MOULDING OF *SILASTIC* SILICONE RUBBER

Silastic silicone rubber is moulded to produce a broad range of parts in many shapes and sizes. There are three principal moulding methods: (1) compression moulding, (2) injection moulding, and (3) transfer moulding. All three methods are similar in that each forms the rubber in a mould by application of pressure and heat, which shape and vulcanize the parts. They differ as to mould loading method, time and temperature of moulding cycle, and other details, which are discussed in following paragraphs.

The design of moulds for silicone rubber is generally speaking similar to the design of moulds for thermoplastic. Nevertheless, a few important differences of the behaviour of silicone rubber should be noted. Silicone rubber does not shrink in the mould like a thermoplastic material. The silicone rubber expands in the hot mould. Therefore, the articles do not necessarily remain on a core or more generally on the positive side of the mould as desired. Usually, the articles remain in the cavity half with the larger surface area.

Mould Design

Accuracy

Dimensional accuracy of moulded silicone rubber parts is usually very important; and in such cases, the design of the mould must allow for shrinkage of the parts. Linear shrinkage values can be obtained from test moulded samples of flat rubber sheets and can be used as a rough guideline to mould design values for very simple parts only.

Determining the Shrinkage of complex Moulded Parts

With parts of complex shape, shrinkage is difficult to predict. It depends on several factors:

- tool temperature and demoulding temperature
- pressure in the cavity and consequently the compression of the materials
- location of injection point (shrinkage in the direction of the material flow is usually somewhat higher than perpendicular to the direction of flow)
- the dimension of the part (the shrinkage of thicker articles is lower than of thinner articles)
- post curing the article causes additional shrinkage of about 0.5-0.7 %

Therefore, in designing a mould for producing such parts, it is often helpful to mould a part in an existing mould of similar shape and size -using the same rubber, vulcanizing agent and moulding temperature that will be used with the new mould. The shrinkage values obtained on this part can then be used as a guide in designing the new mould. Conventional rubber moulding presses are used for all methods; and in some cases, moulds used for organic rubber

may be employed.

However, silicone rubber shrinks more than organic rubber during vulcanization; so where dimensional accuracy is critical, moulds designed for silicone rubber are required. This and other factors of mould design are discussed below. In many cases, the parts produced require an oven cure after moulding, to stabilize the physical properties and remove decomposition products formed during press vulcanization.

NOTE: The following sections state basic principles that apply in all cases;

and some give processing data for specific parts. Your moulding operation may differ significantly as to part dimensions, rubber or processing equipment. Accordingly, these figures may not be the best for your particular conditions; but they will be helpful as a starting point in determining what values will give you best results.

Air venting

Moulds should include provision for the release of air trapped in the mould cavity. This can be done by designing the mould so that it is split at undercuts or sharp corners.

The clearance between mould parts should be large enough to allow the air to escape from the mould cavity, but not so large that the *Silastic* silicone rubber also flows out. Generally, smooth-machined surfaces are satisfactory. The air which is enclosed in the cavity is first compressed by the injected silicone rubber and than expelled through the venting channels. If the air can not escape entirely, air entrapments in the article occur which can often be recognised by a white edge along the article. In this case special venting channels with 1 -3 mm width and 0.004 -0.005 mm depth can be inserted into the parting line so the air can escape.

Optimum venting is created by a vacuum. To produce such a vacuum, the mould stops during the closing movement at 0.5 -2 mm before it is completely closed. A gasket is built into the parting line, so a vacuum pump can draw the air from the cavities. Only when the vacuum has reached a certain reduced pressure or a time cycle has come to its finish, the machine closes the mould completely and the injection process is started.

Multi-Cavity Moulds

In designing multi-cavity moulds, it is important to quickly load the mould to avoid scorching. If the total loading time is too long, the moulding temperature may have to be reduced, and this will lengthen the moulding cycle, reducing the advantage of using multiple cavities.

Moulding Tips

Mould Material and Finish

- Retainer plates are fabricated from unalloyed tool steel. **Steel-No.: 1.1730** DIN-Code: C 45 W
- Moulding platens, which are exposed to temperatures between 170 and 210°C should be made out of pre-tempered steel.
- **Steel-No.: 1.2312** DIN-Code: 40 CrMnMoS 8 6
- The mould platens which contain the cavities are preferably produced from hot work steel, tempered later and possibly nitrided.
- **Steel-No.: 1.2343** DIN-Code: X 38 CrMoV 5 1
- For highly filled silicone rubbers, for example for HV insulators, the use of even harder materials such as flash chrome plated steel or powder metallurgy steel, which has been developed especially for this application, is recommended.
- **Steel-No.: 1.2379** DIN-Code: X 155 CrVMo 12 1

The surface of the cavities influences the process in different ways:

- The article duplicates exactly the surface of the steel and thereby fulfils various optical requirements. Polished steel must be used for the production of transparent articles.
- An eroded surface normally provides less adhesion between the LSR and the mould than a polished surface, so demoulding can be specifically designed.
- Titanium/Nickel surface treated steel has a very high wear resistance.
- PTFE/Nickel renders easier demoulding of the articles possible.

Mould Release Agents

It is usually necessary to use a mould release agent when moulding silicone rubber, though it may not be needed for chrome plated or highly polished mould surfaces.

A light coat of a 2 percent to 5 percent solution of household detergent in water, will prevent sticking in most cases. In making aqueous solutions of release agents, it is best to use distilled water if the plant water has a high mineral content. With rubbers that are formulated to give good adhesion to metals without priming, these detergents are ineffective, but a light coating of fluorocarbon lubricant can give good results.

Mould release agents should be used sparingly, to prevent buildup on the mould. Usually, one application every 5 to 10 moulding cycles is adequate. *Silastic* MRA-2 modifier can be milled into the rubber prior to vulcanization to increase mould release. Use of this modifier will decrease the need for conventional spraying, but may affect compression set of the cured rubber.

CAUTION: Silicone mould release agents, which are highly effective with organic rubbers, do not provide good release of silicone rubber.

Making Preforms

Preforms are roughly formed pieces of unvulcanized rubber that are placed in the compression mould, the cylinder of the injection moulding machine, or in the pot of the transfer mould (explained below). They are normally made by die-cutting or extruding -and in some cases, for compression moulding, by hand-forming, where parts are of highly complex shape.

For compression moulding, preforms should be of approximately the shape of the mould cavity, and should contain enough rubber to fill the cavity and produce a slight flash.

For injection and transfer moulding, preforms can be of any shape that is convenient for feeding the injection cylinder or transfer pot. Rubber compounds are ready-to-use and can be supplied in strip or coil form and cut to length, or in chunks or sheets. Strip preforms are especially suited to injection moulding.

Bumping

To dislodge air bubbles entrapped in the mould or rubber, most moulding operations require "bumping" - that is, sudden release of the moulding pressure, followed by buildup "to full pressure. This is done several times while the parts are being moulded and before vulcanization has started. Some presses bump automatically as part of the moulding cycle.