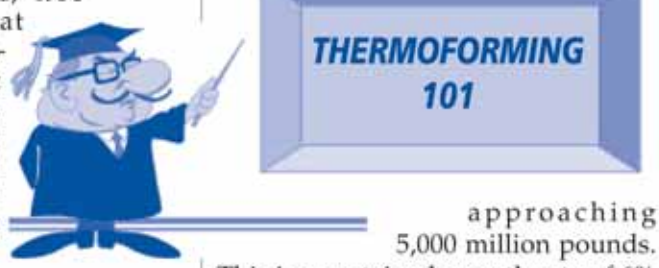
IN THE BEGINNING

Introduction

The thermoforming cognoscenti among you know that this series has focused on some of the general concepts in thermoforming. We began with brief descriptions of polymers, then discussed heat transfer, mold materials, heaters, oven design, forming temperatures, sheet stretching and cooling, trimming, and ended with regrind. A complete list of topics appears at the end of this article.

In truth, the series was to have ended in the last issue. But, after reviewing the 18 "lessons," it became apparent that there were some monstrous holes, the most obvious of which was the lack of substantial discussion on product design. So, consider the next few articles to be "hole pluggers."



Just What is Thermoforming?

Thermoforming is the manufacture of useful articles of commerce by heating, shaping, cooling, and trimming thermoplastic sheet.

Where Did It Come From?

Although historians consider the forming of tortoise shell, tree bark, and horn to be the earliest forms of thermoforming, purposeful manufacture of products from semi-manmade thermoplastic sheet began in the mid-1800s, with the commercialization of polymerized cellulose nitrate. The production of thermoformed household items such as hairbrush backs, mirror cases, baby rattles, and piano keys was a reasonably large business by the turn of the twentieth century. With the invention of Bakelite, a completely synthetic thermosetting polymer in 1909, the emphasis on product development moved quickly to compression molding. The commercialization of new thermoplastics such as polystyrene, polymethyl methacrylate (acrylic), and cellulose acetate in the 1930s spurred the development of thermoforming, as did WWII. Then, drape forming over male molds and free-blow forming were the common ways of forming heavy-gauge sheet. Vacuum forming into female molds was the common way of forming thin-gauge sheet.

How Big is Thermoforming?

In 1960, U.S. thermoforming produced about 100 million pounds of product. In 2000, that number was approaching 5,000 million pounds. This is a sustained growth rate of 6% per year over forty years. Thermoforming amounts to about 5% to 6% of the total U.S. plastics consumption. Conservatively there are about 500 U.S. heavy-gauge thermoformers and 125 U.S. thin-gauge thermoformers.

Is All Thermoforming the Same?

No. Thermoforming is usually (loosely) categorized in several ways.

Probably the most apparent way is in terms of sheet thickness. Simply put, thin sheet is provided to the thermoformer as a continuous roll. Thick sheet cannot be rolled and is supplied as palletized cut sheet. Thin sheet forming is frequently called thin-gauge forming. Thick sheet forming is called heavy-gauge or thick-gauge forming.

Here is one way of categorization:

Foil (very thin sheet)	Less than 0.010 in., 10 mils, or 250 microns in thickness
Thin-gauge	Less than 0.060-in., 60 mils, or 1.5 mm in thickness
Mid-range	0.060-0.120-in., 60-120 mils, or 1.5-3.00 mm in thickness
Heavy-gauge	Greater than 0.120-in., 120 mils, or 3.00 mm in thickness
Plate	Greater than 0.500-in., 500 mils, or 13 mm in thickness

Keep in mind that "foil" may be used for any thin-gauge sheet in Europe. Another way of categorization is:

Roll-fed	Sheet provided to the thermoformer in a roll
Cut sheet	Sheet provided to the thermoformer on a pallet

This category is useful for determining the type of machine to be used to form the products. Another:

Packaging	Usually considered as thin-gauge sheet products
Industrial or structural	Usually considered as heavy- gauge sheet products

And another:

Disposable	Usually considered as thin-gauge sheet products
Permanent	Usually considered as heavy-gauge sheet products

And finally one more:

Vacuum forming	Draw-down by evacuating the space between the sheet and the mold
Pressure forming	Application of air pressure in excess of one atmosphere

Be careful of using one of these ways as shorthand in formal communication. Always define the terms you use to avoid misinterpretation. For example, even though low-density polystyrene foam can range in thickness up to 0.250-inch (250 mils, 6.4 mm), it is delivered to the thermoformer in rolls. ■

Keywords: history, categorization, thin-gauge, heavy-gauge, market size

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