klöckner pentaplast

white paper

PRACTICAL CONSIDERATIONS FOR THERMOFORMED FILMS IN BLISTER PACKAGE DESIGN

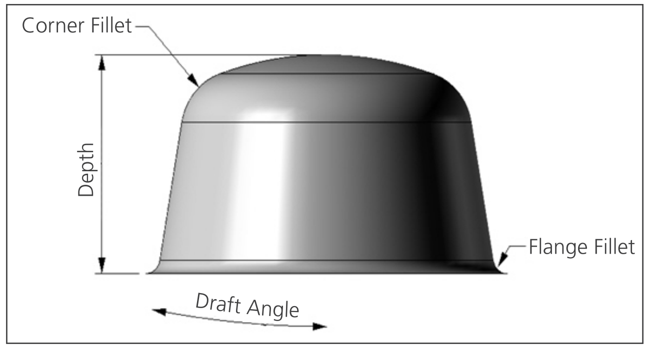
Many industries, such as those in the areas of food, consumer products, and pharmaceuticals, rely on thermoformed films as one of the main components in blister packages. These industries, like many others, through the application of theory and the course of experience, commonly develop very useful tricks of the trade and rules of thumb in order make the best use of the available technologies; efficiently convert materials; and achieve a set of desired attributes in the product they make. Of course, this set of desired results and array of necessary product features usually presents designers and engineers with the challenge of balancing these properties by paying close attention to each without overly promoting one or more characteristics at the expense of others. Accomplishing this balancing act means making sound judgments about what path has a high probability of producing the expected outcome and what choices, misconceptions, and assumptions will lead down a road to unforeseen and unwanted consequences.

Therefore, making blister packages, like most other manufacturing challenges, has its set of good and bad choices, this white paper presents a few concepts and ideas of what we would consider a fundamental collection of some of the more critical and influential features of blister package designs. The information presented here has a specific focus on the thermoformable film portion of the blister package. We also highlight some relevant material properties of the film when used in conjunction with other common blister package components. Effective selection and implementation of materials usually starts with a good understanding of individual and interactive properties. The objective is to reduce at least a few of the unwanted and unintended consequences encountered, while achieving a more optimized set of necessary and expected results when utilizing blister packages.

BASIC CAVITY GEOMETRY

A necessary step in the production of a blister card requires the reshaping of flat film into a contoured part by forcing the plastic into the shape of a mold. This typically takes place through the use of air pressure and sometimes with the assistance of a plug on heated film. This reshaping step involves the stretching and the thinning of the heated plastic and then subsequent cooling in the mold. Because all materials tend to have their limitations as to how much stretch and thinning they can take, not all geometric shapes provide ideal results.

In general, avoiding a squared-off or cube-shaped blister and opting for a more rounded and spherical shape tends to provide benefits and robustness. More spherical geometries lead to thicker and more evenly distributed film. More uniform thickness helps reduce the likelihood of blowing holes during forming and helps prevent parts with poor rigidity or strength.

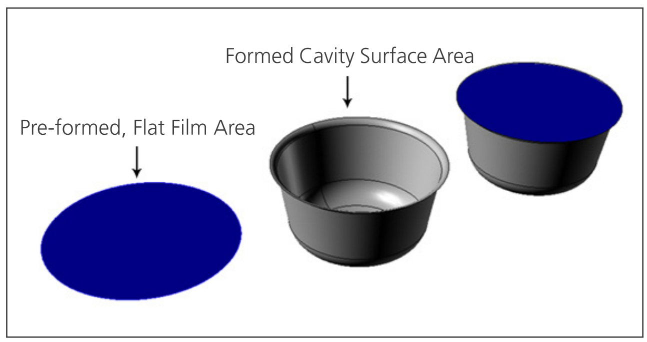


The most practical way to create a more spherical cavity typically involves increasing the draft angle, incorporating a generous corner fillet radius, and minimizing the depth. In an effort to preserve film thickness, many mold designs utilize depths no more than about ½ mm of clearance above the height of the dosage shape. Some other rules-of-thumb include: a) the use of draft angles two or three times larger than traditional values of 3° or 5°; b) corner fillets >1mm; and c) flange fillet radii > 0.5mm and preferably 1mm. A larger flange fillet allows more material to flow into the mold especially when using matched upper and lower forming tools that clamp and restrict the material in the flange during the forming step.

Although these considerations may sound trivial, very often, small changes to this set of parameters beyond conventionally chosen values can provide the critical difference between a frustrating processing problem and a package design that has the robustness to perform under a range of disturbances, such as temperature and tension fluctuations in the process or inherent defects in the material.

BLISTER DRAW RATIO

When considering whether a package fits into the category of shallow, moderate, or deep draw, very often only the depth of the mold gets scrutinized. Examining the three-dimensional draw ratio of the blister presents a more comprehensive and effective way to classify the difficulty of draw.



To calculate the three-dimensional draw ratio, divide the flat film area above the cavity by the surface area of the cavity. Of course, to conduct this calculation it greatly helps to utilize the tools provided in many, if not all, of the contemporary 3-D CAD software packages readily available in the market. This calculation carries the assumption, that once again, the process utilizes dedicated or matched thermoforming tooling that clamps the flange area.

For a rule-of-thumb, and in the context of commonly seen commercial blister packages, 3-D draw ratios of less than 2 typically do not subject the film to very high stretch. In most cases, they adequately preserve the original film thickness. Most commercial packages have draw ratios somewhere between 2 and 3. Ratios greater than 3 tend to put high demands on the materials, such as a need for a material with excellent melt strength and low defect counts while accentuating the need to run a well-tuned process that includes plug-assist. Interestingly enough, the same rules that apply for creating a more rounded and spherical type blister and avoiding some undesirable pitfalls of an "ice-cube" shaped cavity also help drive the 3-D draw ratio below 2, thus resulting in a well preserved cavity and more robust forming operation.

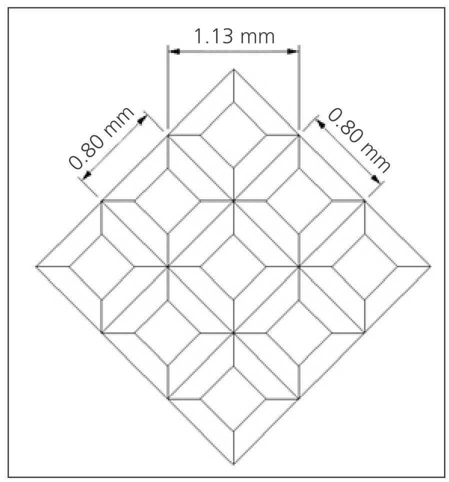
PLUG-ASSISTED THERMOFORMING

The use of a plug assist in thermoforming often provides a very significant difference in the thickness distribution of the film in the blister compared to changes made by temperature settings of preheating plates and molds alone. The need for plug assist tends to arise on opposite ends of the spectrum of draw ratios. For example, blisters with draw ratios close to 1 typically present the situation of having relatively thick film quickly placed in contact with a relatively cold tool. In these shallow-draw situations, plug assist can solve the problem of underforming.

When cavities have draw ratios above 3, the use of plug assist helps to even out the thin spots and allow for the placement of more film at the bottom of the cavities and into the corners. Many users of plug-assist setups will, according to another common rule-of-thumb, tune the timing and position of the mold, plugs, and air in order to have the thickness of the film half way down the wall match the thickness at the center point of the bottom. This usually requires adjustments made 1 cam angle degree at a time, since a 1-degree difference in timing can often lead to a significantly different result. Of course, even though plug assist does not represent a design parameter of a blister package, the choice of blister dimensions necessitates having the capability to run a plug-assist or not.

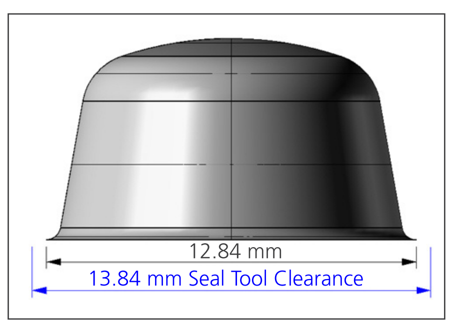
SEAL PERFORMANCE

How well a package seals and prevents leakers when conducting vacuum leak testing depends on a number of things. However, in terms of the thermoforming part of the blister package, a few key tips and tricks come to mind.



Many package designers use a 3mm rule-of-thumb to set the minimum seal distance between blisters; to a score; to a perforation; or to the edge of the card. The size of the knurl pattern chosen usually determines this value. For example, selecting a 0.8mm knurl pitch, positioned in a diagonal pattern means that to include at least 2 full knurl cells in a distance will require a distance of 2.26mm.

Thermoforming films, like most materials, have a tendency to go through dimensional changes based on factors such as the degree of web tension and temperature differences. In blister packaging operations, sealing of the lidding material to the flange of the blister web takes place downstream of the forming and filling operation. Because of this, the web of blisters must maintain a predictable distance from each other in order to correctly make the seal with the upper and lower seal platens and avoid crushing the product and blisters. Some refer to this as “keeping in registration.”



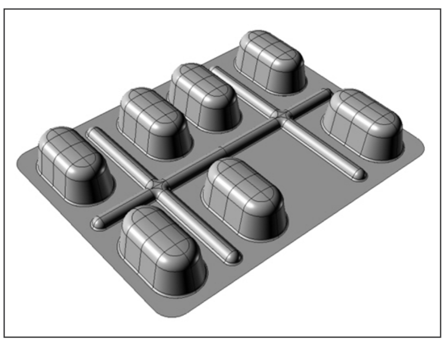
Although not necessarily applicable to technologies that utilize rotary seal drums, when using platen style seal tools, one useful rule-of-thumb to combat dimensional changes in the web relies on building seal tools with enough tolerance to comfortably fit the blisters and compensate for changes in the web. In most cases, platen seal tools 1mm larger than the maximum dimension of the blister do the trick. For more forgiveness during machine starts and stops, choose a 2mm increase in dimension for most solid oral-dose sized blister cards.

So, considering that making cards with good seals usually means leaving enough room to include at least two knurl points in the length along with enough room to hold good registration, a 3mm minimum distance seems to offer a reasonably good rule to follow for many standard set ups. Of course, this does not suggest that today's technology cannot accommodate tighter knurl patterns and more sophisticated approaches to holding registration, thus delivering smaller foot prints for cards, but simply offers up a few concepts to think about how to make life a little easier when processing blister cards.

PACKAGE CURL

Simply stated, blister packages rely on the successful transformation of individual materials and then combination of several distinctly different types of materials with each other in order to make the final cohesive unit. Each of these materials has its own unique set of mechanical and thermal properties. Also, each material has its own unique history prior to combination on the form-fill-seal machine. Most materials have a tendency to remember their history to some degree. Unfortunately, these individual properties, memories, and new variables introduced by the form-fill-seal process often result in an undesirably curly package.

In a somewhat juxtaposed sense, rigid plastic films have the tendency to shrink and grow beyond just linear thermal expansions and contractions in a somewhat flexible manner while aluminum foils although regarded as flexible components can perform with a high degree of rigidity after being glued to the film. The curl in some blister card designs often seems analogous, albeit possibly more complicated, to the curl of the bimetallic coil of a thermostat, where one material expands or contracts differently than the other when going through temperature changes.



Needless to say, a thorough understanding of each of the material properties along with which independent variables to control within each individual process leading up to the final construction of the blister package in order not to have curl presents a daunting challenge. In light of this situation, many designers and package engineers decide to accept that dissimilar materials have a tendency to curl when processed and design the package with stiffening ribs. Preventing curl has particular significance especially in high-speed carton filling or wallet-type applications downstream of blister making equipment. Of course, incorporating ribs into a package sacrifices valuable real estate, but offers a very practical and predictable approach to counteracting the potential for curl.

Stiffening ribs come in many forms, but some common attributes and key requirements allow for the establishment of some rules-of-thumb. Ribs should prevent curl in both the machine and transverse directions of the web. However, many cards tend to curl more severely in the direction parallel to the long direction of the card rather than just aligning consistently in the machine or transverse direction of the machine.

For common blister cards having blister depths ranging from roughly 4 to 12mm, stiffening ribs should have depths of 2 to 3 mm with at least the same amount of width. Reversing the rules for thinning in cavities to promote some thinning in ribs, such as draft angles of 0°, help to get film to the bottom of the rib without having to overheat the plastic. Adequate forming of the stiffening ribs will also require an ample number of vent ports primarily in the bottom corners of the ribs or the last point the film touches to avoid air entrapment.

When designing ribs into the blister card, the scenario discussed earlier of having relatively thick film in contact with a cold tool comes into play. This usually necessitates specifying a large enough web width to account for the width loss during forming when running higher temperatures to form the ribs.

For PVC-based films, a good rule-of-thumb for specifying web width is to multiply the minimum allowable web width due to punching, trim scrap, etc., by a factor of 1.03 and add 10mm. PVC films coated with PVdC often follow the same rule. PCTFE laminations often require a factor of 1.05 while polyester-type films can need a factor as high as 1.08. When specifying web width, taking the machine design into consideration will matter since some machine designs do an excellent job of preserving web width through the heated uniaxial index prior to moving film into the mold, while other machines do not.

HOW TO DETERMINE BARRIER PROPERTIES

Providing a barrier to moisture and oxygen in a food, medical, nutraceutical, or pharmaceutical product represents one of the most important functional attributes of a blister package. The application of the law of diffusion along with a few assumptions, such as steady state conditions, no transmission through the seal areas, etc., allows for the calculation of transmission rates of moisture and oxygen through the thermoformable film. It is possible to calculate moisture or oxygen transmission rates by integrating the contribution to the total transmission rate of each infinitesimally small local area of film, which determines the impact of geometric changes to the overall barrier performance. Klöckner Pentaplast's computer simulation program, BlisterPro®, provides a calculation of blister barrier performance which makes it possible to implement different schemes and strategies to help navigate through various stages of package development, such as prototypes, stability runs, and, finally, the establishment of optimal designs for robust and reliable use in the production environment.

CONCLUSION

For just about all design and engineering projects, a good understanding of material properties coupled with some solid rules of thumb can provide some welcome aid and guidance towards a successful endeavor. The rules presented here arose from a combination of scientific knowledge, engineering practice, and some old-fashioned common sense. Along the lines of common sense, the ideas discussed here apply rather effectively in many situations. However, presentation of these concepts does not replace or eliminate the need to carefully assess each situation and make well-informed judgments about how well a rule applies or if other considerations change the situation.

Klöckner Pentaplast Group
The Americas:
3585 Klöckner Road
P.O. Box 500
Gordonsville, VA 22942 USA
Phone: +1.540.832.3600
Fax: +1.540.832.5656
www.kpfilms.com
kpainfo@kpfilms.com

Klöckner Pentaplast Group
Europe:
P.O. Box 1165, 56401 Montabaur
Industriestr. 3-5, 56412 Heiligenroth
Germany
Phone: +49 2602 915-0
Fax: +49 2602 915-297
www.kpfilms.com
kpinfo@kpfilms.com

Klöckner Pentaplast Group
Asia:
64/48 Moo. 4 T. Pluakdaeng,
A. Pluakdaeng, Rayong 21140
Thailand
Phone: +66 38 927400
Fax: +66 38 955462
www.kpfilms.com
kpinfo@kpfilms.com