The Impossible Draw Ratio

A Technical Article – 2006 Volume 26, #3
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(Technical Editor's Note: Looking back over the last 9 years at 36 Thermoforming 101 *articles, which are all presented in our annually updated booklet, it is the most comprehensive collection of basic technical information one could find on our process. For this issue I have chosen to talk about a subject that my predecessor Jim Throne wrote about in 2000 and 2001 – pre-stretching the sheet. But this time I want to discuss what type of pre-stretching should be used in a very difficult application.)*

Knowing It Can Be Done

The customer knows what he wants and you want to give him a part that will do what he wants but in the back of your mind you are thinking, "I should be telling him this is impossible." However, you know it is possible with the right tooling.

The main ingredient in getting hot plastic to form tight over a mold is vacuum. Air pressure and other various forms of assist tools make vacuum forming, thermoforming. The trick is to decide what tooling options to use to give the customer what he wants without creating problems for your production department, while staying within the customers tooling budget.

Back in the days when we used to say thermoforming is half art, half science we would make a mold, put it into the press and see what happens. Then start adding pieces of wood we called web stretchers and if we had a top press at that time we could build a pusher to assist the plastic into a problem area. OK, so maybe some of us still do this in prototyping but the ultimate aim for all of us is to build production tooling that will go into the machine and start forming good parts on the first shot.

Part Design/Tool Design

You can't design a thermoformed part unless you have a full understanding of tool design and what capabilities you have in your equipment. This seems obvious but when the part has extreme draw ratios and wall thickness requirements that must be met, it is imperative.

Let's take a heavy gauge part that has towers that defy all principles of thermoforming, 8" high, only about 2" diameter at the top and only 6" between towers and it must be polyethylene which makes matters worse. The configuration of the part is such that the tall sections are at the perimeter. In other words, this is a job that would seem impossible. But the customer is faced with having to build these parts on a limited budget and other processes are too expensive. The designer must make a decision knowing that he has a number of tooling options available.

Pre-Stretch Tooling

The main problems that must be addressed in designing the tooling for this part is a) how to pre-stretch the material so that there is enough material in the areas around the towers and b) how to get the material down into the valleys between the towers without webbing or bridging.

Pre-stretching the material can be done by forming a seal on the material around the edge of a box and drawing a vacuum to pull the sheet into a bubble. This is called a pre-draw box and this is done on the opposite platen to the mold platen. So now we have stretched the material to give us enough surface area to cover the towers without getting too thin. Now how do we get all that material down to the bottom of the valleys?

Plugging or Pushing

This is where a newer technique of plug assist can be used effectively. Visualize the material in a bubble hanging below the mold in the clamp frames. It has been pulled down by the pre-draw box. With an independently acting air cylinder inside the pre-draw box, a plug or pusher tool can be mounted and used to push the pre-stretched material into the valleys. Obviously you must have this capability built into your machine and the timing must be such that the mold, vacuum and pusher are activated in the right sequence.

If the machine does not have the capability to have this third motion tool then it may be possible to mount a fixed pusher inside the pre-draw box. However this means the material must then drape around the pusher during the pre-stretching and this could mean that the material cools in these areas causing other forming problems. Pusher shape and heating then becomes critical.

Impossible No More

We see thermoformed parts now that once would be impossible to thermoform – especially in roll-fed, thin gauge applications. Third motion tooling, improved materials and plug assist design has made severe draw ratio's common place in the packaging and drinking cup sector. The same principals can be used in heavy gauge, sheet-fed thermoforming to form large heavy parts. ➤

[This is one in a series of articles introducing general concepts in thermoforming.]