In-House Moldmaking

Patented Casting Resin System for Producing Sophisticated Thermoforming Molds in just a Few Hours

Compared with conventional thermoforming molds made from epoxy resins or aluminum, a new type of casting resin system not only enables heat-resistant and high-quality thermoforming molds to be produced in a much shorter time, but the user can make the molds himself. The system can also serve as an alternative to injection molding to achieve a favorable price-performance ratio.

Thermoforming molds determine the surface texture (sometimes including letters and logos) and are responsible for the geometry of the film to be thermoformed. The molds must be able to withstand the forces that arise during production and be rugged enough to produce the desired numbers of thermoformed parts. The best results are obtained with thermoforming molds made from synthetic resins and metals.

Easy to process: using the patented Mould D casting resin system, companies can produce their own thermoforming molds © Alwa

Synthetic Resin versus Aluminum

In industry, synthetic resins, especially those based on polyurethane and epoxy, have long since become established for the manufacture of tools for the vacuum thermoforming process (e.g. construction industry, automotive industry, furniture industry, mechanical engineering, sports and leisure industry). Both positive and negative molds can be cast.

Molds made from polyurethane casting resin offer the user a cheap, rapid solution for the production of negative molds. The disadvantages are shrinkage and inferior mechanical properties (e.g. strength and heat deformation resistance). For their part, epoxy casting resins have the advantage of less odor formation, less shrinkage and comparatively better mechanical properties. Their disadvantages are time-consuming production and the necessary post-curing before the mold can go into service. Moreover, the process is unsuitable for the production of larger molds, as stress cracks form in the mold after only a few thermoforming operations (**Fig. 1**).

Polyurethane and epoxy resins are often only used for producing prototypes and small production series, whereas aluminum molds are the first choice for medium and large runs, due to their better mechanical properties, albeit they come at a higher cost and longer delivery times. Aluminum molds are capable of high production volumes because they have very good thermal conductivity and heat resistance, which permit fast cycles, and they have a long service life.

Aluminum molds are typically CNC-milled or cast. However, milling a solid material is time-consuming and cost-intensive and aluminum casting, for its part, is usually carried out of house in a foundry. Casting resins not only offer economic advantages, but also allow molds to be produced in-house at short notice.

This gap has been closed by a patented casting resin system with very good mechanical properties. The casting resin, Mould D, meets users' needs in terms of processability, strength and range of applications and has unique selling points that distinguish it from conventional materials. The advantage of Mould D (**Title figure**) is that, after a waiting time of just 1 to 2 hours, a ready-to-use, fully utilizable production mold is available that meets high production requirements without the need for additional post-curing. This opens up the door to low-cost, very high-quality molds produced in-house.

Comparison with Aluminum Molds

Mould D has several advantages over aluminum molds milled from solid material: a mold can be cast in just a few hours and be placed on the thermoforming machine immediately after demolding. The use of silicone-coated steel wires during casting avoids the need for time-

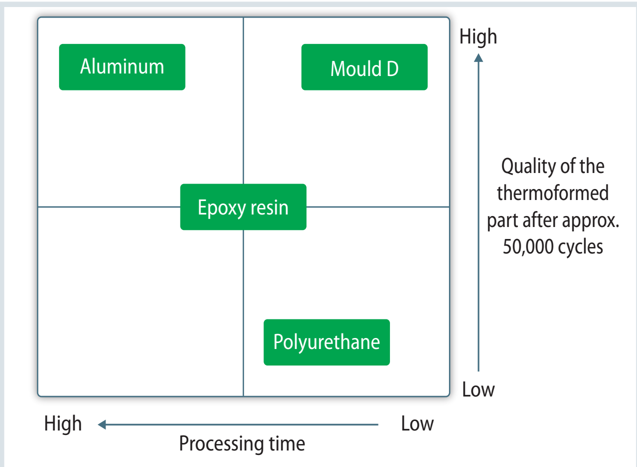

Fig. 1. Comparison of materials: Mould D is quick to process and a match for aluminum in terms of quality Source: Alwa, graphic: © Hanser

consuming drilling of vacuum holes in the mold (**Fig. 2**). In addition, pipes to heat and cool the mold are also cast in the pattern to provide temperature control during production runs (**Fig. 3**). Due to the resin's mechanical properties and simple scalability, even very large molds can be produced (e.g. 2500 kg; **Fig. 4**).

In the case of aluminum molds, and especially large ones, the high thermal conductivity leads to uneven heat dissipation, with the result that in particular the edges often cannot be thermoformed without optical defects. In contrast, Mould D molds dissipate heat more evenly due to their lower thermal conductivity, yielding optically perfect thermoformed parts with uniform film stretching (**Fig. 4**). The only time aluminum is preferable to its reaction resin counterpart is in the case of high-speed molds, because it permits faster cycle times and high production numbers (100,000 to 150,000) on account of its better thermal conductivity and greater heat resistance.

The material costs of aluminum molds are particularly high when the molds have cavities and accordingly a large amount of aluminum chips are generated during their manufacture. By contrast, casting in Mould D permits a displacer to be used, which not only saves on mold material, i.e. reduces resin consumption, but also reduces weight.

Design changes can be implemented in just a few hours, compared with the time-consuming casting and repairing aluminum molds. In addition, molds made from synthetic resin are easier to mill than their aluminum counterparts. With Mould D, it is possible to achieve 100% molding accuracy and, by maintaining the given temperature, to achieve non-shrink casting (**Table 1**), with the result that a 1:1 copy of the pattern is always produced.

Thermoforming or Injection Molding?

Thermoforming is an economical alternative to injection molding. Since less pressure is built up in thermoforming, the mold can be made from much cheaper materials. The cost of a thermoforming mold is about one-tenth that of an injection mold. Further advantages are that both large molds and molds of complex geometry can be thermoformed.

The choice of processing method ultimately depends on the complexity and size of the mold, the production volume and costs, delivery time and material employed. On account of the high level of surface detail and because undercuts can be made with the aid of aluminum slide molds, thermoformed parts produced with Mould D are comparable in quality to injection molded parts (**Fig. 5**).

Preparing for Pattern Casting

Almost all pattern materials are suitable for casting (wood, gypsum, plastics, leather, metal, acrylic, etc.), with the exception of polystyrene. All materials must be dry. To cast the material, a casting box is built around the pattern. If mold-temperature control is needed during the production process, copper pipes or heating elements can be placed at a distance of 3 to 4 cm from each other and 1 to 2 cm from the surface of the pattern. This kind of mold-temperature control usually shortens cycle times substantially during subsequent production. For this purpose, the copper pipes or heating elements first have to be pre-bent to match the contour of the pattern (**Fig. 3**).

For flat and long molds, it is best to use perforated aluminum sheet as reinforcing material to avoid bending of the mold (due to the bi-metallic effect). The copper pipes or heating elements can be attached to the perforated aluminum sheet (e.g. with wires) to ensure uniform pipe spacing. Displacers made from PU foam can be used to economize on material. All inserts should be spaced at least 10 mm from the pattern surface.

Time-consuming drilling of vacuum holes on the finished mold can be avoided by incorporating steel wires sheathed in silicone tubing in the pattern. Porous master patterns made of gypsum or wood have to be sealed. Each pattern is pre-treated with a surface tension remover which ensures smooth coverage of the release coat applied afterwards, and then the steel wires sheathed in silicone tubing are inserted into the drilled 1 mm holes (**Fig. 2**). A release coat is carefully applied with a brush or spray gun (at »

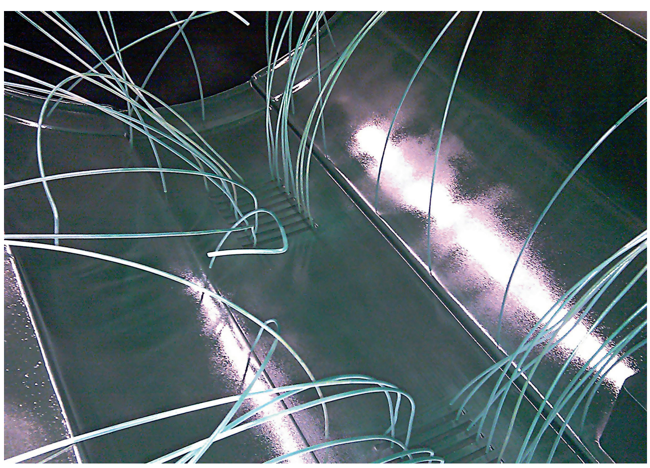

Fig. 2. Saving on drilled vacuum holes: where a vacuum is to be applied in the thermoforming mold later, silicone-sheathed steel wires used during pattern preparation keep the cavities open during casting © Alwa

least 3 to 4 layers in the case of fine structures). The copper pipes or heating elements attached to the perforated aluminum sheet and the displacer can now be affixed to the pattern. Drive-in nuts for better demolding or later mounting to the thermoforming machine should be incorporated into the pattern.

Fig. 4. An approx. 2500 kg, high-quality thermoforming boat-mold that can be molded perfectly, even at the edges © Alwa

Working Steps for Casting the Model

The synthetic resin system consists of a resin-filler combination of 40 parts by weight Mould D casting resin with a density of 1.7 kg/dm^3, 60 parts by weight aluminum spray grit and 1.2 parts by weight hardener powder (3 %, expressed in terms of the casting resin content). In the first step, the two resin components are mixed with a special agitator that introduces only a tiny amount of air into the mixture, and then the filler, an aluminum spray grit, tailored to the resin components is added. The finished batch is left to stand for 1 to 2 h until air bubbles have stopped rising. For casting, the casting compound should have a temperature between 19 °C and 22 °C. If possible, both the pattern and the ambient temperatures should also be in this range. Below 19 °C, the casting material will expand so much that it will not shrink back to its original size after cooling down while, above 22 °C, it will undergo shrinkage. The hardener powder is then carefully stirred into the casting compound over the course of 3 to 5 min.

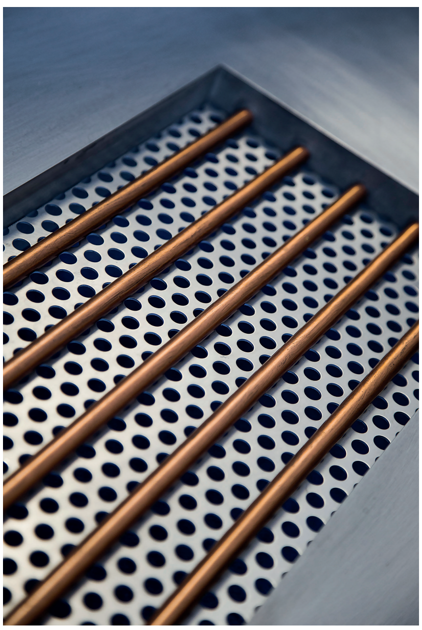

Fig. 3. Cross-section of a thermoforming mold made from Mould D: the copper pipes provide temperature control and the perforated aluminum sheet is used to reinforce the mold © Alwa

After venting and within the pot life of approx. 17 min, the casting compound is poured into the prepared pattern in a thin stream. Some 20 to 25 min after addition of the hardener powder, the reaction sets in: the liquid resin mixture starts to gel and increasingly solidifies. Further hardening is characterized by a rapid temperature increase and reaction temperatures of up to 130 °C. This hardening characteristic permits even heat-sensitive patterns, e.g. wax patterns, to be accurately molded. The casting is completely cured by free-radical polymerization about 30 minutes later. Once peak temperature has been reached, the mold starts to expand (**Table 2**). The steel wires then have to be pulled out quickly – at approx. 80 °C – as otherwise star-shaped cracks may occur around the approx. 1 mm drilled vacuum holes. Because the mold expands, the screws on the long sides of the casting box should be removed to enable it to expand properly.

Casting temperature	Peak reaction temperature	Pot life	Expansion	Expansion/shrinkage in open casting
21 °C	126 °C	17 min	1.2 mm	± 0 mm

Test specimen 500 mm x 60 mm x 30 mm

Table 1. Shrinkage-free casting of Mould D Source: Alwa

The mold shrinks back to its original size as it cools. Demolding can be started after the casting has cooled to 80 to 100 °C.

Flat or thin molds must be clamped to a level surface while hot (immediately after hardening) and weighted down with a plate coated with a release agent or melamine resin to prevent mold bending and thus the bi-metallic effect. The molds can now be easily mechanically processed (drilled, milled, ground, planed, sawn, turned). Holes can be drilled into the mold and threads can be cut. However, it is more effective to first cast nuts or bolts into the mold. Wet grinding and the use of polishing paste produces a shiny metallic surface due to the aluminum particles in the resin. Design changes and small repairs to the surface can be made with a special synthetic resin filling compound.

Thermoforming with and without Machine

If the mold is to be affixed to the base plate of a thermoforming machine, sufficiently large holes must be drilled into the base plate to allow the Mould D mold to expand. The fixing screws must be tightened only slightly, as the mold expands when heated. Molds made from Mould D are suitable for continuous use at up to 135 °C. Brief exposure to the Vicat softening temperature of 180 °C (**Table 2**) is possible, but the compressive strength of the mold will be lower due to the higher temperature.

To produce thermoformed parts without a thermoforming machine, vacuum tubes can be cast into the mold and a vacuum connection attached. A clamping frame is fitted around the mold to fix

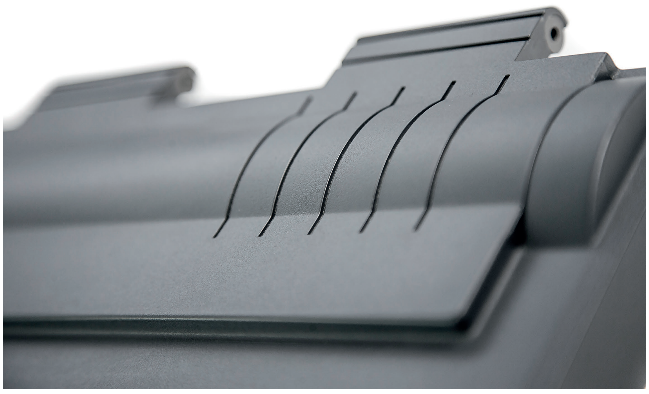

Fig. 5. Cost-efficient relative to injection molding: thermoformed part for a measuring instrument for airborne and waterborne pollutants: produced by KVH Hartung GmbH, Krailing, Germany, using vacuum thermoforming with a negative mold © Alwa

the plastic film. Polymer sheeting is then heated in the oven to soften it, placed on the mold and held by the clamping frame. The thermoplastic is then preblown (or stretched). When the vacuum is applied, the thermoplastic material nestles directly against the mold. After cooling, the clamping frame can be opened, and the molded part can be removed after a short blast of air for demolding.

Fields of Application

Manufacturers in the sanitary industry, especially in the field of bathtub and shower tray production, such as Duravit AG, Egypt, use Mould D in the production of their negative molds, because it has proven to be not only the most cost-efficient and fastest system, especially for medium series, but also the best system on account of the quality of the thermoformed parts. CIV-Service Outillage, Chanas, France, uses Mould D in the production of electric vehicles in a thermoplastic design under the Aixam brand name. The customer appreciates the fact that all production can be done in-house. Meanwhile, by using a synthetic resin system, thermoforming companies (such as Menschik GmbH & Co.KG, Lindlar, Germany) gain from being able to offer all processing steps from a single source.

Recent project results show that molds made from Mould D are very likely to be suitable as compression molds for forming sheet metal. Such molds could supersede the steel and sheet metal molds used up to now, and that would save companies both time and money. Initial test results reveal that, even under a pressure of 3500 t (280 bar), a small mold will not be damaged during sheet metal pressing. Mould D is also suitable as a backfill compound for foam molds and RTM (resin transfer molding) molds. Some applications require a better surface quality, heat resistance and chemical resistance. In these cases, a metal mask of low-melting alloy is sprayed onto the pattern and then backfilled with Mould D.

Property (standard)	Value
Permanent heat resistance	135 °C
Pot life	~17 min
Reaction temperature	120–130 °C
Hardness (Shore D)	~± D86
Compressive strength at RT 20 °C and 100 °C (DIN 53454)	8–9 and 7–8 kN/cm²
Impact strength (DIN 53453)	3400 J/n (3.5 kJ/m²)
Viscosity of the mixture	~7000 mPa·s
Specific density	1.7 kg/l
Thermal conductivity (DIN 1341)	~1 W/mK (~0.86 kcal/h·m·°C)
Linear shrinkage after hardening (test specimen 500 x 100 x 25 mm)	~± 0.1 %
Vicat softening temperature (DIN 53460)	180 °C
Shelf life at 16 °C to 22 °C	~18 months
Coefficient of thermal expansion (DIN 53752)	$45 \cdot 10^{-6}\,K^{-1}$

Table 2. Technical data of Mould D

Source: Alwa

Conclusion

Mould D offers a way to produce high quality thermoforming molds in a much shorter time compared with conventional moldmaking materials. It even allows users to produce demanding and large molds while conserving resources.

At K 2019, the Mould D system opened the door for new collaborative ventures, especially in the Indian market, with Machinecraft, Mumbai, Pinnacle Industries Limited, Pithampur, and Therm O Pack, Kanchipuram. The product is also set to be launched on the Chinese market in 2021. ■

The Authors

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Dr. Manuel Jäger has been Head of the Research and Development Department at Alwa since 2019 and has a patent in the field of catalysis.

Company Profile

Alwa Technische Produkte für Kunststoffverarbeitung, Modell- und Formbau GmbH, Gronau, Germany, specializes in the development, production and distribution of synthetic resin systems, primarily for pattern and moldmaking. The family-run business was founded in 1986; the family of shareholders is the second generation to run the company. The company distributes the partly patented (Patent Nos. 4141963, 2583995, 2801463) synthetic resin systems, which are produced exclusively in Germany, in 23 countries. Currently, the company is conducting collaborative research with the University of Applied Sciences in Münster, Germany, on a water-insensitive EPIC resin (epoxy modified isocyanate resin) as well as a filter medium for wastewater treatment plants.

Service

References & Digital Version

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