What’s Up Down Under

John E. Barnes, Titanium Technologies, Future Manufacturing Flagship

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Titanium Technologies in a Nutshell

1. CSIRO and its partners are creating domestic Titanium metal production
2. We can value add the resulting metal powder to mill product and machined product
3. We believe that additive manufacturing is an important innovation for Australian firms to access regardless of the metal composition
4. Once CSIRO Titanium metal production technology is in place, we will drive for other additional metals based on technology and commercial considerations
ore to more
from ore to *more*

- Rank of Australian titanium ore reserves in the world
- Amount of Titanium metal produced in Australia
- Number of years until known ore is depleted
- The factor of economic value of metal over ore
- Resource that could be used to yield the same revenue
- Years of resource left
Relativity – The Big Picture for Australia, and you

Continuous Kinetic Metal Production
Powder Modification
Additive Manufacturing
Thermally Assisted Machining

Make it Efficiently, Use it Efficiently, Remove it Efficiently
Additive Manufacturing Strategy

Casting & Welding
- Simulation
  - New Material Development
  - Distortion Management

Alloys + TiRO + Processing
- Feedstock
  - Novel Sources
  - Physical Modification
  - The AX - Powder Flow

Industry Engagement
- AM Network
- Build, Consult, SIEF

CSIRO Titanium Technologies | ITA 2013
50% of the cost in operation is labour
20% is depreciation (i.e. Cost of the unit)

If the equipment cost comes down and
labour gets more productive
Powder becomes the mostly costly
component of AM
CSIRO can modify powder for various results: Size, Shape, Flow & Density
# Powder Modification for Flow and Density

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Flow density (g/cm³)</th>
<th>Flowability (Seconds /20 cm³)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arcam (Benchmark)</td>
<td>2.5 (56% theoretical)</td>
<td>25</td>
<td>45 -106 µm</td>
</tr>
<tr>
<td>Arcam (As Measured)</td>
<td>2.61 (58%)</td>
<td>23</td>
<td>45 -106 µm</td>
</tr>
<tr>
<td>Novel Powder #1</td>
<td>0.95 (21%)</td>
<td>38</td>
<td>45 -106 µm</td>
</tr>
<tr>
<td>Novel Powder #2</td>
<td>1.84 (42%)</td>
<td>25</td>
<td>45 -106 µm</td>
</tr>
</tbody>
</table>

3X Improvement in Flow for Novel Powder #1  
Good improvement in Flow for Novel Powder #2
Distortion Control and Management in Sciaky Electron Beam Direct Manufacturing (EBDM)

- Sciaky EBDM is a rapid metal deposition additive manufacturing process that works efficiently with a variety of weldable alloys for the manufacture of near net shape, custom-made workpieces.

- Residual stress and shape distortion are inherent features of AM, due to the high deposition rates which require high heat input into the substrate and previously deposited layers, resulting in large thermal gradients.

- In most cases, fabricated parts need to be heat treated post-deposition to relieve residual stresses and distortion, adding to cycle time and cost.

- CSIRO and Boeing are conducting a project to establish and implement modelling techniques to predict distortion and stresses during and after deposition as a first step towards developing an active distortion management system.

**Benefit:** Reduced part cost through the reduction of: material, fabrication time (i.e. machining), and part distortion/residual stress.
SIEF – Microturbo Aero-engine Project
2011 winner, Callaghan Forsyth, an Honours Industrial Design student at Swinburne University in Melbourne, VIC for his concept of an advanced radiator.

Matt Troup is the 2012 winner from the University of Canberra for his concept of the Ti Pack.

Afshin M. Hosseini, Ph.D. Candidate from Swinburne University, is the 2013 winner for his Unitized Impeller concept.
Thermally Assisted Machining of Titanium

Target is to reduce roughing cycle time

Localised surface heating lowers:
• yield/shear stresses and,
• work hardening rate in the shear zone, thus allowing to cut at high speed without tool damage
TAM – How it Works

Depth of cut: 1.5 mm
Feed speed: 1 m/min
Spindle: 3571 rpm
Tool diameter: 25 mm
Tool engage: 70%

As received

1.5 kW
Laser Enables Precise Control of Heat Affected Zone

Line beam allows to generate
- straight heat zone to match cutter
- Shallow heat affected zone (<1mm)

4 kW @ 1.2 m/min
# Case Study – Generic Aero Part

<table>
<thead>
<tr>
<th>Example Component</th>
<th>Unit</th>
<th>Conventional</th>
<th>TAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of raw material</td>
<td>cm³ / (in³)</td>
<td>10,407 (635)</td>
<td></td>
</tr>
<tr>
<td>Volume of finish component</td>
<td>cm³ / (in³)</td>
<td>541 (33)</td>
<td></td>
</tr>
<tr>
<td>Material to remove</td>
<td>cm³ / (in³)</td>
<td>9,866 (602)</td>
<td></td>
</tr>
<tr>
<td>Roughing cycle time</td>
<td>minutes</td>
<td>822</td>
<td>130</td>
</tr>
</tbody>
</table>

85% Reduction in Cycle Time
Thank you

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