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DFMA®

Part Redesign with Minimal Disruption and Additional Cost to Assembly Process

About Acorn

- Founded in 1993
- Comprehensive product engineering/mechanical engineering services
  - Turnkey product development
  - Subassembly development, engineering analysis, materials cost analysis
  - Manufacturing cost reduction
- Serve leading companies around the globe

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Who We Serve

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Acorn Advantage

PROVEN PROCESSES

- Extensive simulation / analysis
- DFx
- Project peer reviews
- Acorn CAD check

GLOBAL RESOURCES

- Four design centers
- Worldwide ecosystem of contract manufacturers and suppliers

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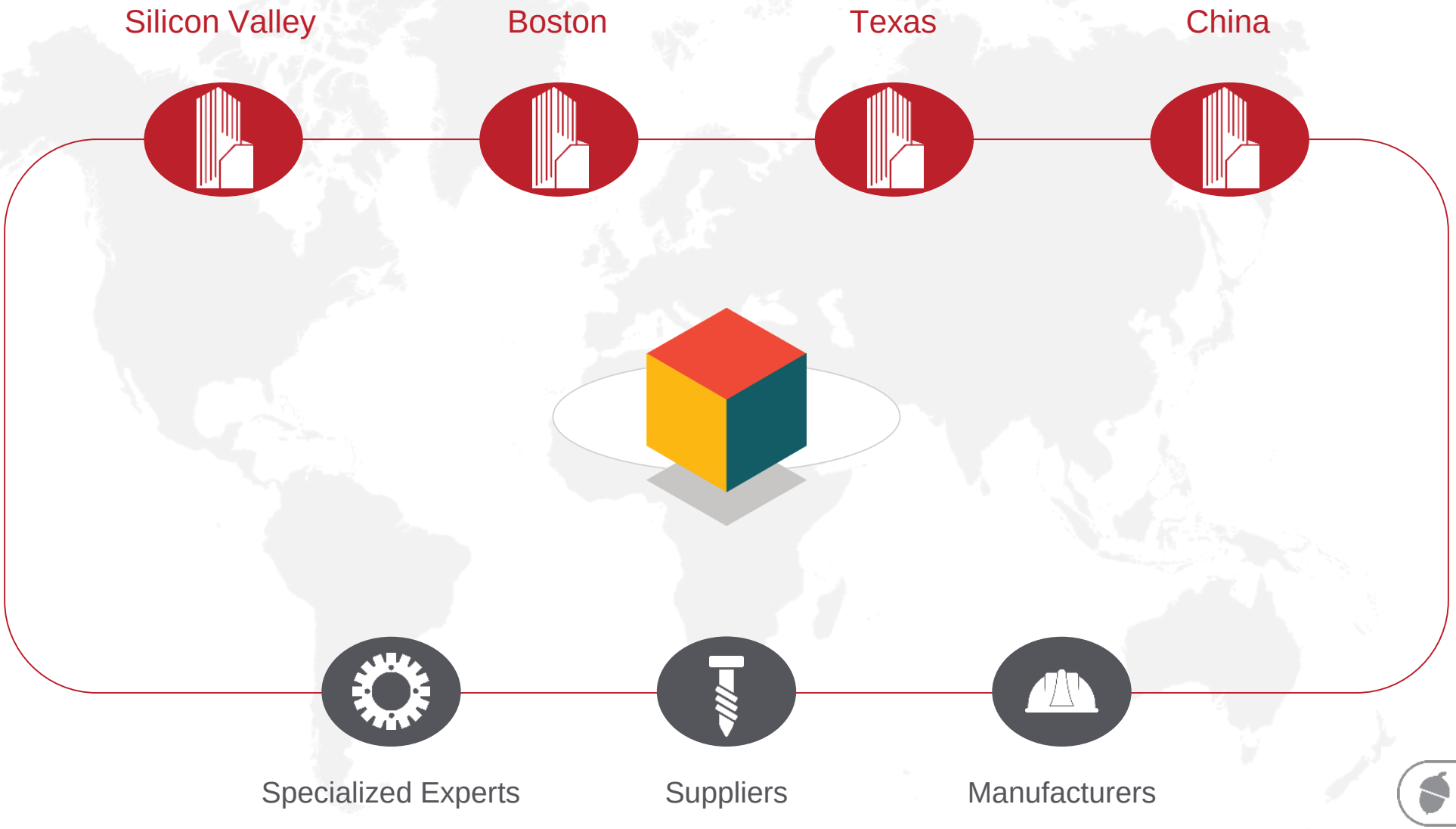
Acorn Advantage



Consumer Products

Apple
Desktop Computer

Flip
Consumer Video Camera

Logitech
Cameras

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Industrial / Robotics

Boston Dynamics
Numerous Projects

RoboteX
Avatar Micro II Surveillance Robot

Teradyne
Automated Disk Drive Test

Medical

Siemens
Ultrasound Imaging

Intuitive Surgical
Training Module

Cholestech
Blood Analyzer

Rack Mount Products

DFMA Boothroyd Dewhurst, June 2015

WATER PITCHER SLEEVE DESIGN

PART REDESIGN WITH MINIMAL DISRUPTION AND ADDITIONAL COST TO ASSEMBLY PROCESS

Iconic Product

…refreshed

- new and exciting
- differentiation
- colors
- patterns

“…look as good as possible,
as inexpensive as possible.”

Development Team

Industrial Design + Engineering + Manufacturing

“Before we put this design on paper, how do you, the manufacturing and assembly people, want us to proceed to make your job easier?”

- Lew Veraldi

Ideas, Restrictions, Reality

Engineering Design Goals

- No modification to existing tooling
- Existing supply chain
- Interchangeable design patterns
- Robust attachment
- Minimize assembled cost

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Development Team

Industrial Design + Engineering + Manufacturing

Design Process

Phase 1: Concept Development

"75% of the product costs are locked at the end of conceptual design" - ASME

Phase 2: Detail Design

Phase 3: Testing, Production Design

Phase 4: Production Ramp, Pilot

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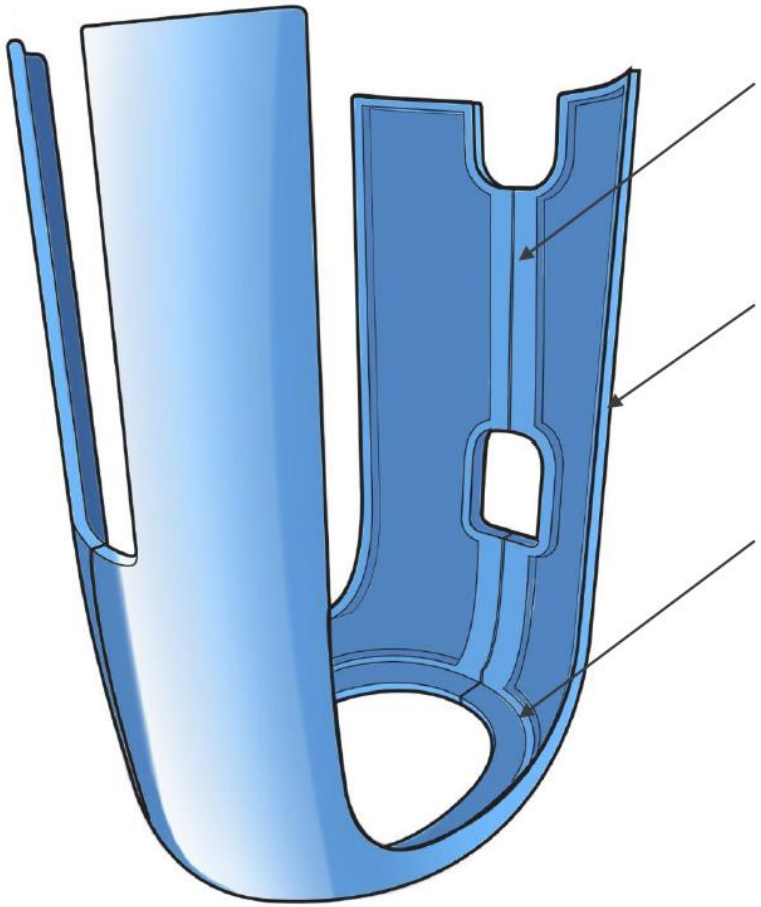
Risks

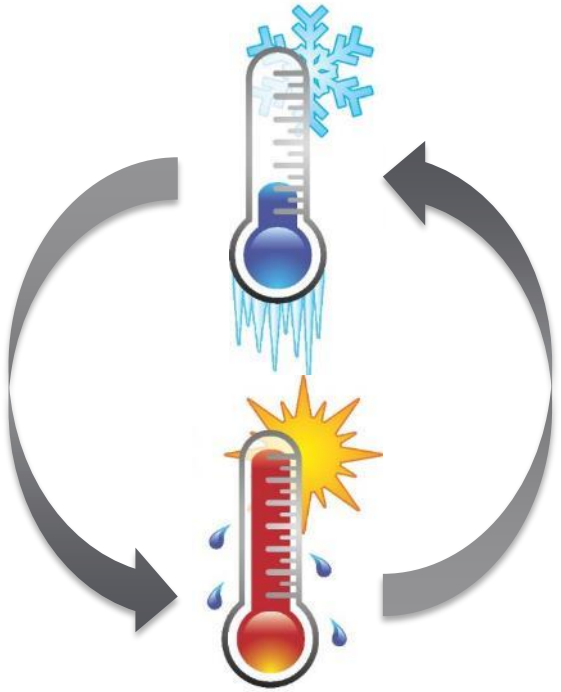


part break and
assembly strategy

heavy handling and
attachment method

drainage features

thermal cycling
(fridge - dishwasher)



Concept Development Brainstorm

Industrial Design + Engineering + Manufacturing

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Concept Development Brainstorm

Manufacturing:

- Injection molded
- Thermoformed
- Vinyl die cut
- In-mold labelling
- Sputtering
- Painting
- Flocking
- Thermal spraying
- Printing

Assembly:

- Thermal stakes
- Spot welds
- Solvent bond
- Snaps
- Ultrasonic weld
- Laser weld
- Pins
- Adhesives

Industrial Design + Engineering + Manufacturing

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Analysis Leads to Down Selection

Attachment Method									
Concept	Description	Pitcher Tool Simplicity	Sleeve Tool Simplicity	Assembly Simplicity	COGS	Ease of implementation	ID Intent	Integration	Alternative materials
F01	Press in Tab	0	0	1	0	0	-1	1	1
F02	Tab	0	1	0	1	0	-1	1	0
F03	Hook	0	0	1	0	0	0	0	1
F04	Spout Hook	0	1	0	1	0	-1	0	1
B01	Handle Hook	0	1	0	1	0	-1	0	1
FB1	Clip	1	-1	1	0	1	0	1	0
B02	Interlock	1	1	0	1	1	0	1	0
FB2	Groove	1	-1	0	0	-1	-1	1	1
FB3	Thermoformed	1	1	1	0	1	1	1	0
FB4	Vinly Die Cut	0	1	1	0	1	0	1	-1
FB5	In Mould Labeling	0	1	1	0	0	1	1	0
FB6	Sputtering	1	1	0	0	0	-1	1	-1
FB7	Painting	1	1	0	1	1	0	1	-1
FB8	Modified Flocking	1	1	0	1	0	1	1	-1
FB9	Flame Spray	1	1	-1	0	0	1	1	-1
FB10	Printing	1	1	0	1	1	0	1	-1
FB11	Thermal Staking	1	1	0	1	0	0	0	0
FB12	Hot Pin Stake	1	1	0	1	0	0	0	0
FB13	Solvent Bonding	1	0	0	1	0	1	0	-1
FB14	Ultrasonic	1	0	-1	0	0	1	1	0
FB15	Laser Welding	1	1	-1	0	0	1	1	0
FB16	Welding Pins	1	1	0	0	0	0	1	1
FB17	Adhesive	1	1	1	0	1	1	1	0

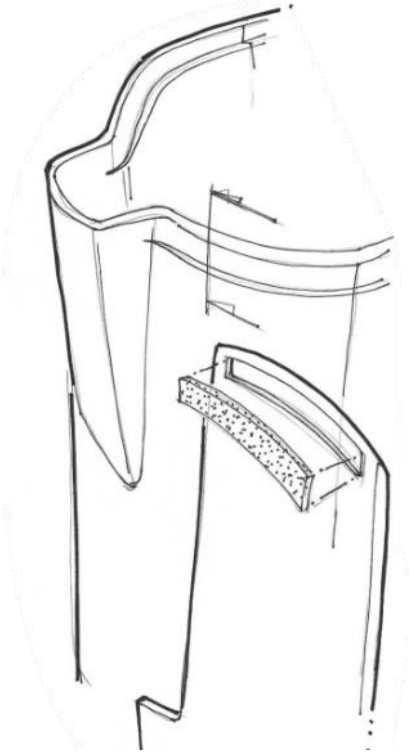
requires tool modification

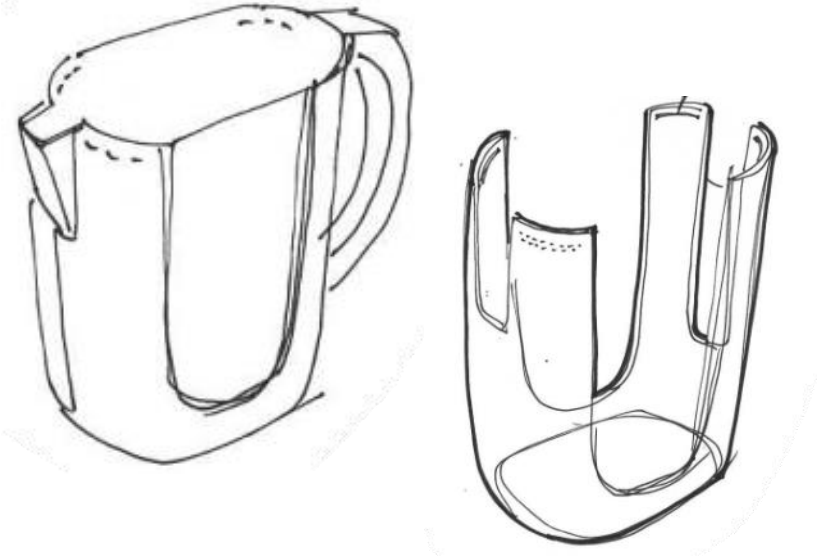
performance / functionality

outside vendor capabilities

Attachment Method

- Foam Tape
  - \+ Allows for different sleeve material options
  - \+ Simple fixture, less tooling
  - \+ Flexibility to allow for thermal expansion / contraction
  - \- Highly visible
  - \- Larger surface area required
  - \- Additional cost per unit





- Welding
  - \+ Bond line can be well hidden
  - \+ Same material eliminates concern of thermal cycling
  - \- Requires same material for sleeve as base
  - \- Tooling required

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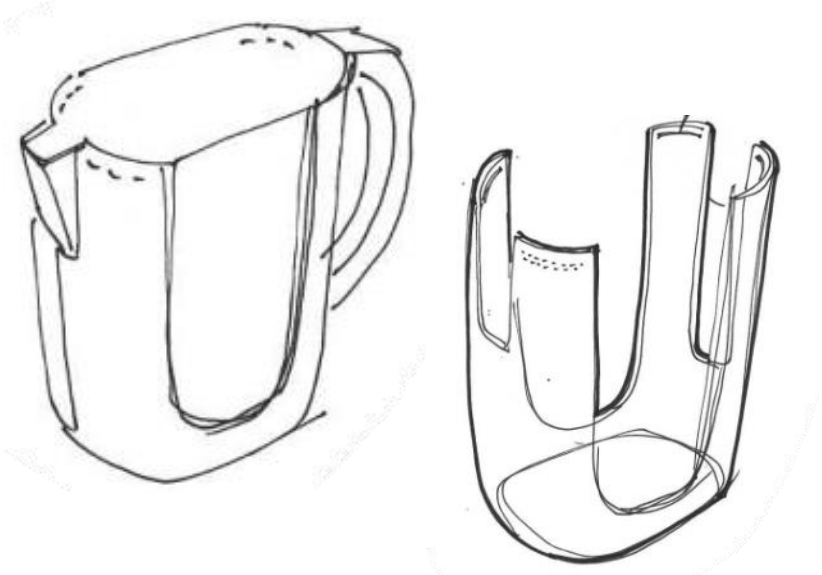
Attachment Method

Method	Equipment Cost	Fixture Cost	Assembly Time	Material Cost
Laser				
Ultrasonic				
Adhesive				



- Welding
  - \+ Bond line can be well hidden
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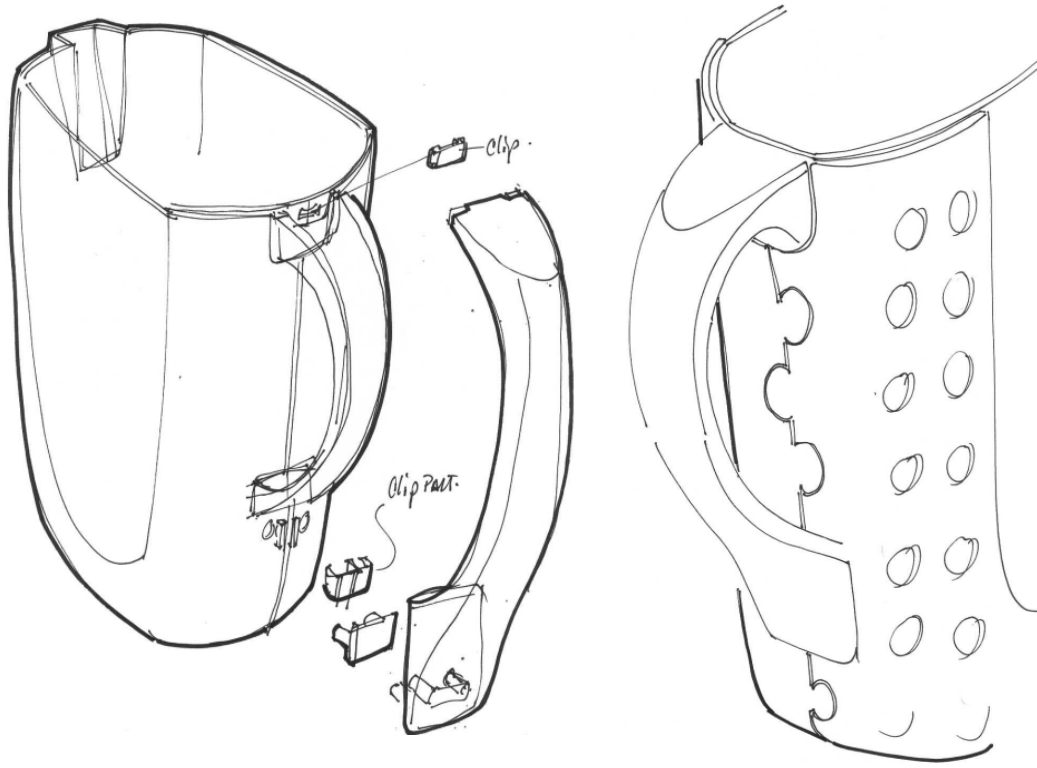
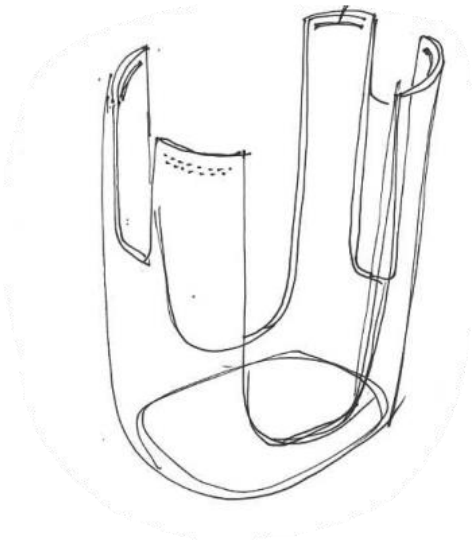
Injection Molded Sleeve

- Two Piece
  - \+ Full coverage under the handle
  - \+ Undercut easy to mold
  - \+ Simple tooling
  - \- Fitment due to two tools (not a common core)
  - \- Additional handlings
  - \- Additional parts
  - \- More raw material





- Single Piece
  - \+ Less time handling
  - \+ Tighter fit
  - \- Undercut in areas of sleeve
  - \- Less material required

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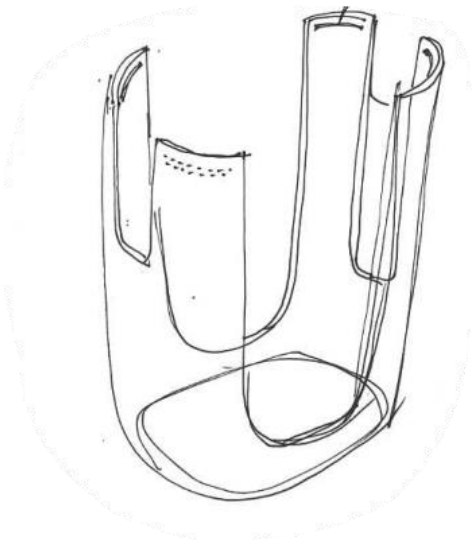
Injection Molded Sleeve

“Bumping” it off the tool is the cheapest production solution.



- Single Piece
  - \+ Less time handling
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  - \+ Simple tooling

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Design Process

Phase 1: Concept Development

Phase 2: Detail Design

Phase 3: Testing, Production Design

Phase 4: Production Ramp, Pilot

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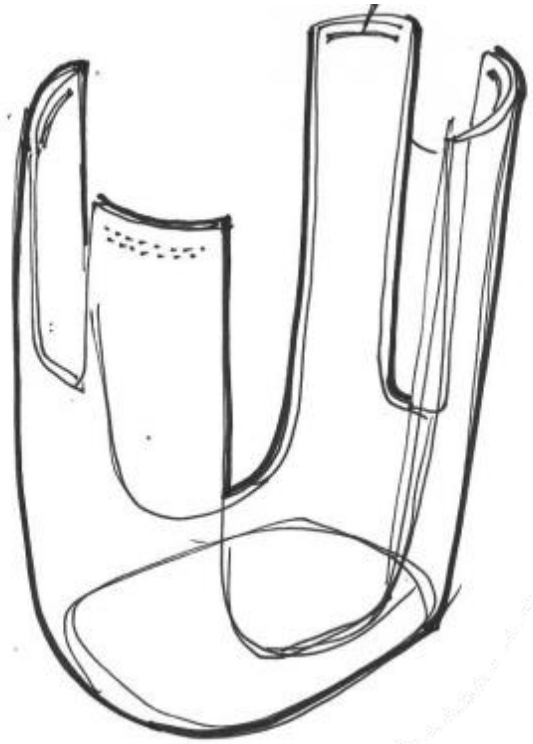
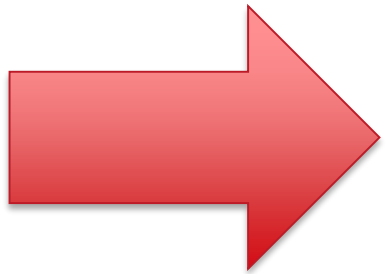
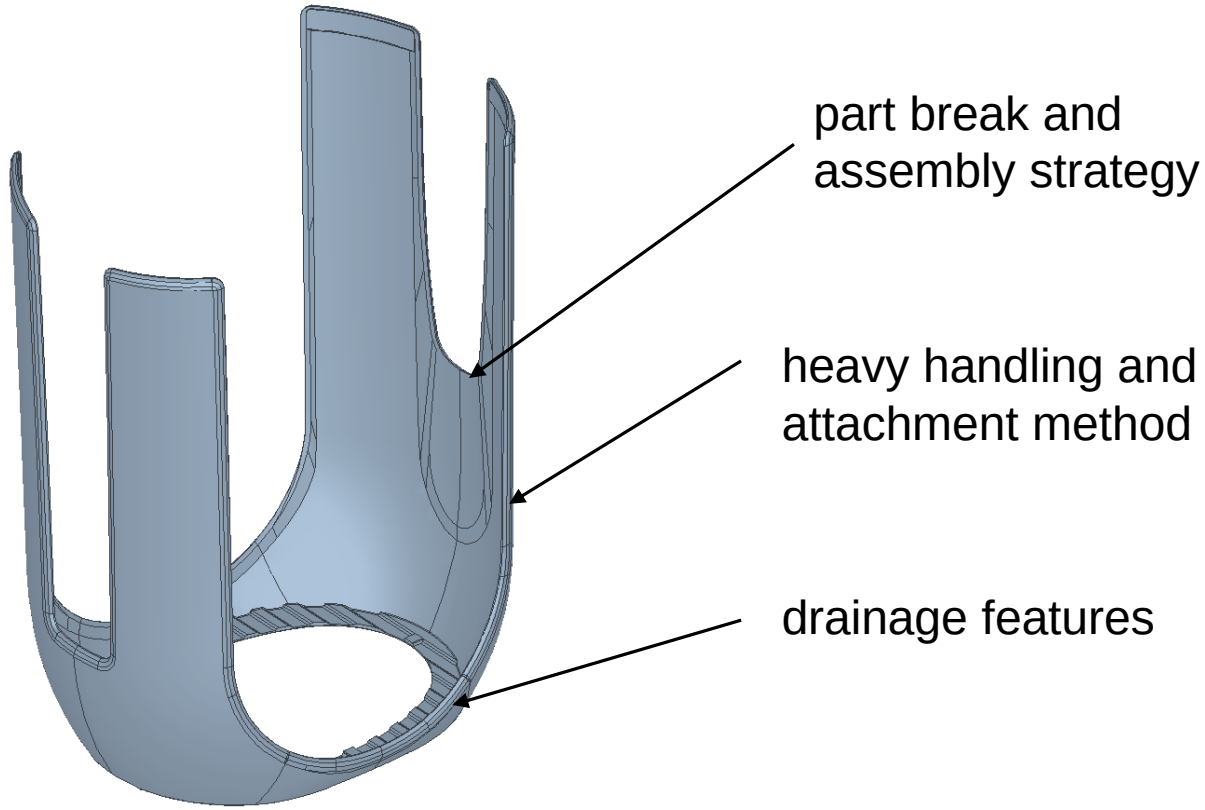
Detail Design







Design Process

Phase 1: Concept Development

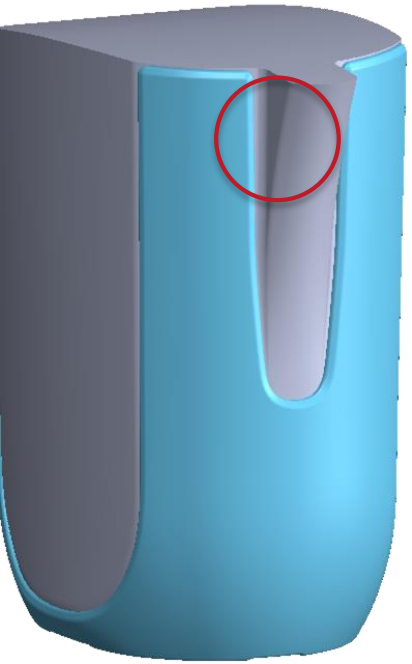
Phase 2: Detail Design

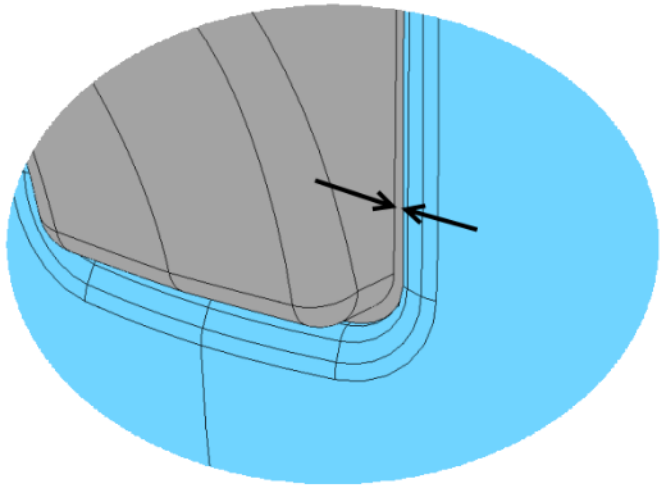
Phase 3: Testing, Production Design

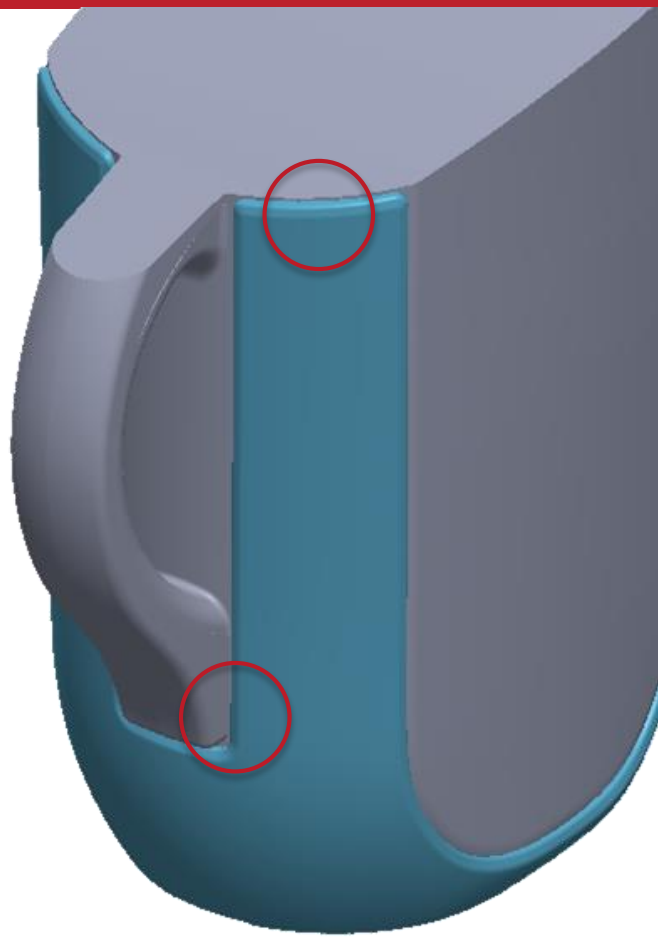
Phase 4: Production Ramp, Pilot

Tolerance Analysis, Production Design

- Tolerances are a key aspect of the detailed design
  - Cosmetic gaps under scrutiny
  - Maximize yield
  - Ease assembly







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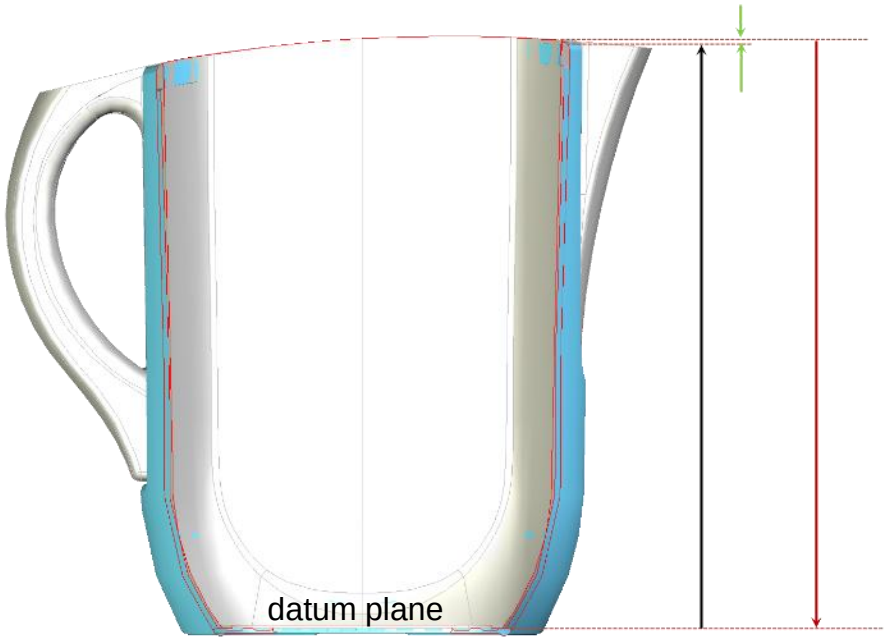
Tolerance Analysis, Production Design

- Tolerances are a key aspect of the detailed design
  - Cosmetic gaps under scrutiny
  - Maximize yield
  - Ease assembly

  ➤ Reduced Cost
- Manufacturing partner involvement provided:
  - Historical part data
  - Specific manufacturing capabilities



Tolerance Stack Up Analysis

Loop Name	Sleeve Gap
Revised Date	7/18/2011

Element Name	Nominal	±Ti	PDF	Effective Process Variation	Normal SD
Sleeve Height		0.5000	n	0.166667	0.1667
Pitcher Height		0.5080	n	0.169333	0.1693
Nominal Gap	1.19	**Z Predicted**	**Alpha (Single Sided)**	**DPPM**	**Percent Defects**
Upper Spec Limit	5	16.04	0.000000	0	0.00%
Lower Spec Limit	0	5.00	0.000000	0	0.00%
			Total DPPM	0	0.00%
			Effective Z	5.00	

Solving for our predicted distances:

Z (Sigma) = 5.0

Or, 99.99997% of the time, we would expect the gap to be between 0-5mm.

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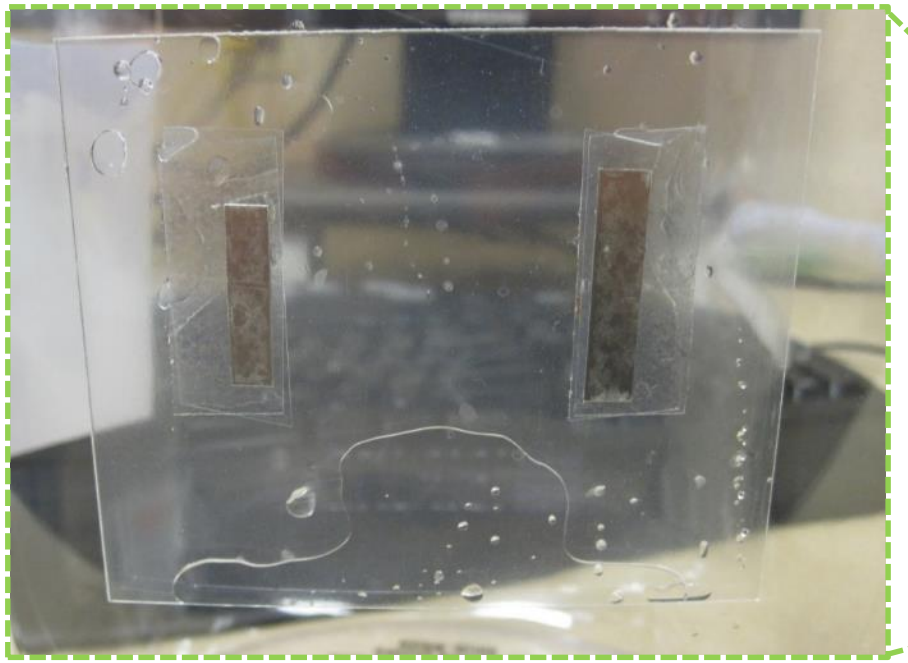
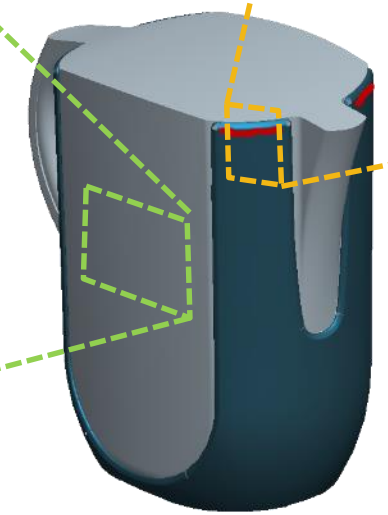
Testing, Production Design

- Drainage → pitcher sleeve spacing
- Validate weld strength and aesthetic
- Drop testing, 42” counter





Design Process

Phase 1: Concept Development

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Concluding Thoughts

Engineering Design Goals

- No modification to existing tooling → no tools modified, one new tool
- Interchangeable design patterns → new mold cavity per design
- Robust attachment → ultrasonic welding passed drop test
- Minimize assembled cost → maintain current MSRP

Keys To Success

- Consumer products are a balance → team effort, DES + ENG + MFG
- Work closely with your manufacturing partner → reduce time to market
- Assess manufacturing costs often → save $$

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Q and A

“Designs That Perform”
for Global Manufacturing and Worldwide Customers

Visit our website at www.acornpd.com for more information

Drew Blouch
Sr. Mechanical Engineer
dblouch@acornpd.com
(617)758-4163 (office)

Barry Braunstein
Vice President Business Development - East
bbraunstein@acornpd.com
(617)475-1541 (office)
(617)312-0104 (cell)

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Analysis Leads to Down Selection

ASKING DANIEL FOR BETTER EXPLAIN ON DOWNSELECTION PROCESS → for cost / DFM / DFA

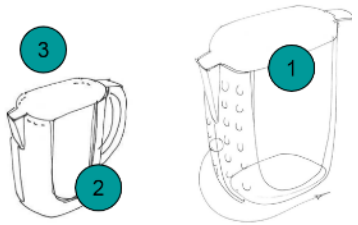
Best Cost

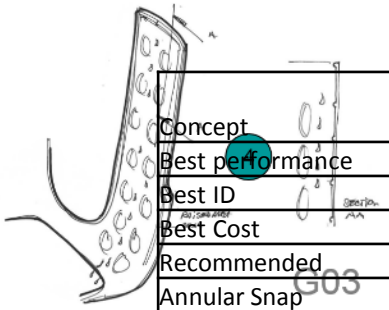
1. Each half injection molded with microban
2. Sleeve joined with ultrasonic weld in the front, back,
3. Sleeve welded to the pitcher at the top
4. Drainage features

Other features:

Additives: Yes
Sleeve Feature: Debossed
Mold Method: Traditional
Material: SAN

Single Piece





Concept	# Pieces	Front Bond	Back Bond	Top Bond	Microban Additive	Sleeve Features	Cosmetic Mold Method	Material	Drainage Feature
Best performance	One	Laser	Laser	Laser	No	Debossed	RHCM	SAN	No
Best ID	Two	Laser	Adhesive	Laser	Yes	Holes	RHCM	PC	Yes
Best Cost	One	Ultrasonic	Ultrasonic	Ultrasonic	Yes	Debossed	Texture	SAN	Yes
Recommended	One	Ultrasonic	Ultrasonic	Adhesive	Yes	Debossed	RHCM	PC/ABS	Yes
Annular Snap	Five	Mechanical	Mechanical	Adhesive	Yes	Holes	Texture	PC/ABS	Yes
Metal Clip	Five	Mechanical	Mechanical	Adhesive	Yes	Debossed	RHCM	PC/ABS	Yes

Attachment Method

Concept	Description	Sleeve Tool Simplicity	Assembly Simplicity	Assembly Cost	COGS	Ease of implementation	Integration	Microban Additive	Material Cost
G01	Best Performance	1	0	0	0	-1	1	0	1
G02	Best ID	1	-1	0	0	0	1	1	0
G03	Best Cost	1	0	1	1	1	1	1	0
G04	Recommended	1	1	0	0	1	1	1	0
G05	Annular Snap	-1	0	0	-1	0	0	1	0
G06	Metal Clip	0	0	0	-1	1	0	1	0

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