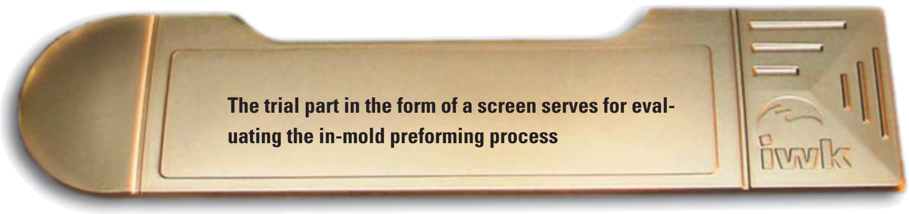
Foil Technology for Metal Surfaces



The trial part in the form of a screen serves for evaluating the in-mold preforming process

In-Mold Decoration. In-mold decoration of metal foils, in contrast to other decoration processes for plastic parts, not only achieves a metal surface, but also provides the familiar cold sensation when it is touched. New developments in the field of mold and printing technology increase the cost effectiveness and added value of such products.

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Many manufacturers from the electrical, small electrical, household appliances or auto industries increase the market attractiveness of their products by following the trend towards individual design and greater exclusiveness. Since metal surfaces play a greater role in these sectors, in-mold decoration of metal foils is increasing in importance. Foils of, e. g. stainless steel or aluminum with a thickness up to 0.3 mm are backmolded with plastic. The metal foils form the part surface, providing it with the desired metallic look and cool-touch effect, i. e. they give a sensation of cold when touched. The polymer forms the stable substructure. The injection molding process allows functions and processes to be integrated, e. g. snap hooks or bosses to be incorporated. Since the metal foils are very thin, the injection pressure is also sufficient to reproduce the surface structures of the mold on the part surface. This results in new design opportunities.

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State of the Art

In-mold decoration with metal foils is still a young process that has so far mainly been used in the automotive industry for producing door sills or trunk sills. A few isolated publications on this topic can be found in the literature [1–4]. Most of these are descriptions of the possibilities that this technology opens up, and basic research about the adhesion of aluminum foils to various plastics and the warpage of the parts. The first more comprehensive studies additionally deal with surface structuring, forming and stainless steel foils [5].

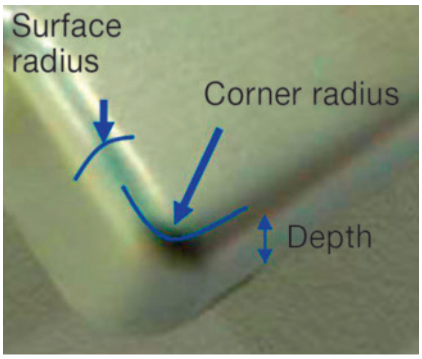

Fig. 1. The interplay of geometrical parameters for a suitcase edge influence the feasibility

There are many parallels with in-mold decoration using plastic film, however some properties of metal foils deserve particular attention. The different coefficients of thermal expansion of aluminum and polymer and the increased shrinkage potential of the plastic influence the warpage of metal foil-decorated parts. To minimize the potential warpage, fiber-reinforced plastics are generally used, which are dimensionally stable even at demolding temperatures above 120 °C. It should also be noted that, in comparison to plastic films, metal foils are more sensitive to marks on the surface as a result of dust particles, robot grippers and positioning in the mold. This problem plays a particularly important role in multistage processes – the production of three-dimensionally formed decorative part surfaces includes the punching and forming of the metal foil and its transfer to the injection mold. An alternative consists in locating the forming process in the injection mold ("in-mold performing"). This

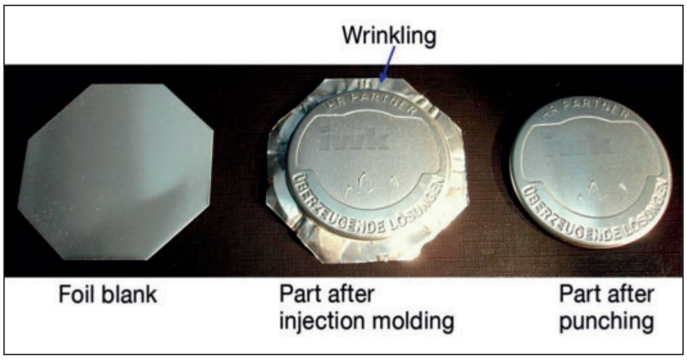

Fig. 2. A badge with fold is produced in several process operations

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additionally saves the investment for the press, the forming tool and handling.

Forming the Foil Actually in the Mold

Metal foils have different drawing properties from plastic films. They have a lower elongation at break and are therefore limited in the extent they can be deformed. This weakness makes itself noticed in the form of tearing. Aluminum foils are often provided with a protective lacquer to protect the surface against scratching, and they are therefore brittle. Therefore, in the worst case, the protective lacquer is destroyed or peeled off before the aluminum tears. This can lead to corrosion as a result of undermining of the coating. Developments on the market attempt to strike a reasonable compromise here. On the other hand, the lower elongation at break limits the scope for reducing wrinkling: The foils cannot be freely clamped, since otherwise the above-mentioned tears would develop. Important factors influencing the part design are minimum surface and corner radii, depending on the folding depth (Fig. 1). The interplay of these geometrical factors, and adjustments to them of the order of several tenths of a millimeter, have a considerable influence on the feasibility.

At the Institute for Materials Technology and Plastics Processing (IWK) at the Rapperswil University of Technology, a badge with a diameter of 47 mm was manufactured in initial trials. The aim was to achieve a small radius at the edge and to shift the wrinkling to outside the visible area by controlled sliding of the foil in the mold parting line. The parts were produced in several process steps (Fig. 2) on an injection molding machine (type: KM 130-380 CX, manufacturer: Krauss Maffei GmbH, Munich, Germany). The blank was chosen to prevent cracks occurring and to allow wrinkles to form but only outside the visible region. The pressure during injection molding reproduces structures and lettering. The metal foil backmolded with plastic was inverted in the mold and then the overhanging edges were punched off.

Based on this simple geometry, a part was developed whose form is similar to a trim used, e.g. in the electrical or automotive industry (Title photo). Particular technical challenges include the lowered edge and the recess with the varying radii at the upper edge of the part. At the beginning of the process (Fig. 3), the metal foil is inserted into the injection mold. The foil is first preformed by the injection step and then formed it over a movable core by the subsequent embossing step. At the same time, this movement of the insert cuts off the part of the foil that is not backmolded via a sharp edge (Fig. 4). This can significantly shorten the process.

The process in particular permits the production of injection moldings with surfaces completely covered by the metal foil. In such a part, the plastic is not visible from the side, not even by a tenth of a millimeter as is the case with preformed and inserted metal foils. Since the foil does not need to be preformed before insertion into the mold, and the injection molded part does not need to undergo secondary processing after demolding, it is possible to manufacture such parts with metal decoration cost effectively and rapidly in large quantities.

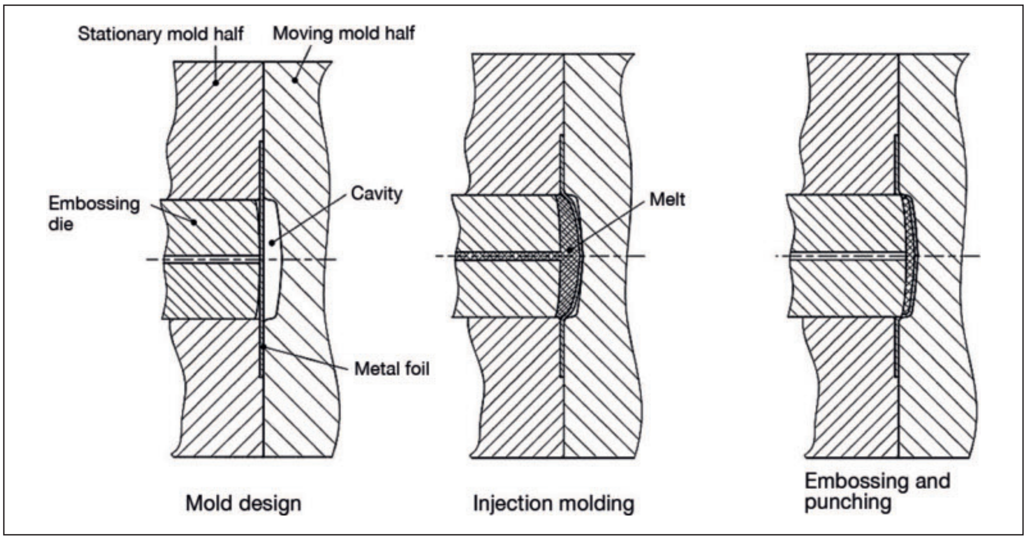

Fig. 3. The panel is manufactured in a multistage process (schematic)

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Embossing and Printing

As explained above, the thin metal foils allow legends and design elements to be reproduced from the mold surface during injection molding. To improve the appeal and added value, the metal foils should be printed in advance. In this way, e.g. different (individual) decoration levels can be represented. This requires appropriate ink systems, that adhere to metal foil surfaces and withstand the high pressures and temperatures of injection molding.

The IWK performed the first studies in cooperation with Karl Zitt GmbH & Co., ▶

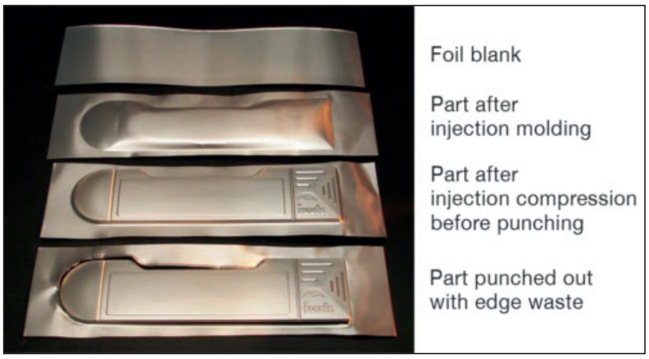

Fig. 4. The blank inserted in the mold is back-molded; the contours are produced by embossing and subsequently the panel is punched out in the mold

Munich, Germany. The company specializes in printing aluminum sheet, and knows how to combine embossing and printing. The injection molding trials showed that some ink systems did not withstand the above-described high temperatures and pressures. A functioning system was eventually achieved by modifying the ink composition and reducing the melt temperatures by using more readily flowing polymers. Fig. 5 shows a printed badge with the raised, embossed “Z” of the Zitt logo. On the reverse side, the integrated snap hooks for directly attaching the badge can be seen. Further studies with different metal foil surfaces will follow in the near future.

Fig. 5. The combination of printing and embossing offers new design possibilities (pictures: IWK)

Outlook

In-mold decoration with metal foils holds great potential for all cases where additional functions and processes can be integrated. There are therefore considerations of replacing metal screens that must be specially formed for fixing, or which must be welded to the additional parts. Another example is the chrome plating of plastic parts: By replacing the process with in-mold decoration with metal foils, it is possible to reintegrate the decoration process, which is usually subcontracted, into the company’s own production. The developments shown here have the potential to further reduce manufacturing costs and increase the added value of the products. ■

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