

DECORATIVE LAMINATES FOR THERMOFORMING AND INSERT MOLDING PROCESSES

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Abstract

Decorative films laminated to plastic substrates have been used for many years, but the recent wave of technological advances and increased competition, offer more variety in design, colors, materials, and performance properties, than previously available. This offers part designers and plastic processors the option to use decorative laminate technology for more applications, while reducing costs, eliminating environmental concerns, conversion from non-plastic materials, and improving product performance.

Introduction

The usage of decorative laminates for insert moldings in large production quantities extends back to the early 1970's, primarily in the automotive interior industry. Improvements in materials, coating technology, design capabilities and performance properties, have expanded potential applications to a vast array of industries.

Exterior capabilities were added in the 1990's with performance properties that met the demanding specifications of Automotive OEM's, color match capabilities to exterior body colors including metallics, and color shifting micas. Graphic designs including fine brushes and carbon fibers were also available. Usage of TPO, and PP increased due to weight and cost saving value, and superior cold impact properties. Decorative laminates offer improved adhesion over typical paint systems due to their continuous film builds and thermal bonds as demonstrated by stone chip impact tests.

Approximately eight to ten companies manufacture decorative laminate films worldwide. They are supplied to extruders, custom laminators, or laminated internally and shipped to custom thermoformers or injection molders with integrated thermoforming operations. This process has been used to decorate tens of thousands of different injection molded parts.

The Products

Laminate films are coated and/or printed on polyester film and subsequently laminated to a thermoplastic substrate. Although chemistry varies by

manufacturer and application, most begin with a protective clear topcoat. Substrate materials commonly used include ABS, polycarbonate and TPO. Substrate gauges may range from .005" to over .500". Thin gauge constructions are normally used in conjunction with injection-molded parts, while heavy gauge products are thermoformed and supplied as a finished product. A cross-section of a typical laminate product is shown in Figure 1. Gravure printed patterns can be added to simulate wood, stone, metal, or geometric effects.

Recent innovations in the industry include a soft feel, (soft to the touch), created by the properties of the specific topcoat polymer, and a thermoformable bright chrome. Laminates are available in several gloss levels ranging from high gloss class "A" to low gloss of 5-6 on a 60° gloss meter. Textures can be incorporated with the injection mold finish. Heavy gauge products, thermoformed only, include exterior applications on ABS, TPO, and PE.

The Process

Decorative laminates are first thermoformed into the shape of the desired part over a male thermoform tool, trimmed, and inserted in the cavity side of the injection mold, to produce a completed decorated part directly from the injection mold. (See Figure 2) Process control, a clean environment and precision trimming are equally important for successful applications.

Most thermoform operations use a high-grade aluminum molds such as 6061 or equivalent, which are temperature controlled by heating/cooling lines, or for very shallow parts, mounted on a cooling plate. The equipment used should be dictated by part geometry, quantity, and material utilization. Critical parameters include sheet temperature, mold temperature and time on mold (cooling). Vacuum holes or slot gap is used for most parts, and the addition of pressure assist where high detail is required due to small radii or flatter part areas which prove difficult to evacuate air.

Trimming is accomplished by use of hardened matched metal dies, which has proven to be the most precise method of trim to date. Robotic routing or laser cutting can accomplish larger parts, where cost of trim dies may be prohibited. Undercuts are accomplished by side motion cutting. Typical tolerances are $\pm .25$ mm from the injection mold parting line, although wrapping past

the parting line can be accomplished on some parts, if proper design techniques are incorporated.

The completed decorative appliqué is then ready to be inserted into the mold. Standard injection molding equipment can be used, with mold cavity finish, cavity temperature and gating being the critical parameters. A mold finish of SPI 1 or 1200 polish is recommended for all class "A" finish parts.

Most appliqués are loaded in the cavity portion of the mold. Openings or cutouts aid in location, and prevent the appliqué from moving during the injection phase of molding. Gate locations should allow the melt to flow evenly to the parting lines while pinning the appliqué to the mold surface. Adequate venting is required to avoid gas or air entrapment. Gating through ejector pins is the most common method utilized. Parts that are difficult to locate in the cavity, may be located on the core side, and held with vacuum, or with the addition of locating tabs on the appliqué itself, can be mounted on pins on the cavity half of the mold. Care must be taken to relieve the location area for the thickness of the tab. Loading the appliqué in the mold can be accomplished by hand or robotically.

A clean environment is essential, and the manufacturing culture should reflect the mode of handling of a finished part, throughout its operations. Clean rooms (not necessarily classified) are common in automotive parts industry dealing with class "A" finishes. Typical features include a separate area protected from forklift traffic, aisle ways, or operations that may contaminate the decorated surface. Filtered air may pressurize enclosures to reduce potential sources of contaminate during both the thermoforming and injection molding operations. The most sophisticated operations use fully automated robotic operations that include loading and unloading, de-ionizing air blow off of the mold cavity, and use of a web cleaner, (de-ionizing with vacuum and brush contact on the appliqué before loading), all in a positive hepa filtered air enclosure. These operations tend to provide the highest yield rates.

Heavy gauge parts, those that do not require injection molding, can be protected by use of a thermoformable mask film, or conventional housekeeping methods. Trimming of heavy gauge parts is normally handled by CNC routing, or water jet.

The Applications

Current applications are common in the automotive industry where decorative parts are used to provide added value; by differentiating trim levels, *i.e.* high line, and sport version, versus the base model, while using the same tooling. (See Figure 3). The usage of multiple appliqués in different finishes on the same part also

provides designers a cost efficient solution of decorating complex parts. (See Figure 4). Most interior appliqués are thermoformed in ABS and injection molded in ABS, ABS/PC blends, or PC. Applications also exist with thermoformed polycarbonate laminate and polycarbonate injection molding resin.

Exterior applications on TPO provide the OEM with excellent weathering, stone chip resistance, and color match capability on parts such as body side moldings, rocker panels, and mud guards. (See Figure 6) Appliqués thermoformed in TPO can be molded with injection molding resins of TPO, PP, and TSOP. Exterior body color pallets typically have 7-10 different colors, most with metallic and pearlescent finishes. Automotive pillar applications thermoformed and mounted with transfer adhesives have displaced parts typically manufactured of sheet metal. (See Figure 5).

Other industries are beginning to use decorative film technologies such as appliance, electronics, aviation, heavy truck, and the recreation industry. One example includes the use of exterior durable decorative films, laminated to heavy gauge HDPE for boats and ATV's.

Summary

It should be no surprise that this environmental friendly decorating technique is gaining acceptance in other industries, and that the advancement in available finishes, materials, and product performance will continue to open new applications wherever complex shaped decorative plastic parts are desired.