Vis-à-vis with the Driver

A Steering Wheel Cover Produced with the DirectCoating Process Illustrates the Varied Design Possibilities for the Automobile Interior

The design versatility of a polyurethane coating on part surfaces, including metallic effects and a fine grain with matt and glossy sections, is being illustrated with a steering wheel cover at the K trade fair. In contrast to injection molding with separate spray painting, this prototype is produced using an integrated process. Flooding the injection mold with the coating was simulated in advance.

The steering wheel cover demonstrates the full range of colors, surface textures and haptics that can be realized on the part with one mold using DirectCoating (© Covestro)

More and more car buyers are choosing a customized vehicle interior with an upscale appearance and attractive design that is also robust and durable. Furthermore, the automobile industry is attempting to produce parts as cost-effectively as possible, with high productivity. Both trends have led to increased interest in the DirectCoating/DirectSkinning technology in material and technology development. An initial series application has already been implemented. The process for hard and tough or haptic coatings makes the economical and efficient production of high-quality parts possible, with numerous decorative options in terms of color, feel and surface texture.

Integrated Production versus Separate Spray Painting

The process integrates Reaction Injection Molding (RIM) for polyurethane (PU) processing with the injection molding of thermoplastic materials. A coated part is produced in a two-component injection mold using a two-stage production process. First the plastic substrate is injected into the first cavity and transferred to a second cavity that is larger by the thickness of the coating. Then the solvent-free, aliphatic PU system is injected onto the substrate in this cavity with a RIM mixing head. The result is a PU-coated part that requires virtually no post-processing and exhibits favourable properties. In DirectCoating the substrate is coated in lacquer with a thickness of less than one millimeter, in DirectSkinning it is covered in decorative PU integral foam. Short cycle times and high productivity result when a rotary plate or turnover board is used, since the next substrate can be injection molded in the first cavity during the PU setting reaction in the second cavity.

Compared to the separate spray painting of injection molded parts, the

process offers potential savings in terms of costs, logistics effort, energy consumption, space requirements and resources. Parts can be coated with transparent, translucent or opaque lacquer in various colors, finished with a mat lacquer or piano lacquer look, or protected with scratch-resistant functional coatings. Hard or soft haptic surfaces that feel pleasant to the touch and various surface textures such as grains are possible. Contours including sharp edges, curves or raised surfaces can be created with the injected lacquer because it sets in a mold and therefore accurately represents the details of the mold surface.

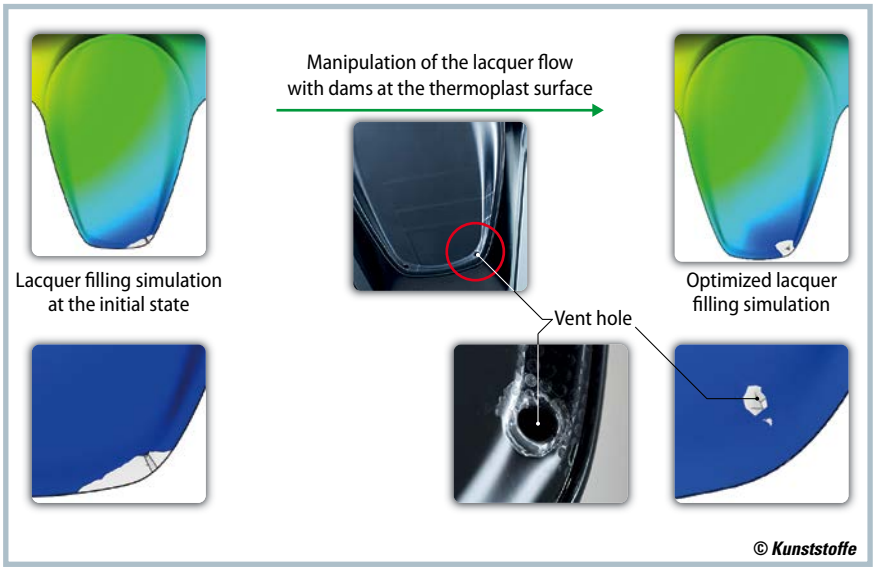

Fig. 1. Simulation of mold filling with PU lacquer: By integrating barriers, the vent hole in the middle of the part is only filled with lacquer and sealed once all areas of the part surface have been flooded (source: Covestro)

Tailor-Made Carrier Materials and PU Systems

The full range of design options in terms of color, surface and haptics that are typical for the process is illustrated by a steering wheel cover (**Title figure**). Since the cover is practically vis-à-vis with the driver, it has to meet high standards in terms of appearance. The flexibility of the process for the design of curved surfaces is demonstrated by the 3D geometry of the part. Experience gained with this prototype can be transferred to other elements of the automobile interior.

Both polycarbonate blend materials and PU lacquer raw materials were developed for the DirectCoating process. They are part of an integrated material concept from Covestro AG, Leverkusen, Germany, for the future design of the automobile interior. The blends in the acrylonitrile-butadiene-styrene+polycarbonate (ABS+PC; brand name: Bayblend) and polycarbonate+polybutylene terephthalate (PC+PBT; brand name: Makroblend) assortment meet all requirements for materials to produce automobile interior parts. They are highly heat resistant and break-proof in case of a crash thanks to their great toughness. What's more, they exhibit favourable adhesion properties with the PU systems used in DirectCoating. In addition to good toughness at low temperatures, the PC+PBT material versions are also highly resistant to weathering and chemicals, making them predestined for exterior applications. Conceivable uses include decorative trim in a range of colors and B-pillar trim. The lacquer systems based on the PU materials Desmodur and Desmophen exhibit good resistance to weathering and chemicals as well as scratch resistance. These lacquer systems also have a self-healing effect (reflow effect).

Filling Simulation for the PU Lacquer

In laying out the mold for the steering wheel cover, it was essential for the PU cavity to be sealed all around the part in order to ensure stable filling and good reproducibility. Filling the mold with the PU lacquer can be calculated in advance based on a material dataset developed by Covestro for the simulation using Moldflow (provider: Autodesk GmbH, Munich, Germany). Influencing variables taken into account by the simulation model include among others the geometry of the carrier material, the viscosity of the material system, the required filling pressure and the distribution of the coating thicknesses. Minimal changes in the wall thickness of about one-tenth of a millimetre have a major influence on the filling behavior. The geometric design tips developed by the material manufacturer assist with the layout.

Possible air pockets are localized by the simulation of the PU filling phase lasting about 1.5 s. This makes it possible to position vents and sprues so the melt fronts do not trap any air. By designing the part accordingly, the flow of lacquer can be controlled so that the lacquer first flows around vent holes with a diameter of two millimeters and only seals them once the rest of the part has been coated. In case of the steering wheel cover for example, one of the vent holes is centered in the foot of the part (**Fig. 1**). The model has been tested sufficiently in the meantime that calculating a suitable sprue and vent design for the PU lacquer component is being offered to users.

Streak-Free Metallic Effect Lacquer and Grain Design

Choosing the coatings for the steering wheel cover was initially based on common designs for such parts in compact, midsize and upper class vehicles. Various colors, surface textures and haptics were applied to one and the same part. Design characteristics that cannot be realized with spray painting – or only with great effort – were chosen as well.

For example, the cover was decorated with high-gloss and matt sections next to each other in one version. A matt surface results when the corresponding section of the mold is grained. On the other hand, a polished mold surface produces a high gloss. Both effects can be produced with one lacquer system – unlike separate spray painting, where two different paint systems are required. Combining two different lacquer systems, such as a hard coat lake with a soft feel lacquer in a different color, is also possible with DirectCoating. One version of the steering »

Partners in Development

In the implementation of the steering wheel cover, the material producer Covestro worked together with partner companies covering all important component development steps:

- Designing the 3D geometry of the part: Northern Works Oy, Turku/Finland – Design agency with international experience focusing on automobile design
- Tool and mold construction: Hofmann Innovation Group, Lichtenfels – A manufacturer of injection molding tools, among other things for automobile interior elements
- Grains for the steering wheel cover: J. & F. Krüth GmbH, Solingen – Surface technologies such as etching, laser etching and 3D laser engraving
- Lacquers: Votteler Lackfabrik GmbH & Co. KG, Korntal-Münchingen – Puriflow lacquer system, including a metallic effect lacquer with automobile specification for the DirectCoating process

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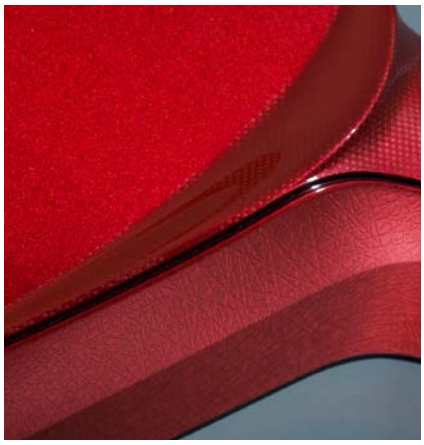

Fig. 2. The gloss levels of the effect lacquer system range from high gloss to matt; surfaces can be smooth, textured or feature a soft feel (© Covestro)

Fig. 3. Such a fine grain is especially scratch resistant since the high gloss is recessed in the "valleys" and therefore protected (© Covestro)

wheel cover is decorated in two colors, with matt and high-gloss sections in different areas and a soft feel surface. The new VarioShine effect lacquer system from Votteler Lackfabrik GmbH & Co. KG, Korntal-Münchingen, Germany, lends surfaces a metallic look (**Fig. 2**), without streaking caused by the alignment of the effect pigments, for example on flow obstacles.

In addition to the color and gloss level effects, sections of the cover were designed with surface textures such as randomly oriented fiber contours. These can be produced by correspondingly lasering the mold surface. Very fine grains with sharply delineated high gloss and matt sections constitute a decorative characteristic that cannot be realized with spray painting – or only with a lot of effort. J & F Krüth GmbH, Solingen for example has developed a point-shaped grain design where the raised points are matt and the "valleys" in between are high gloss (**Fig. 3**). This fine grain can be represented in flowing surfaces and for example permeated with unstructured high-gloss and/or matt contours.

Ambient Light and Integrated Foliation

Ambient light effects are another design possibility for parts produced with the DirectCoating/DirectSkinning technology. A version of the steering wheel cover with a thin fluorescent strip in the form of a fine edge highlighting its contour will be presented at K 2016. This effect is produced by injection molding the thermoplastic substrate using a translucent material that remains uncoated in the area of the strip. Light from a source installed behind the substrate can therefore shine through the strip.

Thermoplastic films can also be integrated into the DirectCoating process. The molded films are back injected and reinforced similar to the film insert molding process. This makes it possible to produce surfaces with a printed décor, logos and symbols, and displays with a day-night design. Capacitive switches can be integrated directly into the part as well. The DirectCoating lacquer protects the film surface and can also serve as a haptic orientation aid, for example when searching for a switch. ■