

White Paper

Vacuum Forming Applications Using Rapid Prototyping Technology

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ABSTRACT

Vacuum-forming or thermoforming is one of the most common methods for processing plastic materials. Vacuum-formed products are prevalent in our daily lives. The process involves heating a plastic sheet until soft and then draping it over a mold. A vacuum is applied sucking the sheet onto the mold. The sheet is then removed from the mold. In its advanced form, the vacuum-forming process utilizes sophisticated pneumatic, hydraulic and heat controls thus enabling higher production speeds and more detailed vacuum-formed applications.

Nature of use and limitations: Vacuum-forming offers several processing advantages over other forming processes. Low forming pressures are used, which enables comparatively low cost tooling. And, since the process requires only low pressures, the molds can be rapid prototype models, thereby shortening the mold fabrication time. Using prototypes for the molds makes it economically feasible to produce low quantities of large parts and to operate medium size production runs. More sophisticated machines and molds are used for the continuous automated production of high volume items like yogurt pots and disposable cups and packaging. Unlike other thermoplastic forming processes, where powder or resin are the starting point, vacuum-forming uses extruded plastic sheet. A secondary process may be required to trim the formed sheet to attain the finished product. The trimmed waste can be re-ground and recycled.

This whitepaper provides an evaluation of how Objet PolyJet Technology fits within a vacuum forming applications framework. The PolyJet Technology, specifically the introduction of the process technology, is expected to revolutionize

vacuum-forming production and to bring with it additional benefits including, labor-cost savings, a shortening of product development time and new design developments.

Objet's family of 3-dimensional printing systems brings high-resolution rapid prototyping (RP) solutions to vacuum-forming environments. Objet's patented PolyJet Technology-based printing systems, which work with Objet FullCure® materials and Objet software, provide a complete 3-dimensional printing solution for virtually any vacuum-forming application.

INTRODUCTION

Vacuum-forming is a technique to shape a variety of plastics using a mold. The process begins by fixing a sheet of plastic of uniform thickness onto a sturdy frame inside a vacuum chamber. The frame is heated and slowly moved toward the mold until the frame touches the bottom of the chamber and the soft plastic is draped over the mold.

Next, air is pumped out of the chamber, adhering the plastic to the mold. If the mold contains holes that are too deep, "blowouts" may occur in which the plastic rips and the process must be restarted. Blowouts limit the shape of the mold. The vacuum in the chamber can be created using simple, readily available technologies like an off-the-shelf vacuum unit; a high-intensity vacuum is rarely necessary.

After being adhered to the mold, the plastic must be allowed to cool. Once the plastic has cooled, it is removed vertically from the mold. Unless a special stand is used, vacuum-forming creates a form that encircles only one side on the mold

because the mold rests on the bottom of the vacuum chamber. If it is difficult to remove the plastic from the mold, a knife is used to score the perimeter.

The following figure illustrates the vacuum-forming process. The mold is an Objet 3D printed model.

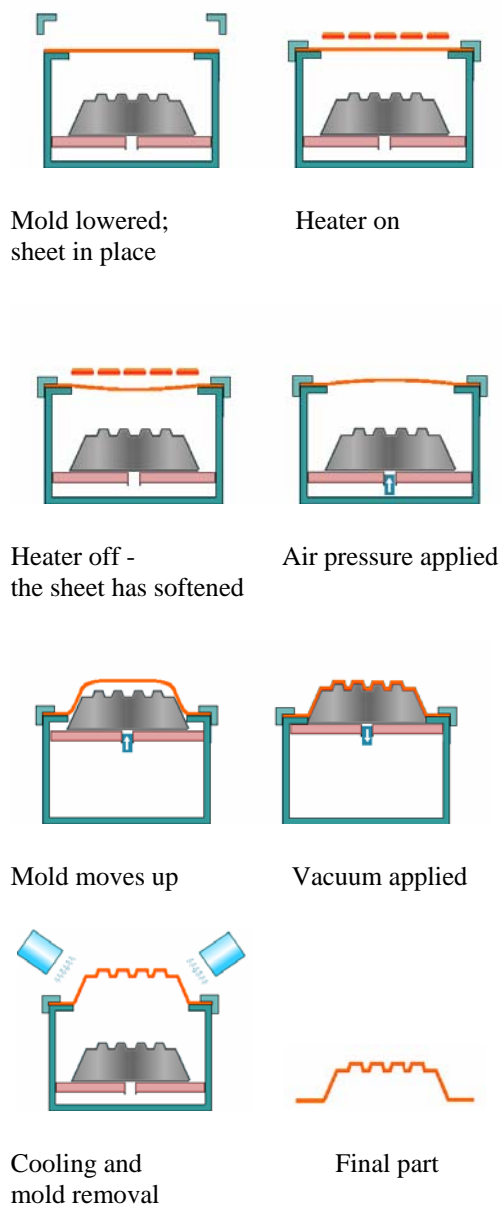


Figure 1: Workflow of vacuum-forming process

The vacuum-form table requires a mechanism to the heat plastic and places it over a rapid-prototype mold and a chamber from which all the air can be pumped out to form a vacuum, ensuring that the plastic adheres closely to the mold. Most of the plastic products we use daily are produced using this technique. Common plastics shaped using this technique include polystyrene, polyethylene, polycarbonate and acrylic. First-time users often use the inexpensive plastic styrene. In industrial process settings or for specialized purposes, sophisticated machines possessing a variety of fine-tuned pneumatic, hydraulic and thermal controls shape the more expensive plastics.

Vacuum-forming facilities employ Objet’s 3-D printing systems because they offer high resolution printing and utilize materials that fit the requirements of this application niche. Objet’s flagship line of Eden™ 3-dimensional printing systems offers unprecedented return on investment for professional rapid prototyping applications. Printing with the high speed mode and 16µ layers, all Eden systems produce models with exceptionally fine details and smooth surfaces.

The Eden 3-dimensional printing systems line includes systems designed to address disparate manufacturing needs in terms of build size and productivity and varying budget requirements. Their compact design and clean printing process make Eden systems ideal in any environment.

Objet’s 3-dimensional printing systems have been gaining ground due to their attractive combination of high resolution printing with fast building times. These jetted photopolymer systems can be used to match vacuum-forming requirements, namely the creation of final master molds.

THE PROCESS

Clamping: The clamp frame ensures the plastic sheet is held firmly in place during the forming process. **Heating:** Radiant heaters are usually used to heat a sheet which has been positioned over the aperture of the vacuum forming machine. For thicker sheets, a more sophisticated machine is necessary to heat both the frame’s surface and the mold. Heaters move into position both above and below the sheet. The heating is done at a temperature of about 150°C, for a period of 20 seconds.

Pre-stretch: To achieve an even wall thickness, air pressure is applied to blow a small "bubble" and the mold is then raised into the pre-stretched sheet. **Vacuum:** A vacuum is applied. The sheet is drawn into contact with the mold and the sheet acquires the mold's detail. **Plug Assist:** When a deep draw is required, a top plug is used to push the plastic material into the mold during the forming process. **Cooling and Release:** The material is allowed to cool. The cooling process can be shortened using blown air or a fine water spray. The molding can then be released from the mold by introducing a little air pressure. **Finishing:** After molding, mold finishing may be performed including, trimming, cutting, drilling, polishing, decorating etc.



Figure 2: Printed 3D model using PolyJet Technology

To summarize, vacuum-forming is an industrial technique used for batch production or mass production.

This process enables thermoplastics to be formed into complicated shapes such as packaging, storage trays and seed trays.



Figure 3: PolyJet models used in the vacuum-forming process

Taken as a whole, the vacuum-forming process is often less expensive and faster than other techniques available. In addition, it can produce a wide range of shapes with a quick turnaround time, especially when based on previously used molds or standard designs. However, it does suffer from some disadvantages. Vacuum-forming produces a product that required further edge-cutting. It also produces more waste than a number of other processes, especially since unused material can not be used in the next vacuum-forming task.

Objet's family of 3-dimensional printing systems brings high-speed rapid prototyping solutions to the vacuum-forming environments. The patented PolyJet Technology-based printing systems provide a complete 3-dimensional modeling solution for virtually any vacuum-forming application.