Outline

- ATI 425® Alloy Introduction
- Cold-Rolled & Annealed Coil
  - Processing
  - Mechanical & Product Properties
- Cold-Rolled & Annealed Sheet/Coil Attributes
  - Quality Advantages
  - Manufacturing Advantages
  - Performance Advantages
- Summary
ATI 425® Alloy

INTRODUCTION
Overview

- An α/β titanium alloy that can be processed to a balance of properties comparable to Ti-6Al-4V
- Formulation utilizes higher O & Fe containing recycle streams
  - US Patent No. 5,980,655
- Specifications
  - AMS 6946B (Aerospace)
  - ASTM B265-08 (Grade 38)

<table>
<thead>
<tr>
<th>Element</th>
<th>Min (wt%)</th>
<th>Max (wt%)</th>
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<tbody>
<tr>
<td>Al</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>V</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Fe</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>O</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>C</td>
<td>--</td>
<td>0.08</td>
</tr>
<tr>
<td>N</td>
<td>--</td>
<td>0.03</td>
</tr>
<tr>
<td>H</td>
<td>--</td>
<td>0.015</td>
</tr>
<tr>
<td>Other (each)</td>
<td>--</td>
<td>0.10</td>
</tr>
<tr>
<td>Other (total)</td>
<td>--</td>
<td>0.30</td>
</tr>
<tr>
<td>Ti</td>
<td>balance</td>
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</table>
ATI 425<sup>®</sup> Alloy

CR&A COIL

PROCESS & PRODUCT
ATI 425® Alloy – Process Comparison
Continuous Coil vs. Pack Roll Sheet

ATI 425® Alloy - Revolutionary Titanium Alloy

Today's Industry Standard: Ti 6-4

Continuous Processing
High-Speed Production
Superior Yields

Labor Intensive
Non Productive
High Rejection Rate

J. E. Nordheim et al
US Patent 2,985,945
May 1961; Filed Feb 1954
ATI 425® Alloy Processing

Vacuum Melting → Hot Working → Cold Rolling → Anneal → CR&A → Coil → C-T-L → Sheet

AMS 6946: 0.020” → 0.156”
(0.5 to 4 mm)

EXPANDED GAUGE RANGE
0.002” → 0.187”
(0.05 mm → 4.75 mm)
Mechanical Properties

ATI 425® Alloy Sheet

Product comparable to Ti-6Al-4V pack rolled sheet

Data in MMPDS 2010 Handbook
(Approved April 2010)

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Mechanical Properties

ATI 425® Alloy Sheet

Product comparable to Ti-6Al-4V pack rolled sheet

Tensile Elongation

Data in MMPDS 2010 Handbook (Approved April 2010)

AMS 6946 Minimum

AMS 4911 Min

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ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

QUALITY MANUFACTURING PERFORMANCE
Quality Advantages

ATI 425® Alloy Sheet

Gauge Performance on Cold Rolled Coil

Commercial Tolerance

Precision Gauge Tolerance System leads to tight gauge control

Statistics

• # Coils: 5
• Mean: 0.0398”
• Std. Deviation
  • Coil-to-Coil: 4.6E-5”
  • Overall: 2.6E-4”

Gauge (mils)
## Quality Advantages

### ATI 425® Alloy Sheet

### Tight Gauge Tolerance Control

<table>
<thead>
<tr>
<th>Target Gauge (inch)</th>
<th># Coils</th>
<th>Data Points</th>
<th>Average (inch)</th>
<th>Standard Deviation</th>
<th>Standard Pack-Rolled (1/2) Tolerance</th>
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</thead>
<tbody>
<tr>
<td>0.078</td>
<td>5</td>
<td>1827</td>
<td>0.0771”</td>
<td>0.0004”</td>
<td>0.074-0.082”</td>
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<tr>
<td>0.040</td>
<td>5</td>
<td>24972</td>
<td>0.0398”</td>
<td>0.0003”</td>
<td>0.036-0.044”</td>
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<tr>
<td>0.030</td>
<td>3</td>
<td>1944</td>
<td>0.0295”</td>
<td>0.0008”</td>
<td>0.026-0.034”</td>
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<tr>
<td>0.020</td>
<td>2</td>
<td>468</td>
<td>0.0193”</td>
<td>.00001”</td>
<td>0.016-0.024”</td>
</tr>
</tbody>
</table>
Quality Advantages

Example: Aerospace Part at 0.180" gauge

Material: 0.180" x 48" x 144" Ti 6-4 Sheet

<table>
<thead>
<tr>
<th>Range</th>
<th>Gauge</th>
<th>Width</th>
<th>Length</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Maximum</td>
<td>0.192</td>
<td>48</td>
<td>144</td>
<td>212</td>
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<tr>
<td>Nominal</td>
<td>0.180</td>
<td>48</td>
<td>144</td>
<td>199</td>
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<tr>
<td>Minimum</td>
<td>0.168</td>
<td>48</td>
<td>144</td>
<td>186</td>
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</tbody>
</table>

Material: 0.180" x 48" x 144" ATI 425® Alloy Sheet

<table>
<thead>
<tr>
<th>Range</th>
<th>Gauge</th>
<th>Width</th>
<th>Length</th>
<th>Weight</th>
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<tr>
<td>Maximum</td>
<td>0.181</td>
<td>48</td>
<td>144</td>
<td>200</td>
</tr>
<tr>
<td>Nominal</td>
<td>0.180</td>
<td>48</td>
<td>144</td>
<td>199</td>
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<tr>
<td>Minimum</td>
<td>0.179</td>
<td>48</td>
<td>144</td>
<td>198</td>
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Material: 0.169" x 48" x 144" ATI 425® Alloy Sheet

<table>
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<th>Gauge</th>
<th>Width</th>
<th>Length</th>
<th>Weight</th>
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<tr>
<td>Maximum</td>
<td>0.170</td>
<td>48</td>
<td>144</td>
<td>188</td>
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<tr>
<td>Nominal</td>
<td>0.169</td>
<td>48</td>
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</tr>
<tr>
<td>Minimum</td>
<td>0.168</td>
<td>48</td>
<td>144</td>
<td>186</td>
</tr>
</tbody>
</table>

Average savings of 6-12 lb/piece (3 - 6%)

Average savings grow larger to 19-22 lb/piece (10 - 12%)
Quality Advantages

Improved Surface Finish

- Process delivers improved surface finish
  - No Grinding Required
    - Gauge Uniformity
  - Limited Pickling
  - Enhances Diffusion Bonding Process

ATI 425® Alloy Sheet

Courtesy of Aeromet Int. Plc
Quality Advantages

ATI 425® Alloy Sheet

“Endless” Sheet Lengths

- Coil instead of individual sheet
  - Monolithic parts, capability to reduce joints
  - Similar superior quality in each sheet
ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

QUALITY MANUFACTURING PERFORMANCE
Manufacturing Advantages ATI 425® Alloy Sheet

Distinctive Cold Formability

• ATI 425® Alloy offers better bending and spring-back Behavior than Ti 6-4

• Improves fabrication productivity

<table>
<thead>
<tr>
<th>GAUGE</th>
<th>DIRECTION</th>
<th>BEND</th>
<th>ANGLE</th>
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<tbody>
<tr>
<td>0.125&quot;</td>
<td>Long</td>
<td>2.5T</td>
<td>105°</td>
</tr>
<tr>
<td>(3.2 mm)</td>
<td>Trans</td>
<td>3.6T</td>
<td>105°</td>
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<tr>
<td>0.040&quot;</td>
<td>Long</td>
<td>2.2T</td>
<td>105°</td>
</tr>
<tr>
<td>(1 mm)</td>
<td>Trans</td>
<td>3.7T</td>
<td>105°</td>
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<tr>
<td>0.012&quot;</td>
<td>Long</td>
<td>0.83T</td>
<td>135°</td>
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<tr>
<td>(0.3 mm)</td>
<td>Trans</td>
<td>0.83T</td>
<td>135°</td>
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Manufacturing Advantages

Welding Capability

- ATI 425® Alloy has been welded successfully by modern & traditional techniques
  - Laser
  - Friction Stir
  - Electron Beam
  - Autogenous Gas W Arc
  - W Inert Gas + Wire
Manufacturing Advantages ATI 425® Alloy Sheet

Exceptional Super Plastic Forming Characteristic

- SPF Behavior at Lower T
  - Increases Tool Life
  - Better Yield
  - Superior Operator Safety

Excellent m-Values

1425 °F (775 °C)

SR=10^4 s⁻¹

Parts SPF at 1500°F

0.080” (2mm)
ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

QUALITY MANUFACTURING PERFORMANCE
Performance Advantages

**Weight Savings**

- vs. 6-4 Ti
  - Improved tolerances
- vs. CP Ti
  - Higher strength

**Cycle Time**

- Significantly shorter lead time as compared to pack-rolled sheet
ATI 425® Alloy

SUMMARY
ATI 425® Alloy – Product Comparison

**Continuously Rolled ATI 425® Coil**
- +/- .001”
- Up to 2500 ft
- Up to 10,000 lbs
- 16 weeks
- Superior to Ti 6-4

**Ti 6-4 Pack Rolled Sheet**
- +/- .008”
- 20 ft Max
- 500 lbs
- Up to 52 Weeks
- Inferior to ATI 425® Alloy
Cold Rolled and Annealed ATI 425® Alloy

- It is a cold-rollable titanium alloy with higher ductility and strength comparable to Ti-6Al-4V

- ATI 425® Alloy offers:
  - Improved formability due to higher, room-temperature ductility and bending
  - Improved SPF capability- lower forming temperature, pressures
  - Improved DB capability- bonds similarly than FG Ti 6-4
  - Improved thickness tolerance over ground and pickled sheet
  - Cold-rolled surface finish with no grinding
  - Good weldability by conventional aerospace techniques
ATI 425® Alloy

THANK YOU