powders containing various impurity levels of oxygen, nitrogen and hydrogen has been investigated.

BACKGROUND

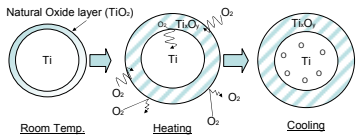
Titanium and Titanium alloys are attractive materials due to low density, high strength and good corrosion resistance. However, they are very expensive materials and difficult to manufacture to products due to titanium has a great affinity for oxygen. Thus, high production cost requires. As results, they were confined to high value applications such as aerospace and defense. However, They are now widely used for automotive, jewelry and medical implants.



Titanium Powder Metallurgy is one of the possibilities to avoid such high material cost, difficult fabrication and complicated process via near net shape components without the material loss, minimized machine operation and reduction of process steps.

Powder Kinetics – Oxidizing, Nitriding and Hydriding

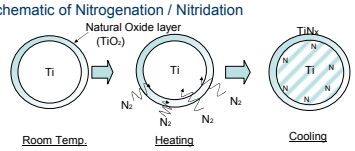
I. Schematic of Oxygenation / Oxidation



• Oxygenation = Ti + O

• Oxidation (Formation of oxide layers) = Ti_xO_y

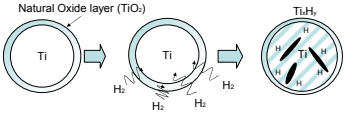
II. Schematic of Nitrogenation / Nitridation



•Nitrogenation = Ti + N

•Nitridation (Formation of nitride layers) = Ti_xN_y

III. Schematic of Hydrogenation / Hydride formation



• Hydrogenation = Ti + H

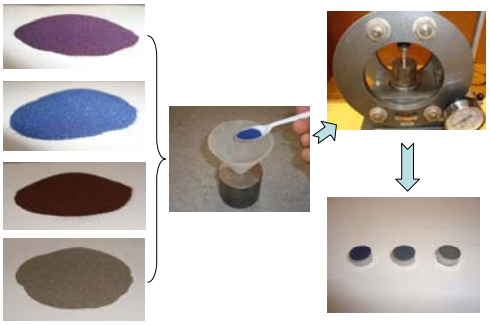
• Hydride formation = Ti_xH_y

OBJECTIVE

To investigate the compaction response of the powders containing various impurity levels

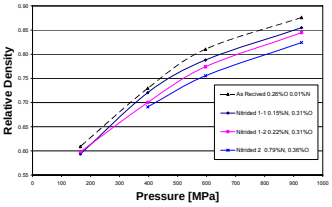
METHODS

- Introducing impurity elements into the powders
  - Oxygen: Muffle furnace in air
  - Nitrogen: Tube furnace under pure nitrogen gas
  - Hydrogen: Aging in evacuated capsule with TiH_2 pellet
- Powder Compacts
  - Steel Die & Uniaxial hydraulic compress
  - Compact Size: Φ=13.82mm, various thickness
  - Applied Pressures: 165,397,596 and 927 MPa

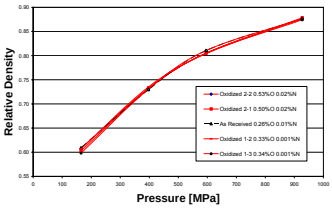


<The process of powder compacts>

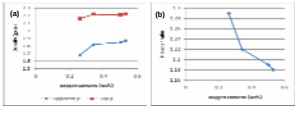
RESULTS



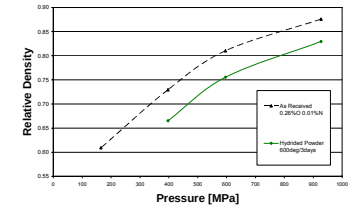
The effect of compaction pressure on the green density of nitrided powders



The effect of compaction pressure on the green density of oxidize powders



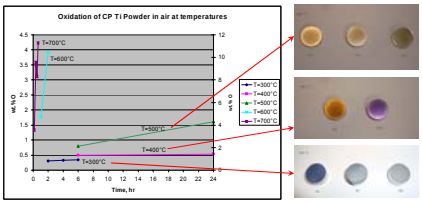
The effect of oxygen content on (a) the apparent and tap densities and (b) the Hausner ratio.



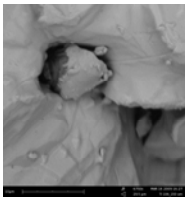
The effect of compaction pressure on the green density of hydrided powder

OBSERVATIONS

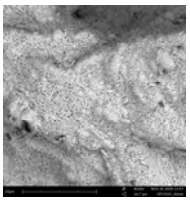
Color changes – oxidation of powders



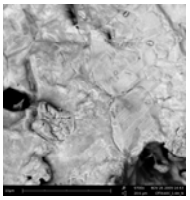
SEM Images



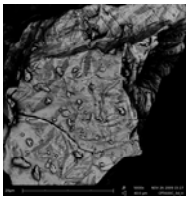
As-received powder surface



Oxidized powder surface (700°C/ 40min)



Nitrided powder surface (640°C / 1hr 40mins)



Hydrided powder surface (600°C/ 3days)

CONCLUSIONS

- Identified methods of introduction of impurity element into the Titanium powders.
- Understood the compaction behaviour (green density) of the powders containing various impurity levels (oxygen, nitrogen and hydrogen).
  - powders containing high levels of nitrogen have lower relative densities than those with lower nitrogen contents.
  - oxygenated powder compacts are not significantly different from the as received powder in terms of green density but there are significant changes to the flow properties of the materials.
  - hydrogenated powders indicates that hydrogen addition reduces the density consistently across all pressures.

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