

Time Required ■■■

Cost ■■■

Skill Level ■■■

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OVERVIEW

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

Although the molding process uses urethane materials, which are thermosets – not thermoplastics – the number of applications is not limited. In fact, the wide variety of highly engineered urethanes that are on the market offer a vast array of mechanical, thermal and electrical properties. In many cases, the urethane can match or mimic the properties of injection-molded plastics.

Due to cycle time, cost per piece and tool life, RTV molding is best suited for projects requiring one to 100 parts. However, since molds are inexpensive and made quickly, multiple silicone rubber molds are a viable option for larger quantities.

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. It also has a significant impact on the lead time for casting delivery. So, like the rubber molding process, pattern making must be quick and accurate for even the most intricate and complex parts.

FDM AND RTV MOLDING

Parts built on a Fortus 3D Production System using FDM technology provide the fast, accurate and affordable patterns that drive RTV molding. By replacing machined patterns, the entire process can be completed in two to three days. And unlike machining, complex and intricate shapes have no effect on the time or cost for the FDM pattern.

An important consideration, which is often overlooked, is that the pattern must be able to endure the mold making process. The strength and heat resistance of the thermoplastic FDM materials 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.

FDM is unique in its use of soluble support technology, and this offers two advantages. When complex parts have internal chambers, deep and narrow pockets, or inaccessible features, the soluble supports simply dissolve away. This preserves the geometric details of the casting and simplifies pattern finishing. Soluble supports also offers a solution to a common rubber molding challenge. If the RTV rubber cannot be extracted from a feature, such as an S-shaped passage, soluble cores can be made with the soluble support material.

PROCESS OVERVIEW

Producing urethane casting from an RTV mold is a three-step process. The first step is to make a pattern that forms the molding cavity in the RTV rubber mold. The second step is to make the rubber mold. The pattern is combined with a parting surface to form a parting block. Silicone rubber is poured over this combination and allowed to cure. The process is repeated to make the second half of the mold. The third step is to cast liquid urethane into the cavity in the silicone rubber mold. After curing, the urethane casting is extracted from the mold.

PROCESS

There are many methods for making RTV rubber molds and casting urethane parts. The procedure described below is just one of the alternatives. For reference, a simpler method is

SUPPLIES:

- Cast urethane
- RTV rubber
- Mold release
- Modeling clay
- Plywood or similar
- Rod stock
- Disposable containers
- Sandpaper

TOOLS AND EQUIPMENT:

- X-Acto round carving cutter
- Vacuum chamber

OPTIONAL:

- Table saw
- Pressure pot
- Bead blaster
- Oven
- Rubber mixer/dispenser
- Urethane mixer/dispenser



FDM pattern ready for use as an RTV mold.

illustrated in the "RTV Molding With Soluble Cores" application guide, which also describes a method for casting complex internal cavities.

For pattern production, all of the Fortus materials can be used. However, the most commonly used pattern materials are ABS, ABSplus and ABS-M30. The ABS family of materials offers options in build parameters, support material and finishing techniques that can maximize quality while minimizing time, labor and expense.

PATTERN DESIGN

Prior to creating the STL file for the pattern, incorporate any desired modifications in the CAD data. The most common changes are shrinkage compensations and removal of features that will be machined after casting.

Since the cast parts will have a small net shrinkage, typically one-tenth to one percent, many find it unnecessary to add shrinkage compensation to the pattern. However, if accuracy is critical, scale the CAD data to compensate for the combined shrinkage of the RTV rubber and urethane. Alternatively, the shrinkage compensation can be added to the STL while processing the file in the Insight™ software application.

If there are features that will be machined into the cast urethane parts, they should be removed from the CAD data. This is a common practice when a feature will complicate the mold, which can cause delays and unnecessary expense. A simple example is a hole with a center line parallel to the mold's parting line. If left in the pattern, this hole would require either a hand-loaded insert or an additional mold component that would be pulled from the side (perpendicular to the core and cavity).

Note: the pattern does not require draft angles since the silicone rubber is flexed to release the casting.

PATTERN BUILDING

For pattern construction, use standard part orientations and build parameters. When the build is completed, remove the support structures and finish the patterns to the desired smoothness. As the rubber molds pick up very small details, it is important to smooth all surfaces to the quality level needed in the cast parts (figure 1).

To expedite the finishing process, consider vapor smoothing or solvent dipping if the pattern is made from ABS, ABSplus, ABS-M30 or ABSi. If constructed in PC-ABS or PC, consider solvent dipping. Next, use a combination of sanding, filling and priming to smooth the surfaces of the pattern.

MOLD DESIGN

For clarity, this guide addresses a simple, two-part mold. Note that the "A" side of the mold refers to the half of the mold that forms the external, cosmetic side of the cast part (the cavity in an injection mold). The "B" side forms the internal, non-cosmetic side of the casting (the core in an injection mold). Side B will have the vents and gates since witness marks will not affect the part's cosmetic quality.

An important step in mold design is to evaluate the pattern to determine if there are any undercuts that would lock the casting in the mold. Small undercuts, less than a 0.250 inch (3.2 mm), can be ignored since the silicone rubber mold can be flexed for release. For larger undercuts, use hand-loaded inserts. These inserts are demolded with the urethane part, removed from the casting, and placed back in the mold prior to a second urethane pour. The inserts can be machined or built with FDM.

When a casting has features that cannot be addressed by a removable insert, a soluble core may be used. After casting, the urethane part is placed in a solvent that dissolves the core, which leaves the desired cavity in the part. For information on this process, refer to the "RTV Molding with Soluble Cores" application guide.

For features that will yield a thin wall of rubber, consider a machined plastic or a metal insert. Thin sections of rubber will shift when casting the urethane and are prone to tearing when demolding the part. In general, the mold will exceed the maximum dimensions of the pattern by one inch (25.4 mm) on the top and bottom, and one to two inches (25.4 to 50.8 mm) on each side. These general guidelines will vary with the size of the part, the type of silicone rubber used and the casting process.

MOLD BUILDING – PARTING BLOCK

Begin the mold construction by making a parting block that creates the parting line for the core and cavity. The parting block will be comprised of the pattern, base plate and modeling clay.

Cut a rigid substrate to the length and width of the mold to form the base plate. Suitable



Figure 1: Pattern Building - FDM pattern ready for use.

materials include plywood, medium density fiberboard (MDF) and other sheet materials. On this surface, mount the pattern so that the bulk of the parting line is located where it rests on the base plate. If there are any hand-loaded inserts, mount them in the pattern.

With modeling clay, define the remainder of the parting line. To prevent inhibition of the silicone rubber's curing, use non-sulfur based modeling clay, such as Kleen Clay. Apply the clay by hand to all features that are captured in the opposite side of the mold. Also, use the clay to build up from the base plate to elevated areas of the parting line. The clayed-up pattern defines the cavity for side B and the parting surface of the mold.

MOLD BUILDING – SIDE B

Build a four-sided box with inside dimensions equal to those of the B side of the mold. Any rigid, smooth material can be used, including MDF, finished plywood or a Formica laminate. Next, mount the parting block in the bottom of the box with the pattern facing inward. Seal all joints with caulk or modeling clay to prevent leakage of silicone rubber.

Next, add vents and gating to the pattern (figure 2). Venting allows air to exit the mold. Without venting, air pockets will prevent complete filling of the mold cavity. The gate is the channel that will feed urethane to the cavity. The vents are formed from 1/16 inch (1.6 mm) metal or plastic dowels, and the gate uses a 1/4 inch (6.4 mm) dowel. If casting a viscous urethane, use a larger diameter rod for the gate. Cut the vent and gate dowels so that they are long enough to extend from the pattern surface out through the top of the mold. Attach them to the pattern with cyanoacrylate (Super Glue).

Once the mold box assembly is complete, coat all surfaces with a mold release. Note that the type of mold release may be specified by the manufacturer of the RTV rubber.

The mold is formed by pouring a liquid silicone rubber into the mold box. The rubber is a two-part material that is mixed just prior to pouring the mold. Combine and thoroughly mix the two parts of the rubber kit in a disposable one-gallon or five-gallon bucket. Make sure that the bucket is only partially filled because the rubber will expand to three times its volume when it is de-aired. The rubber must be de-aired to remove any bubbles that may rise and create voids in the surface of the mold. To de-air, place the silicone rubber into a vacuum chamber for three to four minutes.

The silicone rubber typically has a one-hour pot life—the amount of time that the material remains fluid—so there is sufficient time to mix, de-air and pour the rubber. Gradually pour the silicone rubber into the mold box but not directly onto the pattern. Fill the mold box to the top and allow the rubber to cure for the amount of time recommended by the manufacturer (typically 24 hours).

After curing is complete, remove the parting plate but leave the pattern in the mold cavity. If the pattern is removed, it is nearly impossible to reinsert it into the mold. Next, remove all the clay from the pattern (figure 3) and thoroughly clean it with alcohol or a mild detergent. Rinse and dry the pattern and the exposed surface of the mold.

MOLD BUILDING – SIDE A

To locate side A with side B, cut channels into the rubber of side B. Using an X-Acto® round carving router, cut a channel around the periphery of the mold (figure 6). For larger parts, a channel may also be cut around the contour of the cavity. The channel should be kept at least 1/4 inch (6.35 mm) from the sides of the mold and 1/8 inch (3.2 mm) from the cavity. To create a lock between sides A and B, cut the channels to a depth slightly more than the radius of the round carving router (figure 4).

Next, build and attach a mold box for side A of the mold and spray all surfaces with mold release. As with side B, mix and de-air the rubber and pour it into the mold box. Allow the rubber to cure and then remove the pattern (figure 5), vent rods and gate rod. The mold is now ready for casting parts.

PART MOLDING

There are many cast urethanes available with a wide variety of mechanical and thermal properties. The urethanes will also have different pot lives. The selection of the urethane will depend on the desired properties for the cast part, the desired pot life and the method of casting. To enhance the material properties, or to change the color, fillers and pigments can be added to the urethane.

Short pot life materials, generally less than one minute, are attractive since they allow many casting per day. However, cavities that are difficult to fill may not be well suited for short pot life urethanes. Additionally, these materials require a material dispenser that mixes and feeds the

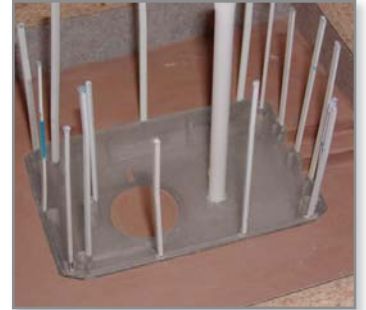


Figure 2: The pattern and the modeling clay (reddish brown material surrounding the FDM pattern) define the parting line for the mold. Vent and gate rods have been attached to the pattern.

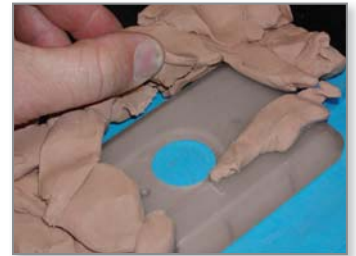


Figure 3: Remove the parting block and modeling clay after the mold has cured.



Figure 4: Using a round carving cutter, cut locator channels in the mold.

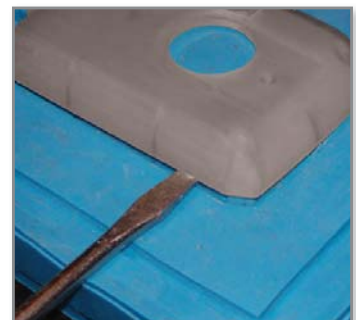


Figure 5: After the mold has cured, remove the pattern. The rubber will grip the pattern, so it may need to be pried from the mold.

urethane into the mold (figure 6). There is not enough time to hand mix and pour the urethane before it begins to set. Long pot life materials, generally two to five minutes, take longer to cure and therefore decrease the number of castings per day. However, these materials can be hand mixed and gravity cast, which eliminates the need for a dispensing unit.

To start the casting process, thoroughly mix the urethane's parts A and B and de-air the urethane in a vacuum chamber. The urethane may be gravity cast, vacuum cast, pressure cast or injected. The determining factors are the available equipment, the material's pot life and the difficulty in filling the mold.

Gravity casting is simply a pouring of urethane into the mold cavity without vacuum or pressure assist (figure 7). In vacuum casting, the mold is filled with urethane and then a vacuum is drawn. The evacuation of air pulls the urethane into the mold. A similar process is used for pressure casting, with the exception that the chamber is pressurized to force the urethane into the mold cavity. For long pot urethanes, allow the casting to cure for two to four hours. For short pot life urethanes allow the casting to cure for 15 to 30 minutes after the casting.

PART FINISHING

To demold the casting, separate the two halves of the silicone rubber mold. Due to the locking locators and the rubber's grip on the casting, separation will require some force. In most cases, tool separation will require a prying tool or mold spreader. Once the mold is open, the casting will be in the B side of the mold. Carefully, yet forcefully, extract the casting from the mold (figure 8) and remove any hand-loaded inserts. The mold is now ready for a second casting. Some urethane materials will require a thermal post-cure to reduce brittleness and improve mechanical and thermal properties. Typically, post-cure takes a few hours at 130° F (54.4° C). Refer to the urethane manufacturer's instructions for more information. The final step is to cut off the gate, vents and flash (figure 9). The casting is now ready for secondary machining, paint or decoration.

CONCLUSION

RTV Molding is a simple, affordable and fast method for prototyping or low-volume production. When combined with FDM patterns, urethane castings can be made in just a few days.

Like FDM, RTV molding produces functional and accurate parts in durable plastic. Use FDM technology to manufacture a small number of parts in thermoplastic materials that include ABS, polycarbonate or polyphenolsulfone. When the application demands different material properties or repetitive production of 25 to 100 parts, turn to RTV molding for urethane castings and use FDM for making the patterns that drive the process.



Figure 6: For short pot life urethanes, the material is simultaneously mixed and injected.



Figure 7: An alternative to gravity casting is to assist the pour by injecting the urethane with a large syringe.

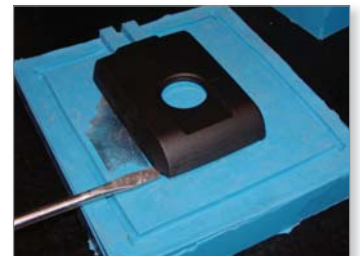


Figure 8: After the urethane has cured, separate the mold and remove the cast part. Extraction may require a prying tool.



Figure 9: Trim the vents, gates and flash from the cast part with clippers, shears and X-Acto® knives.

FDM PROCESS DESCRIPTION

Fortus 3D Production Systems are based on patented Stratasys FDM (Fused Deposition Modeling) technology. FDM is the industry's leading Additive Fabrication technology, and the only one that uses production grade thermoplastic materials to build the most durable parts direct from 3D data. Fortus systems use the widest range of advanced materials and mechanical properties so your parts can endure high heat, caustic chemicals, sterilization, high impact applications.

The FDM process dispenses two materials—one material to build the part and another material for a disposable support structure. The material is supplied from a roll of plastic filament on a spool. To produce a part, the filament is fed into an extrusion head and heated to a semi-liquid state. The head then extrudes the material and deposits it in layers as fine as 0.005 inch (0.127 mm) thick.

Unlike some Additive Fabrication processes, Fortus systems with FDM technology require no special facilities or ventilation and involve no harmful chemicals and by-products.

For more information about Fortus systems, materials and applications, call **888.480.3548** or visit **www.fortus.com**

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