klöckner pentaplast

white paper

Market demand for more sustainable packaging solutions drives thermoformers to make technical considerations for converting to polyester films in pilfer-resistant packaging

How to make best use of existing assets for forming, trimming, and sealing RPET

CONVERTING PILFER-RESISTANT PACKAGING

Consumers have become increasingly vocal influencing sustainable consumer product packaging options. Their voice is effective as they vote every day with their purchasing power on millions of consumer products. Although there are many materials that could be compared to review the impact of meeting consumer driven packaging material demand, this paper focuses on the most common conversion in clear plastic packaging; from rigid vinyl to rigid polyester films for blisters, trays and clamshells.

In choosing which type of polyester to use, one must consider the type of package to be created and what the critical properties are to achieve that package. For some products, a high cosmetic look with RF seals may be desired, for some, lowest cost or a good scorecard rating may be important, and for others a basic face-seal blister with less demanding cosmetics may be sufficient. To assess the choices successfully, it is critical to understand film properties; for example, that recycled-content APET films typically have higher heat history and somewhat lower impact strength than prime APET films. In this example, higher heat history material selection could lead to brittle trim failure and ductile brittle cold drop failure if the packaged product testing protocol requires it.

To meet consumer demand for post-consumer recycled content (PCR), Klöckner Pentaplast has developed PCR content films called Pentaform® SmartCycle® rigid films for applications that are suitable for a wide range of physical capabilities, which contain anywhere from 25% to 100% recycled content. High recycled content looks good on scorecards, but may not always achieve necessary levels of performance and cosmetics. Comparatively, 50% PCR-content films provide a good balance of improved impact strength, general performance characteristics, and cosmetics, while still strongly supporting the market for recycled-content goods. Lower PCR-content films (35% or less) and prime grades may be desired for the best overall performance properties, especially when used to package heavy products and where better cosmetics are desired for printing on the package.

Consideration should be given to planning a brief DOE at the beginning of any packaging project to balance the competitive price of recycled content films versus the higher cost/higher performance of lower recycled-content or prime grades. A “mid-grade” product can hold down cost while delivering adequate trim and package integrity performance for a wide range of products.

When converting packages on existing thermoforming, trimming, and sealing assets, there are key considerations that will make a big difference in how successful the conversion will be. The key areas we will focus on in this paper are oven configuration, forming process, tooling modifications, trimming and seal methods. Once these areas are managed, the rest of the process will quickly take shape for successful packaging film replacement.

Oven configuration is an important initial focus area in the evaluation of existing assets for material conversion. If a thermoforming line is already up-to-date with separately grid-zoned top and bottom heaters, then only new heat-profile recipes will be needed. Temperature strips or other methods can be used to ensure proper film temperature for job set-up recipes. To ensure the proper forming recipe is entered, it is important to know how the actual material temperature correlates to machine temperature settings.

If the line has old cal-rod heaters or if heaters are top or bottom only, then it is time to do some updating of the oven, to control heat with both top and bottom heaters in separate zones. Without making this change, the old cal-rod style heaters will cause under heating of polyester or they will force the line to run so hot that the material will begin to crystallize before it is even formed - losing control of stress and part definition.

Oven profile for vinyl required a steady soaking of the film typically through approximately three indexes of preheating prior to the material entering the forming station. With APET in particular, the initial oven index is more of a warming oven with primary preheat at temperature in indexes 2 and 3. This reduction in total time at temperature prevents the material from crystallizing prior to reaching the forming tool. Preferably the primary preheat area can be sized to two full indexes of the forming station size. With this line setup, the film will be ready to form with minimal stress and with excellent part definition. APET films usually form at ≈10°C – 20°C lower film temperature than vinyl allowing the potential for faster forming cycle times. Typical forming film temps: ≈135°C for APET versus ≈150°C for vinyl depending on type of tooling and complexity of the mold.

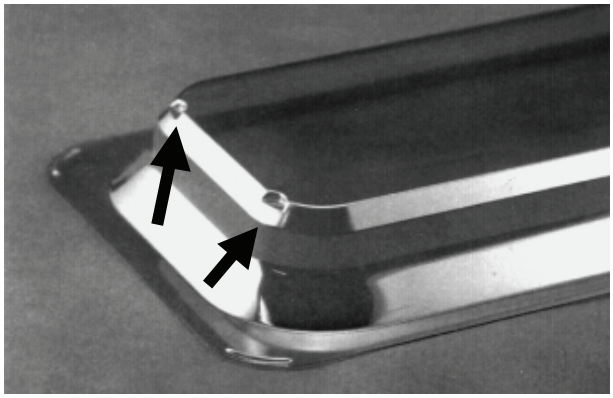
FORMING PROCESS AND TOOL MODIFICATION

While many polyester parts can run on vinyl tooling, better part definition, and lower part stress can be achieved with slightly more draft on the sidewalls and with a more open radius going from the cavity area to the seal flange. All radii should be a minimum of 5/64" (2mm). Female tooling recommendation is minimum draft angle of 5 degrees; male tooling at minimum 3 degrees draft angle. The Association of Visual Packaging Manufacturers Blister Card Sealing Guidelines Manual (2006) recommends a minimum of 5/16ths seal flange.

In addition, a stacking feature (denest lugs) should be included in each corner of the package for nested blisters and clamshells.

Tool temperature control requires 20°F to 40°F higher temperature than with vinyl parts, allowing the polyester to stretch more easily into the forming cavities with reduced tool mark off or flow marks. Good mold temperature control will improve overall formed part material thickness distribution including more uniform flanges, again, with less stress than a cooler forming tool would cause.

Remember that with vinyl, white blushing in the formed part typically meant the part was cold formed and that the flanges would continue to move when the parts next saw heat in the sealing process. However, with APET polyesters, white blushing is a sign of early crystallization meaning that material



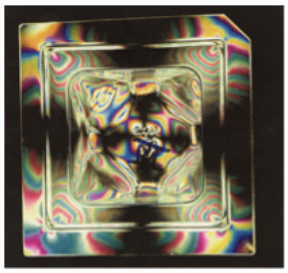
Denest Lugs (photo courtesy Eastman Chemical)

elongation into the cavity and, ultimately, sealing and impact strength, will all be compromised. If this is observed, consider where excess heat in the process can be taken away to achieve the process temperature just below the crystallization temperature. First review how many indexes of preheat are turned on and whether there is too much heat in the first index of the oven or if it is simply too hot through the whole process. Then make sure the top and bottom heaters are balanced with the right amount of heat soak, typically with the bottom heat approximately 25% to 35% lower than the top heaters. Also consider decreasing the cycle time10 to 20% while still allowing adequate primary preheat time in the second and third indexes of the oven. Finally, be sure the forming tool temperature is controlled to stay warmer than with vinyl, but controlled not to be excessive. These measures will enhance material distribution and flow while reducing internal stress or "birefringence" in the formed parts.

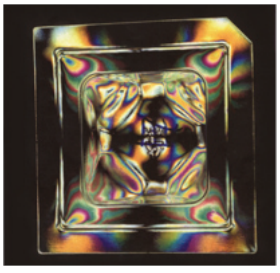
REDUCING BIREFRINGENCE: 1 MINUTE LESSON

Birefringence is a refractive index which correlates directly to internal stress in the formed part. It is visible through 2 polarized sheets; one in front of the formed part and one behind it, turned approximately 45 degrees from the top sheet orientation, or use a StrainOptics® Stress Tester. To determine internal formed part stress, count the violet rings from any single geometric feature.

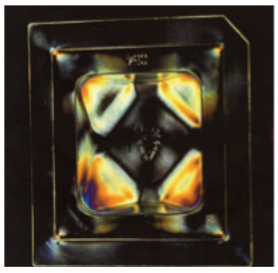
Example of reducing internal forming stress or birefringence:
(Photographs courtesy of Eastman Chemical)



High Stress
5+ orders of fringe
Temp settings:
Top is 95% of max heat
Bottom is half of top heat
Initial cycle time: 12 sec.



Reduced Stress
3 orders of fringe
Temp settings:
Top at max heat
Bottom at 2/3rds of top
Cycle time: 8 sec.



Minimal Stress (desired state)
0 orders of fringe
Temp settings:
Top reduced 20%
Bottom at 75% of top
Cycle time: 8.1 sec.

TRIMMING

Types of trim knives:

1) The most common trim knife used by blister manufacturers is steel rule knife. Typical recommended knife width is 2-3 point (W.R. Sharples Co., Inc.), hardness is recommended for polyesters at Rockwell Shore C 55 hardness; 45 hardness for more complicated trim jobs to prevent breaking the knife while bending into shape.
2) Forged knives are more expensive, but give longer wear. They are especially suited to medium runs and dedicated tooling.
3) Match metal knives or punches for dedicated form fill seal equipment require a "zero clearance" and regular maintenance to ensure knife longevity.

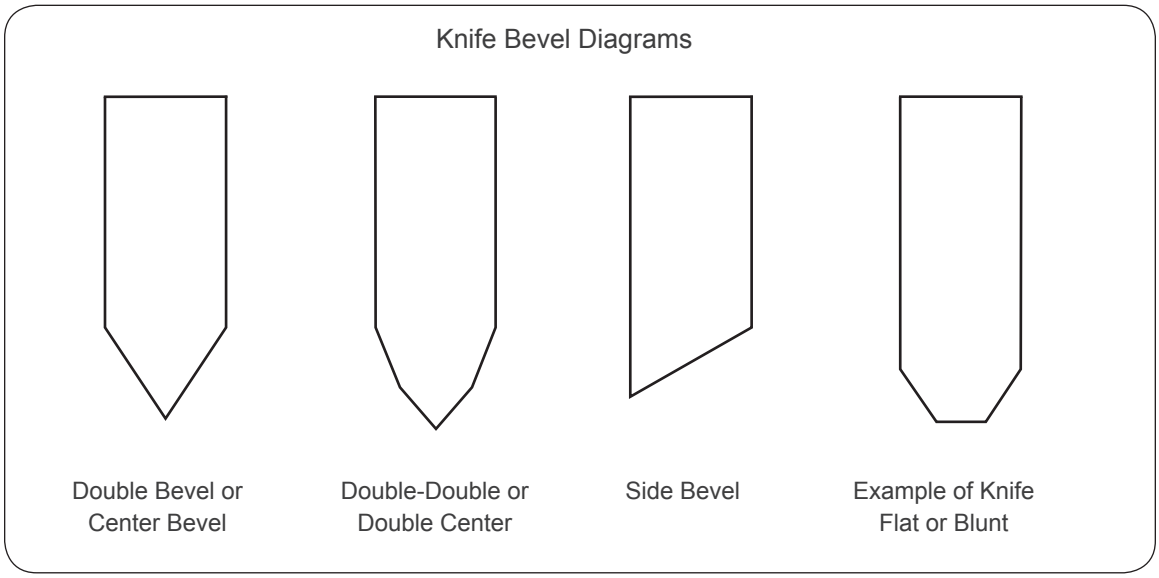
Knife travel and notch sensitivity: Unlike vinyl, APET is not notch sensitive, so knife travel through the sheet must be 100%. Where vinyl knife travel was approximately 50% to 75% before the cut was completed by the notch sensitivity, the APET material structure requires the knife to fully penetrate the sheet to complete the part trim. The extra knife travel and the hardness of APET require more tonnage on the trim press per lineal inch of knife unless heat can be added to soften the material.

Press tonnage: APET polyesters are harder materials than vinyl, which presents the package manufacturer with some decisions to make about how to operate their existing equipment. From a productivity standpoint, the combination of heated knives and increased press tonnage will maximize the total linear inches of APET the machine can trim. In contrast, if the trim press is already maxed out and heated knives are not installed to help soften the material (thereby reducing required trim pressure), the process may require reducing the linear inches of trim by approximately 33% to keep the APET job on the same machine. If additional trim press tonnage is added without heated knives, up to 50% more tonnage would be needed to maintain line productivity. As an example, thermoforming machinery manufacturers, such as Sencorp, typically sold a large thermoforming machine like their 2500 model with a 75 ton trim press for vinyl forming and trimming. On their newer models, to meet customer demand in the shift from vinyl to polyester, they have increased trim press tonnage to 115 tons (a 53% tonnage increase).

Knife heating and maintenance: Heated knives are helpful in reducing overall trim press tonnage required when cutting most plastics and the same is true with APET. Nonetheless, trim knife maintenance will increase compared to vinyl trim knives proportionately with the extra tonnage required to cut this material. This is not a show stopper, simply a necessary step to consistently trim APET parts with smooth edges and minimal angel hair. This maintenance must be factored in to overall machine capacity and available up time, so consider spare knives when making long runs with dedicated tooling.

Whether using a mechanical up-stacker to remove formed parts at the end of the line or using human power, the nicks or notches used to transport the parts through the machine with the web, will have to be smaller than with vinyl to separate the parts cleanly from the web. Larger notches, such as those used with vinyl, can cause the finished APET part to fracture by the additional tearing force. Some tooling manufacturers score the cutting plate instead of the knife itself, providing a very small notch that tears away easily on up-stackers, reducing the probability of machine jams.

Knife Bevel: There are different schools of thought on preferred bevel for polyesters. Sharper bevel knives cut more cleanly while they remain sharp, but have increased knife wear compared to decreased knife angles. With this in mind a center bevel knife with decreased angle would be expected to withstand more strokes than a side bevel knife with reduced knife wear. Plan on increased knife maintenance either way, as the increased press tonnage is an indication that the knife will become dull more frequently than with vinyl.



SEALING

Face Seal Blisters are typically made from utility grade or PCR content PET films which seal inconsistently at best to most traditional water based adhesive heat-seal coatings, and only if the forming stress has been kept to a minimum based on the steps recommended above. To meet market demand, kp has developed improved sealing grades where the films have higher crystallization temperatures allowing higher heat-activation-temperature adhesives on the board stock. Some board stock converters are also using lower heat-activation-temperature adhesive heat-seal coatings to enhance the seal process.

Ultrasonic seals are possible with standard APET grades, but may show some brittle characteristics with heavier products and/or with higher recycled content grades that have lower impact strength. These package closure seals are better made with prime or mid-grade APET films to reduce possibility of brittle failure.

Full-perimeter pilfer-resistant impulse, hot/cold, or fusion sealing has proven less reliable with APET. PETG may be a better solution within the scope of this paper due to APET crystallization at the heats required to fuse the materials. Of course, if PETG is chosen, the scrap must be segregated from the PET scrap to prevent cross contamination of these polymers, even though both carry the same #1 SPI resin identification code.

Until recently, RF sealing used for full-perimeter pilfer-resistant packaging has been unique to the properties of vinyl and PETG. The growing market demand for RF-sealable APET has driven our

development of RF sealable APET films; most recently our Pentaform® SmartCycle® TH-ES135R rigid APET thermoforming film. This particular RF-sealable film includes 35% PCR bottle content and must balance the PCR content with the performance properties required to achieve the RF-seal performance without crystallizing the material in the process. This breakthrough in post consumer content APET films for RF sealability goes a long way to achieve vinyl replacement materials that are much closer in cost than PETG films. For those used to RF tear seals as the final trim of the sealed package, there is a high probability of arcing through the APET to the buffer material and/or simply not cutting through the APET before crystallization begins. This potential problem can be avoided either by sealing pre-trimmed parts or by post-trim of RF sealed formed part arrays.

A word of caution in RF sealing polyester parts – the softened material may try to stick to the seal plate or buffer, if the preheat or energy setting combinations are too high. Where traditional heat-sealing requires managing time, temperature, and pressure, RF sealing requires time, temperature, pressure, RF-seal energy, and tuning. While achieving the right settings is more complex, the benefit of RF sealing is producing a package with minimal seal-flange area. Commonly RF-sealed packages are often preferred for high cost products where pilfer protection of the product is balanced with a package that is functionally robust yet visually pleasing for the consumer at the "moment of truth."

SUMMARY AND CONCLUSIONS:

With the right material selection and the right machine set up, pilfer-resistant face-seal or full-perimeter-seal packages with competitively priced PCR-content vinyl alternatives are now viable throughout our portfolio of polyester and SmartCycle® specialty grades. In general, higher recycled content films may sacrifice some performance and cosmetic properties, while films with a balance of recycled content and virgin resin typically improve impact strength, seal performance and cosmetic appearance. Similar to other non-plastic packaging materials, demanding processing requirements require the right balance of PCR-content and virgin raw materials to achieve robust material performance in the packaging process, as well as through the distribution cycle to meet consumer demand for recycled content packaging materials.

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