Welcome

Titanium: Taming the aluminum of the 21st Century
Aerospace

The major components

Engine

Structure

Landing gear
Titanium - 3 groups

<table>
<thead>
<tr>
<th>HCP</th>
<th>Mix</th>
<th>BCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti-5Al-21/2Sn</td>
<td>Ti-6Al-4V</td>
<td>Ti-3AL-8V-6Cr-4Mo-4Zr</td>
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<tr>
<td></td>
<td>Ti-6Al-2Sn</td>
<td>Ti-10V-2Fe-3Al</td>
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<tr>
<td></td>
<td>Ti-4Al-2Sn-4Mo-0.5Si</td>
<td>Ti-5Va-5Mo-5Al-3Cr</td>
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<td>Ti-17</td>
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</tbody>
</table>
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Two competing (?) Technologies

- **High Power Machining**
  - Horse power 30-50 hp/22-38Kw
  - **Torque over 900 up to 3,000 ft lb / 2,230 Nm**
  - Base speed 50-100 rpm, max 3-5,000
  - Coolant through spindle 1,000 psi essential
  - Machine tool stiffness – essential
  - Cutting tool design, edge prep and coatings
  - Metal removal rates 1 -2 cubic"/hp

Primary challenge is utilizing available torque

- **High Speed Machining**
  - Horse power 30-50 hp/22-38Kw
  - **Torque 500~1000 ft lb**
  - Base speed 5,000~10,000
  - Coolant through spindle 1,000 psi essential
  - Machine tool stiffness – not as critical
  - Cutting tool design, edge prep and coatings
  - Metal removal rates 12+ cubic / min

Primary challenge is optimizing tool path and identifying machine capability
High Speed Machining

- High speed machining of Titanium is normally not possible due to risk for Alfa case and also risk for fire.

- But with high pressure coolant the speed can be increased
  - low coolant pressure cutting speed 100%
  - 70 bar coolant cutting speed 150%
  - 200 bar coolant cutting speed 200%

Alpha case is the oxygen-enriched phase that occurs when titanium and its alloys are exposed to heated air or oxygen. Alpha case is brittle, and tends to create a series of microcracks which will reduce the metal’s performance and its fatigue properties. Alpha case can be avoided by processing in a vacuum.
Example from a customer turning Ti6Al4V with 200 bar in SECO Jetstream holder

- **Coolant pressure**: 200 bar
- **Cutting speed**: 90 m/min
- **Feed**: 0.15 mm/r
- **Tool life**: 120 min.

- **Coolant pressure**: 7 bar
- **Cutting speed**: 60 m/min
- **Feed**: 0.15 mm/r
- **Tool life**: 20 min.

Material: Ti6Al4V
Use the right chip breaker
Test with Superturbo in Ti6Al4V
Cutter: SECO R220.69-0040-12-5
Insert: XOEX120416R-M07/XOMX120416R-ME08
Cutting data: Fz= 0.14 Ap 2 mm Ae= 15 mm
Coolant pressure: 10 bar
High Density cutter
Example: SECO Octomill 220.43-07T

Inserts in Ti6Al4V: OFER070405TN-ME10,F40M v= 45 m/min fz= 0.20 mm/t
or OFER070405TN-ME15,F40M v= 40 m/min fz= 0.28 mm/t

Super close pitch Ø63-160mm
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#### Tools for Ti-6Al4v

<table>
<thead>
<tr>
<th>Tool Type</th>
<th>Advantage</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H.S.S</strong></td>
<td>Cheap cost</td>
<td>Capable of a life expectancy prediction Low cutting rate</td>
</tr>
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<tr>
<td><strong>Solid</strong></td>
<td>High cutting rate</td>
<td>High chip removal rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High cost Low tool life</td>
</tr>
<tr>
<td><strong>Insert Cutter</strong></td>
<td>Exchange to new edge very easily</td>
<td>Restrictions: tool profile Sudden damage of edge causes failure Cost effective</td>
</tr>
</tbody>
</table>

*Tools for Ti-6Al4v in Aerospace industry*
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Machine Structure that Maximizes Cutting Performance

Tool Spindle

Main and Sub Spindle

Lower Turret
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Machine Platform Solutions
• Root forms are replaced by simple platforms on the disk.
• Blades are friction welded to the platforms.
• Hollow blades enable large BLISKs to operate at high speed.
• Ease of repair makes vulnerable first stages feasible even for high cycle applications.
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Machine Platform Solutions

Engine: Rotating Components

Solutions:

Large BLISK / Friction Welded

- Beam workholding allows access to the fore and aft sides of the blade root and flash for complete machining in a single operation
Engine: Rotating Components
Solutions:
Single Blades
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Active Vibration Dampening
NextGen Machine Designs

Hydrostatic Spindle

Hydrostatic Machine Designs
Thank you!

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