Molding Silicone Rubber

Manufacturing processes for high volume and
mass production of silicone rubber parts and products

Silicone rubber is a unique synthetic elastomer that is made from a cross-linked polymer which is reinforced with silica. Some if characteristics include: stability at both high and low temperatures, no taste or smell, translucent and hence easy to color, wide hardness range, chemically resistant, weather resistant, high level of sealing performance, electrical properties and resistant to compression. There are four main molding methods: liquid injection molding, compression molding, transfer molding and extruding (or "extrusion" / "extrusion molding") (Dow Corning, 2007).

Compression molding is a process, in which the pre-loading of the silicone compound is usually placed straight up into a cavity where the molding process is started. Next, the material is compressed into the mold and after properly cured, the material is removed, the mold is cleaned and the process is repeated. In compression molding, a preform is placed on one half of a heated mould. When the mould is closed and put underpressure in a press, the rubber is forced into all parts of the mould cavity; and excess rubber flows into a flash groove around the mould cavity. Single cavity molds are loaded by hand. With some multiple cavity moulds loading boards may provide faster mould loading, which helps prevent scorching of the preforms. Enough pressure should be applied to obtain sufficiently rapid flow of rubber in the mould. When molding thick sections or fabric reinforced parts, it may be necessary to cool the mould before releasing the pressure -to help prevent backrinding, porosity, and delamination. The following factors must be taking into consideration during compression molding with various vulcanizing agents: molding time, vulcanizing agents, molding temperature (KDL, 2007).

In transfer molding, the unvulcanized rubber is placed in a chamber (called a pot), usually located between the plate (also called the top plate) and the plunger at the top of the mould, and the assembly is placed in a press. The press applies pressure to a piston-like plug in the open end of the pot, clamping the halves of the mould together and forcing the rubber to flow through one or more sprues into the heated mould. In other words, it is squeezed from the pot through small gates (also "sprue cutters") into the main mold cavity. Transfer molding is particularly useful in producing parts that require precise positioning. The time and temperature for transfer molding are the same as for compression molding. Transfer molding combines the advantages of injection molding with the ease of compression molding. This is the ideal process for forming parts that require exact positioning, bonding rubber to fragile metal parts - such as wire, mold designs that contain multiple cavities and can trap air and intricate parts with lower volume requirements (Qualiform, 2007)

In extrusion molding, silicone rubber is extruded to make tubing, rods, gaskets, seals, wire insulation, and preforms used in compression molding. With this process, the rubber is continuously forced through a die that forms it to the desired cross-sectional size and shape. Screw extruders used with silicone rubber should have the following equipment: a screw designed for silicone rubber; a feeding roller attached to the screw by a gear or separately driven in the intake zone; an extended barrel, suited to the length of the screw; a breaker plate with recess to hold screens that will produce enough pressure in the rubber to ensure removal of trapped air; a spider flange or crosshead for holding purposes. In this process, silicone rubber moldings are made by forcing it through a shaped orifice by means of pressure. The rubber is continuously forced through a die that forms it to the desired cross-sectional size and shape before curing . Silastic silicone rubber should be extruded at room temperature. In fact, it should not be allowed to reach a temperature above 54°C during extrusion, since higher temperatures may produce scorching and loss of vulcanizing agent (Dow Corning, 2007).

LIM, or "liquid injection molding" is the most efficient method used for manufacturing silicone. This process yields the lowest costs with the highest effectiveness. The LIM process allows the production of parts with nearly zero waste of the material used. Heated, dual-component silicone in flowable state is injected or forced straight into the mold cavity. Liquid injection molding is quite similar to transfer molding, but manufactured material is supplied on without breaks through injection nozzles. This process typically involves injection molding a thermoplastic material such as PBT or nylon, followed by co-molding or over molding with an LSR. LSR is vulcanized under heat using three main parts: an injection molding machine and a metering/mixing system and a specially designed mold to handle the material, which is cured to about 160°C to 200°C. Most injection molding machines for LSR use a reciprocating screw injection unit. The two-component LSR material is pumped to the injection unit using a meter/mix device with a static mixer mounted at the feed throat to aid in mixing and/or dispersion of additives. The LSR is injected into a mold, which is typically heated by four to six electric mold heating zones for each mold half. Adequate clamp force must be maintained throughout the molding cycle, since during the 10 to 100 seconds of curing, LSR will expand in volume by 1% to 2%, which is sufficient to cause flashing (Dow Corning, 2007). Pressure must also be maintained so that material is not permitted to migrate back through the bushing into the nozzle. Many LSR injection molding machines have water-cooled or insulated platens to ensure that the high temperature of the mold is not transferred to other areas of the injection molding machine.

In order to provide a silicone rubber composition that does not foam or have an unpleasant odor during its cure, it has been found that the silicone rubber composition must include a polydorganosiloxane gum, microparticulate silica, bis(ortho-methylbenzoyl)peroxide, and bis(para-methylbenzoyl)peroxide (Patent Storm, 1999). This has a high cure rate and provides silicone rubber extrusion moldings that post-cure and are either free of bubbles or contain bubbles to limited extent. The silicone rubber composition includes: 100 weight parts of a silicone rubber base compound and 0.1 to 10 weight parts of organoperoxides (Patent Storm, 1999).

In all of these methods, rubber is placed in a mold and subjected to pressure and heat in order to shape and vulcanize the product. The methods differ from each other in a number of ways such as mold loading method, time and temperature of molding cycle, etc. The source material is in the form of a mixture of compounds in the case of injection method and extrusion method. In the compression method and transfer method, unvulcanized rubber is used. The final product of the extrusion method is odor free and does not foam.

Similar molders are used in all of these processes. Preforms are rough pieces of unvulcanized rubber that are placed in the compression mould, the cylinder of the injection molding machine, or in the pot of the transfer mould. Strip preforms are especially suited to injection molding. For injection and transfer molding, preforms can be of any shape that is convenient for feeding the injection cylinder or transfer pot. Transfer molding offers several advantages over other methods by providing: shorter production cycle, maintains closer dimensional tolerances than compression molding, provides uniformity and fast mold setup although non of the processes are better than LIM for avoiding flash and eliminating the excess waste of material.