Pressure-sensitive, adhesive-coated film for package decoration

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Shape changes during the life of a plastic package require a label material that can return to its original shape without cracking, edge lifting, tunneling, bubbling, or delaminating.

Film labels have been used for years as a primary means of product identification in applications where durability and performance are required. Recent developments in raw materials, graphics application techniques, die-cutting mechanisms, and label-application systems—as well as increased use of plastic containers for packaging—have accelerated the use of pressure-sensitive films for primary labeling.

Packaging in plastic

Plastic containers offer both convenience and performance for the consumer. Problems of weight and breakage associated with glass packaging and the inflexibility of metallic containers have limited their appeal in the marketplace. Sales of food products in squeezable plastic packaging have risen 147% since mid-1984 (*1*). Plastic bottles can go from the refrigerator directly into the microwave. The number of blow-molded plastic bottles shipped or consumed increased at an annual average rate of more than 11% from 1983 to 1985 (*2*). Industry experts expect these trends to continue. In fact, 1986 may well be remembered as the year in which just about everything came out in plastic (*3*). The era of conservatism ended when many well-known packagers introduced flagship products in plastic containers.

The trend toward plastics has created some unique challenges for packaging engineers. Two areas of prime concern involve (a) adhesion of graphics or label systems to some of these relatively low-surface-energy materials and (b) the complex issue of how to decorate a package that may change shape.

Unlike hard materials, a plastic container is susceptible to a change in shape at four different stages in its lifetime. Initially, when a bottle is manufactured, shrinkage may occur as the bottle is cooled at room temperature. Secondly, high-viscosity liquids, such as condiments and hair-care products, are often hot-filled to maximize line speed. This causes the package to expand and contract in proportion to the change in temperature. A similar situation occurs under uncontrolled shipping and warehousing conditions, which fluctuate with seasonal changes. Finally, plastic packages often change shape as the product is dispensed from the package. It is interesting to note that the success of plastic containers has been mirrored by self-cleaning plastic flip-top closures.

Label materials for use on shape-changing plastic packages must have memory characteristics that enable the label to return to its original shape without cracking, edge lifting, tunneling, bubbling, or delaminating.

Material developments in pressure-sensitive films

Most pressure-sensitive labels have three basic components: the face stock, the pressure-sensitive adhesive, and the release liner. The face stock is the surface film to which graphics are applied via conventional printing processes. The adhesive system is the bonding mechanism that promotes adhesion of the face stock to the package. The release liner is the carrier web, which is treated to release the label when it is dispensed. Only the face stock and adhesive system are applied to the package. **Figure 1** illustrates a complete pressure-sensitive film coating line capable of manufacturing pressure-sensitive film laminents.

Face stocks

The volume of pressure-sensitive labels made of paper face stocks has been significantly larger than the volume of labels made with film face stocks. This is due primarily to the relative cost differences between the face stocks. Previously, the only opportunity for film-based primary labels was in situations where the package might be exposed to harsh environments or where superior graphics were necessary. Packagers looking for striking graphic effects chose to use relatively expensive plastic face stocks because of their smoother, more uniform printing surface. The benefits of film substrates for pressure-sensitive label systems are centered on appearance and performance (*4*).

Calendered polyvinyl chloride and biaxially oriented

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polyester face stocks have dominated film applications in primary labels over the last ten years. However, a number of new, less expensive, thinner-gauge films have narrowed the cost difference between film and paper labels (*5*). Polystyrene, polyethylene, and polypropylene films are responsible for much of the excitement involving pressure-sensitive film labels. Each has its own benefits in regard to pressure-sensitive labeling of plastic containers.

Polyethylene face stocks offer excellent chemical, solvent, moisture, and shrinkage resistance. Because of its flexibility, polyethylene has been used successfully as a squeezable label material on plastic packages.

Polystyrene and rubber-modified polystyrene films are considered semisqueezable because of their stiffness. These films are used mostly as front and back panel labels on plastic containers where the product is either poured or pumped out.

Polypropylene films offer high clarity and good resistance properties. Polypropylene labels offer potential as lower-cost alternatives to polyester labels in numerous applications.

Pressure-sensitive adhesive systems

There are many demands placed on the pressure-sensitive adhesive systems used for package-decoration applications. The ideal adhesive offers short-term repositionability (up to 24 h); moderate-term removability (24–72 h); and long-term permanency (beyond 72 h). These build characteristics allow either on-line or off-line rework in the event of misapplied labels. This criterion is difficult to meet, given the variety of plastic resins used in packaging, their surface energies, and the tear resistance of various face stocks.

High-speed automatic label application requires moderate to high initial tack to prevent label delamination in the production cycle. Moderate to high shear properties are necessary on squeezable containers to allow the label to remain in contact with the bottle during deformation. Good wet-out characteristics are extremely important for proper application of clear label stocks. See-through labels also require water-like clarity of the adhesive system.

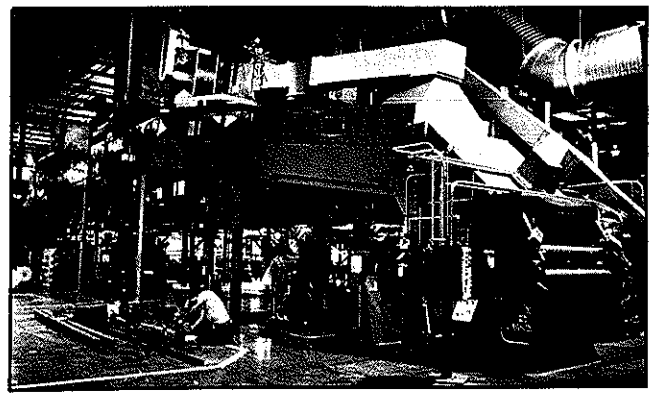
Most commercial labeling applications utilize solvent-based acrylic pressure-sensitive-adhesive chemistry. Some applications using opaque label materials require rubber-based systems. Recent improvements in performance of emulsion acrylics have allowed their use in specific applications. Some hot-melt adhesive systems show promise for packaging applications with film face stocks.

Release liners

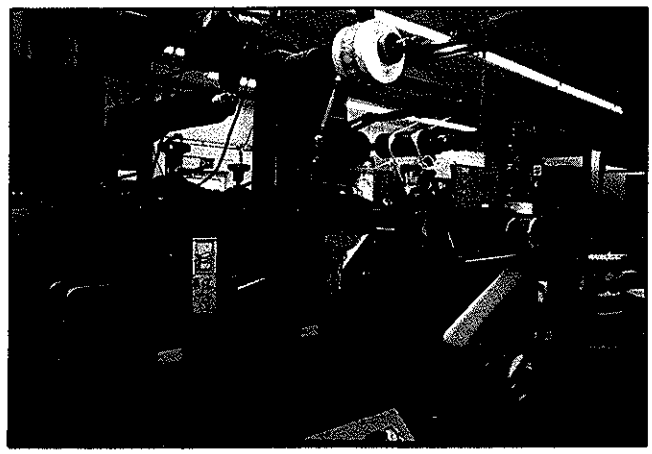
For years, the only release liners used in primary label applications were bleached, calendered kraft papers in the 40–50-lb basis-weight range that had been silicone-coated on one side. As processing speeds increased, web breaks and V-tears in paper liners became a growing concern. The introduction of 150-gauge siliconized polyester as a release base resolved the problems associated with high-speed dispensing applications. Since its introduction, the polyester release liner has been considered the standard of performance because of its caliper uniformity, free-release characteristics, and inherent strength (*6*).

Paper and polyester are just two of the commercially available release-liner systems. Oriented polypropylene and polyolefin blends are also used for high-speed application systems. Another technology incorporates a liner structure of 30-lb natural kraft paper extrusion coated with 14 lb of polypropylene. These materials, which offer a greater margin of error in die-cutting, are designed to process at high speeds without tearing and to reduce the high costs associated with polyester release liners.

1. State-of-the-art pressure-sensitive adhesive coating line



2. In-line rotary letterpress printing and rotary die cutting



Applied graphics

The ability of label converters to apply high-quality graphics has increased significantly in recent years. The commercial success of rotary letterpress systems using ultraviolet-light-curable inks, further advancements in flexography, improvements in ink technologies, superior photopolymer plate materials, and computerized register control have all had a positive impact on the graphic quality associated with roll label converting. Market demand has generated the need for 6-color and 8-color presses with options such as rotary embossing, in-line varnishing, flexo units for overprint panels, corona-discharge systems, adhesive-side printing, and rotary screen printing (*7*). **Figure 2** displays in-line rotary die cutting with UV curable rotary letterpress printing on a pressure-sensitive film laminent.

3. High-speed automatic label application equipment for pressure-sensitive film labels

4. Film pressure-sensitive labeled package resistant to the environment and end-use conditions

Die-cutting

In general, the overall quality of die-cutting has improved because of tighter-tolerance dies, heightened awareness of requirements, and in-line quality control. These factors have also been influenced by market demand. The emergence of high-speed, dispensable, roll label stocks has provided better results for both rotary and flatbed die-cutting techniques.

Label dispensing and application equipment

One of the most important factors in obtaining a functional label on a container is the application system. Advancements in label dispensers have also influenced materials used for high-speed application. Conventional dispensers for paper-based pressure-sensitive materials do not require special applicator systems because of the inherent stiffness of paper. With today's conformable and squeezable pressure-sensitive film products (**Fig. 3**), accurate, workable application systems have been incorporated with conventional dispensing heads to offer excellent performance and aesthetics. The accuracy of label application has been increased significantly through improvements in sensing mechanisms and in product-handling equipment. Equipment modifications have resulted in tight label-placement tolerances within 0.015 in. on automatic application systems (*8*). The ability to code and imprint in-line during label application has been beneficial to the pharmaceutical and food packaging industries. The ability to add information at the time of label application is useful because it facilitates product traceability and adjustment of expiration dates.

Primary labels and package decoration

The environment- and product-resistant properties of film labels are significant advantages. These advantages are obvious in high-humidity environments, such as the bathroom. But they also provide a significant marketing advantage. Package designers have long sought labeled packages that look beautiful (**Fig. 4**) when purchased and retain their attractive appearance right up to the moment the consumer pitches the empty container into the trash. The consumer's last look at a package as it is discarded is believed to have a major influence on future purchases (*9*).

Packaged-goods manufacturers expect the package to do more advertising and selling than ever. As one cosmetic executive put it, "Good packaging will help sell a poor product, but poor packaging will inhibit sales of a good product" (*10*). Quality looks, convenience, and performance are required from a shelf-appeal standpoint as well as promoting a quality image at disposal. These considerations have contributed to the growth of film-based pressure-sensitive labels in primary-label applications.

Techniques for package decoration

Pressure-sensitive film labels are just one of many options to consider when choosing a package-decoration technique. Predecoration of packages involves graphic application before a container is filled with product. This is done by bottle manufacturers and contract packagers, usually as an off-line step from blow molding. Methods used to predecorate containers include:

- Application of label in the package mold
- Direct screen printing on container
- Hot stamping
- Heat-transfer decoration
- Shrink-sleeve systems
- Pressure-sensitive adhesive systems.

Decoration can also be applied in-line with filling and packaging systems. In-line decoration techniques are done at the higher line speeds associated with filling operations. This rate can range from 60 to 360 labels per minute, depending on the size of the labels and dispensing system. In-line methods of container decoration include:

- Glue-applied systems
- Heat-transfer decoration
- Pressure-sensitive adhesive systems.

Application of label in the mold

In-mold labeling incorporates a pre-die-cut, preprinted paper label into the blow mold prior to bottle manufacture. As the warm resin contacts the paper, a heat-reactivating adhesive develops a bond to the plastic bottle. This technique is usually associated with large labels on

relatively regular-shaped panel surfaces. The drawbacks of this technique include high startup costs, inability to alter package design, nondurable paper substrates, and high scrap rates. This decoration technique is commonly used on the large plastic containers for laundry and detergent products.

Heat-transfer decoration

Heat-transfer decoration uses a preprinted paper carrier web that transfers the graphic image onto a treated container via a thermal applicator. Inks are transferred by a release coat that becomes the overprint varnish on the package. This technique does not require a label substrate.

The technique does have some drawbacks. At higher filling speeds, heat-transfer graphics must be applied off-line. There are also limitations on the type of graphics that can be used. A metallic appearance cannot be accomplished with heat transfer (*11*). In addition, four-color process work is limited by potential registration difficulties. In the event of a misapplication, the entire package is unusable. The overprint coating is cloudy, mars easily, and can pick up dust and dirt in transit. Long lead times and limited sources of supply are also key factors in evaluating graphics applied by heat transfer.

Hot stamping

Heavy line art work can be achieved using hot stamping to decorate containers. Other types of art work are difficult to obtain. Hot stamping is an off-line, relatively slow-speed process involving a heated platen and temperature-reactivating inks. Improperly applied graphics result in loss of the container.

Screen printing directly on container

Direct screen printing on packages uses screen-mesh ink applicators. This technique is similar to hot stamping in regard to the type of art work achievable. This is also a relatively slow off-line process. Multiple colors create potential registration difficulties and additional cost. As with hot stamping, improperly applied graphics result in loss of the container.

Shrink-sleeve systems

Labeling with shrink-sleeve systems involves the application of a printed-film tube section over the container. This is followed by a heat cycle, which shrinks the band to conform to the package. These labels are placed in a recessed area on the package, which prevents the label from shifting position or sliding off the package. Thus irregularly shaped containers cannot be decorated using this method.

Glue-applied systems

Glue-applied systems involve high-speed glue application to roll label stock in-line with die cutting and a roll-on type application system. Paper is the primary substrate used. Costs for equipment, maintenance, and clean-up are high. Graphic limitations and nondurable substrates are also drawbacks of glue-applied systems.

Pressure-sensitive adhesive systems

Pressure-sensitive adhesive systems feature high-speed, movable, low-cost applicators that offer good flexibility, short changeover times, low maintenance, and no clean-up. Decoration can be applied either before, during, or after the container has been filled with product. This technique also eliminates inventory costs of predecorated containers in cases where multiple products use a common package. Pressure-sensitive film labels also offer dimensional stability, close caliper control, preapproved constructions, time-cured adhesive systems, durable substrates and graphics, conformability, squeezability, and lower scrap rates.

Pressure-sensitive adhesive systems can be customized to meet a particular package requirement. Good accuracy of label placement can be obtained, and the scrap rate is usually significantly lower than those of other decoration systems. A switch from glue-applied to pressure-sensitive labels helped one packager reduce rejection rates from 8% to less than 1% (*12*).

In investigating alternatives, packagers should consider the total applied cost of a label system. This involves analyzing the elements of a given system to determine which is best suited for the needs of a given production situation. Variables to consider include: machinery, energy, floor space, labor, scrap rates, production flexibility, inventory requirements, downtime, maintenance, and line speeds. In many cases, pressure-sensitive films offer the best price/performance benefits.

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