

Mold Materials

Most commercial thermoforming molds are made from aluminum. Aluminum is used because it is light, it is easily worked, is relatively inexpensive and has a very high thermal conductivity. It is also used because the forming forces against the finished mold are low when compared with, say, injection molding.

Larger commercial molds are usually cast from the melt. In addition to the common atmospheric casting, molds can be made by vacuum casting and pressure casting. Smaller molds are frequently machined from plate. Computer-controlled machining stations have made manufacture of many-cavity molds quite competitive with other means of manufacture.

For the most part, thermoforming molds are single-surfaced. That is, one surface of the plastic sheet is forced against the mold surface, while the other surface is "free" or untouched by another mold surface. In certain instances, such as foam and composite forming, the sheet is so stiff at the forming temperature that it must be pressed between two "matched mold" surfaces in order to accurately form the part.

In large, cast molds, water lines are typically attached to the reverse sides by soldering or secondary casting. In smaller, machined molds, cooling is frequently done through flood plates attached to the rear of the molds. When water lines are needed, for deeply drawn parts, they are gun-

bore drilled in, in much the same manner as water lines are drilled in injection molds.

In certain instances, other metals are used for molds. For composites, for example, temperature and pressure requirements may preclude the use of aluminum. Steel, particularly chrome-plated steel, and stainless steel are good alternatives. Steel has about one-third the thermal conductivity of aluminum and about twice the modulus. Stainless steel has about one-fifth the thermal conductivity of aluminum and about 50% greater modulus.

Because thermoforming pressures are relatively low, usually not exceeding 100 psi, many other materials can be used for molds. Although electroformed nickel is much more expensive than other metals, it is used when extremely high detail is needed or when a very intricate pattern must be replicated. Very large parts, such as exterior door panels, have been made on electroformed nickel tools. Usually nickel is electroformed onto a pattern, water lines are placed against the nickel shell, then the nickel is backed with a cheaper white metal.

Sprayed metal is also used for prototyping and limited production. Molten white metal such as zinc is atomized and atmospherically sprayed against a pattern in a fashion similar to paint spraying or polyester spraying. A reasonably thick layer of metal can be sprayed in a reasonably short time. Water lines are placed against the metal shell and sprayed in place. This is then backed with metal-filled epoxy or pot metal. Many sprayed metal applications have been taken over by computer-driven machining, and so typical sprayed metal

molds today are small and highly detailed.

There are even more materials available for straight vacuum formed prototype parts. Wood is an obvious choice, with ash and hard maple offering the best balance of properties such as compression strength, shaping and sanding quality and resistance to splitting, checking, and warping. Hydrocal is a dense industrial plaster that makes a high quality mold. Plaster mold fabrication is quick, with the primary drawbacks being the messy nature of plastic casting, including plastic dust, weight [compared with wood], and brittleness.

More recently, medium density fiberboard or MDF has found extensive use, primarily for shallow draw and male molds, since it can be quickly worked with traditional woodworking tools and has no grain and no propensity to warp, split or check. It is relatively expensive and restricted in thickness. Syntactic epoxy or polyester foam was originally developed as a plug assist material but is now computer-driven machined into smaller molds. It can be expensive, particularly if a substantial amount of the initial billet must be machined away to make the mold.

Keywords: cast aluminum, machined aluminum, computer-driven machining, chrome-plated steel, stainless steel, electroformed nickel, hydrocal, medium density fiberboard, syntactic foam, sprayed metal

