Liquid Silicone Molding— making the case for small and mid-sized volumes

LSR is great for medical applications, but is the tooling worth the trouble?

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Liquid silicone molding (LSR) is often used for medical technologies at large scale volume. Grand View Research predicts that the total LSR market will be worth $3.29 Billion By 2025, and that the medical applications are the fastest growing segment with an estimated CAGR of around 9% from 2016 to 2025.

There are good reasons that LSR is such a sought-after material. But there are tooling challenges and expenses associated with LSR that can keep low-to-mid sized products out in the cold. We'll discuss the allure of LSR, the tooling challenges, and how molders are offering options to get LSR into small- and mid-volume runs.

What's so great about LSR

Many LSR materials are biocompatible, and some grades have been approved specifically for implants. Devices made from LSR are temperature stable (in heat or cold), and can withstand exposure to harsh cleaning and disinfecting chemicals. Further, LSR resists discoloration from UV exposure, is scratch resistant, and retains a cosmetic attractiveness throughout the product's lifecycle.

The attraction to molding with LSR as compared to a transfer or compression process using high consistency rubber (HCR) silicone is the speed in which the LSR material cures. Parts can be fully cured in seconds rather than in minutes as with gum material. It's not uncommon to see cycle times reduced 90% from a transfer process using HCR silicone. Just as important, automation plays a role in LSR processes, ensuring that cycles are consistent by eliminating the operator from creating variation in the cycle times.

From a manufacturing standpoint, there are several characteristics that make LSR valuable to the healthcare industry. LSR has a low viscosity that can be molded into components with thin walls or small features. Once cured, the material is very flexible, so it can be molded into shapes with undercuts that might otherwise be trapped in the mold form. Draft is not necessary for extracting parts out of the mold cavity.

Further, LSRs come in an array of durometers available at 5 to 90 durometer, that can be mixed to match any color. It can also be made optically clear for use in light covers and lenses, and it is second only to glass in light transmission.

LSR is also ideal for overmolding, in which a substrate is inserted into the overmold cavity. LSR is then injected into the cavity, creating a second layer of material. Some grades of LSR materials will bond to specific substrates, thus eliminating a necessary prepping operation on other overmolding processes.

The combination of biocompatibility; resistance to heat, cold, chemicals and UV light; durability; design flexibility; and moldability make LSR a serious contender for any application requiring a silicone elastomer.

Trouble with tooling

This holy grail material has the perception of only being for certain applications, namely, high volume jobs. Many device developers disregard the value of LSR because they believe the manufacturing process can only be used efficiently and effectively at high volume. To a certain extent, this is true. LSR tooling is expensive and building molds is a challenge that requires high levels of precision and expertise, far beyond those used in other rubber processes and thermoplastics.

The liquidity of the material means that the cavity inserts must be absolutely precise to prevent flash extension. For example, high consistency rubber using a transfer molding process can be molded with minimal flash using fits between inserts of up to 0.001 in., but tooling for many LSR processes will flash with fits as tight as 0.0002 - 0.0003 in.

Ejector pins can be used in LSR molds but they must have a tapered shutoff and can’t invade the parting-line shutoff area. Typically, ejector pins are avoided in the mold design because any amount of debris or rubber that builds up on the ejector valve seat will cause flash and process related issues.

It is recommended to incorporate vacuum in most LSR tooling to get rid of outgassing. Thermoplastic molds create outgasses, but by contrast, those molds have vents in the fit and relate areas. LSR comes in two parts and must go through a chemical curing process before being injected into the mold. Depending on the final part needs, venting might need to be ten-thousands-of-an-inch depth to control flash for tight specifications.

LSR curing is slightly different from other methods of molding silicone. The molds are usually heated to 270-360 F to cure, and usually require electrical cartridge heaters strategically placed into the mold. Heating molds to these temperatures will start the cure process very quickly – in seconds as opposed to HCR silicones curing in minutes. Further, LSR starts to cure at room temperature once the reactive components are mixed, therefore the entire LSR system requires a flowing coolant to control the temperature up to the cavity.

There are multiple methods to fill the cavity with LSR. Cold runner system with needle valve gate or open nozzle and hot runner all have their place in the mold design depending on the tool budget and desire to maximize the process. Needle valve gating and open nozzles can be completely wasteless but very pricey, whereas hot runner systems have wastes that must be removed from the molding area.

Shutting down an LSR process can have its own challenges. System clean-out can be a long, drawn out process and can be very wasteful. The dosing system requires disassembly and each component must be cleaned out with a solvent. The A and B hoses are removed and the static mixer completely disassembled and again, thoroughly cleaned with solvent. This down time is normally scheduled for 4 hours and sometimes longer. Tooling as well, is completely disassembled and cleaned, which can use up the rest of the work day.

For these reasons, initial investment for LSR is high, and the high cost can discourage those with limited runs or small-to-medium volumes to opt for a different material, even if LSR has all the material requirements needed for the finished part.

Accommodating small-to-medium volume

There are various ways molders have adopted to help offer medical device makers the option of using LSR in their product design. Simplifying mold construction by creating cavity inserts that go into standardized mold frames is one option. These frames will have a hot or cold runner system that can adapt to the cavity inserts, thus eliminating having to build a frame for each part. Typically, these mold frames are owned by the molder and are not part of the customer cost. Eliminating the need to machine redundant features, not to mention the material savings, is a considerable reduction in mold cost passed on to the customer. The cavity design and construction can be production quality, to not jeopardize the integrity of the tooling and the quality of the part.

Miniature material dosing systems are used to minimize set-up and material waste needed to get the system primed. These table-top dosing systems utilize short hoses to simplify the priming and cleanout process. Another dosing system eliminates hoses altogether by attaching directly to the injection unit. The pressure pot is a sealed reservoir that utilizes air pressure to force the LSR into the injection unit. This pressure pot requires premixing the LSR as part of the set-up, however, the benefits outweigh having to prime and clean out static mixing units. Furthermore, the pots are easily removed from the machine and refrigerated to extend the life of the pre-mixed LSR.

These adaptations will not cut out all costs, but designing LSR tooling to compete with HCR silicone gum molding and being able to simplify the set-up and shutdown procedures can certainly allow justification to utilize the LSR process for many silicone applications, regardless of annual usage. Because of the need for a high level of precision, and the risks of waste, expenses can add up quickly. And it should not go without saying that it is important to work with a molder, such as Robin Industries, that has LSR experience and can offer part design consulting early in the process.

About Robin Industries Inc.: Robin Industries has developed custom molded rubber and plastic components since 1947. It serves medical, automotive, defense, and other industries that require assistance with mission critical applications. Robin provides design engineering assistance, materials development, various secondary operations and other services specific to the medical technology space.