MITSUI SEIKI

Custom Engineered Machine

BLUE ARC™

Machine
Presentation Outline

• Current Aerospace Titanium Machine Examples and typical machining cost outlines

• Cost reduction targets for the Blue Arc production machine tool
Current Aerospace
Titanium Machining
Examples
Wing-to-Fuselage Machined Part Examples

- Upper Side-of-Body Chord
- Lower Side-of-Body Chord
Boeing 787 Side-of-Body Chords

Open Die Forgings

Upper Open Die Forging
41:1

Lower Open Die Forging
25:1
Machining Lower SOB Chord

Buy-To-Fly 25.6:1

5-Axis Nutating Spindle

Face Mill SOB Chord
Helicopter Rotor Hub
Sikorsky 53K Heavy Lift Vehicle

Forging  Finished Machined
Jet Engine Blisks
Typical Titanium Fabrication Costs

Goal: Minimize Total Cost

Primary Cost Drivers:
- Machine Tools
- Material
- Machining
- Cutters
  - Tool Life Aluminum (1,000’s Hrs)
  - Tool Life Titanium (minutes)
- Load Parts (Part Fixturing)

Secondary Processing (19%)
- Deburr
- Dye Penetrant
- Inspection
- Shot-Peening
- Finish, Etc.
Cost Reduction Targets for Blue Arc

• Capitol Machine Tool Cost Reductions

• Cutting Tool Cost Reductions
Current Categorizing Titanium Machine Tools

Purpose-Built
- 60-Taper Simul-Fit
- 3,000+ Ft-Lbs, 4067 N-m
- < 1,000 RPM
- 35 in³/min or 336 Lbs/Hr
- With Blue Arc 45 in³/min

Light-Duty
- 40 or 45-Taper
- 300 Ft-Lbs, 406 N-m
- 10,000 RPM, 30-HP, 22-kW
- 3 in³/min or 29 Lbs/Hr
- With Blue Arc 9 in³/min

Medium-Duty
- 50-Taper or HSK-125A
- 800 Ft-Lbs, 1084 N-m
- < 6,000 RPM, 40-HP, 30-kW
- 7 in³/min or 67 Lbs/Hr
- With Blue Arc 21 in³/min

Heavy-Duty
- HSK-125A, HSK-160A
- 2000+ Ft-Lbs, 2711 N-m
- < 4,000 RPM, 100-HP, 75-kW
- 15 in³/min or 145 Lbs/Hr
- With Blue Arc 45 in³/min

Note: Maximum Material Removal Rates Shown
Cutting Tool costs averages 30 cents per cubic inch of titanium stock removal
Machining Speed Limits & Cutter Technology

**Aluminum**
- Primary Shear Zone
- Cutting Force

- 12,000 SFM or 3660 M/min
- High Temperature in Primary Shear Zone
- Aluminum Softens in Primary Shear Zone
- Cutter Force is Reduced
- Aluminum Softens at Lower Temperature Then Cutter

**Titanium**
- Primary Shear Zone
- Cutting Force

- 400 SFM or 122 M/min
- High Temperature in Primary Shear Zone
- Cutter Softens Before Titanium
- Cutter Force Not Decreased
- Cutter Softens @ Lower Temperature then Titanium

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**Material Softening Temperature**

- 1649 °C Titanium Softens
- 815°C Carbide Cutter Cobalt Softens
- 760°C HS Steel
- 649°C Aluminum
Blue Arc Power Transfer Tool

Note: Copper electrodes are cheaper than carbide and stock removal rates are higher
Reclamation of Material is the same for milling and Blue Arc

Cutting Tool “Chips”  Blue Arc “Chips”
Controlling of Heat Effect Zone at high cubic inch per minute stock removal rates is key.

Modified Metallurgy Noted Up to 76 Mils.
**Target Titanium Fabrication Costs with Blue Arc**

Goal: Minimize Total Cost

**Conventional Fabrication Costs with Milling**

- Material: 43.6%
- Machining: 27%
- Cutter Cost: 10.4%

**Blue Arc cost Reduction Targets**

- Reduce machine tool capitol costs by 30%
- Reduce cutter costs 70%

**Secondary Processing (19%)**

- Debuur
- Dye Penetrant
- Inspection
- Shot-Peening
- Finish, Etc.
Thank You

For more information please contact me

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Note: Contributions to this presentation from Boeing, Sikorsky, Kennametal and Wolf