



FDM Thermoform Tooling

Overview

Thermoforming is a manufacturing process for shaping thermoplastic sheets or films over a mold through the application of heat and pressure. In this process, a sheet is first clamped, heated to the sag point, and then forced against a mold surface using vacuum or air pressure (Figure 1). Traditionally, thermoform tools have been made from wood, RenShape board, cast aluminum, or machined aluminum billet. This results in several disadvantages including:

- High costs
- Long lead times
- Vacuum features must be added into the tool with a secondary process

FDM® (fused deposition modeling) thermoform tooling is a solution for low-volume thermoforming production runs. Additively manufactured thermoform tools provide multiple advantages over traditional subtractive manufacturing methods including reduced tooling costs, material waste, and lead times. The tooling produced by additive manufacturing reduces raw material consumption by only building material where needed. It also reduces tooling costs and the long lead times of traditional subtractive methods by enabling lights-out production and reducing labor. The inherent uniform porosity of the FDM tool provides a unique capability to draw vacuum through the tool without the need for a secondary process of manually creating vacuum channels, which is required with traditional tooling. FDM tooling also allows increased tool complexity with features such as variable wall thicknesses, to better control the thermal gradient, and internal lattice structures to reduce thermal mass. The increased complexity allows the tool to meet the needs of each specific application.

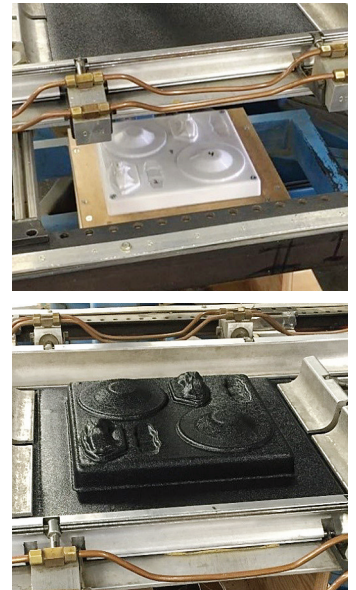


Figure 1 – An FDM tool being raised into the heated sheet (top) and forming the sheet over the FDM mold (bottom).

FDM THERMOFORM TOOLING

Application Outline

FDM thermoform tooling implementation begins with the design of the tool, based off of the design of the final thermoformed part. The tool design process is similar to tool design for conventional manufacturing methods but there are some factors including the size of the build chamber and inherent porosity of the FDM tool that need to be taken into account. To design an FDM thermoform tool that is larger than the build chamber, the tool can be sectioned for manufacturing and later bonded together (Figure 2). The parting line to section the part must avoid critical features.

After designing the tool face with the key features, the remaining parts of the tool can be designed with a custom density. This takes advantage of FDM's natural porosity to both increase air flow through the part during thermoforming and reduce the material required to build the part. The final design step is selecting the FDM material that best fits the project needs. Polycarbonate (PC) and ULTEM™ 9085 resin are the recommended FDM materials for thermoform tooling.

The thermoforming tool is then processed in Insight software to specify the build orientation and toolpath parameters that control how the tool is manufactured. The FDM tool is built with a Fortus 450mc™ or Fortus 900mc™ 3D Production System, which allows for hands-free, lights-out fabrication. Limited post-processing is needed after the tool is built. The tool can be sanded to improve the surface finish of the formed part (Figure 3). Epoxy may need to be applied to some regions of the tool to limit vacuum and promote sheet flow over the regions to obtain a more uniform part thickness (Figure 4).

Standard thermoforming methods can be used provided cycle times and processing temperatures are compatible with the FDM material. The molded part is trimmed after the thermoforming process. An FDM trim tool can be designed for hand-trim tools to increase the consistency of the finished parts and decrease the trim time (Figure 5).

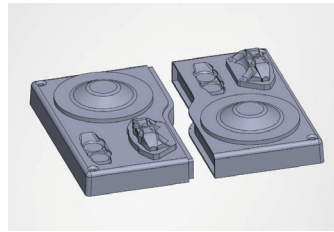


Figure 2 – Tools larger than the build chamber can be sectioned and bonded together post-build.



Figure 3 – Sanding will improve the surface finish of the molded part.



Figure 4 – Sealing particular areas of the tool will promote a more uniform formed sheet thickness.

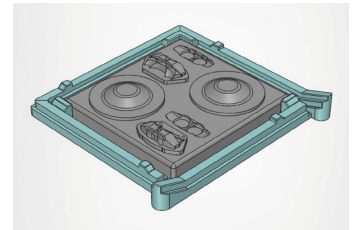


Figure 5 – FDM trim tools can be produced to guide hand-trim tools around the molded part for consistent trimming.

Technology Compatibility:

- Fortus 450mc and Fortus 900mc 3D Production Systems

Companion and reference materials:

- Design Guide – FDM Thermoforming Design Guide

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