Packaging Equipment: Thermoformers

by Randolph Leinhauser

Introduction
This Knowledge Brief explains the general process of thermoforming by touring the smaller, integrated functions found on a thermoforming machine. This Knowledge Brief also compares two widely used methods in the thermoforming process: rotary (continuous motion thermoforming) and platen (intermittent thermoforming).

Thermoforming is a manufacturing process used by the pharmaceutical and consumer product industries to package a product. Thermoformed packages are globally accepted by consumers because they can provide product protection, convenience, tamper evidence, and security.

A thorough understanding of the available thermoforming technologies will allow engineers to select the optimum presentation for their product and specify the appropriate equipment.

Process Overview and Considerations
Thermoforming involves heating a thin-gauge (less than 1.5 mm) flat sheet of thermoplastic material until it softens, but does not melt. The softened sheet is then forced against the structure of a mold by vacuum, pressure, mechanical means, or any combination of these to create a pocket. This mold has been custom designed to leave a pocket that has an optimum shape and size for a specific product. After cooling, the pocket retains the mold’s shape and detail. This newly formed pocket can resemble a blister.

The product is then placed into the blister pocket and a flat sheet of protective material, or “lidding,” is sealed to the non-molded portion of the thermoformed material providing a protective cover for the product. Once the lidding material is properly sealed to the thermoformed material, the required blister size is punched out from the lidding material flat sheet.

Thermoforming is most commonly used to mass-produce parts for the packaging industry called blister packaging. Producing the best quality blister combines selection of the correct thermoforming machine, designing the
optimum blister dimension, and using the most cost-effective material. The following are considerations to keep in mind while making selections:

- The correct thermoforming machine will control material temperature distribution, material wall thickness distribution, and blister surface finish, while avoiding material degradation.
- The correct blister tooling will produce a blister’s correct draw depth, stretch ratios, draft angles, stiffening details, trim lines, and undercuts.
- The most cost-effective material will allow the machine and tooling to fabricate all of the above while producing a product’s desired protective properties.
- The choice of blister and lidding material is important because it can affect factors such as strength of the pack and moisture resistance, etc.

**Selecting the Best Thermoforming Technology**

The scope of this Knowledge Brief is limited to defining the two most accepted methods for thermoforming: 1) rotary or continuous motion thermoforming and 2) platen or intermittent thermoforming.

The rotary and platen thermoforming machines are so named due to the process they use for blister sealing. Aside from the sealing process, all other stages used on thermoforming machines are similar.

Selection between a rotary and platen sealing thermoforming machine is dependent on several variables. The table below shows some of the differences between the two technologies.

**Pros of Platen Sealing**

- Sufficient dwell time T = approx. 0.22 seconds
- Uniform temperature across the entire sealing area
- Lower sealing temperature required (320°F – 360°F)
- Lower energy consumption by thermoformer
- All lidding materials can be used with out risk to burning

<table>
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<tr>
<th>Sealing Pressure</th>
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**Pros of Rotary Sealing**

- Continuous indexing allows easier product feeding for simple shaped product
- Fill control with camera is easier as material speed remains constant
- Very short process time (T=approx.0.012 seconds)
- Reduced wrinkles due to line knurling
- Less lacquer is required for sealing
- Smaller space required due to a combination of indexing, lower sealing tool and cooling in one station
- Smoother operation is preferable for higher speeds
- Uniform film tension in the sealing area
- Higher sealing pressure achieved with smaller forces due to smaller required sealing surface area.

**Forming Film Unwind**

The forming film is drawn off from the reel by the action of the forming film unwind and guided into an accumulation buffer using a film loop. Thus, the single-stroke gripper index is prevented from setting the reel in rotation when web indexing starts. The web guide consists of two sheet-metal plates, which are centered on web centerline via a spindle. The web brake and the web retraction ensure tensioning of the web.

**Heating Station**

The forming film will leave the unwind station and feed into a multi-stage heating station. Heat is transferred to the film through direct contact with heating plates. The film is transported into position between the upper and lower
heating plates. These electrically heated plates press against the film to transfer heat. The heating plates will heat the forming film to a temperature that will allow the film to be formed into the desired shape in the forming station.

Forming temperatures are different depending on material type and thickness, therefore different temperatures are required for different materials.

**Forming Station**
In the forming station, blister pockets are shaped into the heated plastic film through the use of upper and lower forming tools. The pre-heated film is transported between the tools and compressed. The pocket is then formed by either applying compressed air into the cavities of the cooled lower forming tool, or by being pressed into the lower tool by heated plugs (plug assist) then formed using compressed air. The lidding material is formed by mechanical action only; therefore, heating of the film web in the heating station is not required.

**Product Feeding**
Dedicated product feeding systems are used to assure that every blister pocket contains product. There are several methods for blister feeding. The method selected is dependant on the product characteristics.

**Blister Sealing Station**
In the sealing station, the lidding foil is sealed to the formed blister material to create a protective barrier around the product using either platen sealing or roller sealing. As it sounds, platen sealing uses pressure between two plates to apply pressure and heat to the sealing surface. Roller sealing uses a continuous rolling motion to apply heat and pressure. Both methods produce quality blister at specific applications.

Four variables control the sealing process:
- Dwell time for sealing
- Temperature
- Pressure
- Material characteristics of the lid and blister

**Coding or Embossing**
In the embossing station, the formed and sealed web is perforated or notched between the individual pockets to allow them to be separated from the pack at the time of use.

In the embossing station, a code (e.g. batch no. expiry date) consisting of letters and/ or numbers is embossed into the formed and sealed web. This embossing station can be designed to imprint for reading from web side or the lidding side of the blister.

**Punching Station**
In the punching station, blisters are punched out of the formed and sealed web during dwell time of the multiple-stroke index. During punching, the web is fixed in position between the hold-down plate and the die plate. The punching dies of the punching tool press through the hold-down plate into the precisely fitting openings of the die plate, then punching the blisters out of the formed and sealed web.

**Conclusion**
Both thermoforming processes are acceptable methods for quality blister packaging. The majority of the time, thermoforming equipment already exists that will only require additional tooling to handle the required blister format. However, when thermoforming equipment does not exist, many factors are used for selecting a thermoforming machine and associated downstream equipment.

The combinations of the following criteria can direct the thermoforming equipment selection:
- Product environment – determines the blister and lidding material requirements
- Blister size – determines machine output
- Product lot size – determines the time required for equipment changeover
- Plant technical support – determines level of equipment complexity
- Anticipated future use – determines machine flexibility

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For Further Information
For more detailed and related information, the following ISPE resources are available:

**Recorded Webinar:**
- Enabling On-Demand: A Practical Alternative to the Traditional Method of Packaging and Labeling of Clinical Supplies
  [http://www.ispe.org/onlinelearning](http://www.ispe.org/onlinelearning)

**Packaging Community of Practice (COP):**
- Visit our Packaging COP on the ISPE Web site for the most current and up-to-the-minute discussions on thermoformers and other related topics.
  [http://www.ispe.org/communitiesofpractice](http://www.ispe.org/communitiesofpractice)

**About the Author**
Randolph Leinhauser is a Senior Equipment Engineer for Pfizer Global Engineering in Collegeville, Pennsylvania, and is currently leading Pfizer’s Packaging Equipment / Line Efficiency Common Interest group as part of Pfizer’s Packaging Community of Practice. Leinhauser has been involved in developing capital strategies for packaging equipment and managing packaging projects, including new packaging line installations, automation, new product launches, and OEE improvements. Leinhauser is a Steering Committee Member of ISPE’s Packaging COP. Leinhauser received his BS in Mechanical Engineering from Villanova University.