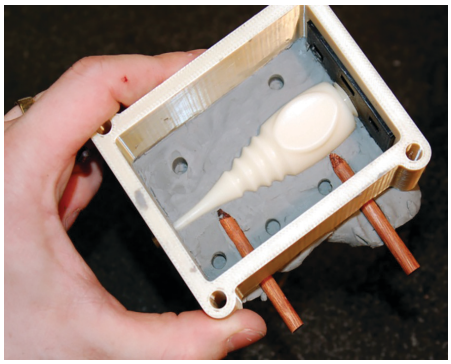
TECHNICAL APPLICATION GUIDE

FDM Patterns for RTV (Rubber) Mold Making

RTV rubber molding is a fast and affordable solution for prototyping and short-run production. Offering lead times of three to seven days at just one-tenth (or less) of the cost of an aluminum tool, RTV molding is an attractive alternative for plastic parts.



RTV (room temperature vulcanized) molds start as a liquid silicone rubber that is poured over a pattern. The rubber cures and becomes firm, yet flexible. The result is a mold that can reproduce extremely complex geometry and intricate detail with tight tolerances.

While RTV molding can produce complex urethane casting quickly, cost effectively and accurately, the ability to do so is dependent on the pattern. The pattern forms the intricate details and dictates the quality of the castings made from the rubber mold. The pattern also adds to the lead time and cost of the project. If machined, a complex pattern can cost as much an RTV mold and take as long to make.

By replacing machined patterns with FDM, mold-making process can be completed in two to three days. And unlike machining, complex and intricate shapes have no effect on the time or cost of the FDM pattern.

An important consideration, which is often overlooked, is that FDM patterns can endure the mold-making process. They can withstand the weight of the rubber and the heat that is generated while vulcanizing. Additionally, the strength of the pattern makes it much more likely that it can be extracted from the RTV mold without breaking. So, the pattern can make multiple RTV molds.

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FDM PATTERNS FOR RTV (RUBBER) MOLD MAKING

1. OVERVIEW

1.1. Application:

FDM may be used in any RTV molding project. Its role is to produce patterns and mold components that form the RTV rubber mold.

1.2. FDM is a best fit when:

- Complex designs:
  - Feature-laden.
  - Internal ports, passages or channels.
  - Organic shapes.
  - Not recommended for very fine features (e.g., jewelry applications).
- Size:
  - No upper limit.
    - May bond sections to build large patterns.
  - Lower limit: >1.0 in. (25 mm) in diameter.
- Stable, inert patterns needed.
  - Preserve accuracy.
  - Avoid curing inhibition.
- Duplicate molds required.
  - May extract pattern from mold without damage.
    - Can be re-used to cast additional RTV molds.

Figure 1: Overmolded connector cast in an RTV mold made from and FDM pattern.

Figure 2: FDM pattern ready for mold making.

2. TRADITIONAL PROCESS OVERVIEW

There are many styles and approaches to the “art” of RTV molding. The following information outlines one of the most common methods.

2.1. The steps in the RTV molding process are:

2.1.1. Pattern-making.

2.1.1.1. Construct pattern (Figure 3).

2.1.1.2. Finish to desired smoothness.

2.1.2. Mold-making.

2.1.2.1. Make casting boxes.

2.1.2.2. Establish parting surfaces.

2.1.2.3. Add gates, vents and locators (Figure 4).

2.1.2.4. Pour A-side.

- Mix two-part RTV rubber.
- Pour into mold box, covering pattern.
- Allow to cure (8 – 24 hours).

Figure 3: Pattern for RTV mold.

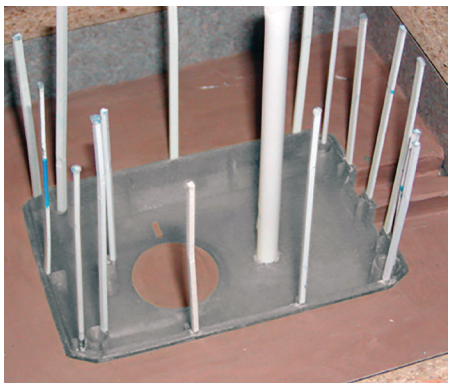

Figure 4: Pattern with parting surface, gat and vents.

2.1.2.5. Pour B-side.

- Remove parting surface.
- Mate second mold box to A-side.
- Mix and pour RTV. Allow to cure.

2.1.3. Cast the urethane parts.

2.1.3.1. Mix two-part urethane materials and pour (or inject) into mold (Figure 5).

2.1.3.2. Allow to cure (1/2 to 2 hours).

2.1.4. Extract cast parts and finish as desired (Figures 6 and 7).

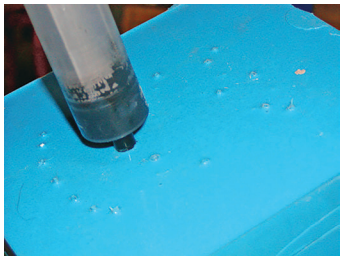

Figure 5: Urethane being injected into RTV mold.

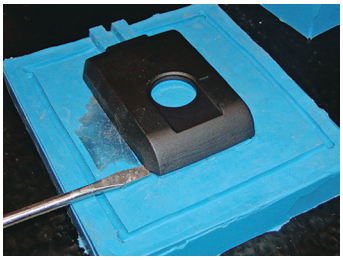

Figure 6: After curing, extract part.

2.2. FDM Adjustments:

To use FDM in the RTV molding process, adjustments are made to the following steps:

2.2.1. Pattern-making.

2.2.1.1. Replace pattern-making method with FDM.

- Prepare pattern in the same manner.

2.2.2. Mold-making and casting

2.2.2.1. No process changes.

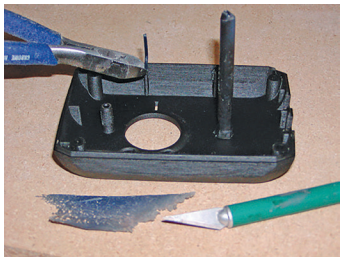

Figure 7: Trim off gate and vents and finish as desired.

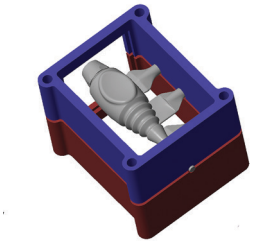

Figure 8: CAD model of pattern, with gate and vents, and mold box.

3. PATTERN DESIGN

Start with the CAD model for the part that will be cast. In most cases, no modifications are necessary (Figures 8 and 9).

3.1. Following are some optional and as-needed suggestions.

Note that these actions apply to patterns made from any process; they are not FDM specific.

3.1.1. Omit draft angles (optional).

Rubber molds are flexible, so draft angles are not needed. However, if they are already in the design (e.g., if it is an injection molded part), there is no reason to remove them.

3.1.2. Remove features (as needed).

Eliminate problematic feature from the CAD model. When finishing the cast urethane part, mill, drill or tap to add the feature.

- "Trapped" features.

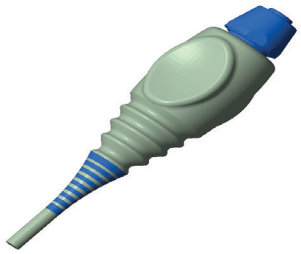

Figure 9: CAD model of pattern for overmolded connector (blue). Overmolding shown in gray.

Example: a hole with a centerline perpendicular to the direction of mold separation. This feature would trap the pattern in the mold unless a side pull were added.

- Narrow holes or channels.

  These features will grip the rubber, which may cause it to tear when the pattern is extracted.

3.1.3. Add gates and vents (optional).

If desired, add gates and vents to the CAD model (Figure 10), which will make them part of the FDM pattern. This eliminates a later step (section 7.3) in the mold-making process.

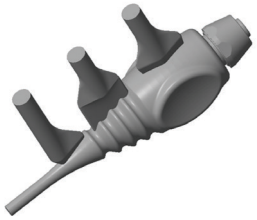

Figure 10: Optionally, add gate and vents to CAD model to construct them as part of the FDM pattern.

3.1.4. Add shrinkage compensations (optional).

Most often the shrinkage of the rubber is offset by the shrinkage of the cast urethane, so compensation is unnecessary. However, if the application demands very high accuracy, or if casting a urethane with high shrinkage (e.g., low durometer materials) calculate the net shrinkage between the two. Scale the CAD model by this value to compensate.

Optionally, shrinkage compensation may be done in Insight (see section 4).

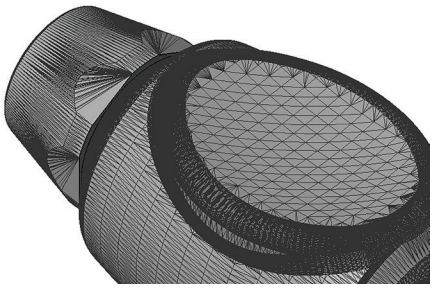

Figure 11: STL file. Use small facets to minimize surface preparation and preserved details.

3.2. Export STL file.

When the CAD design work is complete, save the model as an STL file. Make sure to adjust settings, such as chord height, for the STL file so that small facets are produced (Figure 11). This will produce smooth surfaces that require less post processing when preparing the pattern.

3.3. Overmolding.

The sample used in this guide is an overmolded part. Material is cast around a component—in this case, an electrical connecter—to encase it in urethane. This is an advance application for RTV molding.

The CAD design process for an overmolded part is not changed. Just make sure that the CAD model for the pattern includes both the overmolded component and its overmolding (Figure 12).

Figure 12: The pattern model for an overmolded part (bottom) includes both the overmolding (top) and the connector geometry.

4. FILE PREPARATION

4.1. Import the STL file into Insight (Figure 13) and orient.

4.1.1. STL > Orient by selected facet or STL > Rotate.

4.1.2. Considerations.

The following items are listed in descending order of importance. Note, however, that an optimal orientation requires all to be considered concurrently (Figure 14).

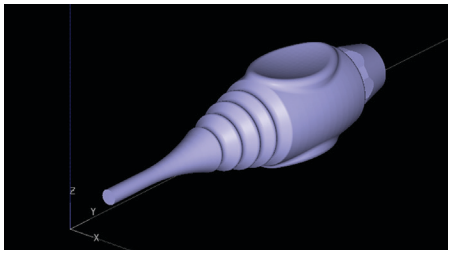

Figure 13: Open the STL file in Insight.

- For best surface quality:
  - Minimize visible steps.
- For best feature detail:
  - Minimize steps.
  - Locate contours in XY plane.
- For best strength:
  - Align layers perpendicular to force.
- For fastest process:
  - Minimize Z height.
  - Minimize post-processing labor.
    - Support removal.
    - Surface smoothing.

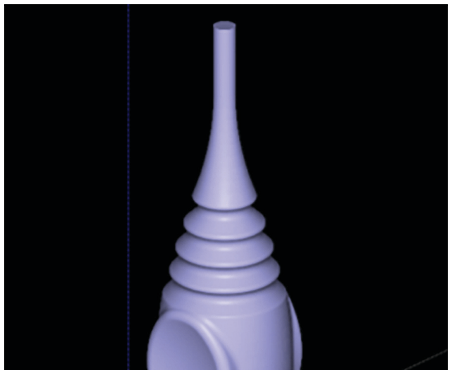

Figure 14: Orient the pattern for best combination of quality, strength and time. Vertical orientation used for overmolding pattern.

4.2. Slice STL file.

4.2.1. Set ***Slice height (Modeler > Setup > Configure modeler)***.

4.2.1.1. Consider using a fine ***Slice height***.

Thinner slices will produce finer feature detail since the toolpath widths can be smaller (Figure 15). Thinner slices also produce higher resolution surface finishes because of smaller visible rasters and stair steps.

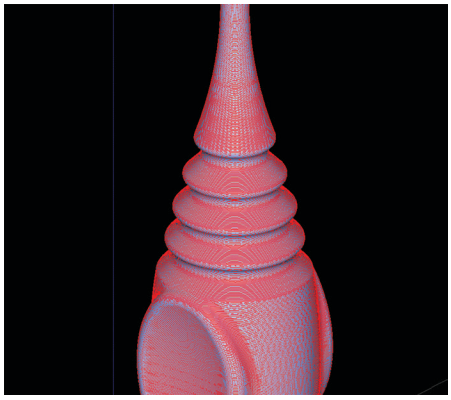

Figure 15: Select a slice height (0.005 in./0.13 mm shown) and slice the file.

4.3. Enable Enhanced mode.

4.3.1. ***Modeler > Setup > Visible surface style***.

Enhanced mode produces smoother surfaces finishes while decreasing build times. It uses small raster widths on external, visible surfaces and larger rasters for the internal fill.

4.4. Select Part interior style.

4.4.1. Modeler > Setup > Part interior style.

The recommend style for most patterns is ***Sparse*** (Figure 16). This provides adequate strength while minimizing build time and material consumption. Large patterns may require a ***Sparse – double dense*** fill to withstand the compressive forces of the RTV rubber.

Set the fill style to ***Solid – normal*** for thin-walled patterns.

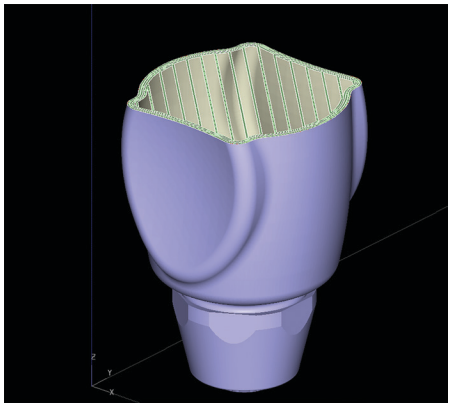

Figure 16: Sparse Part interior style.

4.5. Use support surface finish improvements.

These options improve the downward facing surfaces of parts where the supports interface with the model. These are all defaulted to “checked” for parts with soluble support material. Several options are not activated, by default, when using breakaway support material since removal may be more difficult if the supports trap features.

4.5.1. ***Supports> Setup > Advanced parameters***. Check the boxes for:

- Two layers of support face.
- Two layers of base top.
- Add perimeter to support face.
- Double spacing between part and sparse supports.

5. MATERIALS

All FDM materials are suitable for RTV molding patterns (Figure 17). These include:

- ABS, ABSi, ABSplus, ABS-M30, and ABS-M30i.
- PC, PC-ABS, PC-ISO.
- PPSF.
- ULTEM 9085.

5.1. Recommended materials.

When available, the ABS materials are preferred for pattern making (Figure 18). The mechanical and thermal properties are well-suited for the application. Additionally, pattern preparation is usually easier, faster and less labor intensive. The ABS materials have soluble supports that eliminate manual removal. The material also sands easily and can be smoothed with a chemical finishing process.

6. PATTERN PREPARATION

After constructing the FDM pattern, post process it to remove supports and finish the surfaces to the desired level of smoothness.

6.1. Remove supports (Figure 19)

6.1.1. Breakaway.

If the pattern is made of an FDM material that uses breakaway supports, manually remove them. When complete, clean the pattern to remove any loose debris.

6.1.2. Soluble.

Dissolve the support material from the pattern following the instruction supplied with the soluble support solution (Figures 20 and 21).

When no support material remains, soak the pattern in tap water and rinse thoroughly (Figure 22) to

Figure 17: All FDM materials are suitable for RTV patterns.

Figure 18: ABS is preferred for patterns and was used for the overmolded connector.

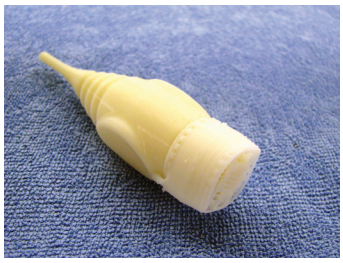

Figure 19: Supports (soluble shown) are removed after FDM construction.

Figure 20: Remove soluble supports in dissolving tank.

Figure 21: After supports have dissolved, remove pattern from tank.

Figure 22: Thoroughly wash pattern to remove dissolving solution.

remove all traces of the support solution, which may react with or inhibit fillers,primers and RTV rubbers.

Next, thoroughly dry the pattern to remove all moisture from within the part. To accelerate drying, expose the pattern to hot, well-circulated air. Do not exceed 165° F (75° C) if using ABS.

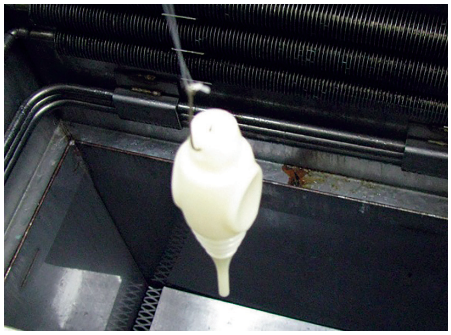

Figure 23: Place pattern in smoothing chamber for 15 to 30 seconds.

6.2. Surface smoothing.

The RTV rubber mold will transfer the finish of the pattern to the molded parts. So, it is important to have all surfaces of the pattern as smooth as that needed in the cast urethane parts.

Surface smoothing may include any combination of chemical smoothing, sanding and filling. The following instructions prepare a pattern for a high-quality finish that mimics that from a polished injection mold. Surface finishing may stop at any point as long as the pattern is smooth enough to prevent ripping of the RTV rubber when the pattern is extracted.

6.2.1. Chemical smoothing (optional).

Solvents will chemically melt the surface of FDM's ABS materials to produce a smooth, nearly mold-ready pattern. This approach may also be used with PC-based materials.

6.2.1.1. Finishing Touch Smoothing Station (ABS family only).

This is the preferred method for chemical smoothing because it is fast, and it preserves dimensional accuracy and feature details. Patterns are exposed to chemical vapors for 15 to 30 seconds (Figure 23). Repeat the process as necessary to reach the desired level of surface smoothness.*

Before proceeding to the next step, allow the pattern to set for 18 to 24 hours. This allows the surface to fully harden and all solvent to evaporate.

* See Finishing Touch Smoothing Station instructions for complete details.

6.2.1.2. Dipping and brushing.

Patterns may be chemically smoothed with a manual solvent application. Either apply the solvent with a brush, or dip the pattern in the solvent.

Limit the duration of solvent exposure and avoid pooling in channels, pockets and corners. Overexposure will result in too much material being removed. And in some cases, it may cause the surface of the part to develop cracks, which must be repaired with filler.

If applied with brush, allow the pattern to rest for 1 to 2 hours to let the surfaces harden. If dipped, allow the pattern to rest overnight to ensure complete evaporation and curing.

6.2.2. Degrease surfaces.

Before application of fillers, putties or primers, wipe the pattern with a degreaser (Figure 24). This will remove contaminants and oils that may inhibit adhesion.

Apply a small amount of degreaser to a cloth and wipe all accessible surfaces of the pattern.

Figure 24: Degrease surfaces between steps to ensure good adhesion of fillers and primers.

6.2.3. Apply primer coat (optional).

A light coating of primer (Figure 25) will reveal the pits, pocks and stair steps on the pattern. Many find that this makes the task of filling and sanding easier by drawing attention to the areas that need work. However, this step will add 1 to 2 hours to the pattern-preparation process.

- **Option 1: standard gray primer.**
  Gray is common primer color, and it works well in showing surface defects. However, most other colors will also suffice. This option is best when fillers will be applied to the pattern.
- **Option 2: sandable primer.**
  Sandable primers have the advantage of self-leveling, which will aid in filling pinholes and layer lines. Use this option if the primer coat will be followed by sanding. With either option, apply a thin coat of primer and allow it to dry. See product instructions for drying times, which are typically 1 to 2 hours.

Figure 25: Spray thin coats of primer (optional) onto surface of pattern.

6.2.4. Apply body filler.

There are many types of body fillers, spot putties and glazing putties, and most are suitable for pattern preparation. Select a filler for its viscosity, working time and drying time.

Recommendations:

- For larger layer lines and deep gouges:
  - 2-part glazing putties – low shrinkage.
- For small layer lines and pin holes:
  - 1-part spot putties – fast drying.
- For exposure to heat and pressure:
  - Hysol EA 9394 epoxy, an industrial-grade material that sands nicely.

Working in small patches, spread the putty/filler on the surface of the pattern to a depth that fills surfaces depressions without too much build-up in thickness (Figures 26 and 27 – MRI hand scanner shown).

Allow the material to dry and repeat until all areas are filled.

Note: for the overmolding sample application, fillers were not used.

Figure 26: Apply a small amount of filler on pattern (alternate part show).

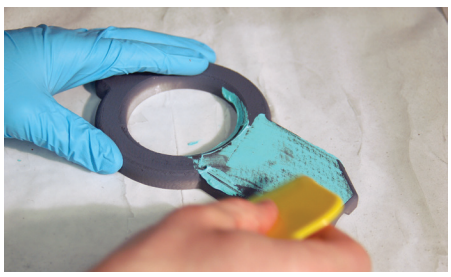

Figure 27: Spread filler evenly to fill depressions (alternate part shown)

6.2.5. Sand surfaces.

After the body filler has dried, sand all surfaces to a smooth finish (Figures 28 and 29). If using a power sanding tool, be cautious to avoid getting the plastic too hot.

Start with a coarse-grit wet/dry sandpaper (180- to 220-grit) and sand until the surfaces are visibly smooth. Complete this sanding step with fine-grit sandpaper (320- to 400-grit).

This is a good level of smoothness for most finish types.

Figure 28: After filler has dried, sand pattern to desired smoothness (alternate part show).

6.2.6. Repeat.

Inspect the pattern. If visible depressions or defects remain, repeat the filling and sanding processes.

6.2.7. Clean pattern.

Remove dust and debris from the pattern before proceeding to the mold-making steps.

Figure 29: If fillers are not used, sand pattern after support removal.

6.3. Surface smoothing (optional: use for high-gloss and clear parts).

Since RTV picks up fine details from a pattern, and since high-gloss finishes or clear castings highlight the tiniest flaws, the pattern finish must be taken to the next level.

6.3.1. Fill surfaces.

Select a thin (low-viscosity) putty that feathers nicely, fills pinholes and dries fast. Apply a small amount to the pattern and spread for a thin coat. Allow to dry (per manufacturer's instructions).

6.3.2. Sand surfaces.

Using 220-grit sandpaper followed by 400-grit, sand all surfaces until smooth.

Next, polish the surfaces by wet sanding with 600-grit followed by 800-grit sandpaper (Figure 30).

After sanding, clean and dry all surfaces.

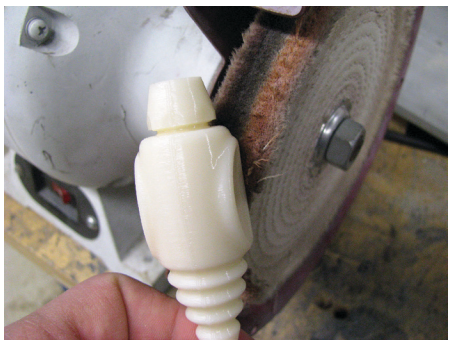

Figure 30: For high-gloss finishes, wet sand parts and (optionally) buff surfaces.

7. MOLD MAKING

The following procedures are intended for general information only, and they represent just one of many approaches to the art of RTV mold making.

7.1. Build mold box.

Construct boxes for both halves of the RTV mold (A-side and B-side). With the exception of the parting surface for the mold, allow one to two inches (25 to 50 mm), or more, on each side of the pattern.

Mold boxes may be constructed from any rigid material that will hold the heavy RTV rubber when it is in its liquid form. Shown here are mold boxes constructed with FDM.

7.2. Establish parting surface.

Place the pattern on a rigid substrate and surround it with modeling clay (Figure 31). Build the clay up to the parting line for the mold and level the clay along this plane. This method gives precise control to placement of the parting line. It also allows stepped parting lines to be created.

Place the mold box for the A-side on the clay surface.

7.3. Add mold features (Figure 32)

Using rod stock (plastic, wood or metal) and many materials or supplies found around the shop, attach material to the pattern that will create channels for the gates and vents (Figure 33).

The gate is the entry point for the urethane. The vents release air from pockets that would otherwise trap it, which would create a void in the casting.

For the overmolding example in this guide, a structure that holds and positions the insert is needed. In this case, an FDM endplate positions the exposed end of the connector (Figure 34).

7.4. Mix and pour RTV rubber (A-side).

Per manufacturer's instructions, weigh and mix the two components of the RTV rubber kit (Figure 36). If available, place the liquid rubber in a vacuum chamber to remove air bubbles (Figures 37 and 38).

Spray the pattern and clay parting line with mold release. Then pour the RTV rubber to fill the mold box (Figures 39 and 40). Allow the rubber to cure, which will typically be 18 to 24 hours.

7.5. Prepare A-side and pour B-Side.

Remove parting line material from around the pattern, but leave the pattern in the A-side of the mold. If locators were not carved into the clay, cut them into the A-side (Figure 41). These locate the A- and B-sides of the mold to ensure that they are properly aligned.

Mount the B-side box to the A-side, and spray the parting line and pattern with mold release (Figure 42). Then mix and de-air the RTV rubber, and pour it into the mold box (Figure 43).

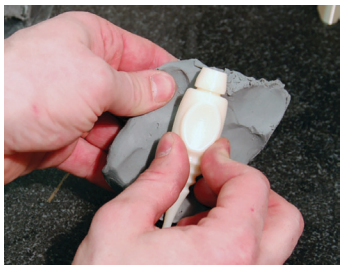

Figure 31: Using modeling clay, build up a parting surface for the two mold halves.

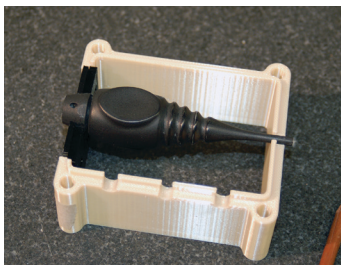

Figure 32: Mold components including: mold box (A-side), pattern (primed) and endplate (black).

Figure 33: Attach gate and vents (for clarity, parting surface removed and primed pattern used).

Figure 34: To position the connector that will be overmolded, an endplate (black) is added to the mold.

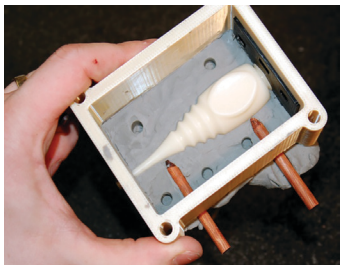

Figure 35: Mold half—with parting surface, gate, vents, pattern and locating features—ready for RTV rubber.

Figure 36: Thoroughly mix the two components of the RTV rubber kit.

Figure 37: De-air the RTV rubber in a vacuum chamber (shown) or pressure pot.

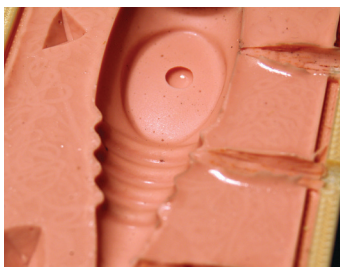

Figure 38: If air bubbles remain in the RTV rubber, they may form voids on the mold's surface.

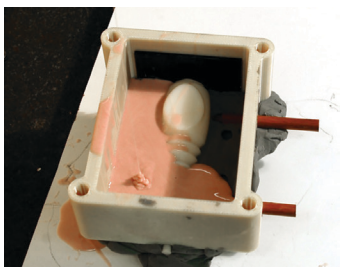

Figure 39: Pour the RTV rubber over the pattern to form the mold's A-side.

Figure 40: Alternative method — for simple parting lines, eliminate the clay-up step and pour rubber to height of A-side mold box.

7.6. Extract pattern.

After the RTV rubber has cured, separate the two halves of the mold. Remove the pattern and any gate or vent hardware.

8. PART CASTING

8.1. Assemble mold.

Spray both halves of the mold with a release agent (Figure 44). If overmolding, place the insert into the mold cavity (Figure 45).

Close the mold and clamp shut with bolts, duct tape or similar materials (Figure 46).

8.2. Mix urethane.

Mix the two parts of the urethane kit per manufacturer's instructions (Figure 47). If a vacuum chamber is available and if the material's pot life is long enough, de-air the liquid to remove air bubbles that may create void on the surface of the casting.

8.3. Pour urethane into mold.

Pour or inject the liquid urethane into the RTV mold until it begins to exit from the vents (Figure 48). Then place the mold in vacuum chamber or pressure pot to drive out air bubbles (Figures 49 and 50).

Allow the urethane to cure. Cure times vary widely, so check manufacturer's instructions.

8.4. Extract cast part.

Separate the mold halves and carefully extract the cast part. In many cases, the rubber will grip the part. To release the part, gently pry the casting from the tool (reverse pliers are ideal tools) while blowing compressed air between the mold and part (Figure 51).

9. PART FINISHING

Snip off gate and vents from the casting (Figure 52) and finish the part as desired.

10. TOOLS & SUPPLIES

10.1. Required items:

- Sandpaper: 120 – 1500 grit wet/dry
- Chemical finisher
  - Micro-Mark SAME stuff, MEK, acetone, Weld-On #3 or similar
- Degreaser: PPG DX330 (or similar)

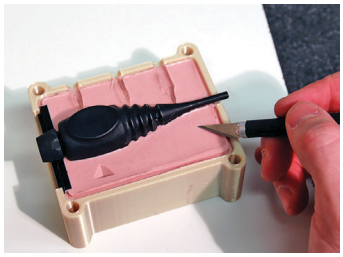

Figure 41: If not formed in the clay parting surface, cut locators into the cured RTV rubber.

Figure 42: Spray mold release on A-side of mold before pouring B-side.

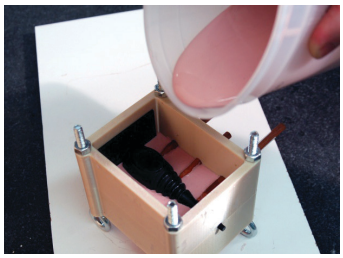

Figure 43: Pour B-side of mold.

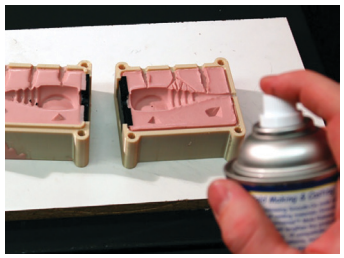

Figure 44: Spray release agent on both halves of RTV mold.

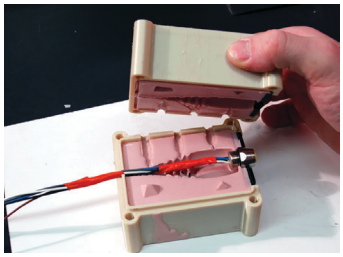

Figure 45: For overmolded parts, insert the component into the RTV mold.

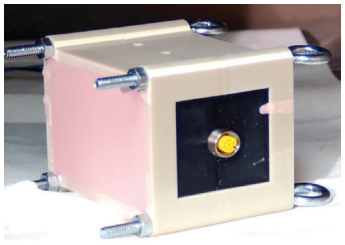

Figure 46: Close the RTV mold and clamp it shut.

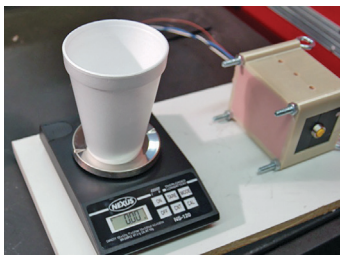

Figure 47: Measure and mix the two components of the urethane casting material.

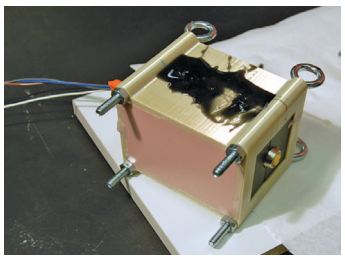

Figure 48: Pour the liquid urethane into the RTV mold.

Figure 49: To remove air bubbles, place the mold in a vacuum chamber.

Figure 50: Another option to remove air bubbles from the casting is a pressure chamber.

- Filler/putty:
  - Hysol EA9394 Paste Epoxy
    - Ideal for demanding applications.
  - 3M Acryl-Green Spot Putty
  - 3M Acryl-Red Glazing Putty
- Primer:
  - Sandable: PlastiKote T235
  - Standard (gray): good quality primer
- RTV rubber (kit)
- Urethane (kit)
- Modeling clay
- Mold release
- Miscellaneous tools:
  - Knives, mixing paddles, jars, et al

10.2. Optional items:

- Finishing Touch Smoothing Station (Figure 53)
- Vacuum chamber (Figure 54)
- Pressure pot (Figure 55)
- Oven
  - For thermal post-cure of urethanes.

10.3. Sources:

All the materials needed are common items available from:

- Automotive supply/painting supply retailers
- Hobby shops/hardware stores
- Mold supply houses

11. RECAP - CRITICAL SUCCESS FACTORS

- Start with smooth surfaces on FDM pattern.
  - Build orientation.
  - Slice selection.
  - Visible surface mode.
- Finish pattern to desired surface smoothness.

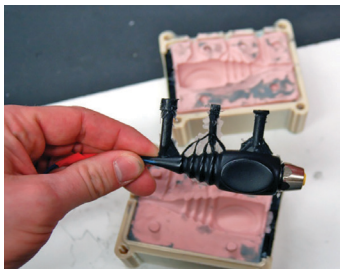

Figure 51: Remove the casting from the RTV mold after the urethane has cured.

Figure 52: Trim vents and gates from casting.

Figure 53: Finishing Touch Smoothing Station.

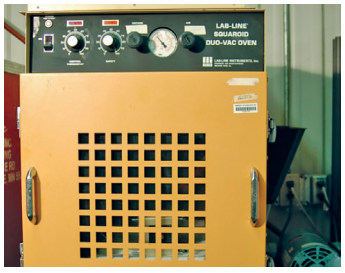

Figure 54: Vacuum oven.

Figure 55: Pressure pot.

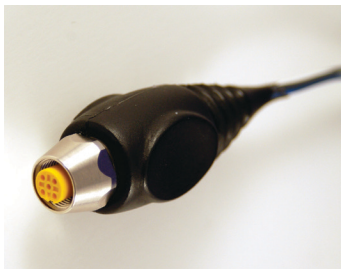

Figure 56: Final cast urethane part – overmolded connector.

Figure 57: FDM pattern.

CONTACT

For questions about the information contained in this document, contact Stratasys at www.stratasys.com/contact-us/contact-stratasys.

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