URETHANE CASTING DESIGN GUIDELINES

URETHANE CASTING PROCESS

Stratasys Direct Manufacturing offers six Urethane Casting products – QuantumCast, CompositeCast, VolumeCast, RotationCast, Engineering Grade, and CompressionCast.

QuantumCast is Stratasys Direct Manufacturing’s flagship Urethane Casting product on which we’ve built our expanded offering. QuantumCast is a proprietary multi-step technology that applies vacuum, heat and pressure to process Advanced Formula Polymers (AFP’s) yielding void-free, strong and stable pre-production and short-run production components. This low pressure injection molding into reinforced soft tools combines the benefits of platinum silicone molds (speed and versatility) with quantum improvements in mechanical properties utilizing AFP materials. Specifically, our AFP3100 has over three times the impact strength of earlier generation cast urethanes while offering excellent rigidity (high flex modulus).

CompressionCast Silicone utilizes a compression molding process with flexible silicone material. Silicone parts are ideal for button and keypad applications as well as water resistant applications.

CompositeCast, offered only by Stratasys Direct Manufacturing, was developed over a two year period with testing at six beta sites. CompositeCast takes QuantumCast to the next level by adding composite sheet material (fiberglass, carbon fiber, Kevlar, etc.) into the cavity of our precision Platinum Silicone molds. The result is a very tough and stiff composite reinforced cast urethane part with B-side detail captured. Typical cloth to resin ratios are 27 - 41%.

RotationCast is ideal for producing hollow parts or complex core geometries. RotationCast combines our premium platinum silicone molds on a multi-axis casting platform with standard QuantumCast materials.

Engineering Grade is a cost effective and quick-turnaround solution for non-cosmetic applications.

VolumeCast produces longer runs of parts at a lower per piece price point, achieved using various casting and hybrid tooling techniques that extend mold life and output. The main advantage of VolumeCast is that it can produce many parts from one tool without having to use expensive hard tooling. VolumeCast is suitable for 25 - 100 part runs and is available with Stratasys Direct Manufacturing’s AFP 4010V black material. VolumeCast projects are reviewed on a case-by-case basis for sustainability.

CONTACT A STRATASYS DIRECT MANUFACTURING PROJECT ENGINEER TODAY TO DISCUSS YOUR NEXT CAST URETHANE PROJECT BY CALLING 888-311-1017, OR VISITING STRATASYSDIRECT.COM.
ADVANTAGES OF URETHANE CASTING

1. **Low Cost Molds**
   Molds are cast using platinum silicone around master patterns built utilizing Stereolithography (SL), PolyJet or CNC technologies. The molds are generally good for 20 - 25 reproductions.

2. **Short Lead Times**
   Upon receiving CAD data, typical cast urethane projects can be shipped in 3 - 10 days.

3. **Greater Design Flexibility**
   - Parts designed for injection molding can be easily cast as urethanes.
   - No lifters or slides are necessary. Most undercuts are acceptable – draft is not a concern.
   - Thin and thick wall sections (non-typical wall thicknesses) can be present in the same part.
   - Threaded inserts are micro-welded into place with precision using Stratasys Direct Manufacturing proprietary technology. The resulting torque and pull out strength are far superior to conventional heat staking or bonding of threaded fasteners into plastic parts.
   - Small features are acceptable. Even figurines can be cast.
   - No sink issues.
   - Snap-fit friendly materials available.
   - Cast-in surface textures are not a problem. MT-11000 to MT-11040, MT-1055-1 to MT-1055-7 and SPI/SPE A1 to D3 are all available. Note that cast-in texture can reduce mold life.

CAST URETHANE MATERIALS

Stratasys Direct Manufacturing has a wide selection of Advanced Formula Polymer (AFP) and Shore A flexible materials to suit most applications. UL 94-V0 and FAR 25.853 flame ratings, high temperature, clear and medical imaging materials are all available. There is also a family of foam materials available with variable densities ranging from 3 to 32 lbs. Materials can be cast in color and textured to achieve the look you need or painted and textured to provide UV stability.
DESIGN GUIDELINES

Urethane Casting production consists of three processes once CAD data is received by Stratasys Direct Manufacturing:

1. Build a master pattern utilizing either Stereolithography or PolyJet Additive Manufacturing technologies, or with a CNC machining center.
2. Create a platinum silicone mold.
3. Cast parts utilizing our proprietary QuantumCast casting method under vacuum, heat and pressure.

The process provides greater freedom and flexibility in producing parts compared to other manufacturing technologies.

WALL THICKNESS

Minimum wall thickness for cast urethane parts is 0.020” and 0.050” for CompositeCast parts. While a good design practice is to maintain a uniform wall thickness, you can vary your wall thicknesses in the urethane casting process without impacting the resulting parts. The process is ideally suited when you require non-typical wall thicknesses.

DRAFT & UNDERCUTS

Draft and undercuts are not a concern when designing for the urethane casting process itself. However, if you’re building prototypes that are intended to move on to another production method like injection molding where hard tooling is required, you should create your design as intended for production. The urethane casting process is still ideal for prototypes and short runs of parts that will move on to other production technologies.

RIBS

Ribs are used in a design to increase the bending stiffness of a part without adding thickness. Ribs increase the moment of inertia, which increases bending stiffness.

\[ \text{Bending Stiffness} = E \text{ (young’s Modulus)} \times I \text{ (Moment of Inertia)} \]

Rib thickness should be less than wall thickness to minimize shrink and sinking effects. The recommended rib thickness should not exceed 60 percent of the nominal thickness. Plus, the rib should be attached with corner radii as generous as possible.

RIB INTERSECTIONS

Because the thickness of the material will be greater at the rib intersections, coring or another means of material removal should be employed to avoid excessive sinking from occurring on the opposite side.

RIB GUIDELINES

The height of a rib should be limited to less than three times its thickness. It is better to use multiple ribs to increase bending stiffness than to use one very tall rib.
RIB/LOAD AFFECT ON STIFFNESS

A rib is oriented to provide maximum bending stiffness to the part. By paying attention to part geometry, designers must be conscious of the orientation of the rib to the bending load or there will be no increase in stiffness.

VOIDS AND SHRINKAGE

In most molding processes, troublesome shrinkage problems can be caused by the intersection of walls that are not uniform in wall thickness. Examples might include ribs, bosses, or any other projection of the nominal wall. Since thicker walls solidify slower, the area they are attached to at the nominal wall will shrink as the projection shrinks. This can result in a sunken area in the nominal wall. Such shrinkage can be minimized if a rib thickness is maintained between 50 - 60% of the walls they are attached to. To further our example, bosses located in a corner produce very thick walls, causing sink, unless isolated as in the illustration below.

The urethane casting process offers an advantage over typical molding processes. While injection molding will leave sink marks as shown in the image on the left above, the geometry is acceptable for urethane casting and won’t cause sink. If the design is ultimately going to an injection molding process, you’ll still want to isolate the boss from the corner as shown in the image on the right.

BOSSES

Bosses are used to facilitate the registration of mating parts, for attaching fasteners such as screws, or for accepting threaded inserts.

Wall thicknesses for bosses should be less than 60 percent of the nominal wall to minimize sinking. However, if the boss is not in a visible area, the wall thickness can be increased to allow for increased stresses imposed by micro-welded inserts or self tapping screws.

The base radius should be a minimum of 0.25 X thickness. Bosses can be strengthened by incorporating gussets at the base or by using connecting ribs attaching to nearby walls.

*Typical sink marks from the injection molding process are minimized with cast urethanes.*
RADII AND FILLETS
A fillet radius of 0.125" is recommended on inside corners to increase strength. The inner corners of bosses can use 0.060" radii to help reduce wall thickness. Use these radii whenever you make transitions between surfaces. Radii are important because rigid urethanes are notch sensitive materials.

JOINTS BETWEEN PARTS
Good design practices recommend that a part in an assembly take its position from its mating part. The urethane casting process offers many options for locating parts relative to one another. Industrial designers often want to incorporate reliefs into the joints between parts.

General guidelines for overlap joints in common situations:

<table>
<thead>
<tr>
<th>Size of Part (length of part's perimeter)</th>
<th>Reveal Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10&quot;</td>
<td>0.025&quot;</td>
</tr>
<tr>
<td>10 - 20&quot;</td>
<td>0.040&quot;</td>
</tr>
<tr>
<td>20 - 60&quot;</td>
<td>0.060&quot;</td>
</tr>
<tr>
<td>&gt;60&quot;</td>
<td>0.080&quot;</td>
</tr>
</tbody>
</table>

Tongue and groove joints can be used to fully locate one plastic part relative to another. The inside portion of the groove can be localized or it can be continuous around the entire perimeter of the part. Allow clearances between the tongue and groove for tolerances and paint thickness (if any). Allow more clearances if the tongue and groove feature extends around most of the parts’ perimeters. Increase the length of the step or rabbet joint as the size of the part increases. Larger parts need a larger reveal gap and interlock to compensate for tolerances and to provide a proportionate look.

LETTER AND Logos
Both raised and recessed letters and logos can be molded into cast urethane parts. The key factors are: height or depth of the feature, width of the feature, radii on the feature and space between features.

The recommended minimum space between features is 0.050". Width to height ratios should be at least 2. The radii should be at least equal to half the height. Larger radii are better.

SNAP FITS AND MOLDED IN HOOKS
Snap fits can be used in all urethane casting processes following design practices used for thermoplastic resins. Molded in hooks can speed assembly time and save the cost of hardware, and are often used to attach component parts, PC boards, tubing, and electrical wires.

OVER-MOLDING
Stratasys Direct Manufacturing QuantumCast and CompositeCast systems allow the option of over-molding your cast urethane parts. Typically an elastomeric urethane material is molded over a rigid urethane substrate to form a component part incorporating both soft and rigid materials.

Other over-molding options like threaded studs, posts, nut plates, strain reliefs on electrical cords or metal stiffening components are available as well with manufacturing approval.

(Design Guidelines continued on next page)
MICRO-WELDED INSERTS

Micro-welded inserts were developed at Stratasys Direct Manufacturing as an answer to our customers’ requirement for extremely strong installment of threaded inserts. This proprietary procedure is offered exclusively in QuantumCast and CompositeCast products. Our torque test results demonstrated that the micro-welded inserts in urethane casted parts were on average 50 - 100% stronger than bonded inserts and over 100% stronger than heat staked inserts. The chart below is intended as a design guide for Dodge Ultrasert II inserts to be Micro-welded into place using Stratasys Direct Manufacturing proprietary system.

<table>
<thead>
<tr>
<th>Insert size</th>
<th>Hole Depth (in.)</th>
<th>Hole Dia. (in.)</th>
<th>Minimum Boss OD (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-40</td>
<td>0.135 or 0.219</td>
<td>0.172</td>
<td>0.232</td>
</tr>
<tr>
<td>6-32</td>
<td>0.150 or 0.250</td>
<td>0.219</td>
<td>0.290</td>
</tr>
<tr>
<td>8-32</td>
<td>0.185 or 0.312</td>
<td>0.250</td>
<td>0.350</td>
</tr>
<tr>
<td>10-24</td>
<td>0.225 or 0.375</td>
<td>0.297</td>
<td>0.430</td>
</tr>
<tr>
<td>¼-20</td>
<td>0.300 or 0.500</td>
<td>0.375</td>
<td>0.520</td>
</tr>
<tr>
<td>M2.5 x 0.45</td>
<td>0.135 or 0.219</td>
<td>0.172</td>
<td>0.232</td>
</tr>
<tr>
<td>M3.0 x 0.5</td>
<td>0.150 or 0.250</td>
<td>0.219</td>
<td>0.290</td>
</tr>
<tr>
<td>M3.5 x 0.6</td>
<td>0.150 or 0.250</td>
<td>0.219</td>
<td>0.290</td>
</tr>
<tr>
<td>M4.0 x 0.7</td>
<td>0.185 or 0.312</td>
<td>0.250</td>
<td>0.330</td>
</tr>
<tr>
<td>M5.0 x 0.8</td>
<td>0.264 or 0.437</td>
<td>0.328</td>
<td>0.460</td>
</tr>
<tr>
<td>M6.0 x 1.0</td>
<td>0.300 or 0.500</td>
<td>0.375</td>
<td>0.520</td>
</tr>
</tbody>
</table>

PAINTING & FINISHING

SPECIFYING SURFACE TEXTURE

Stratasys Direct Manufacturing offers multiple textured surface finishes on cast urethane parts specified through the Moldtech guide from MT-11000 through MT-11040 and MT-1055-3 thru MT-1055-7, or smooth surfaces between SPI/SPE A1 to D3. The preferred method is to texture the master pattern by using a specially adjusted paint spray gun to achieve the specified texture, which transfers to the mold and ultimately to the finished parts. Texture painting can also be applied to individual casted urethane parts. This is sometimes necessary to maximize mold life.

PART COLOR

Cast urethane parts can have cast-in color and texture or can be painted to achieve the color, gloss level and uniform surface appearance desired. While cast-in color has the advantage of not chipping or peeling, painting can eliminate mold parting and witness lines and differences in shade that can occur with changing wall thickness, and has greater UV stability. While urethanes are not generally known to maintain excellent paint adhesion, Stratasys Direct Manufacturing has developed a proprietary surface preparation method that maximizes paint adhesion and durability.

Another option for applications where parts may be scratched is to cast in a matching color to the painted parts. This provides a “scratch resistant” color-on-color that will have a better appearance over time for production applications in demanding environments.
TECHNICAL DETAILS

MAXIMUM PART SIZE
Approximately 1,000 in³. Parts need to be reviewed on an individual basis to determine compatibility with Stratasys Direct Manufacturing’s casting processes.

MINIMUM FEATURE SIZE
Shallow and small surface features of any size can be reproduced (a thumbprint on the master pattern may show up on the final parts). A minimum wall thickness of 0.020 - 0.040" is required for QuantumCast parts, and 0.050" for CompositeCast and VolumCast parts. All minimum wall thickness requirements need to be reviewed with manufacturing.

ACCURACY
Standard tolerances are ± 0.015" or ± 0.003 “/”, whichever is greater. Tighter tolerances may be offered on a case-by-case basis.

INSPECTION
Molded parts are manufactured in an ISO 9001 or AS9100 certified facility and come standard with a 6-point inspection: X, Y, and Z measurements, and overall visual inspection of feature integrity and aesthetics. Any parts with inserts will undergo an insert inspection. For standard tolerances, only the first part from each mold is inspected. For premium tolerances, all parts receive the 6-point inspection. Parts requiring a fit check need to be identified at time of quote by the client so each fit check can be identified and performed. For production projects, inspection plans are geometry specific and negotiated as part of contract review.

COLOR MATCHING
Paint color is best established by specifying the color you want to achieve, typically done by specifying a PMS (Pantone Matching System) color. When casting colors, we can commit to providing a shade in or out of the specified color as the casting process involves manually mixing the two-part urethane with color immediately before casting. If an exact color match is required, painting may be your better option as there’s more control over the process. Some cast-in metallic looks can be achieved through additives to the raw urethane materials but consistency and uniformity will most often require the use of metallic paints.

EMI/RFI SHIELDING
Plastic enclosures designed to house sensitive electrical components often require EMI (Electro Magnetic Interference) or RFI (Radio Frequency Interference) shielding.

EMI and/or RFI are generated by the electronics or power supplies in your device or exposure from other devices can generate it and cause interference with your device.

Stratasys Direct Manufacturing offers EMI/RFI shielding formulas specifically designed for use with plastic parts in copper, nickel and silver. These formulas can be applied to the specified surfaces of your cast urethane parts to achieve effective EMI or RFI shielding.
Advanced Urethane Casting
QuantumCast | CompositeCast | VolumeCast | RotationCast | Engineering Grade | CompressionCast Silicone

- Process begins with creation of a master pattern
- Platinum silicone mold is formed around master pattern, gating and venting
- The mold is cut along parting line and master pattern is removed
- The reassembled mold is filled with liquid polyurethane and placed under heat and pressure
- Cured part is extracted and gates and flash are removed
- Mold can be reused to create multiple castings