IS ADDITIVE MANUFACTURING USHERING IN A POST-INJECTION MOLDING ERA?

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Carbon
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REVOLUTIONIZING DESIGN CYCLES

- Eliminate tooling... $10K–$1M+
- Zero lead time... 8 weeks average
- Faster iterations
- Faster validation

By designing on the means of production...
CARBON PROPRIETARY CLIP PROCESS

- Build Platform
- UV Curable Resin
- Oxygen Permeable Window
- Dead Zone
- Projector
PROGRAMMABLE LIQUID RESINS

1. Liquid Programmable Resin

2. UV Light Cured Green Part

3. Thermally Cured Strong Part

CLIP

BAKE

Liquid resin with no cross-linkage

Cross-linked UV system with an unreacted thermal system

Post-bake an interpenetrating network of UV system and thermal system forms

Continuous Liquid Interface Production shapes the part

Thermal curing locks mechanical properties

GREEN YOUNG’S MODULUS

250-280 MPa

CURED YOUNG’S MODULUS

3800-4000 MPa
ISOTROPIC MECHANICAL PROPERTIES
<table>
<thead>
<tr>
<th>Item</th>
<th>Manufacturer</th>
<th>Type</th>
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<tbody>
<tr>
<td>CarbonResin PR 25</td>
<td>Carbon, Inc.</td>
<td>Unspecified</td>
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<td>CarbonResin FPU 230</td>
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<td>CarbonResin RPU 60</td>
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<td>CarbonResin CE 220</td>
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<td>Cyanate Ester Resin</td>
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<td>CarbonResin EPX 81</td>
<td>Carbon, Inc.</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Cardia Biohybrid™ BL-F</td>
<td>Cardia Bioplastics™</td>
<td>TPS+PE</td>
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</table>
CARBON’S EXPANDING FAMILY OF RESINS

RPU Rigid Polyurethane (Similar to ABS)
- Tough + abrasion resistant, stiff
- Highly elastic, resilient

EPU Elastomeric Polyurethane (Similar to TPU)
- Temperature resistant, strong, accurate
- Tough, impact + abrasion resistant, moderate stiffness

EPX Epoxy (Similar to 10% glass-filled PBT)
- Temperature resistant, strong, accurate
- Prints fast and accurately
- Dental production

CE Cyanate Ester (Similar to Ultem)
- High temperature resistant, strong, stiff
- Soft touch, biocompatible, and tear resistant

FPU Flexible Polyurethane (Similar to PolyPro)
- Rigid, fast prints
- Clear, biocompatible, and prints fast and accurately
- Third-party Materials

UMA Urethane Methacrylate
- Dental production

SIL Silicone-Urethane
- Clear, biocompatible, and prints fast and accurately
DLS solution enabled:
• Material properties
• Consolidation of parts to single design
• Fast turnaround and design iteration
• 10,000 parts printed in 2-day turnaround
DLS: PARTS FROM DAY 1
CASE STUDY: RINSING NOZZLE

DESCRIPTION
Vitamix was looking to produce a durable microfluidic nozzle to rinse their commercial blenders in stores across the U.S.

THE CHALLENGE
• Traditional injection molding design used 6 parts
• Potential durability challenges due to multi-part assembly
• Ability to perform in environments with bleach and other sanitizers

THE RESULTS
• 10x durable: Passes 1.5 million rinse cycles in field testing, offering excellent resistance to bleach and other sanitizers
• 30% less material: Design freedom to make single 3D-printed part using Carbon’s RPU material
• 33% more economical: FEA optimized design is lighter, requires no tooling and secondary operations
AUTO SENSOR BRACKETS

INITIAL DESIGN: $4.28
- Injection molded
- 8 unique parts per model
- 6 models under 6K per year
- 48 unique parts under 6K per year
- Tooling $2.4M
- 16–24 week lead time
- Cost: $4.28 with 3-year tooling amortization

CARBON: $3.52
- No tooling
- First parts within a week
- Cost: finished parts $3.52

APPLICATION SIZE:
- 2018: 54K units
- 2019: estimated over 1M units
CASE STUDY: STRAIN RELIEF

LEGACY DESIGN
- Assembly
  - 3 injection molded parts
  - 8 screws
  - 2 O-ring seals
  - Assembled part cost: $5
  - Tooling: $9K
  - Multiple failure modes

DLS DESIGN
- 1 printed part
  - No screws
  - No O-ring seals
- Part cost: $8
- Tooling: $0
- Fewer failure modes
TEXTURES

- Algorithms and UI to automate texture selection and application
- Moving beyond aesthetic textures to engineered, functional surfaces
# Standards & Practices of Plastics Molders

**Note:** The Commercial values shown below represent common production tolerances at the most economical level. The Fine values represent closer tolerances that can be held but at a greater cost. Any addition of fillers will compromise physical properties and alter dimensional stability. Please consult the manufacturer.

<table>
<thead>
<tr>
<th>Drawing Code</th>
<th>Dimensions (Inches)</th>
<th>Plus or Minus in Thousands of an Inch</th>
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<tbody>
<tr>
<td></td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.500</td>
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<td>6.000 to 12.000</td>
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<tr>
<td></td>
<td>for each additional inch added (inches)</td>
<td>Comm. ±</td>
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<tr>
<td>D = Bottom Wall</td>
<td>(See note #3)</td>
<td>0.003</td>
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<tr>
<td>E = Side Wall</td>
<td>(See note #4)</td>
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</tr>
<tr>
<td>F = Hole Size Diameter</td>
<td>(See note #1)</td>
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</tbody>
</table>

Material:
Acrylonitrile Butadiene Styrene (ABS)

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**Carbon**
Carbon x adidas Create Video - 84K Video Views
Adidas Futurecraft 4D

“With Digital Light Synthesis, we venture beyond limitations of the past, unlocking a new era in design and manufacturing. One driven by athlete data and agile manufacturing processes.”

- Eric Liedtke
  Adidas Group Executive Board Member Responsible For Global Brands

- Breakthrough design and performance
- 10x number of design iterations
- Scale up:
  - 100,000+ pairs in 2018
  - Millions in 2019+
- Path to mass customization
MEDICAL DEVICES

RESPIRATOR MASK

TROCAR HANDLE

TRANSCUTANEOUS ACCESS PORT

SURGICAL GUIDES

ENDOSCOPY TIP

Functional Surface Textures
[Comfort, fit]

Customization
+ Digital Texturing

Impossible Geometries

Customized Geometries

Flexible Structures
+ Sterilizable Materials
Stop prototyping. Start producing.

Scott Kraemer, Production Development Engineer
Carbon