New Tools, Techniques, and Technologies

by

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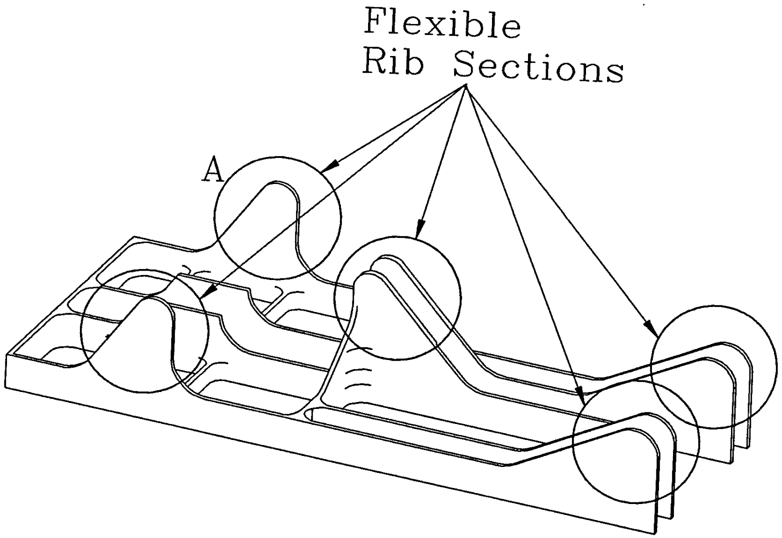
I am going to show you 3 New Things

1. Thin Part Machining
2. Deformation Machining
3. Not So Nearly Net Shape

1. Thin Part Machining

- The work was motivated by weight reduction in aerospace parts.
- Could machined thin walls and floors replace sheet metal assemblies?
- Chatter is a problem because thin walls and floors are not stiff.
- How thin can we cut?


Flexible
Rib Sections
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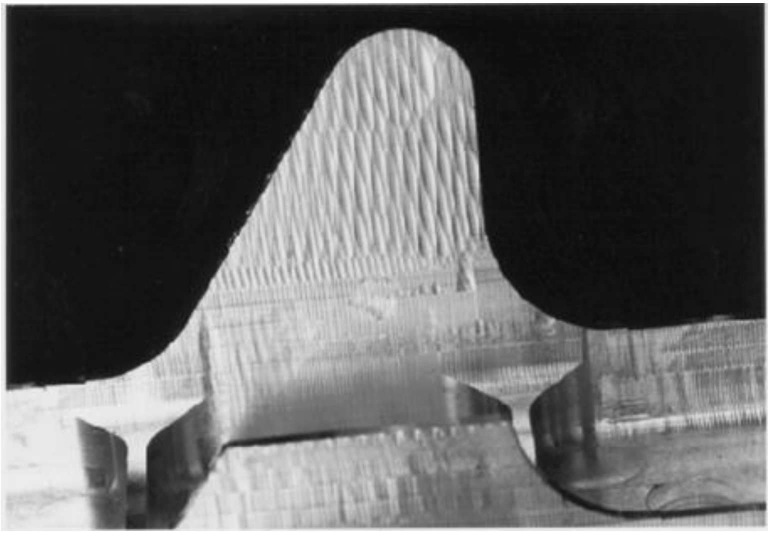
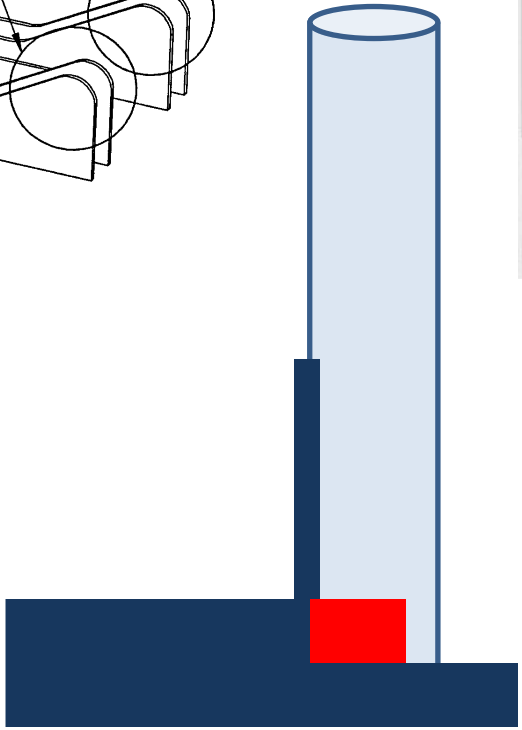
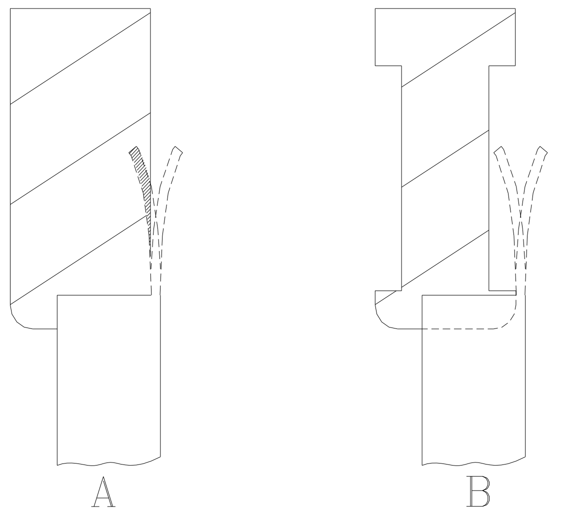
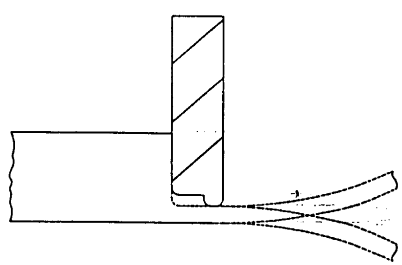
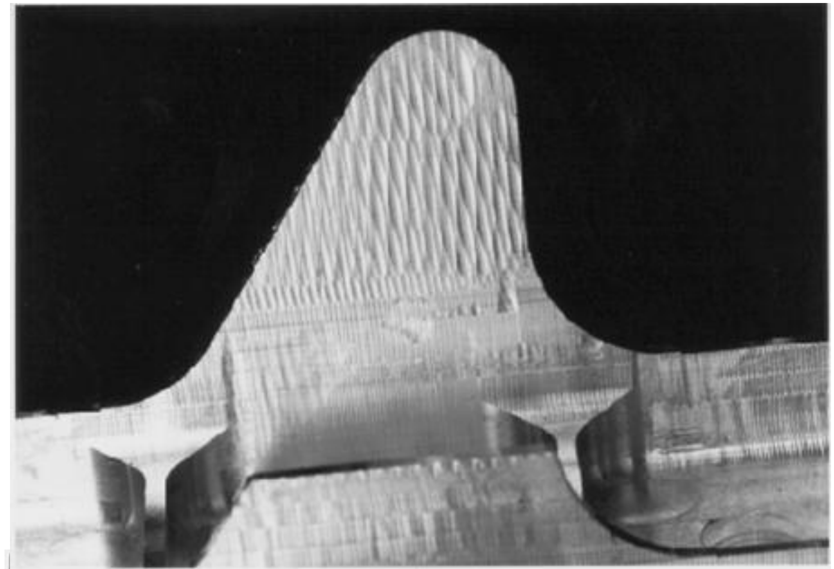


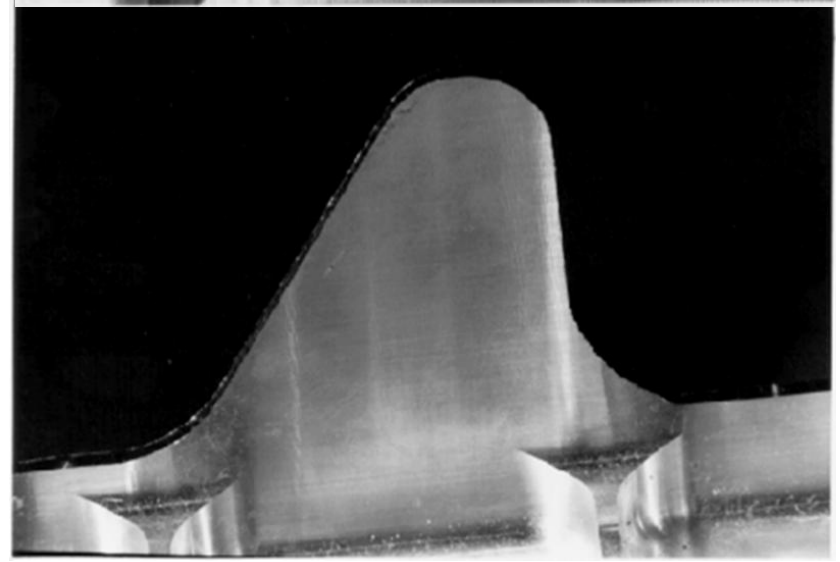


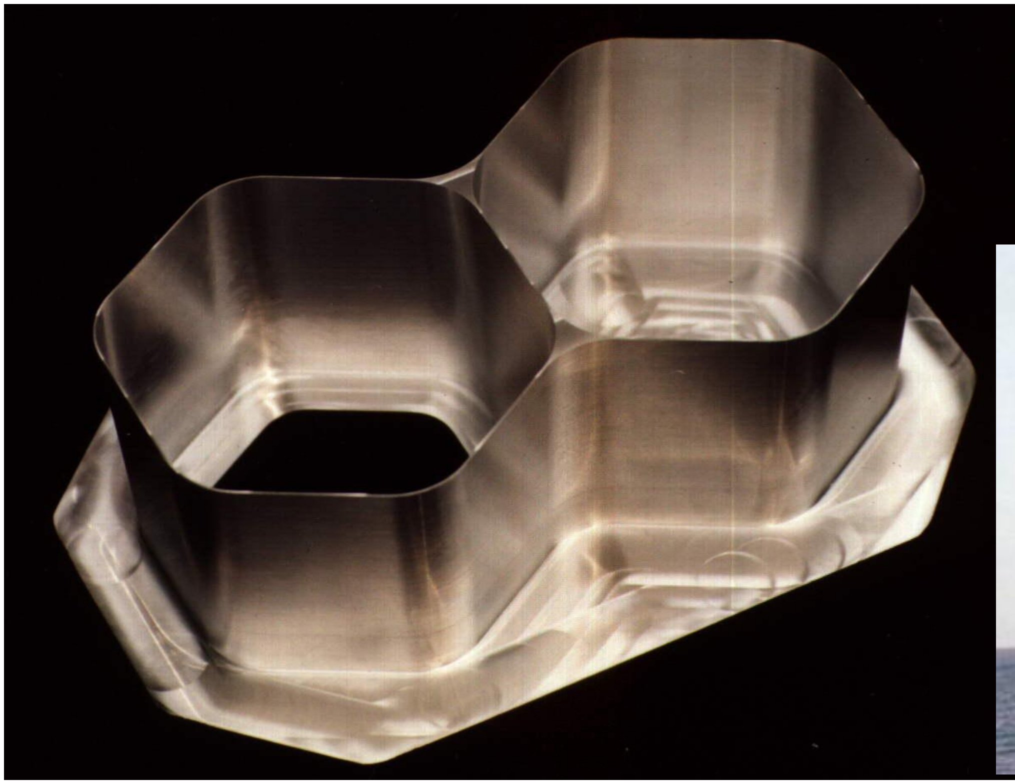
New tools and new tool paths

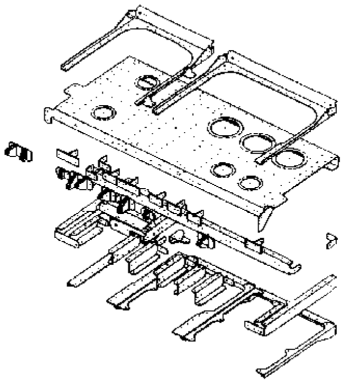


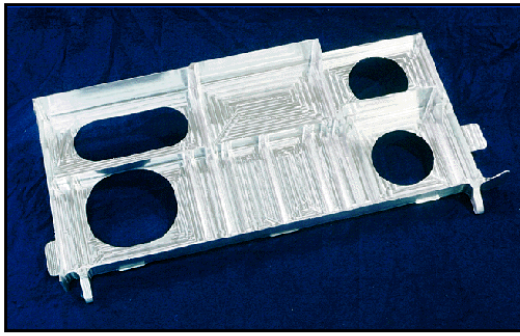








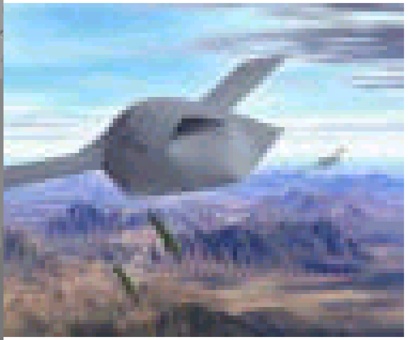




73% Cost Reduction

	Before	After	% Reduction
Number of Parts	44	6	84
Pan Stock	445	108	76
Weight (lbs)	9.58	8.56	11
Assy Time (hrs)	50	5.3	89

Part reduction: ~14,000 on F/A-18C/D to ~8,000 on F/A-18E/F



F-15 Speed Brake

C-17 pod

thousands of pounds (kilograms) of tiny, cut steel wire at the wing skin. This method would not work on the thicker parts of the 747-8 wing skins, so the team used a new technology—laser peening.

"We are the first in the world to use this tool with this type of application," said McKay Kunz, material and process technology engineer, who works at the Fabrication facility in Fredrickson, Wash. The airplane industry has used laser peening for fatigue or compression testing and peening on fan blades, but never before for forming wing skins. Now, the longest part on the 747-8 wing, the lower enclosure panel, receives a quarter-million precisely placed laser spots.

Boeing's fabrication team pushed the limits of another new technology, too—fabricating monolithic parts. Instead of attaching individual stringers (to provide structural support) in the wing-to-body join area, requiring a more complex fabrication process and more work to build, the team adapted a machine used to build 737 skins to cut a 9,800-pound (4,445-kilogram) block of solid material into a final 747-8 part that weighs 588 pounds (267 kilograms). "The first part we cut went on the airplane," said Tom McDonald, team leader for monolithic side-of-body 747-8,

(continued on Page 17)

"Two things haven't changed: It still looks like a 747 and it still flies like a 747, and quite frankly, it just doesn't get any better than that."

– Mark Feuerstein, command pilot of the first flight, speaking at news conference afterward

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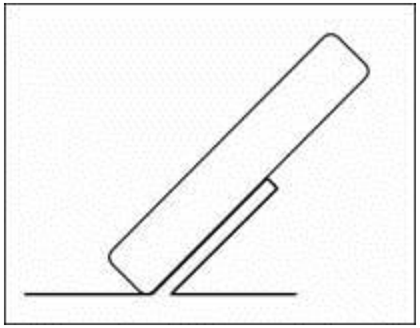
Why does this work so well in aluminum?

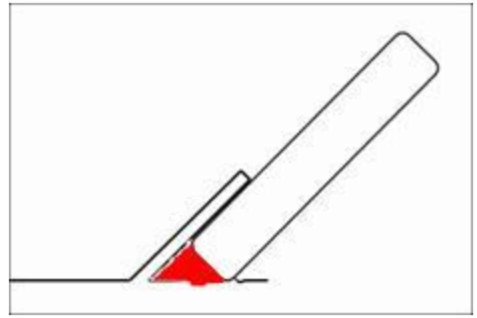
- Availability of stress-free plate stock (up to about 150mm thick)
- Tool wear is not an issue
- Material cost is relatively low
- High metal removal rates

2. Deformation Machining

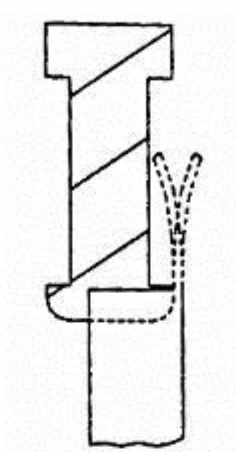
- Combination of thin part machining and Single Point Incremental Forming (SPIF) on the same machine
- Cut it thin first
- Switch to the deformation tool
- Bend it

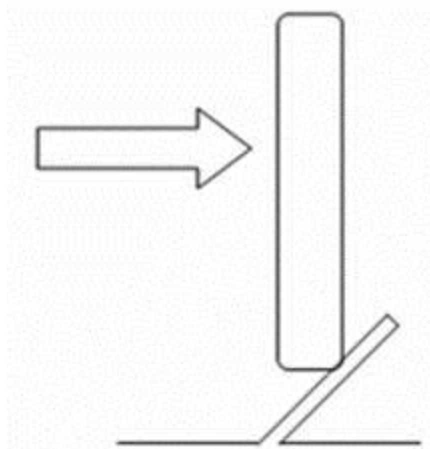
Lighter weight –

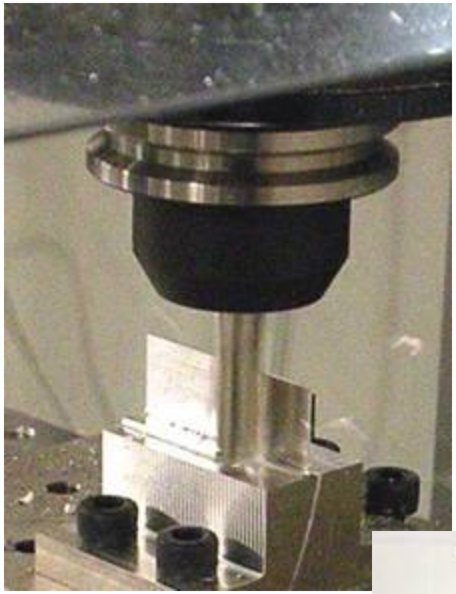




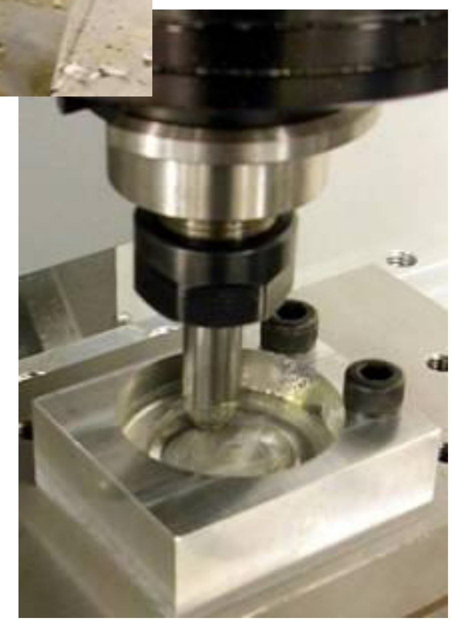
New Deformation Machining Process:



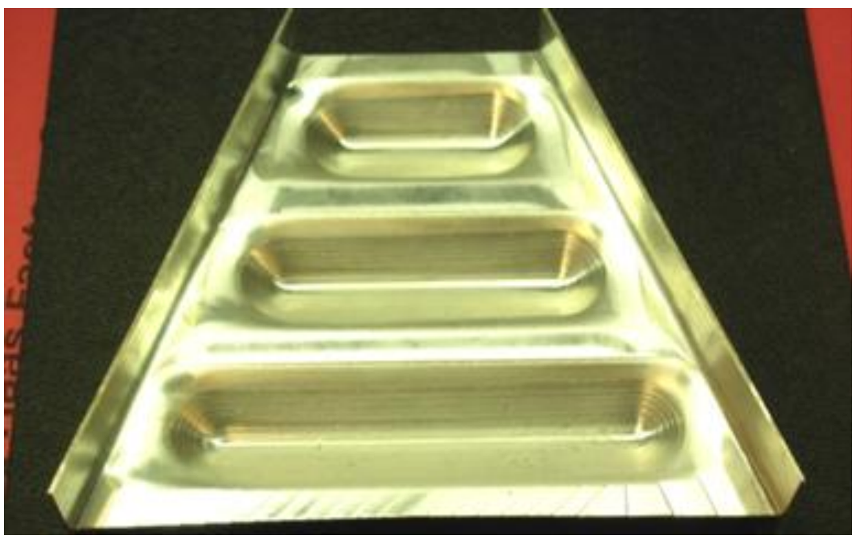


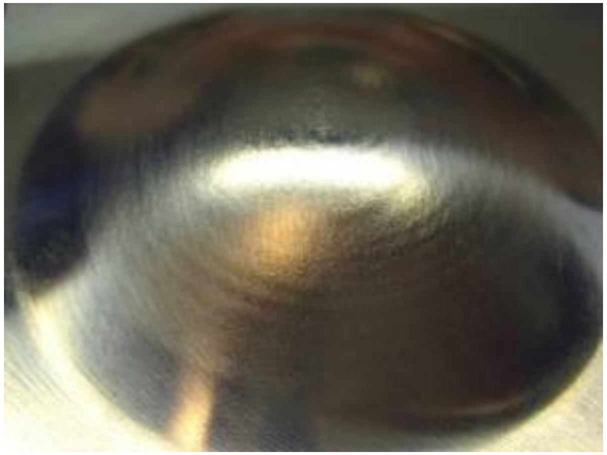


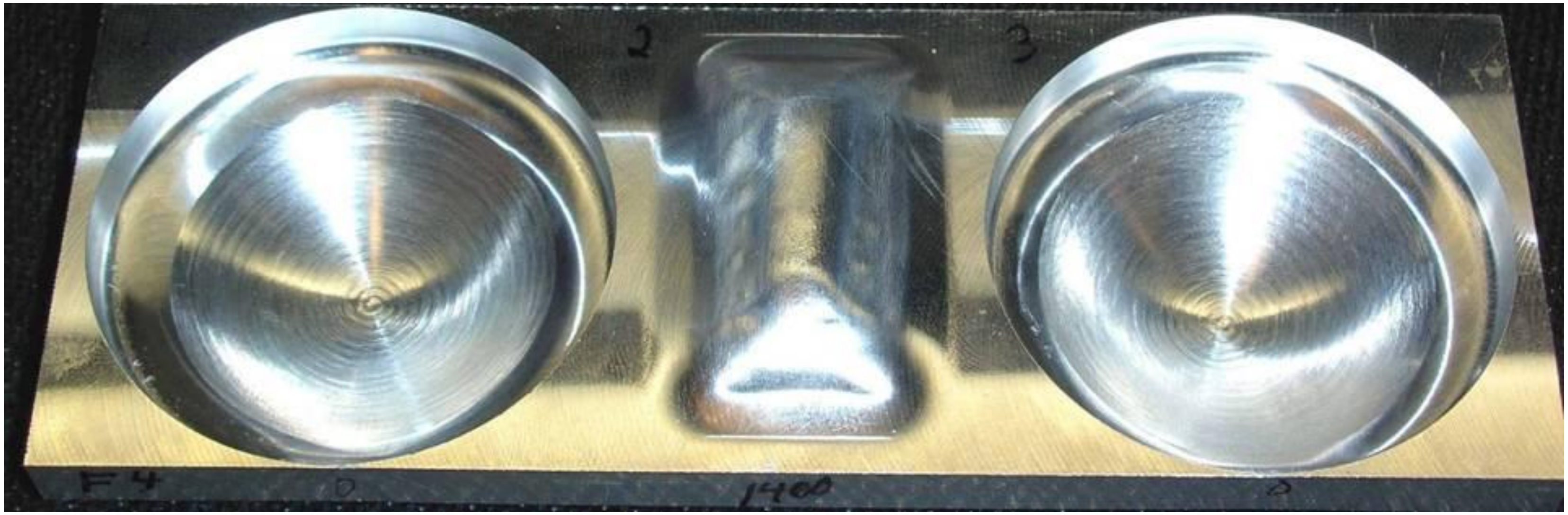
radial



axial



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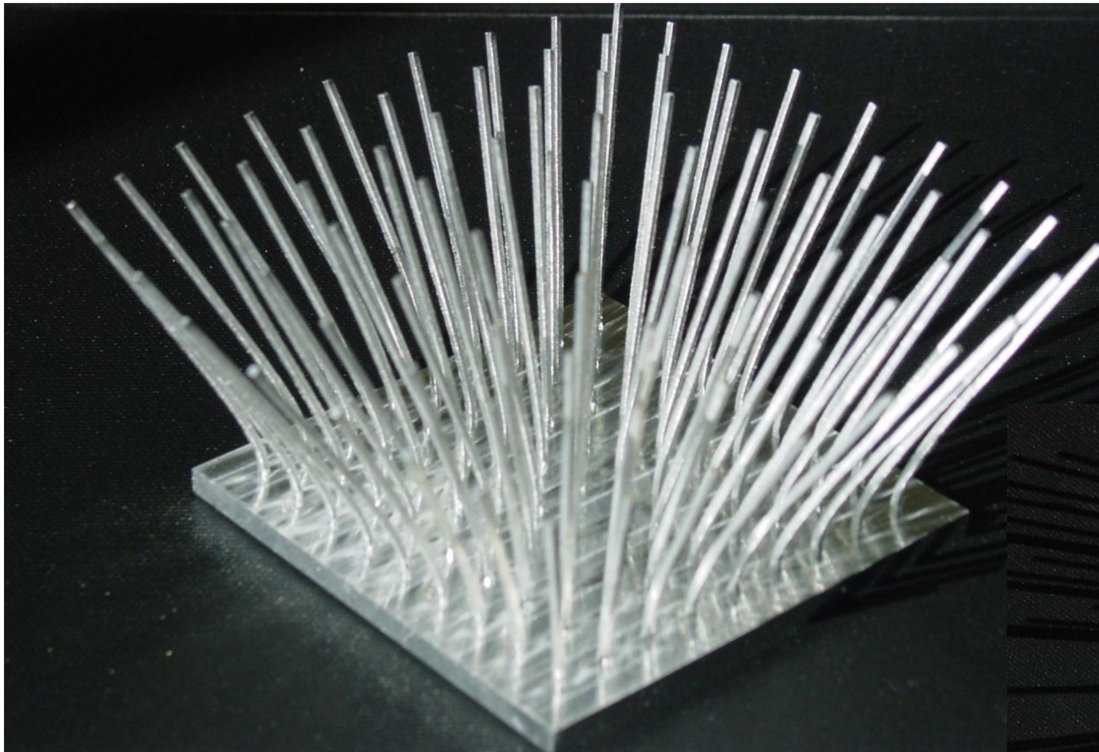

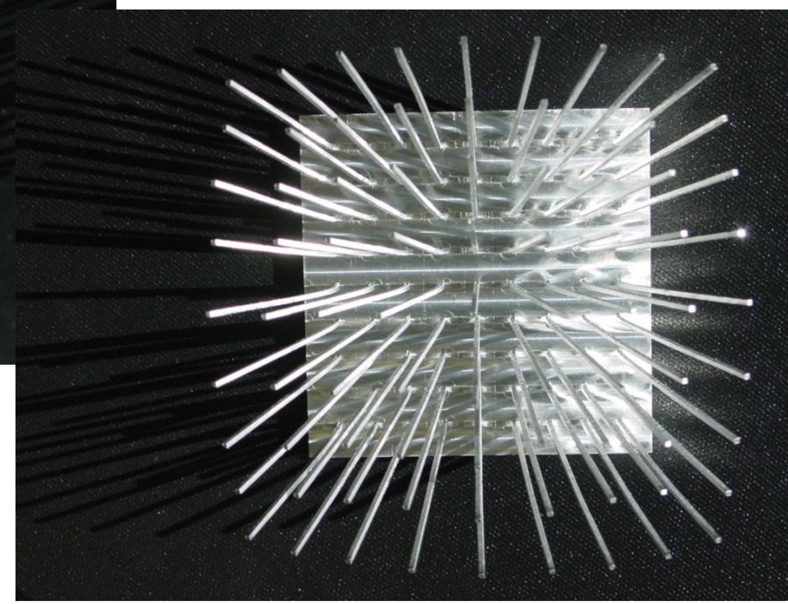

3. Not So Nearly Net Shape

The thin aluminum machining strategy runs into trouble in other materials, such as Titanium alloys

- Workpiece material is expensive, and not available in satisfactory plate forms (residual stress, properties)
- Many people are looking at additive processes
- Tool wear trouble. Ti needs small radial depths of cut to keep the temperature low

Metal Additive Manufacturing

- Laser melted powder, as an example of an additive process
- Some promising things
  - Cost does not scale with complexity
  - Low production volumes
  - Short process development time
  - Material consumption is low
- Some problems
  - Powder is expensive
  - Health risks
  - Powder is sticky
  - Powder can be explosive
  - Residual stress and roughness are inversely related to powder size and directly related to laser power
  - Roughness directly impacts fatigue life
  - Small powder is more costly
  - Larger powder causes worse finish

Engineering technician Ryan Hanks analyzes a 7E7 prototype part fabricated from laser additive titanium. Laser-forming technologies now are being used to produce parts.

Boeing Frontiers
December 2004/January 2005
Volume 03, Issue 8 ,
Special Features

Not So Nearly Net Shape

- Many parts made by additive processes still need machining
- Additive is a “near net” process, but
- If you can’t get net, don’t go so near
- Machining thin parts from thick is easy, but machining thinner parts from parts that are already thin is hard

- Let’s just accept that we’ll have to machine the parts.
- Can we be creative in the additive shape (preform) to reduce the total time?
- Make some features that help machining, but are not functional in the finished part

Preform Requirements

- Contain the shape of the finished part while reducing workpiece material consumption
- Increase the minimum stiffness of the preform so that it is higher than that of the finished part by an order of magnitude or more
- Support expected machining forces while allowing tool paths that reduce tool wear
- Sacrificial structures

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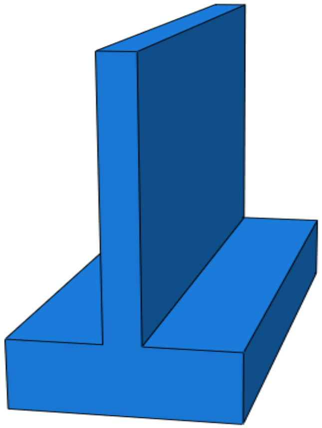

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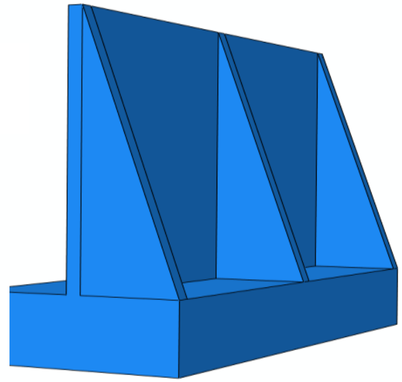

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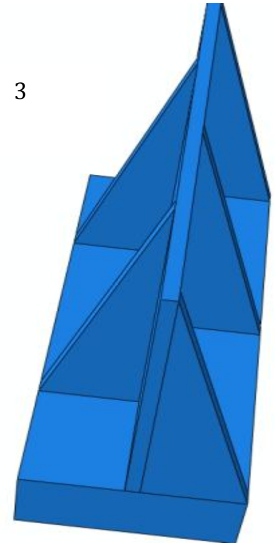

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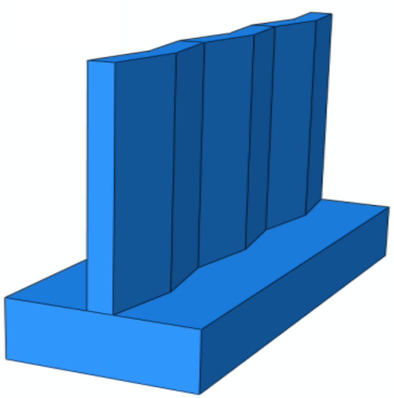

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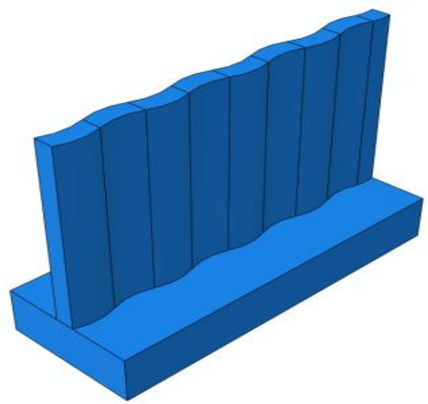
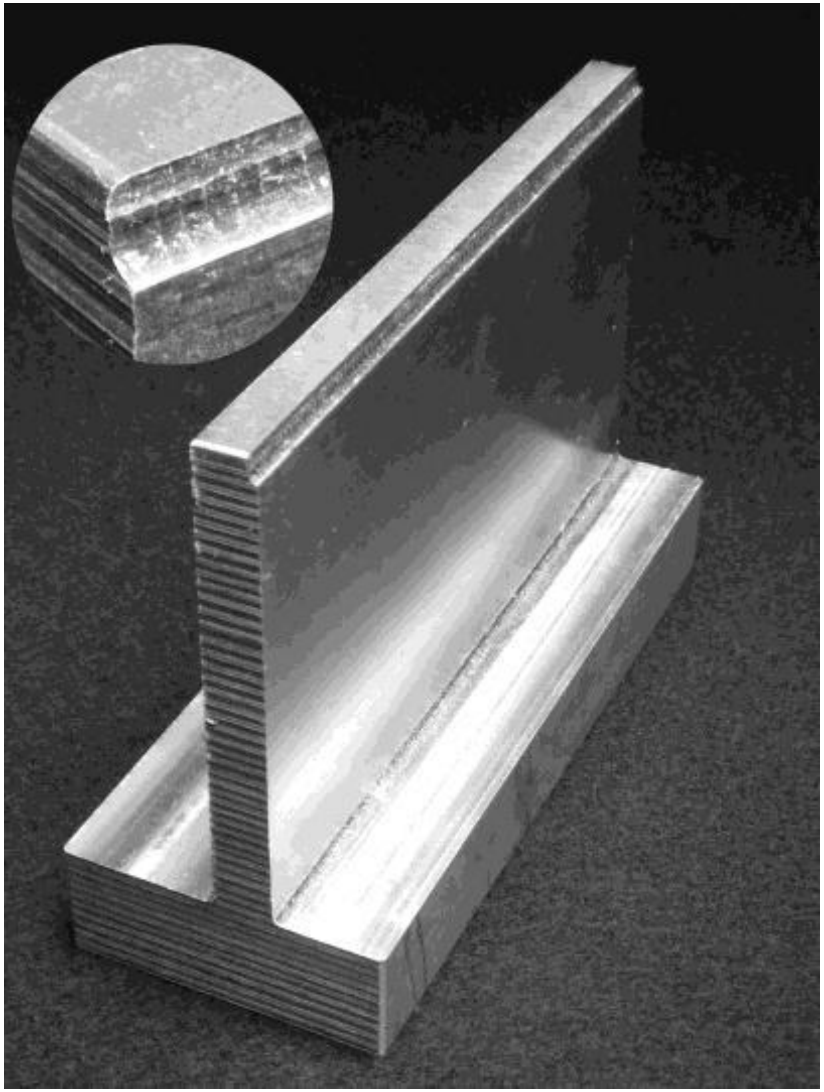
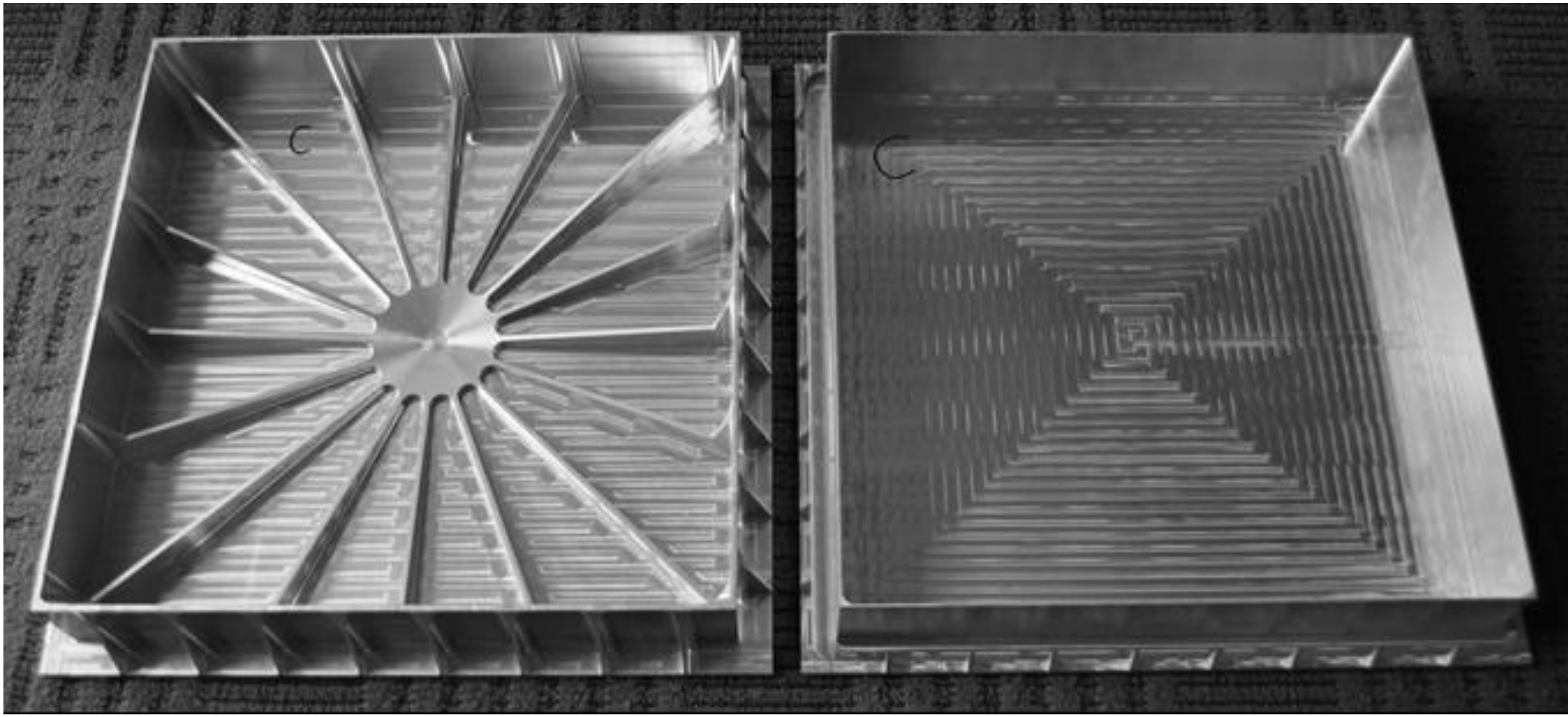
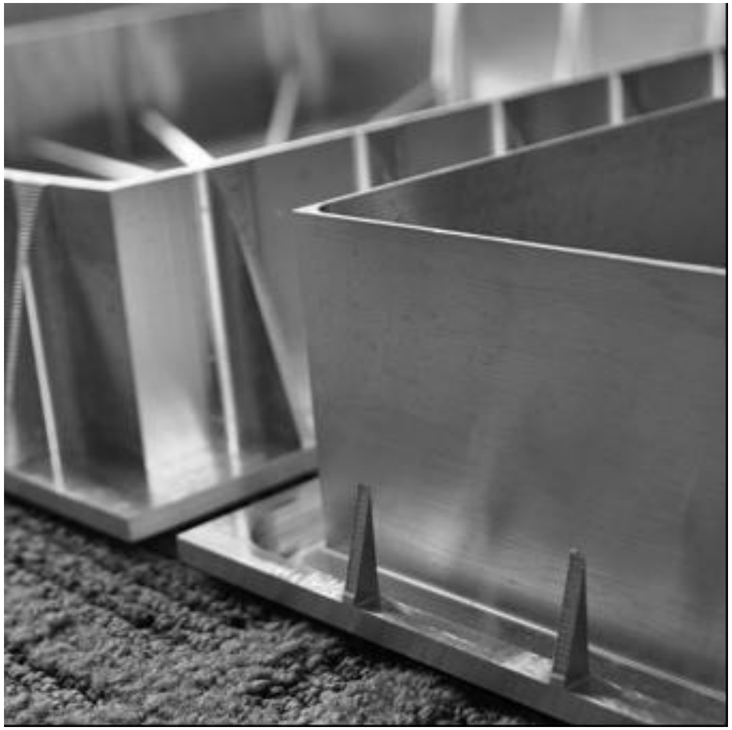


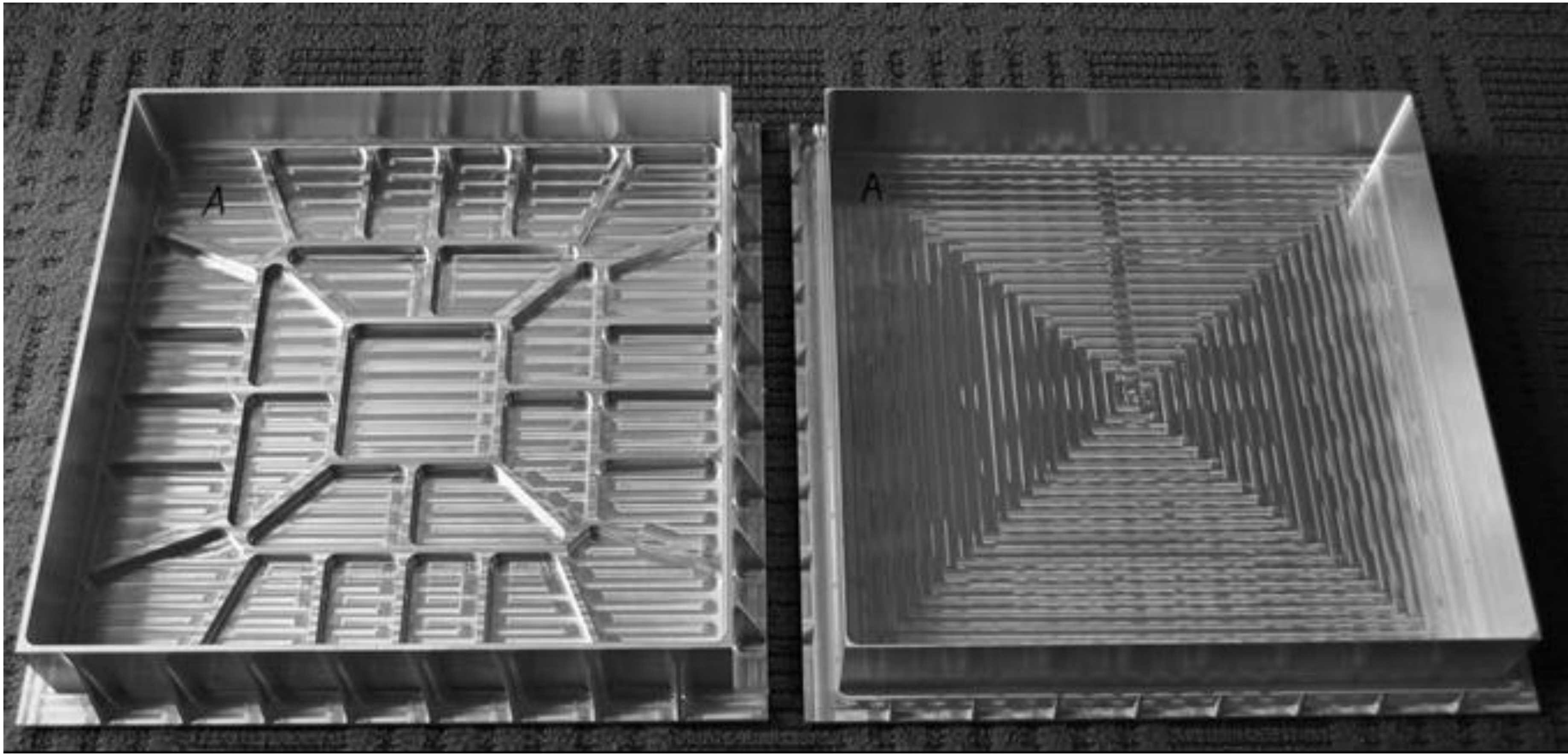
It is not good enough to simply thicken the preform







- Total machining time less than 10 minutes
- Ribs on the pan floor important
- Buttresses on side walls easily separated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