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# Mold-Making Handbook

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# 1.6 Rotational and Slush Molds

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## 1.6.1 Process Description

For the economic manufacture of seamless hollow articles made of plastic materials, the well-known procedures for blow molding and rotational molding can be used. In the origins of rotational molding, PVC or plastisols were used for the manufacture. Since "industrialization" of rotational molding in the 1950s, PE is the most widely used processed material. PE is available in different densities and qualities, dry blended and compounded, ultraviolet-(UV)stabilized, electrically conductive, and phosphorescent. Other common materials are PVC, as well as PP, PA 6, PA 12, and PC. All of the RAL colors are feasible and even colors that imitate natural colors are possible (e.g., stone, terracotta, etc.).

The plastic material is mostly powdery. The dosed material is then inserted into the one- or multi-part mold. With the given part size and surface geometry, the amount of the plastic material determines the wall thickness of the hollow part. The filled and closed rotational mold (using clamping elements) is attached to the mold carriers, which are attached to the machine and drive elements.

The most important characteristic is that the molds should rotate slowly around two axes at right angles to each other. This rotation takes place during the melt process and during the cooling process. After melting the plastic material, in a circulating air oven (up to 350 °C), the mold and product are cooled in a cooling station using a water-air mixture or using cold air.

The cycle time for the manufacture of a rotation molded product can be between five to forty minutes, depending on various factors. Important influencing factors are the type and size of the molds, machine performance, material choice, and wall thickness.

## 1.6.2 Strength of a Rotomolded Part

Where in other plastic molding processes the outer contour of products is thinner in some spots of the wall, the outer contour and radii of rotomolded products is thicker. Therefore, rotomolded products are very stiff. To increase the stiffness of a rotomolded part, the easiest solution is to increase the weight and the wall thickness.

Besides the possibility to fill the plastic hollow room with PUR foam, PE foam can be rotated into the mold as a second layer. A precise dosage of the material mix is necessary for this application (e.g., plastic powders from two materials with different melting point). Therefore, a solid plastic skin is rotated first, followed by activation of the propellant-coated material of the second material (due to heat induction), which then starts the foaming process. Another possibility is to insert the propellant-coated material into the mold after rotation of the first plastic material layer. This can either be done using a manually operable filling opening, or by using a so-called “drop box”. This is a well-insulated container that is attached to the outside of the mold and opens (at a desired time) a passage to the mold to insert the “second shot”.

Increased stability can be achieved through stiffness ribs or through targeted integration of tie points between the individual walls of the plastic product.

### 1.6.3 Mold Requirements

During production as described above, rotational molds are exposed to many heating/cooling cycles. Typically, molds are heated to a minimum of 300 °C and then cooled to ambient temperature (in each production cycle).

These extreme temperature changes require not only the selection of the proper mold but also, more importantly, a suitable design. In order to heat/cool the mold with a minimum amount of energy, molds must be made as thin-walled as possible and of a good heat-conducting material. Furthermore, the mold closures and the mounting of the mold in the carrier must be designed so that they are fast and safe in handling. It is most important that the leakage between the mold and the closure between the cavities (in multi-cavity molds) is reduced to an absolute minimum. Plastic leaks cause problems if they occur during production: the product thickness can be reduced and the plastic material can bake onto the outside of the hot mold. This burnt crust is difficult to remove and forms heat insulation, thus affecting the heat transfer through the mold wall. This can lead to different wall thicknesses of the plastic products. Furthermore, excessive flash builds up, which increases the finishing costs.

The surface quality and the shape of the mold cavity are transferred to the surface of the molded part. The shape of the article, the position of the possible undercut, and the surface quality, possibly with grained texture, will determine both the choice of the correct molding material and the most suitable production process. Also, the different requirements for processing PE, PP, X-PE, PA, PC, and PVC (e.g., corrosion problems that can occur through hydrogen chloride when manufacturing PVC) should be taken into account in the mold design.

### 1.6.4 Nomenclature of Rotational Molds

The design of a rotational mold can be very diverse due to the general simplicity of these molds. Besides the single cavity mold (in which one product is manufactured in one mold), there are also double or multi-cavity molds (in which two or more products are manufactured in one mold and are mechanically separated) and combination molds (in which different products can be manufactured in a convertible rotational mold). Figure 1.174 shows such a combination mold.

This cast aluminum rotational mold can be modified using inserts so that either a BBQ-Donut® Half (Figure 1.175) with steps of invert or a half with motor and umbrella holder can be molded. The mold consists of 10 mold shells.

**FIGURE 1.174** BBQ-Donut mold


**FIGURE 1.175** BBQ-Donut mold

Figure 1.175 shows an assembled finished product (floating grill island – "BBQ-Donut®"). Both donut halves are manufactured in a modified combination mold. The rotational molded halves are made of PE and the dimensions are each 4,000 × 2,000 × 1,200 mm.

A single mold is a mold that is manufactured for only one product. If the demand is higher than the output of a mold, identical molds can be produced. For the production of large quantities, the so-called spider concept (multiple cavities are assembled to a frame) is recommended. Opening and closing of the assembled single molds is done in one step and leads to significant time savings in handling.

The construction of a rotational mold can be done in two parts (out of two mold shells) or depending on the complexity, in 3, 4, or 5 parts (Figure 1.174).

How a mold is parted mostly depends on the demoldability of the plastic material to be molded. This means that the mold has to be parted so that the removal of the shells off the products or the removal of the rotomolded plastic part out of the shell is done without causing damage. More decision-making criteria for the choice of the mold separation (e.g., optical and aesthetic requirements, general handling of the mold halves, etc.) can demand additional molded parts.

## 1.6.5 Types of Molds

Molds that are needed for rotational production can be manufactured from different thermally conductive materials (where every design has its advantages and disadvantages). The choice of the best suitable rotational mold is based on technical criteria (size, complexity, precision, surface structure, planned quantities, etc.) and economic factors like costs and production time.

Molds from aluminum (aluminum casting and CNC-milled) or sheet steel are used today for rotational molds. Electroplated molding has established itself for special rotational molds for PVC plastisols. There are also a couple of other materials that can be used in prototype production.

### 1.6.5.1 Prototype Rotational Molds

Due to the high temperature loads when producing rotomolded plastic parts, it is almost impossible to use cheap prototype molds. A rotational mold has to have a certain thermal conductivity and has to constantly withstand changes in heating and cooling.

In the construction of prototypes, molds are used where the mold shells are manufactured in the metal spraying procedure. This is only possible for easy and flat contours due to the metal spraying procedure.

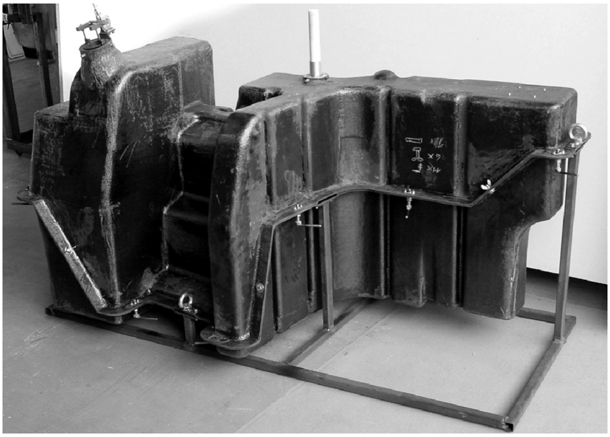

**FIGURE 1.176** Prototype mold with carbon fiber molded shells

The sprayed metal is comparatively porous, which leads to a defective surface quality of the plastic product. In addition, the metal can only withstand the constant temperature change to a certain degree; it gets porous after a while and tends to crack.

An alternative in prototype molding is the use of carbon fiber shells, which are manufactured in an autoclave. The advantage of this application is that there are almost no restrictions for mold design. The disadvantages are the high production costs and limited lifetime.

Figure 1.176 shows a carbon fiber prototype mold for a 400-liter fuel tank with a simplified frame and screwed form flanges. The attachment of required fixtures like a fuel-level sensor, threaded fittings, inserts, etc. enables the rotation of prototypes in production-based design.

#### 1.6.5.2 Sheet Steel Rotational Molds

Especially for high volume products (storage tanks) and for article contours with a low level of difficulty, molds from sheet steel are used. The wall thickness is mostly between 1.5 and 4 mm. Different sheet steels are welded or soldered. After a heat treatment for a stress reduction, the mold fit surfaces have to be refinished for better sealing. The weld and solder lines have to be polished and reground. The quality of the surfaces is dependent on the skills of the tinsmith.

A sheet steel rotational mold for the manufacture of an inspection chamber (diameter 1,000 mm, height 2,200 mm) is shown in Figure 1.177. Before opening of the mold shells, the eight rotating steps, which are located in the contrary to the demolding direction, have to be withdrawn using a hinge system.

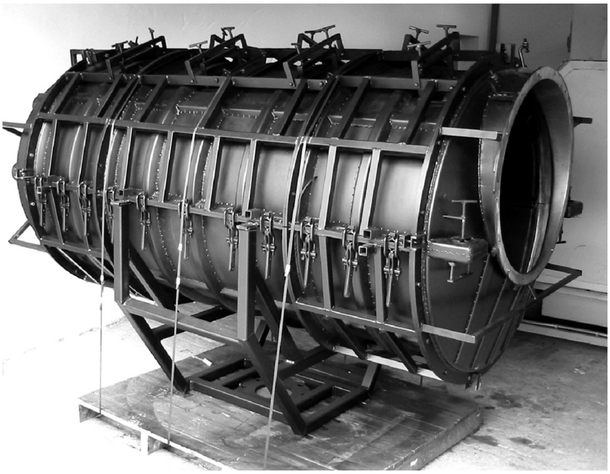

**FIGURE 1.177** Sheet Steel Mold

#### 1.6.5.3 Aluminum Rotational Molds

These molds can be made from CNC-milled or casted aluminum mold shells (a combination between both methods is possible as well). A mold made from a combined cast aluminum and CNC-milled shells can be manufactured. In addition, a lot of different materials in a mold (aluminum with steel) can be used for the manufacture of mold shells.

The production steps of both applications differ from each other significantly. The complete construction of the mold shells and the design of the form separation and flanges have to be determined for the production of a machined aluminum mold. The manufacture of a mold begins mostly with the production of a positive model (per sample, drawing, or 3D data).

CNC-machined molds are mostly used when the aluminum block to be machined is very flat, when the production time is critical, or when the necessary tolerances are very high.

For an economical rotational production, it is necessary to machine the mold shells to a certain wall thickness, which means to machine on both sides. This will ensure an equal and fast heat penetration of the mold wall.

Figure 1.178 shows a CNC-machined aluminum rotational mold for a shaft cover (diameter 700 mm) with bent tubular steel frame and hand closures.

The use of mold shells manufactured in an aluminum casting is advantageous for large and deep mold shells or for necessary follow-on molds. For the manufacture of aluminum casting mold shells, the casting molds made from sand or sand/ceramic molds have to be manufactured first. The aluminum casting process, shown in Figure 1.179, is done by hand.

**FIGURE 1.178** CNC-machined rotational mold

**FIGURE 1.179** Aluminum casting

Negative molds are needed when manufacturing such casting molds. These correspond to the required mold shells and already have the necessary mold flanges and mold thickness (mostly between 7 and 12 mm).

These negative molds are either produced according to the data or using a positive mold that is manufactured before. Structures added to the positive model, like timber graining, terracotta, or stone structures, can be replicated in the casting mold and the aluminum casting.

Depending on the type of aluminum casting process, there are small differences in the manufacture of the casting mold. The most modern type of manufacturing such

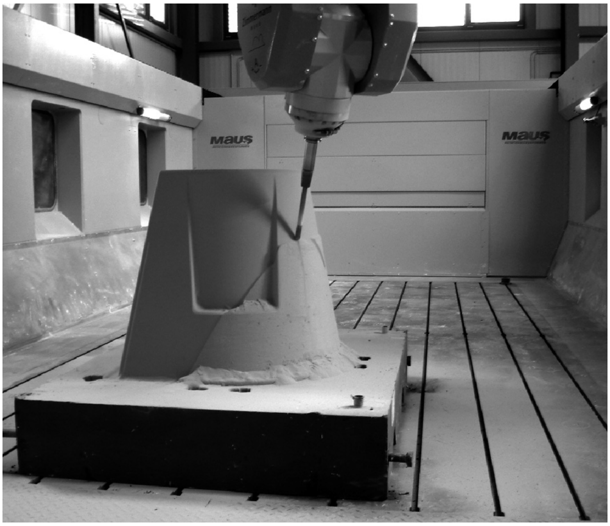


**FIGURE 1.180** Sand mold CNC processing

casting molds is the CNC milling of unmachined sand parts with CAM data. A very complex construction of the mold shells is needed (as seen in CNC-milled molds). The contours of the mold shells can be CNC milled using CAM data. Figure 1.180 shows a 5-axis CNC processing of a sand casting mold for the manufacture of an aluminum casting rotational mold for a designer garden or lounge chair. A CNC-milled mold is manufactured in about five to six weeks, whereas the standard production time of a casting mold takes about eight to ten weeks. The size and complexity of a mold are substantial factors in the production time.

#### 1.6.5.4 Electroplated Molds

In electroplated molds, a model is molded to the smallest detail (see Section 4.3). The positive model, which corresponds to the finished article, is therefore the basis for electroplated rotational molds and slush molds. The necessary finesse, such as surface quality, dimensional tolerances, mounting parts have to be determined. For example, it is possible in prosthesis manufacture to use rotational molds to get an exact impression of which the inner contour is an impression of the human skin. This shows the precision of electroplated molds and the art to manufacture sufficient models made from resistant materials.

The requirements of the models are strongly influenced by the rotational processing methods, as well as by the inserted component material. For the components that almost always have undercuts, elastic materials (PVC, TPU, and TPO) are used. Additionally, it must be ensured that no mold markings are accepted in the visual area of the component.

Therefore, single-parted rotational and slush molds are prerequisite and are provided with openings out of which the elastic components are ejected off. Ejecting components in electroplated molding is also done through small mold openings. Therefore, model materials are used that can be mechanically or chemically destroyed.

For economical mass production of doll parts and toy animals, multiple identical electroplated molds are necessary. Therefore, the models are done as follows:

First, an original model out of suitable wax is modeled. After this step, a so-called master model is manufactured with which individual models (for manufacturing series-production molds) are molded in the rotational oven. Here, thick walled PVC models in a harder setting are very common. Where necessary, the possibly elastic PVC models can be stabilized through coating on the inner side with casting resin and wax. It is important, when manufacturing the original model using this model reproduction process, to take the double material shrinkage into account. It is therefore useful to include extensions (conical connecting pieces, etc.) in the original models and master models, which will be necessary for the clamping system (because for the PVC models, these contours are transferred to the serial mold).

To manufacture prostheses slips, silicone negative models of a human forearm are taken of which models are made using either wax or a specific casting resin. This ensures that fine skin pores and skin structures are exactly transferred to the electroplated mold.

For education in schools, universities, and institutes, scientific and anatomical demonstration objects are needed. These are generally manufactured in the rotational process using harder set PVC. For the model construction, enlarged models (Figure 1.181) or original bone (for skeleton construction) are used. These are embedded in plasticine to be able to model the necessary demolding. Due to anatomical contours, the parting plane is normally waved, is also molded, and is provided with fixations (e.g., tongue and groove), so that the mold elements will fit

**FIGURE 1.181** Model for the manufacture of an electroplated mold for the production of anatomical demonstration objects (e.g., eye)

together (unshiftable). Using silicone negative molds, which can be manufactured of two or more parts, the model maker has the opportunity to make models of two or more parts of epoxy resin, which then can be used as models for further processing. Using this method, the fine bone structures are also projected onto the inner contour of the electroplated mold.

The respective models are provided with brackets and contact feed units, and after cleaning will be coated with a silver coating (with a layer thickness < 1 µ) to make them electrically conductive. During electroplated molding, the silvered model forms the cathode. By using suitable electrolytes in the cathode, as in familiar surface-electroplating, copper and nickel are deposited in the required wall thickness. For small and medium-sized electroformed molds, a wall thickness of 2 to 3 mm is ideal; for large molds, depending on the design and surface geometry, wall thicknesses up to 5 mm are used. The electroplating process takes between two and eight weeks depending on the required wall thicknesses and the complexity of the surface geometry. After reaching the set points for the wall thickness, the brackets and contact feeds are removed, the model is demolded, and the electroplated mold is a negative image of the positive model. To function properly, fixing elements and clamping devices are attached.

Initially, electroplated rotational molds were only processed in acid copper baths. The advantages of this process are the known thermal conductivity of copper and the easy handling of copper baths that are used at room temperature, therefore allowing for the use of wax models. Because the copper, which is separated in these acid baths, is very soft, the (in the bath) molded electroplated molds can easily be mechanically damaged. Another disadvantage is the danger that fission products using PVC can lead to corrosion. To prevent corrosion, the electroplated molds made from copper are provided with a chemical nickel-plating of the inner contour (also the outer contour if necessary). This chemical nickel-coating is in the micron range and can be neglected in regards to the mold surface. However, the very thin nickel coating has a limited service, so the copper electroplated molds have to be nickel plated from time to time.

To eliminate these difficulties and to meet the requirements of a large-scale production of the automobile industry, it is now state of the art to manufacture electroplated molds from sulphamate nickel, which guarantees higher wear and corrosion resistance. During the construction of the sulphamate nickel galvanic molds, it is possible to develop local thickenings (e.g., flange areas of multi-part molds for attachment of clamping elements).

One should note that nickel, in comparison to copper, is a less thermal conductive material. Here, it is possible to manufacture molds that consist of 1 to 2 mm sulphamate nickel which will then be reinforced with hard copper. This combination combines the advantage that nickel offers, with the good thermal conductivity of copper.

## 1.6.6 Mold Construction

### 1.6.6.1 Closing and Clamping of Molds

The rotational process is a pressureless process. This means that the mold halves, as in other processing operations (e.g., injection molding), do not need to close with high clamping pressure. They still have to be kept together during the bi-axial rotational motion to prevent material from leaking. Therefore, the mold halves are either clamped or screw-fastened.

One of the more cost-effective options is to use screws with fixed mold flanges. However, after every cycle, the screws have to be removed, and after filling they will have to be attached again. (An example of a screwed mold flanges is shown in Figure 1.176. The cycle times here are of secondary importance.)

To give the mold halves the necessary stability and uniform clamping, a steel frame is attached above the flanges. Manual clamping devices, pneumatic cylinders, or similar closures are installed to this frame. Furthermore, additional protection for the often fragile, thin-walled mold shells is offered. The steel frame can either be made out of bent or welded steel tube as seen in Figure 1.178, or out of flat materials.

The use of pneumatic cylinders for clamping molds is possible. However, exclusive materials have to be used (e.g., seals from Kalrez®) for the cylinders due to typical temperatures in the rotational production, which will then lead to very high production costs of these special cylinders. Because of the use of such closures, pneumatic cylinders are therefore only suitable for mass production of, for example, planters and children's toys. An example in Figure 1.182 shows a circular spider construction for eight planters with 700 mm diameter each.

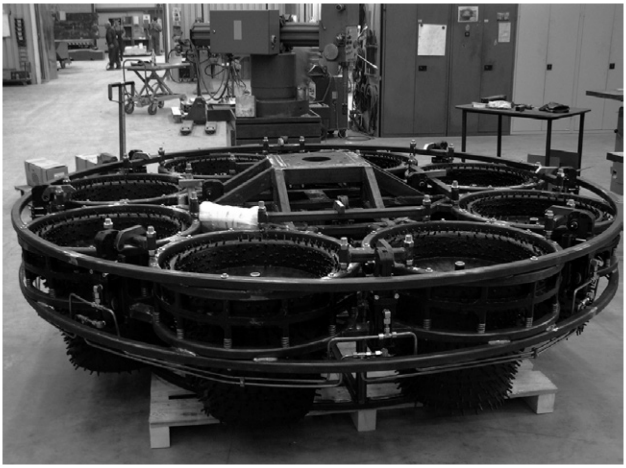

**FIGURE 1.182** Spider with planter molds

Inside the 3,000-mm big spider, clamping of the single molds is done using special pneumatic cylinders. For an optimal heat transfer, the aluminum molds are provided with so-called Profit Pins™ and a permanent release coating.

#### 1.6.6.2 Mold Wall Thickness and Centering

The wall thicknesses of the aluminum molds are very thick in comparison to the thin-walled sheet steel molds (1.5 to 3 mm). Wall thicknesses between 7 and 15 mm are used for casting molds (depending on the quality of the casting process). In the mold shells that are CNC milled out of an aluminum block material, a standardized wall thickness of 7 mm is established.

In regards to the heat transfer material induced disadvantages of higher wall thicknesses in comparison to steel sheet, the thermal conductivity is offset by aluminum (for wall thicknesses of electroplated molds; see Section 4.3).

Independent to the material, one must take into consideration that the wall thickness in a mold should be equally distributed. In general, the more equal the wall thickness of the mold, the more equal the wall thickness of the rotomolded product will be.

To additionally improve the thermal absorption of the aluminum casting molds, the aforementioned Profit Pins can be casted on.

On the outer side of the mold, the small conical plug enlarges the mold surface and improves the heat absorption and dissipation of the mold. Profit Pins can be partially attached (for a better heat absorption) in problem areas or fully attached. To shorten the production process, the planters shown in Figure 1.182 are provided with such Profit Pins.

To make it easier to combine the different mold shells together and to achieve best precision, locating elements are included in the forming flanges. In general, these locating elements are provided as steel dowels. Tongue and groove locating elements on the flange are also possible.

#### 1.6.6.3 Mold Surfaces and Changes

Surface structures (in aluminum casting molds) like wood structures, linen structures, and leather grain structures can be taken over into the model. An example of aluminum molds for the production of anatomical visual models made from PVC is shown Figure 1.183.

In comparison to the method of producing the surfaces directly inside the mold, it is also possible to change the metal surfaces by appropriate reworking. The most popular surface treatments are grinding with different grain sizes up to high-gloss polishing and surface treatment through sand blasting and shot peening.

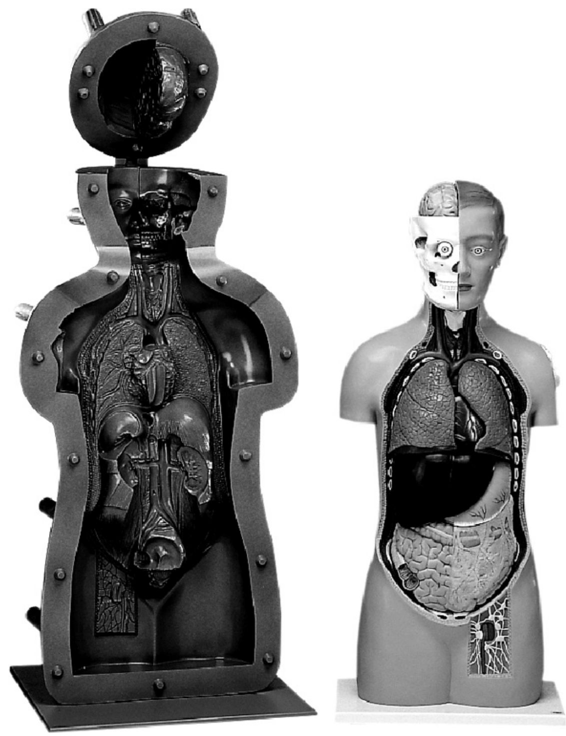

**FIGURE 1.183** Mold and anatomical visual model

The surface structure in aluminum molds is determined with shot peening as a reworking process. This is not possible for steel molds.

Especially in fine surfaces (structure-etched), a preserving and refinement of metal surface through a permanent release coating is recommended.

Due to the comparably simple construction of rotational molds, changes are for the most part simpler to implement than, for example, in injection molds. In general, changes can be done by welding, processing from the existing wall thickness, or by inserting new milled or casted batches.

## 1.6.7 Mold Peripheral

### 1.6.7.1 Mold Venting

Through heating in the oven area, the air expands inside the mold. Conversely when cooling, the air contracts inside the mold. For this reason, it is essential to provide the rotational molds with a venting unit because the over- and underpressure negatively affect the service life of the mold and the quality of the plastic product. Such a mold venting can be done using multiple different methods. The most widely used method is a tube made from PTFE which is pushed through the mold wall and reaches deeply into mold interior and enables air exchange. In mold geometries in which the powder in the mold can come into contact with the PTFE tube or in which powder can leak out of the pipe, compressed steel wool or plastic foil can be used as a seal. Alternatively, filter rods or so-called Supavent™ stoppers (products made from temperature resistant silicone) can be used.

#### 1.6.7.2 Non-Permanent Release Agent

The melted plastics in rotational molds have the property of sticking to the mold wall. This behavior is necessary for the production of rotational parts. However, the adhesion should not be high because demolding of the plastic part out of the mold will be difficult or not possible at all. To prevent this, release agents are used. These are applied to the molding surface periodically and give sufficient adhesion and the necessary demolding properties. The mostly water-based, nonpermanent release agents are sprayed into the mold or are manually applied with a rag. The release agent layer becomes thinner after every production cycle, so the release agent has to be renewed after about 50 to 500 cycles. Depending on the plastic material used (e.g., PVC), the complexity, and mold surface quality (e.g., polished mold surfaces), a release agent is not always required.

#### 1.6.7.3 Mold Coating (Permanent Release Coatings)

Due to better repeatability and economical production, the so-called permanent release coatings have increased in importance over recent years. In general, mold coatings are sprayed onto specially prepared metal surfaces in fine layers and are cured layer by layer. Earlier permanent coatings had very strong demolding properties and were mostly only suitable for the coating of mold cores with strong shrink-on situations. Now, a diversification of mold coatings can be seen.

Today's available coatings allow a downgrading of the release properties (using PTFE parts) and a targeted influencing of the optics and haptics of plastic products. The gloss grade of surfaces (due to coatings) can be chosen in different nuances, from matt to high gloss.

Along with the design influence, coatings take over diverse technical properties, for example the improvement of the heat transfer of the mold, improved flow properties of the plastic melt, and improved gradient blend. The use of permanent coatings is not only restricted to molding surfaces: mold flanges and the outer side of the mold can also be coated to decrease service and maintenance work.

#### 1.6.7.4 Threads

The necessary mounting points in a rotomolded plastic product can be tightly fixed inside the mold as threaded inserts. Around the inserts, the plastic melts and forms a constant bonding. Threaded inserts can be held inside the mold with a screw, which has to be screwed in and out for each cycle. In industry, snap inserts (fixed inserts using spring loaded balls) or magnetic holders have established themselves.

Along with the possibility to mold-in threaded inserts, threads can be shaped directly inside the plastic material. Specific thread formers made from brass, steel, or aluminum are used to shape either internal or external threads. These have to be manually screwed off to allow the demolding of the plastic products.

#### 1.6.7.5 Other Inserts

Besides threaded inserts, other parts can be fixed and molded into the plastic part. A common application, for example, is the molding in of mounting brackets made from metal. In general, inserts made from other materials (e.g., plastic material) can be used. The melt temperature, however, has to be higher than that of the rotomolded plastic material.

### 1.6.8 Post-Processing of Rotomolded Plastic Products

#### 1.6.8.1 Openings

Besides post-processing of the rotated product (e.g., drilling, milling), a predetermined breaking point in the plastic product can be created by introducing a knife edge in the mold. The opening is produced in one stroke in the cooling product. When processing (e.g., with a knife), the edge allows for better guidance.

It is also possible to shape the openings directly in the rotational process. A widespread method is the use of PTFE bars and plates. Because of the reduced heat absorption of this material and the strong release properties, no plastic material sinters at such PTFE bars or plates (which are attached to the mold). An opening is affixed by rotatation.

#### 1.6.8.2 Decoration of Rotomolded Plastic Products

Due to the self-releasing properties of almost all materials (which are rotationally processed), a subsequent decoration of products with screen printing, painting, and placement of stickers is often very difficult. Preparation of the plastic product is possible, but very complex. For some time now, there are specially developed possibilities for decorating plastic products using mold-in-systems.

For example, colorful logos are directly applied to the mold surface using carrier foil. The melting plastic material bonds permanently with the foil during the processing. It is more welded than glued, which means that the applied decorations are scratch resistant and almost indestructible.

### 1.6.9 Electroplated Mold for the Slush Molding Process

Automotive producers demand the highest standards when it comes to the material quality and the outer appearance of the interior of automobiles. The designers demand, besides the functional geometry, good optics and haptics, individually specified surface structures with a defined degree of gloss, as well as dual tonality of the components. To reach these requirements, soft materials like PVC, TPU, and TPO are especially used for instrument panels, door windowsills, glove compartment lids, and center consoles (Figure 1.184). The manufacture of these parts is exclusively done in electroplated molds, which are designed differently depending on the slush technology.

In comparison to rotational molding, in the slush molding technology, open molds are used. After preheating the slush mold, the mold is coupled to a container that is filled with powdered raw material (therefore the internationally used expression "powder slush"). Through rotation and vibration, the raw material is brought into the preheated electroplated mold. A specific, possibly defined amount stays at the mold walls. The powder surplus is brought back into the container. Subsequently, the mold and the container are separated, and in the further process, sintering of the powder to a slush skin is continued. This is followed by cooling of the mold to approximately 40 °C when the slush skin can be removed. The skin is inserted into a foaming mold using a hard set carrier and is bonded with the carrier through back-foaming (Figure 1.185 and Figure 1.186).


**FIGURE 1.184** Detail of the grain pattern to be molded

**FIGURE 1.185** Shaping contour with double electroplated mold to produce two instrument panels at the same time

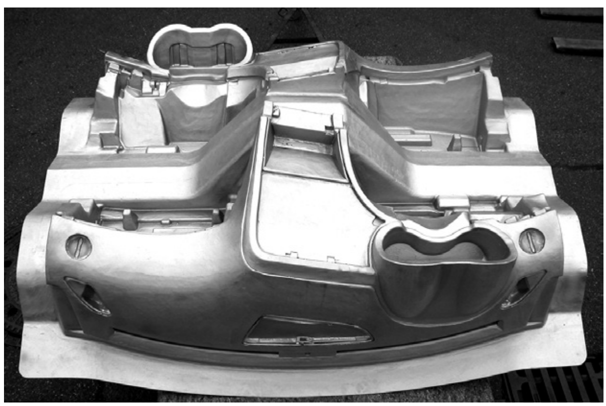

**FIGURE 1.186** Strong jumps in geometry at the outer contour of a double-sided electroplated mold, which have to be overcome when electroplating

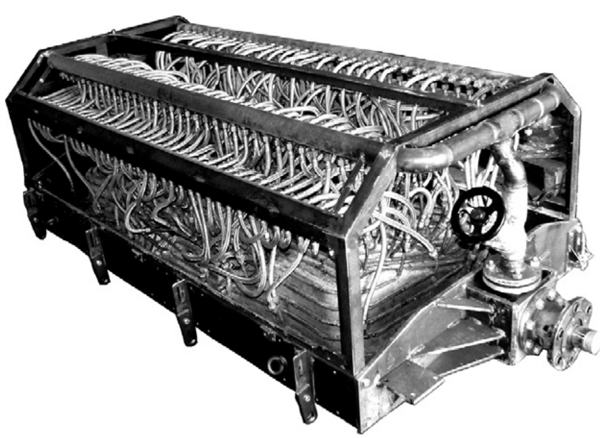

**FIGURE 1.187** A complete electroplating mold to use in systems with temperature control using thermal oil

For heating and cooling, different process systems can be used that need adapted electroplated mold shells:

1. Mold shells from sulphamate nickel with a wall thickness of about 3 to 4 mm, which are heated either with hot air or in a sand bed, where cooling is done through spraying with a water-air mixture or though cold air.
2. Mold shells from sulphamate nickel with a wall thickness of about 4 to 5 mm, soldered onto the temperature control pipes made from steel, so that heating and cooling can be done using heat transfer oils (Figure 1.187).
3. Mold shells from sulphamate nickel with a wall thickness of about 3 to 5 mm, which have a double wall at the back. This double wall is either made from sheet metal or from electroplated mold shells and is oil-sealed bonded to the flanges of the electroplated mold shell. Using specially attached nozzles, the oil is brought through the spacing between the electroplated mold and the double wall to ensure heating and cooling of the mold.

In order to meet the great demands of application technology and the design department on the construction, surface structures, dimensional stability of the slush mold skins, electroplated molds are made available. The goal is reached by using a complex and expensive model technology. Figure 1.188 shows the principle path from CAD data to the finished electroplated mold shell.

Based on the CAD data, which are given by the customer, the so-called “run-off-surface” is determined and the feasibility is verified between customer, foaming mold manufacturer, and electroplating personnel. Additionally, the sealing surface should be designed to ensure a secure sealing against powder losses (using the elastic seal of the powder box adapter), as well as the flange to include the electroplated mold shell in the mold carrier. To keep the material loss, which develops through the run-off surface and the adapter contour, as small as possible and to guarantee the technological feasibility, the construction of these elements must be very carefully investigated.

Using the design and taking into account the shrinkage of the used material and the shrinkages expected in model technology, milling of the original model from tooling material follows as the next process step. After fine-tuning of the original model surface, an acceptance through the design department of the automobile plants is done. Particular attention will be paid to fairing lines, radii progression and transitions, as well as recesses and grooves for mounting parts. Once the original model is released, in the next step, the grain structure can be applied. It does so by one of the following methods:

a) The zones that will have to be grained need to be bonded with real leather or grain foil (when milling, the foil or leather thickness have to be taken into consideration).

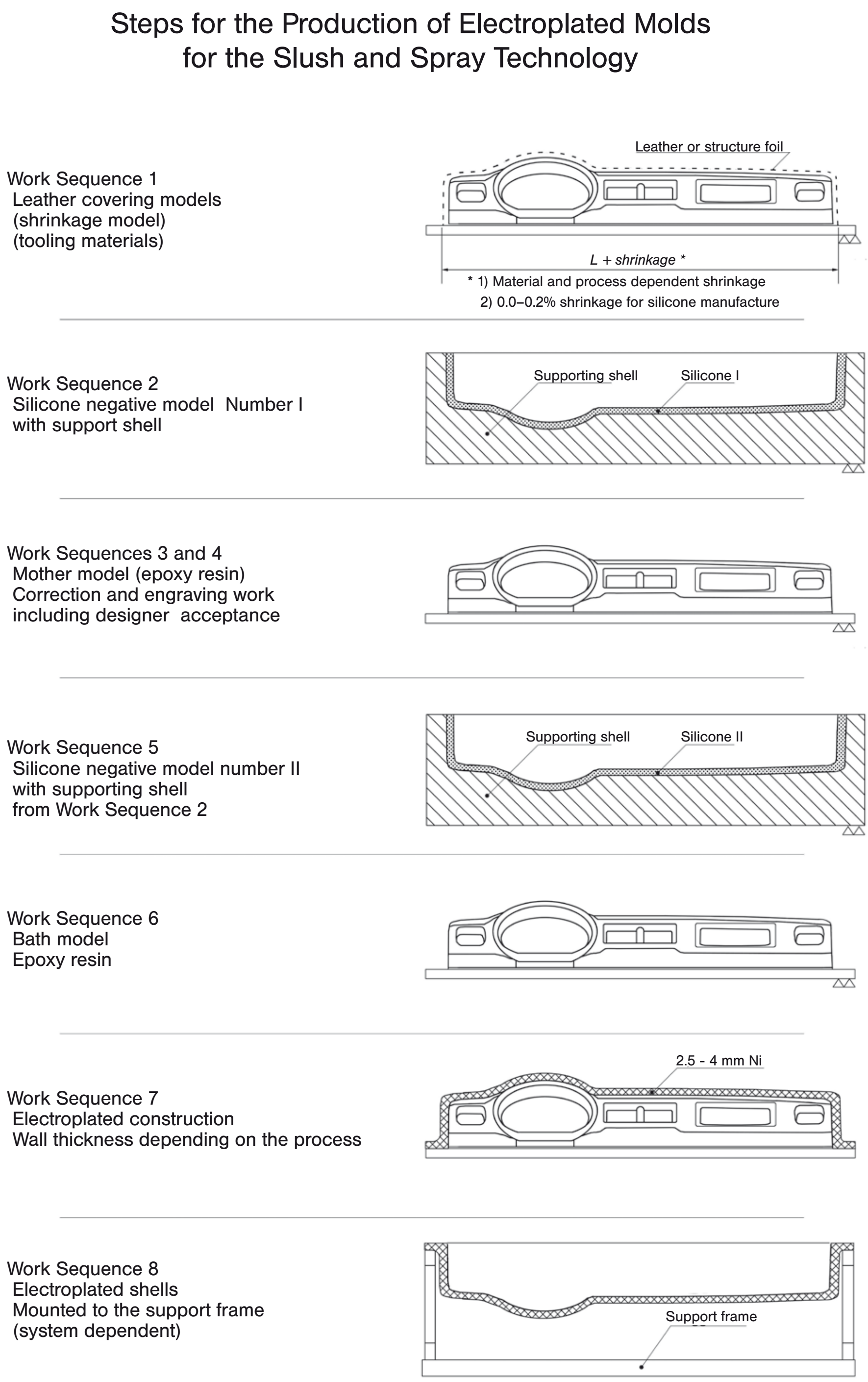


**FIGURE 1.188** Process steps for the manufacture of models and electroplated molds