

RAPID MANUFACTURING OF SILICONE RUBBER MOLDS AS COMPLEX SHAPES FOR FOOD PRODUCTS

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Abstract:

All industries, including food industry have seen spectacular developments in the extent of discovery of new materials with special properties. This paper provides a brief presentation of silicone elastomers used to manufacture some cake forms, to improve product quality, increase efficiency, reduce the time needed for hygienization, diminish the microbial load of the form, and the steps required to obtain these molds by vacuum casting.

1. INTRODUCTION

Silicone elastomers are used since the early 70s in medical, aerospace, electronics, auto industry, in construction, industrial applications, etc. These elastomers enjoy today a success due to their unique characteristics, such as increased compressive strength, flexibility in a large range of temperatures, a wide range of hardness (5-80 Shore A). Silicone rubber is a synthetic polymer with a molecular structure consisting of a huge chain formed by two atoms of silicon and oxygen in alternative way.

The powerful link of silicon-oxygen gives silicone rubber its own performance and characteristics consisting in increased resistance to various chemical agents and variations in temperature, excellent mechanical and dielectric properties, biocompatibility, transparency and natural clarity.

The **Technological advantages** of silicone rubber are:

- light mixing and processing
- very small processing times, depending on part geometry and thickness of the part walls
- easy removal from the mold
- injection without loss
- in general, does not require post treatment
- adheres very well to certain materials
- high clarity
- odorless and neutral taste
- usable in the range of temperatures $-50\text{ }^{\circ}\text{C} \div +250\text{ }^{\circ}\text{C}$
- excellent elastic properties
- very good resistance against the ultraviolet attack and the ozone exposure
- increased aging resistance
- natural rejection of water and resistance against the attack of various solvents
- excellent dielectric properties in a variable range of temperatures
- silicone rubber is not a fuel, it does not melt and does not run
- toxicity of pollutants released is very low

Liquid silicone rubber applications include products from the following areas:

- **Automotive industry:** sheets for spark plugs, various membranes, etc.

- **Electronics:** terminal elements, connectors, keyboards for computers and phones, diaphragms, etc.
- **Home appliances and accessories:** low insulation, membrane, different components for coffee makers, cake forms, etc.
- **Medical accessories:** catheters, teats and soothers, etc.
- **Others:** swimming glasses, diving masks, etc.

2. VACUUM CASTING

Vacuum Casting is the method used for obtaining silicone rubber molds. This method is one of the most used, interesting and spectacular applications for use of RP models to develop new products. Vacuum Casting is a technique that has proved the appropriateness and efficiency in the stage of developing new products, step when prototyping of complex parts must be used for small batches (30-50 parts), for testing new product functionality and/or market testing of the new product.

This manufacturing method reproduces faithfully the details of form and the quality of RP model surfaces used as a master.

Materials used in the vacuum casting are different types of resins, plastics and rubber.

EQUIPMENT PRESENTATION

The Center for Rapid Prototyping of the Technical University of Cluj-Napoca is using a vacuum casting machine type MCP-001 PLC, which is shown in Figure 1. The manufacturing of the molds is performed using silicon-type ESSIL 291. This silicone can be used with one of the following 3 catalysts:

ESSIL 291-for dies which are not using a lubricant, Shore hardness A 38 – this is used in the Technical University of Cluj-Napoca

ESSIL 292 –for products extraction from molds with a lubricant, Shore hardness A38

ESSIL 293 – 291 version with high hardness Shore A40



Fig.1 Vacuum Casting machine MCP-001 PLC

After the completion and the inspection of the RP model used as a master (model produced on one of the LOM, SLS or FDM systems), the Vacuum Casting Technology generally takes place in two stages:

- Formation of silicone rubber mold
- Casting parts in silicone rubber molds

3. MANUFACTURE OF SILICON RUBBER MOLDS FOR FOOD INDUSTRY

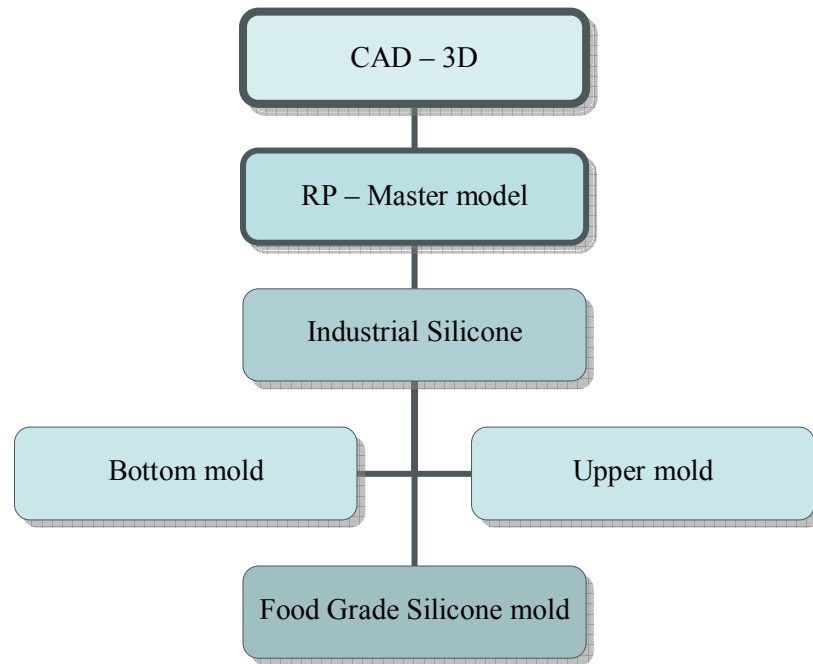


Fig.2 Scheme for obtaining food grade silicone molds for cakes

The steps needed for casting silicone rubber mold for the food industry are:

1. **Developing a CAD drawing of the master model** which is the cake form. This form is intended for the manufacture of savarin cakes, and the model can be rapidly manufactured, using any of the existing RP methods: Selective Laser Sintering, Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM).

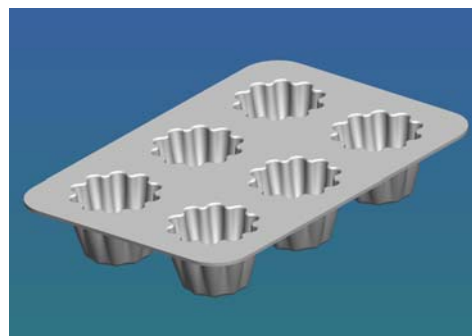


Fig.1 Master model (Savarin form)

2. **Establishing the plan of separation** for future silicone rubber molds and its materialization by sticking an adhesive strip at this plan.
3. **Coloring the contour of the separation plan** to be visible through the semi-transparent silicone rubber, after casting around the piece.
4. **Manufacture of a wooden or plastic box** to fit the RP model and in which the silicone rubber (SR) can be cast in a liquid state. It has a vertical rod attached to the model, which will be removed after casting SR and thus will result the funnel casting from the upper mold (fig.2). The bottom mold is shown in Figure 3..

5. **Casting silicone rubber** in forming box. Before the casting, SR is introduced in a vacuum chamber for de-gassing.
6. After casting in the forming box, SR is again introduced in the vacuum chamber **to eliminate the air bubbles** accumulated during the casting around the RP master model, then the box containing SR cast is introduced in the polymerization oven, where the silicone rubber block is solidified.
7. After the total polymerization, the SR block is removed from the forming box. By a manual operation, the separation plane between the bottom and upper mold is cut and the detachment of the SR master model takes place.

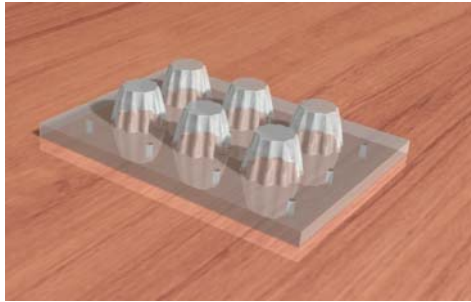


Fig.2 Silicone upper mold

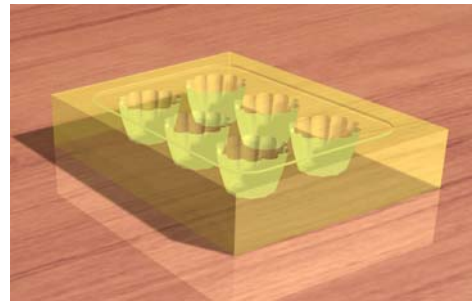


Fig.3 Silicone bottom mold

8. **Getting the Food Grade silicone rubber mold** by casting food silicone rubber between the upper and bottom molds with the funnel formed in the upper mold. Before the casting, SR is introduced in a vacuum chamber for de-gassing.
9. For the solidification of food grade silicone rubber cast in the previous stage, the whole mold is introduced in the polymerization oven at about 70 ° C, for 2-3 hours. The mold assembly is shown in Figure 4.

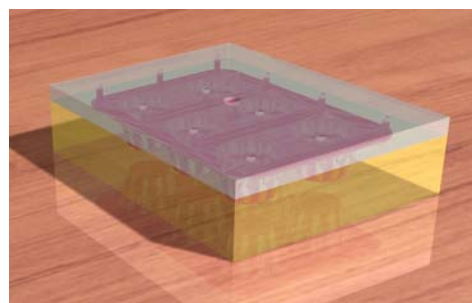


Fig. 4 Cross section through a mold assembly

10. By opening the two silicone rubber molds, the food silicone rubber form can be detached and subsequently used to manufacture savarin cakes.

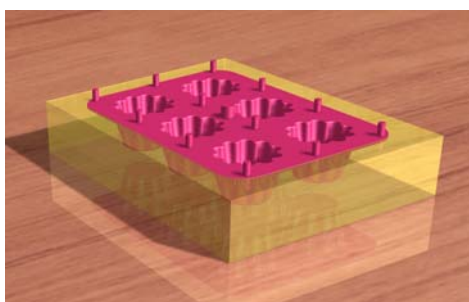


Fig. 5 Savarin form in the bottom mold



Fig.6 Food grade silicone form for Savarin

4. CONCLUSIONS

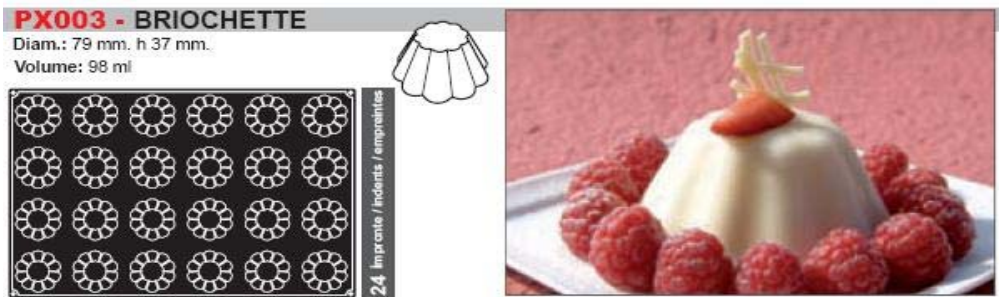


Fig.7 Cake form

Silicone rubber is a two component system (A + B) available from very soft to medium hardness. It is intended for the mold manufacture by casting from a model.

Advantages:

As compared with other rubber-like materials, silicone rubber has the best extraction properties of the models from molds. This is an advantage when resins (polyurethanes, polyesters, epoxy) are used in manufacturing. Silicone rubber does not require release agents, so there is no need for cleaning after use. Silicones also present a very good chemical resistance and resistance at high temperatures (above 205°C). The combination of good extraction properties, chemical resistance and heat resistance makes silicone the best solution in manufacturing when resins are used.

Disadvantages:

The price of silicon is high. This material is also sensitive to substances. Silicones have usually a high viscosity and must be subjected to de-gassing before casting, in order to minimize their contents of air bubbles. Silicon components (A + B) must be mixed accurately by weight (prescribed proportion) otherwise they will not work. When using false catalysts, the mold life will be shortened.

References

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