Sophisticated Skin Design

Are Films the Surfaces of Choice or Merely an Alternative?

The high quality look of surfaces plays an important role in modern automotive interior design. The constant flow of new versions and combinations of materials necessitates that suitable modifications and advances are made to processing methods.

Example of a in-line vacuum laminating machine (figures: Frimo)

Films possess diverse properties that make them attractive and economic options for producing decorative surfaces (**Title figure**). Recent technical advances in thermoforming and vacuum laminating render those suitable candidates for parts that have demanding geometries.

For the manufacture of automotive interior trims, films are used increasingly alongside traditional processing methods like slush or PU spray skin, and are also suitable for even more complex parts or modules. Thermoforming and vacuum laminating offer a number of compelling benefits here. A look at the system costs of producing a film-based part reveals the benefits which they confer in terms of machinery, tooling and energy consumption (**Fig. 1**).

But it is not only cost pressure which keeps rising. As model life cycles become shorter and shorter and the trend toward lightweight construction grows stronger, not least with the spread of electric vehicles, producers of raw materials and semi-finished products as well as equipment and tool specialists are constantly facing new challenges.

Requirements Imposed on Decorative Automotive Interior Surfaces

High perceived value, stylish looks, and a pleasant touch are the chief "soft" factors – in the truest sense of the word. These are becoming less and less the preserve of premium or upper range vehicles, and are finding their way into vehicles in the mid-to-lower price segments.

Components and assemblies in modern automotive interiors are becoming increasingly complex, especially their shapes and contours. This three-dimensionality, which is more demanding, necessarily poses a new challenge for thermoforming and vacuum laminating – not least due to increasing customization in respect of color, grain, and different materials.

The primary demand that manufacturers of semi-finished films must meet with regard to material properties is that the surfaces have to be resistant to mechanical, chemical and climatic influences. In particular, the manufacturing process has to cope with ever greater demands concerning, for example, the bond between the decor and the carrier.

Meanwhile, all the other current requirements on automotive parts and their manufacturing processes have to be met as well. These include the parts' technical functionalities, such as crash properties, environmental impact and recyclability, as well as maximum-possible weight savings, quality consistency, process reliability, and economy.

Diverse Approaches

Frimo is meeting the above requirements imposed on parts and processes by drawing on its longstanding experience to systematically develop a wide range of process technologies and services around thermoforming and vacuum laminating.

If all requirements are to be met, especially those relating to costs, very close collaboration with the OEM or Tier 1 customers is essential at a very early stage of part development. This can lead to the joint development of custom solutions, as will become evident in the aspects and innovations presented below.

Pre-engineering, which includes simulated thermoforming, helps ensure that the part will be made in a reliable process. Computerized simulation of thermoforming is then complemented by a film stretching frame to visualize the simulated film stretching on real film samples. This allows an early check of probable punctual grain distortions (grain stretch), and wall-thickness variations. Also optical impressions such as gloss and scratch whitening can be visualized.

Alternatives in the Film Spectrum

A number of innovative developments and advances with special regard to weight reduction and grain optimization are offered by the market for decorative films for thermoforming and vacuum laminating.

Tepeo2 films from Benecke-Kaliko AG, Hanover, Germany, can be stretched more extensively than conventional TPO films, and in a wide processing window, without visible loss of grain quality.

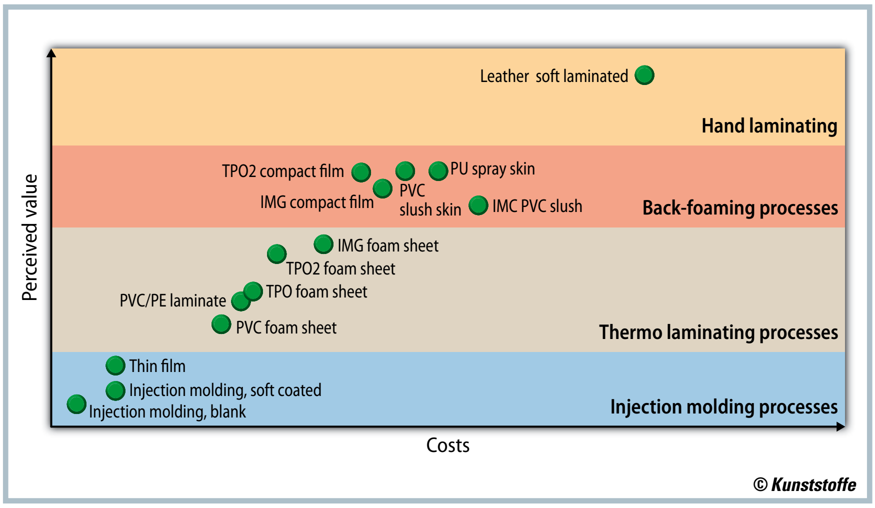

Fig. 1. Comparison of different surface variants by quality and cost

Fig. 2. Grained shell mold for the in-mold graining (IMG) process

Laminated films, which are highly valued by some customers and by OEMs, combine the unique touch of a PVC outer layer with the special elasticity and strength of a polyolefin foam. They also offer scope for substantial weight savings.

PGF films from Benecke-Kaliko are a new generation of polyolefinic decorative surface materials. These consist of partially expanded or so-called partially foamed compact film that combine weight savings and improved touch with scope for tighter radii. Consequently, they are particularly suitable for producing geometrically sophisticated parts, such as instrument panels.

A particularly clever way to partially compensate extensive film stretching, at least in parts' crucial visible areas, is afforded by "scaling" of grains during embossing. Scaled grains appear less distorted after stretching, because the "scaling" compensates for the stretching that occurs during thermoforming.

In-Mold Graining (IMG)

During in-mold graining (IMG), the grain is transferred from a grained shell mold (**Fig. 2**) to the film during the thermoforming process. TPO films are ideal for this, because they do not emit any corrosive substances upon heating and have excellent demolding behavior. IMG thus supports a wide variety of designs, and prevents distortion or loss of grain wherever radii are tight.

In-mold graining can be used to create different grains within a single part. This means that lettering and even »

Fig. 3. IMG enables the attachment of individual symbols on the surface

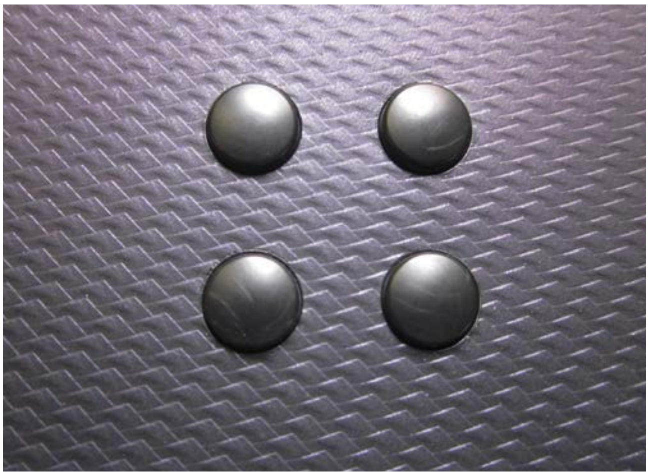

Fig. 4. Socalled pads integrated with the IMG process

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Practical Benefits

Compared with traditional methods for producing high-quality surfaces, such as slush or spray skin, thermoforming and vacuum laminating offer more than just cost advantages. Innovative developments allow optimal grain patterns and combinations of different grains or decorative effects to be incorporated into one part in a single working step. Moreover, the production solutions presented herein afford comprehensive opportunities for saving on part weight and energy during manufacture.

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ornamental seams can be incorporated into the surface design. IMG also lends itself to the insertion and back molding of films, emblems (**Fig. 3**) or pads (**Fig. 4**). Socalled two-gloss effects can be achieved as well. IMG films which are back-molded downstream are also already in series production.

Optimized Processes for Complex 3-D Geometries

Thermoformed parts with demanding three-dimensional contours are especially prone to high degrees of stretching and marked grain distortion.

A patent-pending development from Frimo is the bendable chainrail which is an innovative solution for producing contoured molded parts in high-speed in-line plants. The film (in roll form) is heated and then the chainrail is bent to ensure that the film is directed to the mold cavity in the forming station in a way that follows the precise contours. This not only boosts quality, but also reduces film consumption. The film undergoes less stretching, which in turn exerts a positive effect on the extent of grain stretching and grain distortion. The film's surface area which has to be heated is reduced as a result and the energy demand is therefore also lower (**Fig. 5**).

Decorative films, especially PVC, tend to sag after heating and so the chainrail has been optimized to stretch the film not only across its width but also along its length. Between the heating and forming station, the distance of the two pin chainrails that grip the edges of the film and transport it is increased, so that the heated film is spread in a transverse direction. Longitudinal spreading is achieved by interrupting the chainrail system at a specific transition point. Operating the two subsystems at different feed rates allows the film to be stretched longitudinally as well, after it has been spread transversely at the transition point. These two steps impart more tension to the film, and lower the risk of wrinkling. The wall thickness distribution can be optimized by varying the degree of pre-stretching at different areas along the film's length. These process-optimized chainrails can be retrofitted to existing lines.

The 3-D-sliding clamping frame (**Fig. 6**), comprising a combination of sliding adjustment and preforming of the film, is a further development aimed at harmonizing the film thickness distribution and reducing grain stretching during lamination of complex 3-D part geometries with film blanks. For this purpose, the two film holders on the longitudinal sides are moved toward each other as the carrier part traverses in. The defined sliding adjustment supports film thinning, and improves grain stretching in the order of 15–40 % compared with conventional methods, and is especially ideal for instrument panels with high cowls.

A similar effect is created by film shovelers during lamination of parts that have steep, high contours which lead to extensive film stretching. The selective use of film shovelers, which are continually being refined and optimized, enables film to be "shoveled"

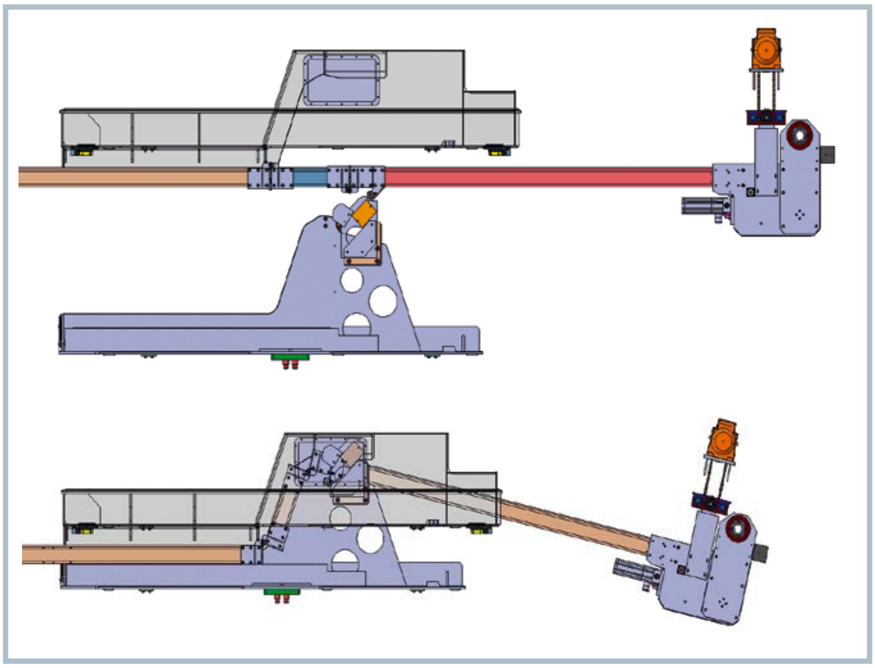

Fig. 5. Functional principle of the bendable chainrail for minimized film wastage

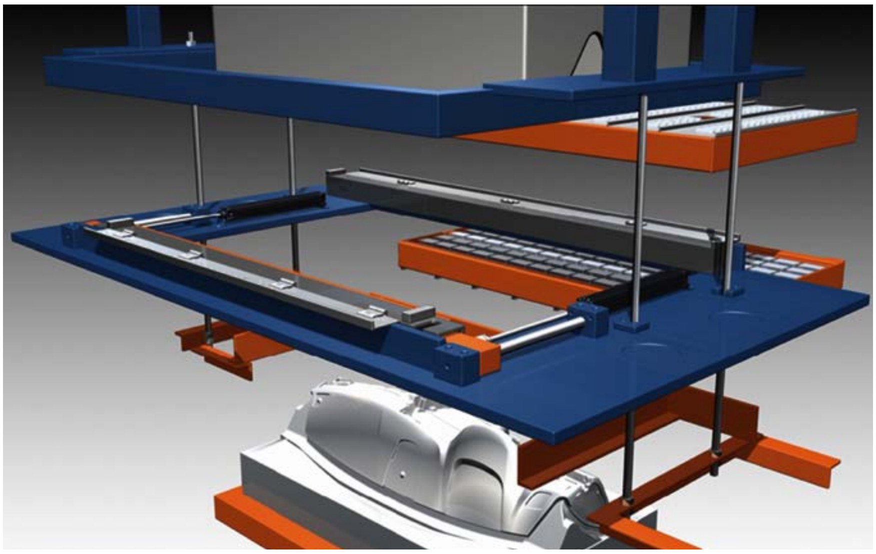

Fig. 6. 3-D-sliding clamp frame comprising an effective combination of sliding adjustment and preforming of the film

from the runoff-area to the part and thus minimizes film stretching at the side walls of the part.

Increased Efficiency

Lamination with integrated glued edge-folding can eliminate a separate process step, especially where smaller quantities are concerned. The so-called snap-stroke method features a movable part receptacle. During laminating, this is lowered toward the mold, so that the resulting oversupply of film can be brought into the folding area behind the part by the vacuum and bonded in one step.

One trend, not only in respect of sustainability and the use of renewable resources, consists in using natural fiber reinforced polypropylene (NFPP) as carrier material. Along with other advantages, such as low density and optimized crash properties, NFPP lends itself to glue-less lamination. In this, infrared lamps heat the surface of the NFPP carrier above its melting temperature. During subsequent lamination and punching, the PP decorative film, which melts on contact with the surface of the carrier, combines with the carrier without the need for additional adhesive. The development of a door-trim solution ultimately led to glue-less lamination being combined with graining (IMG).

The Frimo Advanced Cooling System (FACS) was developed with the aim of shortening cycle times for vacuum lamination. FACS consists in blowing cooled air onto the part at high speed after lamination. This approach allows either the cooling time to be shortened or, with the cooling time unchanged, the demolding temperature to be lowered up to 10 °C to match the composition of decorative films and adhesive system. Lowering the temperature may be necessary to ensure a secure bond. FACS can be retrofitted to existing lines.

As the range of models is so diverse and the number of accessories so huge, films increasingly need to be changed more often. Film cut optimization allows film cross-cut during roll or color changes to be configured for minimal film wastage and avoiding production of a scrap part. Here, the ends of the film are cut manually and automatically welded together ultrasonically. A smart machine controller detects the number of cycles and the feed length and can determine the optimal position of the film-seam line just ahead of the clamp frame.

The Future of Thermoforming

Films will continue to be the optimal solution for many applications.

It is now possible to accommodate current demands for greater diversity by using two-color films having two different grain patterns.

The use of products such as PGF films affords new opportunities for combining weight reduction with enhanced surface appearance.

A key advantage of thermoforming and laminating technologies is the global availability of the films and the technology for processing them.

The aforementioned innovations in equipment and process technology ensure lasting efficiency improvements in film processing combined with continued excellent and increasingly enhanced perceived value of the generated surfaces. ■