

mitsui seiki



Custom Engineered Machine

BLUE ARC™

Machine

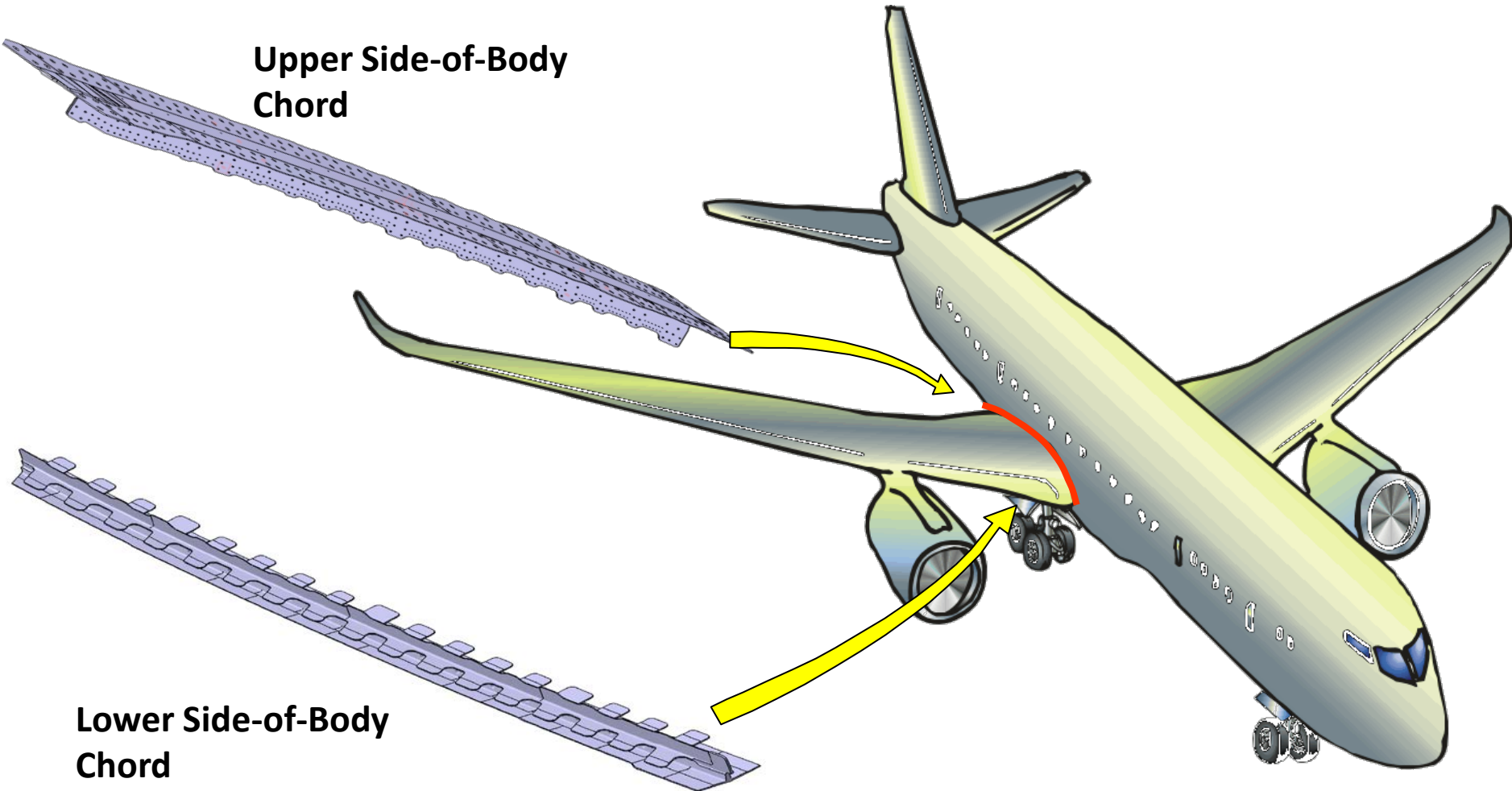
Presentation Outline

- **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

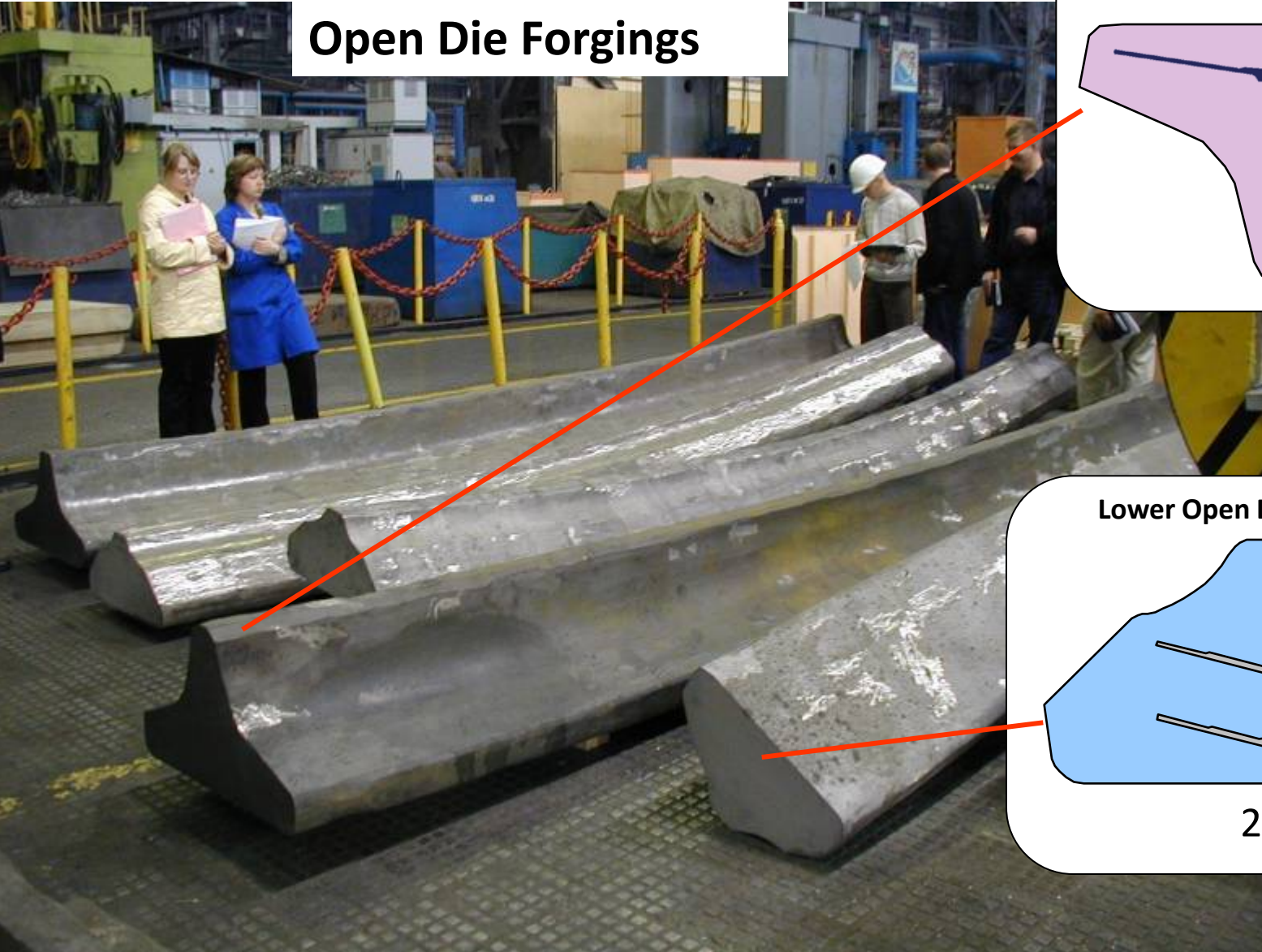
**Upper Side-of-Body
Chord**



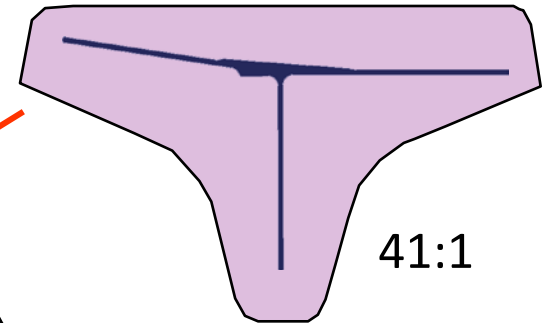
**Lower Side-of-Body
Chord**

Boeing 787 Side-of-Body Chords

Open Die Forgings

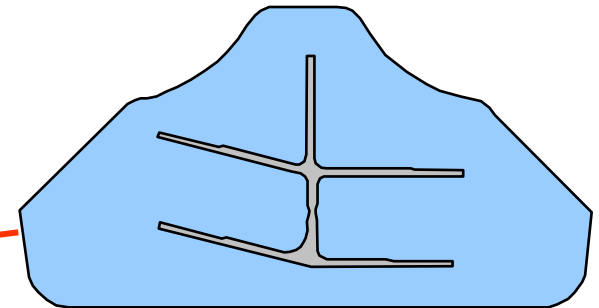


Upper Open Die Forging



41:1

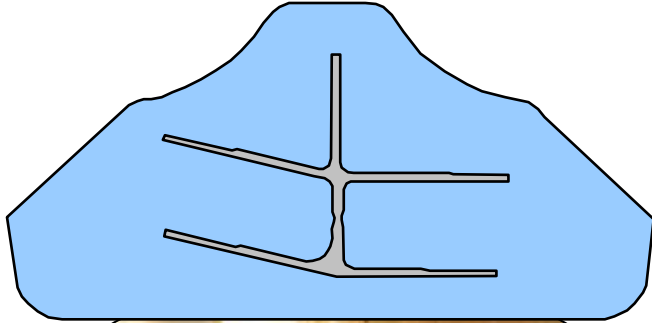
Lower Open Die Forging



25:1

Machining Lower SOB Chord

Buy-To-Fly 25.6:1



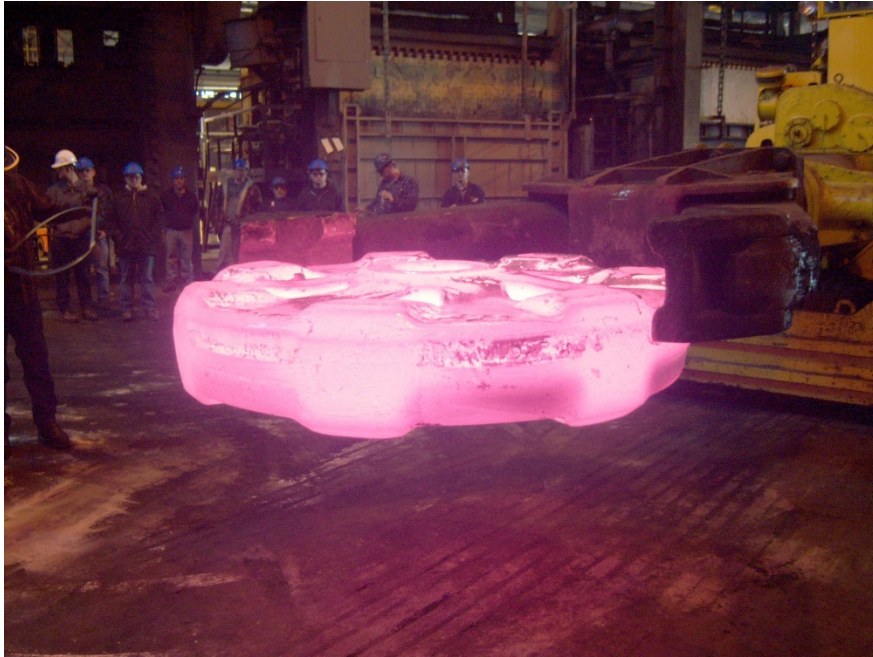
5-Axis Nutating Spindle



Face Mill SOB Chord

Helicopter Rotor Hub

Sikorsky 53K Heavy Lift Vehicle

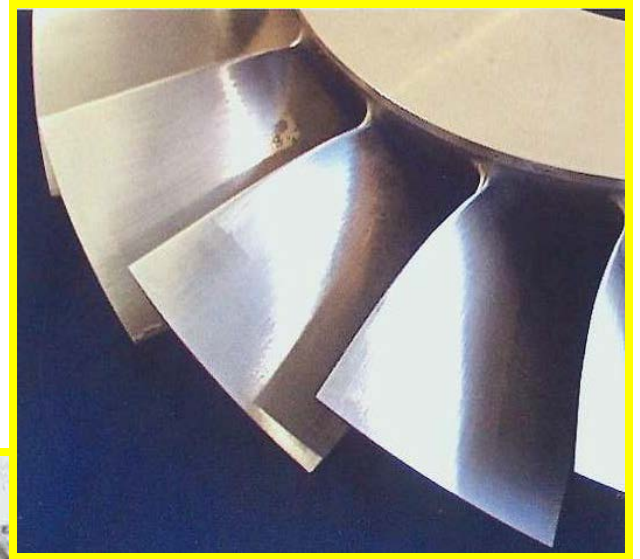


Forging



Finished Machined

Jet Engine Blisks

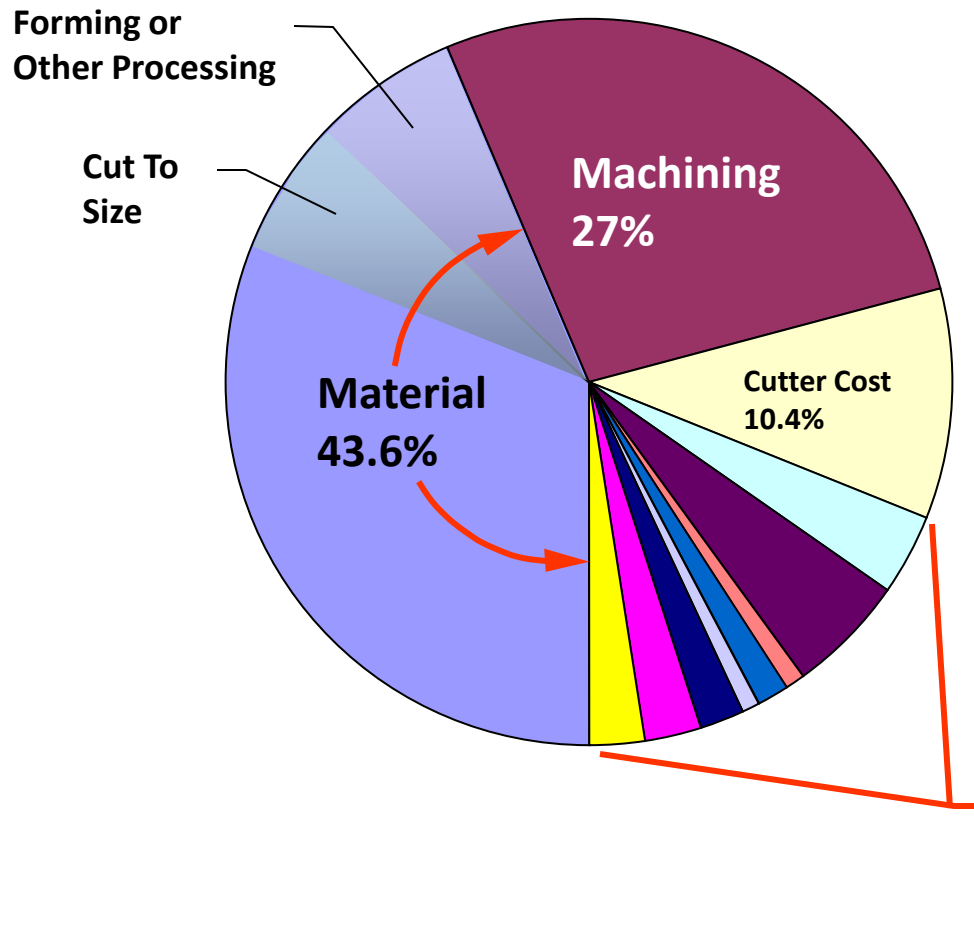


Typical Titanium Fabrication Costs

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)

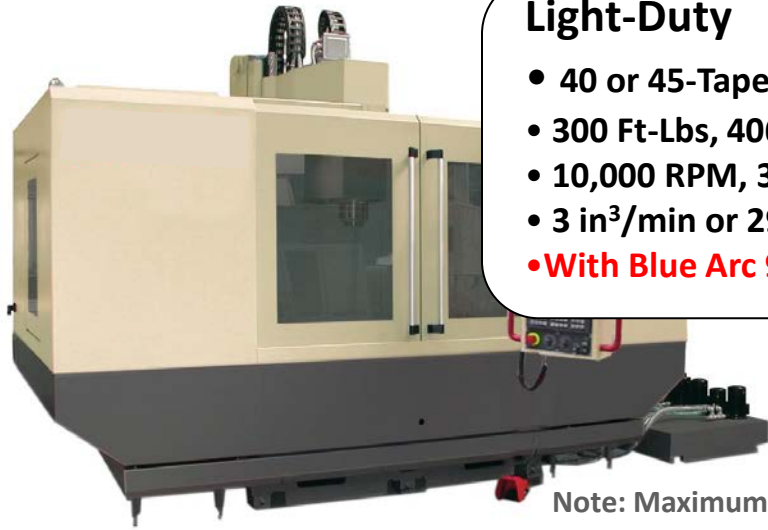


- Deburr
- Dye Penetrant
- Inspection
- Shot-Peening
- Finish, Etc.

Cost Reduction Targets for Blue Arc

- Capitol Machine Tool Cost Reductions
- Cutting Tool Cost Reductions

Current Categorizing Titanium Machine Tools



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**

Note: Maximum Material Removal Rates Shown



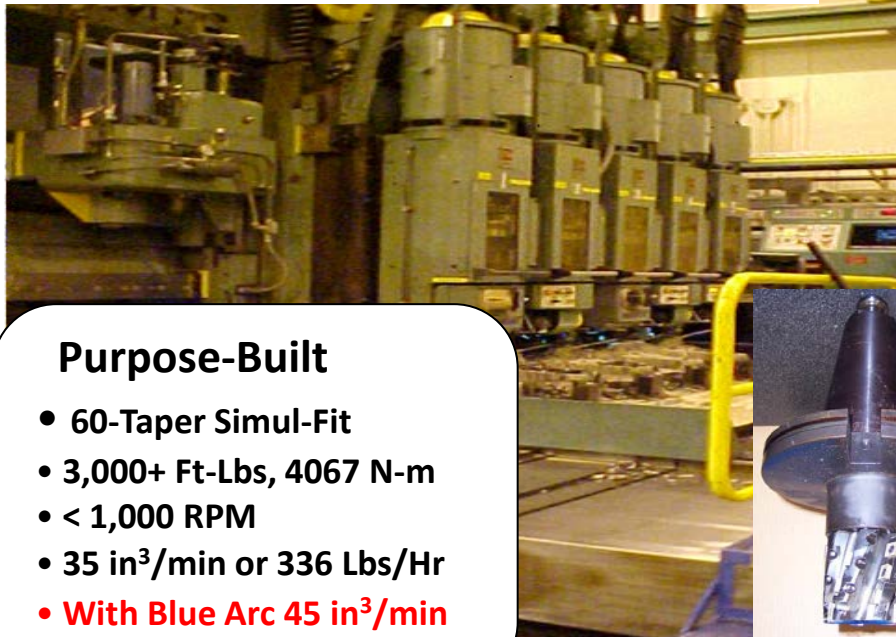
Medium-Duty

- 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**

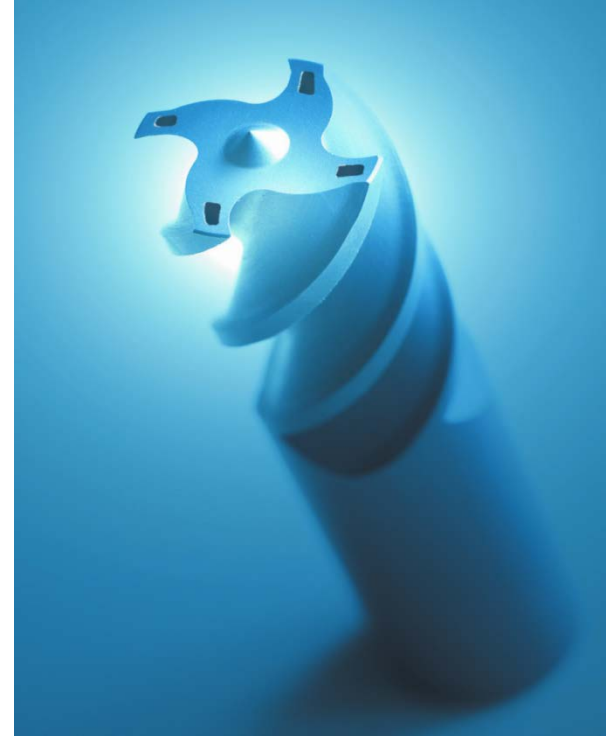


Purpose-Built

- 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**

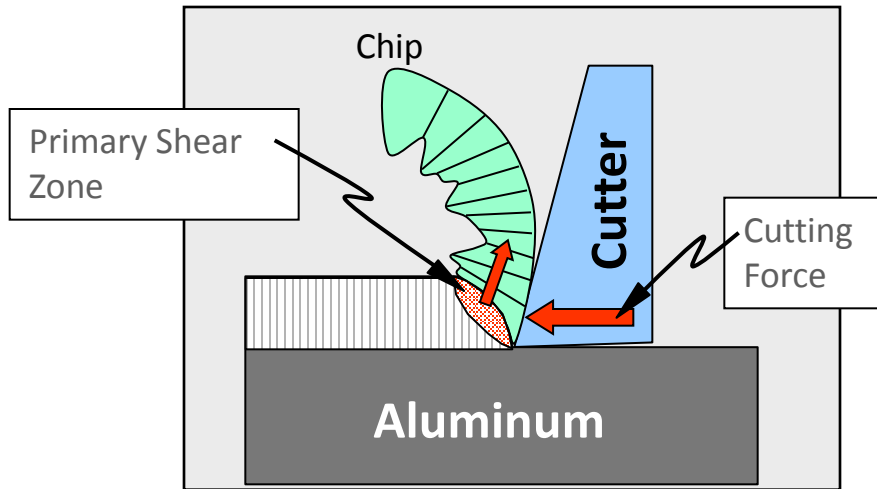


Cutting Tool costs averages 30 cents per cubic inch of titanium stock removal



Machining Speed Limits & Cutter Technology

Aluminum



➤ 12,000 SFM or 3660 M/min

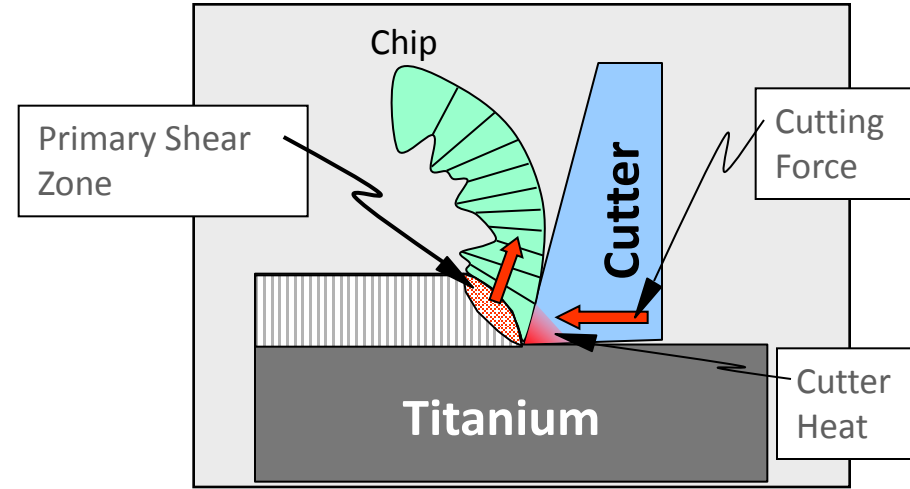
➤ High Temperature in Primary Shear Zone

➤ Aluminum Softens in Primary Shear Zone

➤ Cutter Force is Reduced

➤ Aluminum Softens at Lower Temperature Than Cutter

Titanium



➤ 400 SFM or 122 M/min

➤ High Temperature in Primary Shear Zone

➤ Cutter Softens Before Titanium

➤ Cutter Force Not Decreased

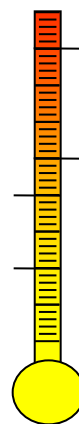
➤ Cutter Softens @ Lower Temperature than Titanium

760°C HS Steel

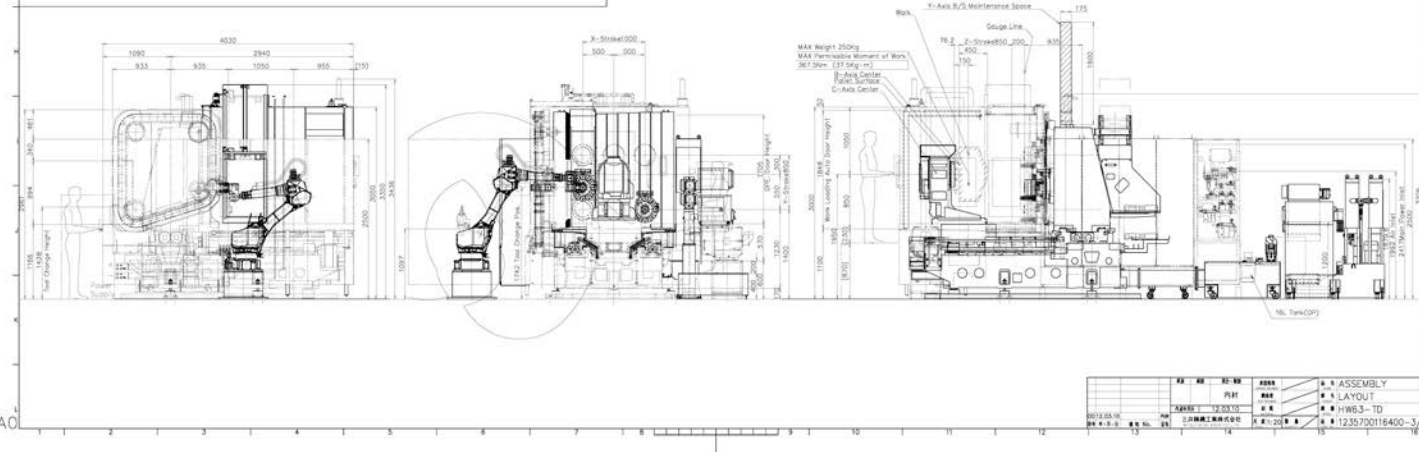
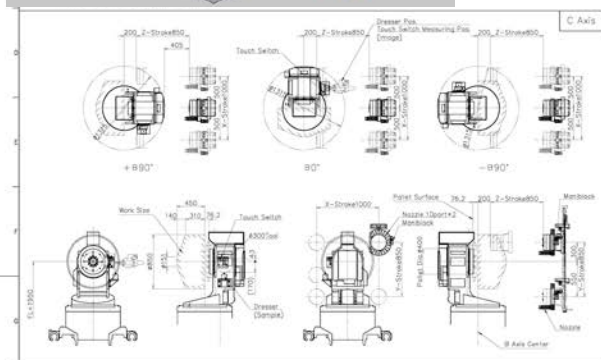
649°C
Aluminum

1649 °C Titanium
Softens

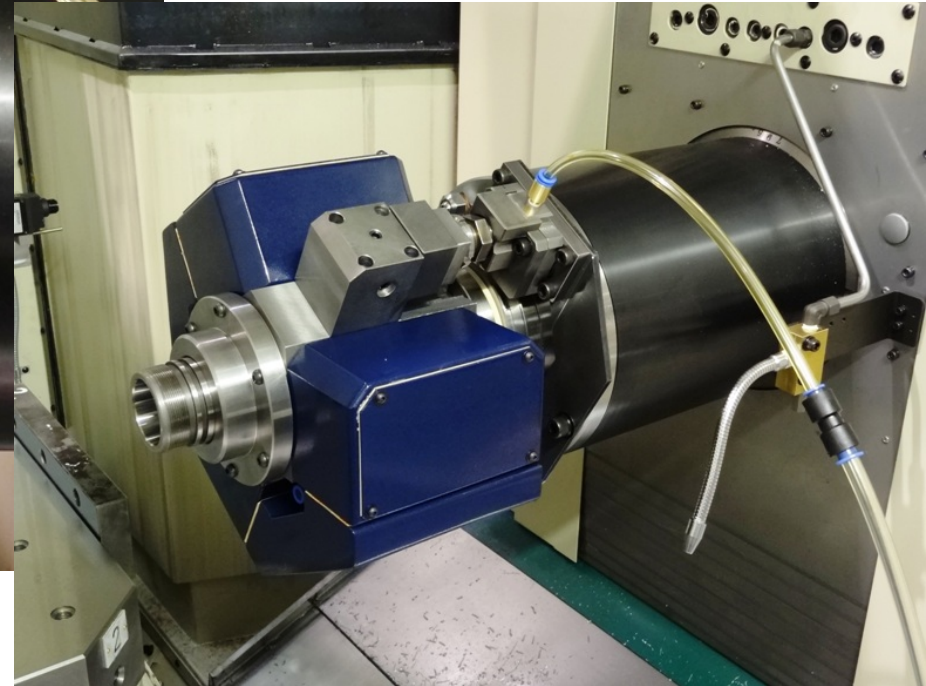
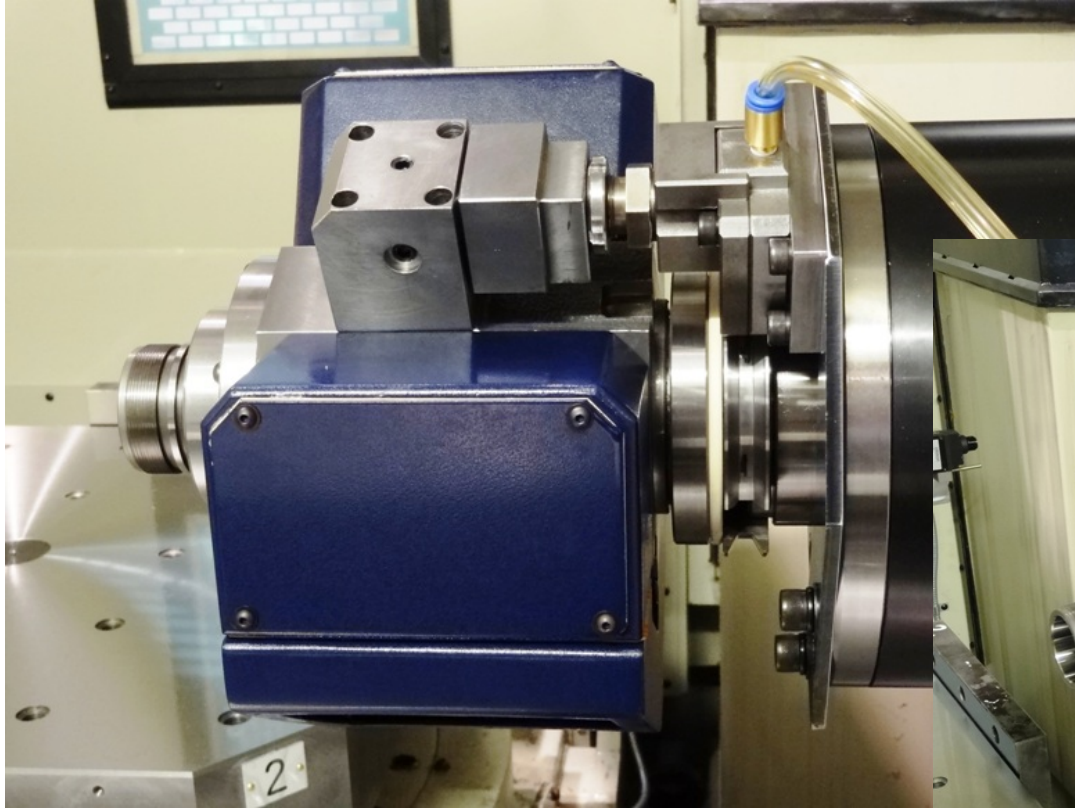
815°C Carbide
Cutter Cobalt
Softens



Material Softening
Temperature



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

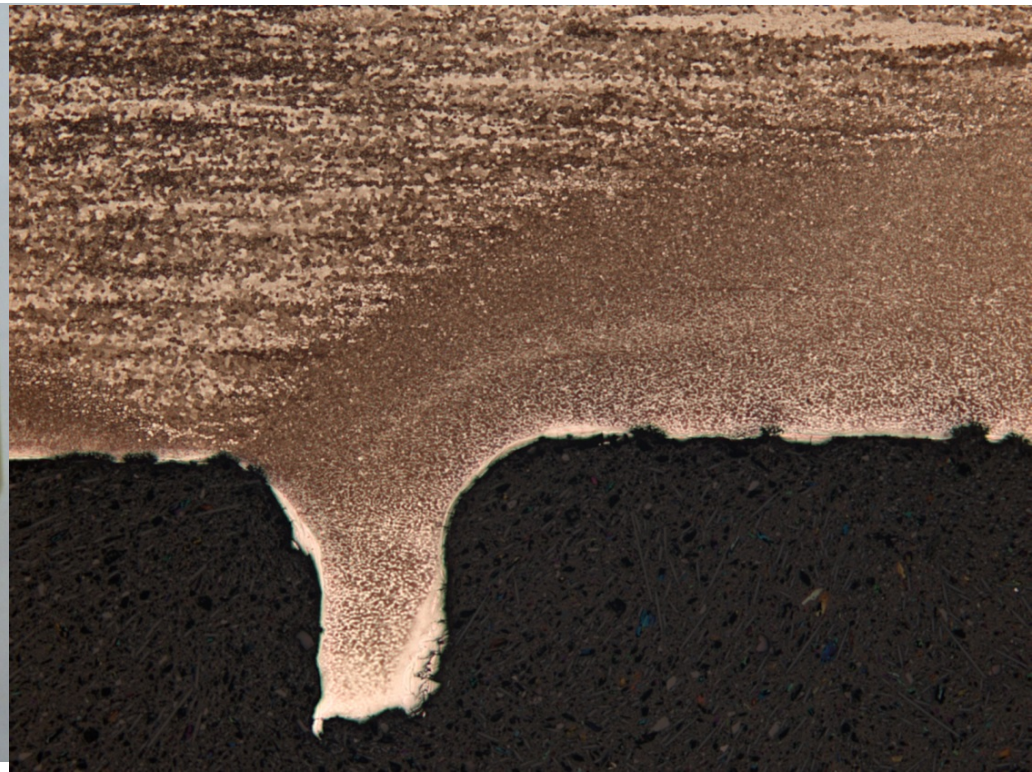
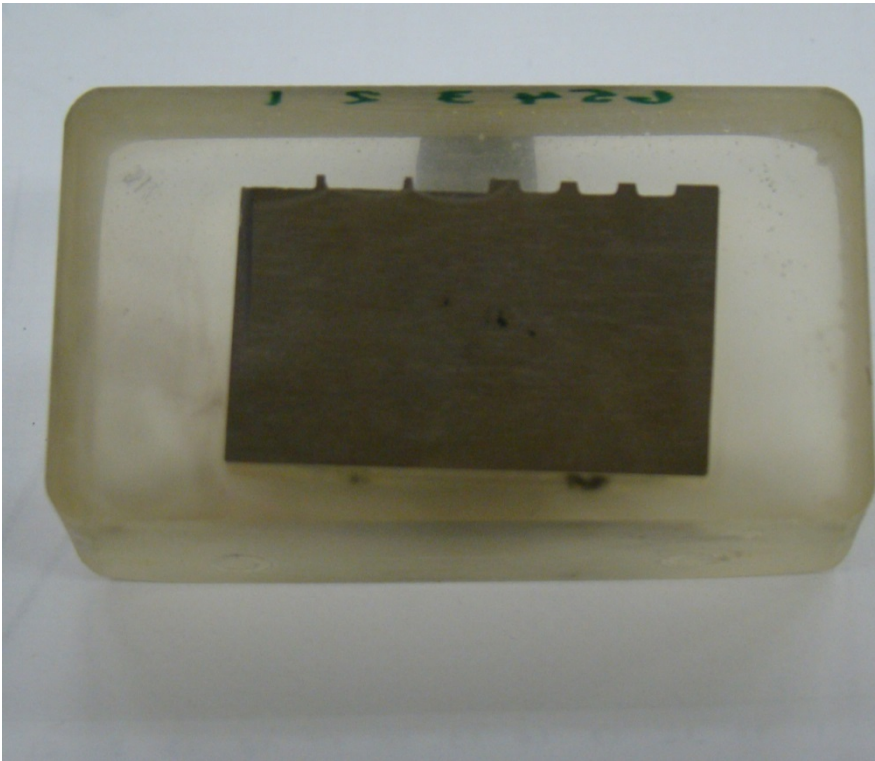


Cutting Tool “Chips”

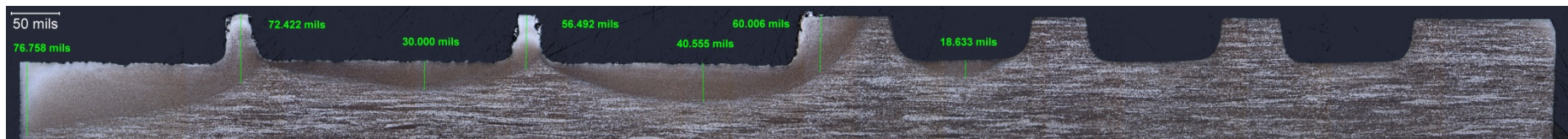


Blue Arc “Chips”

Controlling of Heat Effect Zone at high cubic inch per minute stock removal rates is key



Modified Metallurgy Noted Up to 76 Mils

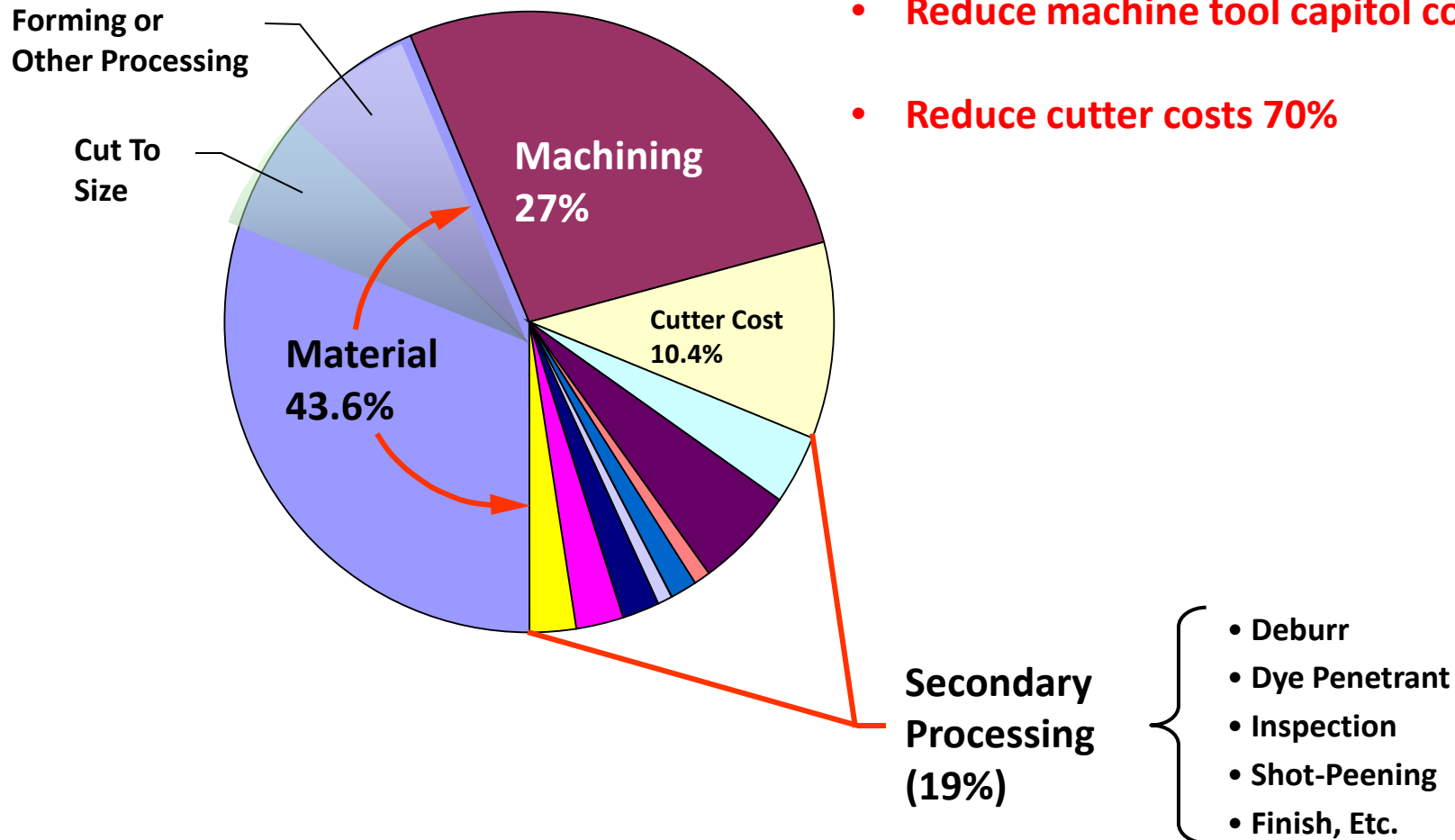


Target Titanium Fabrication Costs with Blue Arc

Goal: Minimize Total Cost

Conventional Fabrication Costs with Milling

Blue Arc cost Reduction Targets



Thank You

For more information
please contact me

swalker@mitsuiseiki.com

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