LSR Injection Molding Design

It is preferred that Liquid Silicone Rubber, or LSR, injection molded parts are built with tight tolerances due to flashing. This increases the demand for even tighter tolerances over traditional thermoplastic molding processes. The first step in the design process is the research and development stage, followed by the construction of a prototype, which will help prevent unforeseen difficulties when production time comes.

This silicone injection molding design guide will examine tolerances, accuracy, shrinkage, gates, part specifications, undercuts, drafts and finishes, as well as a wide range of other topics. The purpose of this guide is to help you understand all of the many complexities that come with designing with LSR, and how following these molding guidelines can ensure the manufacturability of your desired part.

A Guide to LSR Injection Molding Design

These LSR molding design guidelines will demonstrate the significance of designing silicone parts, as well as describe the various tools required for the job. Silicone rubber molding is an indispensable manufacturing process, and it is valuable for use in a range of projects, spanning from the making of props for Hollywood films to the creation of complex components we utilize every day. One of the most common uses of silicone rubber is in the healthcare industry because of its compatibility with human tissue. Silicone is an excellent material that offers unique advantages over thermoplastics. However, there are many design considerations to take into account before working with the material.

INITIAL DESIGN CONSIDERATIONS

Silicone is an elastic material, and when it is removed from the cavity of the mold, flashing may occur. Silicone molds generally comprise two or three plates. When working with LSR, ejector pins are not often used the same way they are with harder, more traditional thermoplastic molds. Consistency is very important, and designers need to use undercuts and incorporate them along with other design features for LSR molds.

Additionally, because silicone is elastic, and ejection requires the application of force, the material can be prone to hot tearing. This makes it difficult to automate the production process for some designs if the parts are not in one location of the mold. It is also important to consider the fact that silicone shrinks. Shrinkage rates are between five percent and seven percent, which is high in comparison to traditional thermoplastic materials.

Shrinkage rates can vary depending on the material and grade of the silicone. This makes it very difficult to determine the precise rate of shrinkage, which is another reason why making a prototype is advantageous to the design process. Prototypes can help iron out small details long before the expense of production begins.

MATERIAL SPECIFICATIONS, GRADES AND DUROMETER

Silicone has unique properties that make it an excellent choice in manufacturing numerous types of components. One big advantage of silicone is that it is biocompatible, and therefore applicable to the creation of medical technologies that need implementation in the body. Medical grade silicone differs from other similar materials in that it is used for healthcare-related components, so it requires sterilization and must meet medical standards.

Thermoplastic molding demands the use of temperature control, with mold temperatures generally not exceeding 170 degrees Fahrenheit. Liquid Silicone Rubber, on the other hand, must be heated between 320 and 450 degrees Fahrenheit to help cure the material.

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The highly elastic nature of silicone allows it to provide elongation of up to 1,000 percent on some of the highest-grade materials. High elongation can cause difficulty when removing it from the mold, but it can also help achieve greater undercuts during part ejection. Silicone is also non-conductive, as almost all other rubbers are, providing unique electro and thermal properties over other materials.

Application is one of the most important aspects to consider when selecting a grade of silicone rubber. With healthcare components, implantability, sterilization and other biological factors should be at least a few of the top priorities. However, with most products, including medical components, durometer is one of the most critical mechanical properties to consider when selecting a material.

Durometer refers to the hardness of the silicone, which corresponds to its other properties such as its modulus and elongation. Different manufacturers offer variation in the properties of their materials, and they usually specify it by the durometer and grade.

Think of durometer as the viscosity of the material, ranging anywhere on a scale of zero to 80. For instance, lower durometer silicone may have a higher viscosity, while the highest durometer silicone will have a reduced flow of bubbles. Silicone grades are available in an array of variations, with many possible applications for general use, medical purposes, food, implantation and specialty.

PART SIZE

Part manufacturability is also impacted by the determination of part size and overall production volume. Compared to lower or smaller volume productions, large volume productions can require an extended period of curing for the silicone, not to mention the higher cost of material.

Component size and dimensions can significantly influence the molding and ejection process. For example, parts that have very thin geometries may be subject to blemishes or surface irregularities during manufacturing. However, the use of finishes can reduce the possibility of this occurring.

Wall Thickness and Tolerances

With LSR injection molding, tighter tolerances require consideration due to flashing and the liquid nature of the material. Walls as thin as >up to 0.040 inches, or zero to 10 mm, are achievable. However, this is dependent on the size of the wall and its position within the component. One advantage to LSR injection molding is that liquid silicone rubber often fills in thin walls without a problem. For a well-designed part, smaller linear tolerances can be achieved using other materials such as resin, but in some cases, specialty molds may provide a benefit for LSR injection molding.

Tolerances are based on both the size range and the parting-line direction, or where the mold comes together. Pressures in the mold and compression can alter these variations, and tolerances need to provide a starting point for the silicone. Consulting with a qualified mold maker can prove to be helpful in the design process, and may help achieve the level of tolerances necessary for a component’s manufacturability.

SHOT SIZE

LSR overmolding, also known as twin shot or multi-shot injection molding, is a process that consists of molding LSR directly onto a substrate comprised of thermoplastic. This is done immediately after the substrate has been molded, a process that occurs within the same mold as the LSR and the machine. By using the LSR Multi-Shot method, you can integrate several parts or materials into a single component, which will be permanently fused. Two-part silicone rubber molding can allow for the best properties of both materials in the finished project. This can also reduce the need for post-molding assembly processes.

DIMENSIONAL ACCURACY

Silicone rubber parts require a high degree of dimensional accuracy, which needs to reflect in the completed product. Prototypes reduce production times and costs by refining and optimizing a component's design before mass production.

For example, shrinkage values can be obtained by using prototyping and testing the material that will be used on the finished product. This can achieve a rough guideline for the values needed, which can then be incorporated into the design phase.

SHRINKAGE

The overall quality of the product will be impacted by the shrinkage rate of the silicone used. Unfortunately, shrinkage is very difficult to predict and requires a lot of adjustment before production. In addition to the shrinkage that can occur during curing, several other factors can affect the rate of shrinkage, including the temperature of the tools during molding and ejection. The pressure in the mold cavity and compression of the silicone, along with the direction of the material flow from the injection point, can also influence the overall shrinkage rate.

Since it is possible that shrinkage rates as high as two to three percent can occur, adjusting for shrinkage during the design phase is crucial. Molding a part in an existing mold of similar shape and size can provide a better idea of how the material will behave. Dimensional accuracy is always of fundamental importance, and it is mandatory for silicone parts as well. As a result, testing the material and allowing it to cure properly can help mitigate design flaws prior to production. Your project has customized requisites and geometries, so consulting with a qualified mold maker during the design phase, along with the creation of a prototype, can substantially reduce the potential for unforeseen expenses.

DRAFTS AND UNDERCUTS

Demolding — or removing the component from the mold during ejection — is a process often improved by the use of drafts, although they are not always necessary, depending on the component. Most silicone rubbers offer a range of mechanical properties and deform well enough that drafts are often not required. However, when designing a component, make sure to pay attention to the placement of draft locations so that they do not limit the parting line of the mold. This will help improve manufacturability.

One of the greatest advantages of LSR molding is the ability to produce parts with undercuts, which is not possible in other forms of molding. One benefit of this process is that most undercuts can be removed without mechanical assistance. Undercuts are achievable with liquid silicone molding, as they are with other traditional thermoplastic part designs. One of the disadvantages of working with silicone rubber is that elongation contributes to the limit of the undercut size. In addition, parts that require more complex tooling with sharp-edged tools may also see an increased risk of damage to the finished component or mold tool.

PARTING LINES/ SPLIT LINES

Designing parts with silicone often requires surfaces that are smooth, as with traditional thermoplastics. Parting lines where the pieces of the mold come together create a closed mold cavity in which the part can form. When joined, the mold creates a single core in the geometry of the component, preventing lines or flashing from occurring on the inside where the part will be molded.

Parting lines should align with the parting surfaces in seals and gaskets to prevent fluid from passing along the line or across the seal. In some cases, irregularities may occur at the edges of a part, so it is important to consider the need for more than two parting lines when designing your component.

GATES

Unlike traditional materials, liquid silicone rubber parts tend to require smaller gates, due to the properties of the material. A gate feeds into the thickest section of the component. Because gates leave blemishes on finished components, placing them on a surface that is not dimensionally nor aesthetically critical during the design process can provide for a better product. If that is not possible, leaving a recess specifically for the gate when designing the mold can help mitigate this problem.

Vents or overflow areas may also come in handy when designing your component, depending on your needs. This can help improve the finished product and increase its quality by allowing air to exit during molding.

AESTHETICS

Reviewing all of the different design principles listed above for LSR molding will help create a higher quality product and increase the aesthetic of your component. By taking into account the type of material and how those interactions in the molding process will behave, you can incorporate the placement of undercuts and gates in a way that can reduce the common blemishes or surface irregularities that molding can cause.

In addition to practicing better design techniques when creating prototypes for silicone molding, the use of mold finishes and tooling can also improve the aesthetic of your product. Silicone rubber is versatile and comes in a wide variety of colors and grades. In some cases, a machined finish within the mold cavity can help provide smoother surfaces and lessen the need for mold release agents. Special textures can also be achieved when applied in the mold cavities to enhance the surface features of a finished product.