Titanium Components for Aircraft, Medical and Industrial Applications by Powder Metal Manufacture

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Overview

• Introduction – Focus on Powder Technologies
• Processing Approach, Micros & Properties
• Overcoming Barriers to Use
• Specialty Materials
• Aircraft, Industrial, Medical
• Summary & Conclusions
The CHIP Process
Ti-6Al-4V Microstructure
(As Sintered)
Ti-6Al-4V Microstructure
CHIP Condition
# Tensile & Chemistry

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>UTS (ksi) min</th>
<th>YS (ksi) min</th>
<th>EL (%) min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrought Bar</td>
<td>130</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>Grade 5 AMS 4928 &amp; ASTM B348</td>
<td>130</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>Ti-6Al-4V CHIP</td>
<td>130</td>
<td>120</td>
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</tr>
</tbody>
</table>

**Chemical Analysis:** Meets Grade 5 chemistry for all alloy elements, interstitials and impurities, with exception of oxygen, slightly elevated compared to wrought specs.

**CHIP Materials** meets the minimum strength and ductility of Grade 5 bar without requiring hot work.
PM Buy-to Fly Examples
Manufacturability
Ti Mill & Wrought Products Forms

Extruded

Forged
THE Titanium User – Aerospace

• Increasing demand driven by
  • Compatibility with composites
  • Market dynamics

• Heightened interest in near-net shape technologies to reduce buy-to-fly

• Major barrier has been the significant qualification effort. This requires a mature process technology and aerospace quality system.
Qualification for Aerospace
(Presented at AeroMat2011)

The New Era of Titanium Manufacturing – Powder Metal Components
Industry Specification
Facilitates Wider Use of PM Ti

- ASTM B988-13 Standard Specification for Powder Metallurgy (PM) Titanium and Titanium Alloy Structural Components, Published May 2013
- Covers PM parts from
  - CP Ti Powder
  - Pre-alloyed powders
  - Elemental powders
ASTM Specification
Designation: B988 – 13

Compositions:
• Grades 1 - 4 - CP
• Grade 5 – Ti-6Al-4V
• Grade 9 – Ti-3Al-2.5V
• Ti-6Al-4V Low Interstitial (LI)
• Ti-6Al-6V-2Sn

Chemistry:
Elements, impurities same as wrought, except with higher \( O_2 \) (0.30 %max)

Tensile - Grades:
PM100: Equiv wrought
PM90: 90% wrought

Issued May 2013
PM-Enabled Specialty Alloys

- Development of titanium materials not readily produced by melt processes
  - Metal Matrix Composites
  - Novel alloying elements
PM-Enabled Specialty Alloys

- Abkolloy® family of PM titanium-tungsten near beta alloys
  - High Strength: Range from 150 ksi -200 ksi
  - Hardness: Range from 40-50 HRC
  - Wear Behavior: Significantly improved
Metal Matrix Composites

- CermeTi® Particle Reinforced Titanium Alloy
- Medical Applications
- Industrial Applications
Industrial Product Application:
CermeTi® Lined Shot Sleeves for Al Casting

- PM Ti MMC Liner Preform
- H13 Sleeve & End Caps
- High Pressure Cold Chamber Cross Sectional View
Summary

• Efficient processes for manufacturing of titanium components

• Innovative alloys with unique properties for new applications

• Recent breakthroughs in novel titanium material compositions for medical devices and Ti-6Al-4V for aircraft.
Conclusion

• New specifications and development of design allowables will lead to significant adoption of PM titanium in aerospace and other industries in the near and continued future.