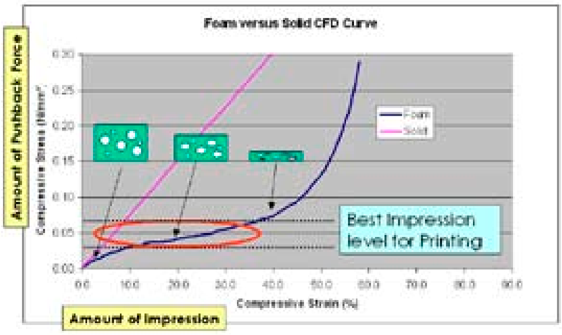

FIGURE 1.
Stress-strain or CFD (Compressive Force Deflection) curve of foam shows how cells allow for compression till the point it begins to behave like a solid. The portion circled in red is the useful region of impression for the printer.

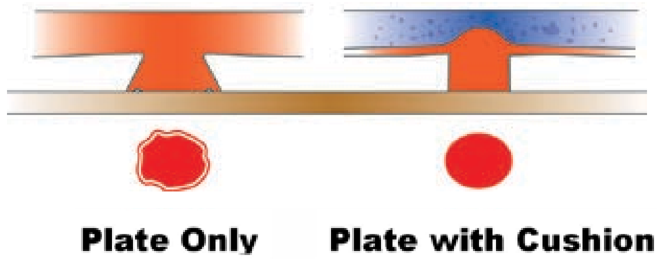

FIGURE 2.
The effect of adding a foam layer is shown on printing of a single dot.

Open and Closed Case

The Difference Between Various Mounting Tapes

By Brett Kilhenny

It would be difficult to overstate the importance of foam in flexographic printing. Foam compensates for thickness variations in plate and substrate, allows better control of impression force, and absorbs vibration allowing for faster press speeds while delivering higher print quality. The vast majority of flexo printers today use foam in their mounting systems to achieve the best print results and improve efficiency.

How does foam achieve these benefits? The simple answer is foam is compressible. Unlike a solid, when foam is compressed, it provides a pushback force that remains essentially unchanged for a considerable amount of its thickness. A solid, on the other hand, will continually increase its pushback force from the point of first contact. Foam is able to do this because of the air in its structure. As it is compressed, the supporting solid portion of the foam moves into the empty voids as shown in Figure 1.

Figure 1 also contains a graph used by engineers to show how materials behave when impressed. This stress-strain curve plots the "pushback force" (stress) as the material is compressed (strain). The flat portion of the curve is the region of impression that is useful to the printer. Here the impression level (strain) can vary, but the pressure of the plate against the substrate (stress) remains essentially the same.

We can better see what this means for flexo printing in Figure 2 below. The image on the left uses only a thick photopolymer plate that distorts significantly when impressed resulting in considerable dot gain. The image on the right has significantly less distortion because the foam layer compresses to minimize distortion while still ensuring sufficient contact force for ink transfer.

THE NEED FOR REBOUND

In addition to being compressible, foam must also rebound quickly to its original shape in order to be useful for flexo printing. In a typical wide-web application with an impression of 4mils on a combination of 20mil tape with 0.067in. plate, printing an 18in. repeat at 1,000fpm, the foam is compressed one-fifth its thickness 22 times per second (assuming plate and anilox impression are equal).

The two most common foams in flexography use different mechanisms to achieve this rebound force. Closed cell polyethylene foams use a lightly cross-linked blend of polyethylene and EVA (ethylene vinyl acetate) co-polymer in which the trapped air provides a significant portion of the rebound force when compressed, much like when one tries to squeeze a balloon. The other type of foam is open cell urethane that uses a cross-linked polyurethane elastomer that acts like a collection of springs, returning the material to its original shape after being compressed. The open cell structure allows free passage of the air within the foam and plays no role in supplying a rebound force. Both of these materials have a proven track record, but there exists much controversy as to which is better for a given application.

A CLOSER LOOK

It is quite remarkable that these foams can be used interchangeably in many applications in light of how different they are from one another. Figure 3 is a SEM cross section that clearly shows the difference in their cell structures. The view on the left shows the micro cellular structure of an open cell urethane. The smaller circles within the larger cells, which look like little portholes, are cell openings between cells. This structure is called open cell. The view on the right shows the closed cell polyethylene foam. The cells are larger and angular in shape. There are no openings between cells, so each cell is analogous to an individual micro-balloon.

As one can imagine, because these foams use different mechanisms to achieve compressibility and rebound, they have very different properties. In general, the open cell urethane mounting tapes have a higher density of 20 to 30pcf (pounds per cubic foot) and rely on changes in the chemistry of the elastomer to control compressibility (whether the tape is soft or firm). The closed cell polyethylene tapes are not as dense as urethane tapes, typically 4-18pcf. They vary their density (i.e. how much air is entrapped) to control whether they are soft or firm, hence the terms "high density" for a firm tape and "low density" for a soft tape. Some manufacturers of polyethylene tapes have recently introduced new versions with modified polyethylene blends to provide properties beyond what can be achieved by varying density alone.

There are three properties of these materials that are significantly different and occasionally factor into the selection of one over the other.

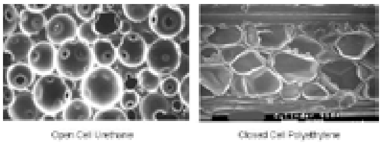

FIGURE 3.
SEM cross-sections of open cell polyurethane (left) (100X) and closed cell polyethylene (right) (50X).

Compression set resistance and long run capability. The open cell urethane has a greater resistance to compression set compared to closed cell polyethylene. This property is measured by compressing the foam to ½ of its original thickness for 24 hours and then releasing the pressure and re-measuring the thickness after 30 minutes, the percentage of thickness lost is the compression set. The typical values for open cell urethane are 2 to 3 percent, while closed cell polyethylene ranges from 10 to 30 percent. What does this mean for the printer? It can mean that on long runs open cell urethane will be able to provide more consistent print results whereas most closed cell polyethylene tapes will begin to lose impression and require replacement.

Energy dissipation. When the print area of the plate contacts the substrate, the action can be likened to an impact. The foam layer underneath the plate will control the nature of this impact much in the same way shock absorbers control what you feel when your car's tires "impact" the road. Extending this analogy, one can have different shock absorbers to deliver a different level of performance, depending on the preferences of the driver; firm shocks for a sporty ride, softer shocks for comfort. It turns out open cell polyurethane and closed cell polyethylene handle energy dissipation very differently and this can result in differences on press.

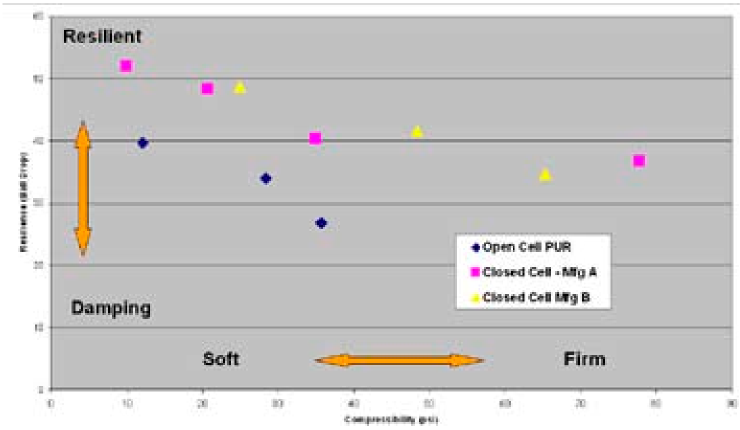

FIGURE 4.
A compressibility-resilience plot of both open cell urethane and closed cell polyethylene tapes.

Open cell polyurethane is typically more energy absorbing than closed cell polyethylene. This difference is readily seen using the drop ball rebound test. When a ball is dropped on the open cell urethane, the ball bounces 25 to 35 percent of its original drop height. In the case of closed cell polyethylene the ball bounces 40 to 50 percent of its original drop height meaning the material is more energy reflective or resilient. What does this mean on press? The resilience plays an important role in control of "banding" as well as overall print quality.

Banding is visible web direction variation in print results, typically in tonal areas that appear to be "chatter" or "gear bands." There are many causes for it including machine vibration as well as graphics design of the plate. Many studies have demonstrated that the combined resilience of the plate and tape can influence the amount of observed "banding." If this problem plagues your work it would be worthwhile to investigate changing the type of tape to determine if it can help eliminate or reduce this defect. In some instances using a more resilient tape can help, but in other situations, a more energy absorbing tape is required.

It is well known that the compressibility of a cushion tape, soft or firm, will influence the dot gain and solid ink density. It turns out that the resilience of the cushion tape will also have an effect. Figure 4 below shows a plot of compressibility and resilience for a number of common cushion tapes of both the closed cell polyethylene and open cell urethane types.

At a given compressibility, the open cell polyurethane tapes have lower resilience than closed cell polyethylene. Interestingly, the closed cell polyethylene tapes from two different manufacturers form a nearly straight line showing the similarity in the underlying foam technology. When facing the challenge of achieving good ink coverage without excessive dot gain, changing the "shock absorbers" can be one way of improving the end result.

Unfortunately, at present no guidelines for selecting a given tape based on the combination of compressibility and resilience exists; since the plate (analog or digital), line speed, substrate, anilox and ink all play a role. However, the resilience of the tape is an often-overlooked factor that could make the difference between mediocre and stunning print results and should be included when trouble shooting a print problem.

Stiffness and cohesive strength. The above two properties influence the handling aspects of a tape. Open cell urethane tapes are less stiff than closed cell polyethylene and therefore "drape" differently during mounting. In general, if one is accustomed to working with closed cell polyethylene tapes, some modification of how the tape is mounted will be required for open cell urethane tapes. The initial line-up of the tape to the cylinder to insure uniform contact of the tape along the cross web direction is more crucial with open cell urethane tapes.

There are also differences when demounting the two tapes. Although the open cell urethane is more durable in compression compared to closed cell polyethylene, it is actually weaker in tensile. This means that more steady and slow removal rate is required during demounting to prevent tearing of the tape.

CHOOSING A TAPE

The above discussion has hopefully educated the reader that the question is not open cell versus closed cell but really a question of different polymer foam technologies that use the cells differently. Both foams require the space the cells provide in order to be compressible, but the closed cell polyethylene uses the trapped air within its cells to contribute to the compressibility and resilience of the foam. The open cell polyurethane relies entirely on the polymer for these properties.

If this article has made you curious to experiment, you should first ask yourself what issues do you face: Do you have long runs, are you unable to reach high line speeds, do you struggle with banding, is it difficult to achieve solid ink density while minimizing dot gain, do you have problems in the mounting department? Hopefully the information above will provide some direction in your efforts to improve your print quality and pressroom efficiencies. ■

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