New Injection Molding Technology for Foamed Parts with Class A Surfaces

Design Surfaces thanks to Innovative Mold Coating

With the MicroJect Advanced, Faurecia, a company of the Forvia Group, is presenting a new manufacturing process for foam injection molding. The motivations for the development were to achieve a sustainable manufacturing process as well as greater design freedom and product quality. By combining an innovative mold coating and modified process control, substantially more lightweight visible components with flawless surface quality can be manufactured with a significantly lower carbon footprint.

Single-source component: the door panel comes directly from the injection-molding machine as a ready-to-install visible component with different grains. © Faurecia

In foam injection molding, surface defects (so-called foam streaks or silver streaks) usually occur, which until now have made it impossible to use foamed components in visible applications. The new "MicroJect Advanced" manufacturing process produces flawless visible parts with intricate textures or other design surfaces (**Fig. 1**). In addition, the parts are significantly more lightweight but still stable thanks to their bionic design, which is inspired by nature. In the overall process, the carbon footprint can be reduced by half compared to conventional solutions. The process is presented at K 2022 at the booth of the machine manufacturer Engel with an example of various textured surfaces in a plate demonstrator and a door trim demonstrator using this technology (**Title figure**).

As a first step, an inert gas (CO_2 or N_2) is dissolved in the plastic melt under permanent back pressure. During injection into the cavity, there is a pressure drop resulting in foaming of the plastic melt comparable to suddenly taking the cap off a bottle of soda pop. In the injection mold, a so-called integral foam is produced: a molding with unfoamed skin and a foamed core.

Without an appropriate countermeasure, the part has a rough surface

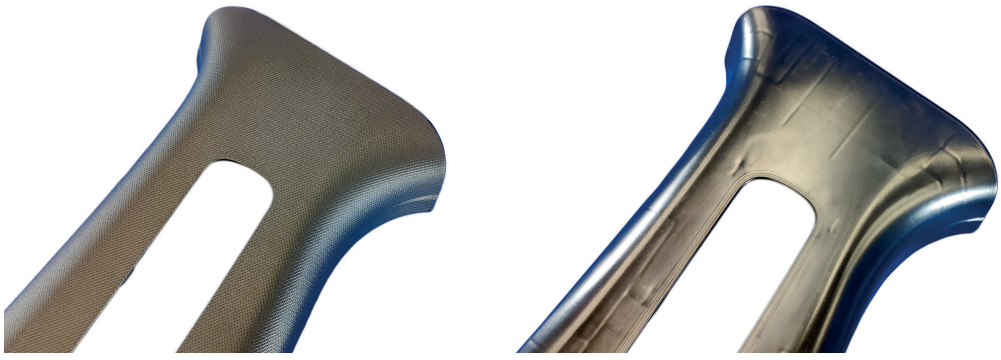

Fig. 1. TFIM component from traditional manufacturing (right) and MicroJect Advanced demonstrator with graining (left).
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with foam streaks, which make it difficult or impossible to use the thermoplastic foam injection molding (TFIM) process for visible applications. Although solutions preventing, or at least minimizing, streaks – one of them is dynamic mold temperature control – have long been available, they have not been able to gain widespread acceptance on the market. Complex processes, higher equipment and material costs, longer cycle times and high energy costs made it difficult to implement them economically. In addition, the surface quality was insufficient.

Passive Variotherm Process

The new technology allows foam injection molding to be used much more widely. The production of lightweight TFIM parts with a flawless Class A surface is made possible by an innovative mold coating (manufacturer: Eschmann Textures International GmbH). This is a thin layer of a technical ceramic that also carries the texture of the visible component.

During injection, the ceramic acts as a short-term heat barrier, which keeps the melt at the cavity wall in a plastic state just long enough for a sufficiently high cavity pressure to build up in order to smooth the surface. Because the mode of operation of the variotherm (dynamic) mold cooling is similar, though without supply of external energy, one can speak of a "passive variotherm process". Despite the thermal insulation, the cycle time is not prolonged. Consequently, not only foam streaks can be completely prevented, but tiger stripes, differences in gloss, pressure marks or ghosting and even visible weld lines are now also a thing of the past.

The surface textures are introduced into the ceramic coating with the latest generation of an ultrashort pulse laser. Its pulse frequency is more than two orders of magnitude above that of normal commercial lasers, such as are used for texturing metal surfaces. Compared with steel surfaces, much more intricate and complex textures can be introduced in a ceramic coating. The method thus offers completely new design possibilities for the surfaces of plastic components (**Fig. 2**), which in the future will even be usable as high gloss decorative parts and will thereby make complicated and expensive painting, or even laminating, unnecessary.

TFIM integral foam components are comparable to sandwich structures in terms of the material mechanical properties. This is due to their outstanding weight-specific flexural and torsional properties, predominantly in aircraft, ships and boats, as well as wind turbines. Moreover, the cross-section of an integral foam, unfoamed on the outside and cellular on the inside, corresponds to the structure of a human bone. This three-dimensional material configuration proves especially useful in lightweight engineering, and is not the only inspiration from nature.

Bionics – Lightweight Engineering Inspired by Nature

Self-developed CAE simulation routines can predict both the mechanical properties of integral foam components (structural simulation), as well as the flow behavior (structural simulation) of gas-loaded melts. Part regions with inadequate mechanical properties are stiffened with reinforcing ribs, which are disposed as honeycombs in a normal case. Slim geometries with ribs can be made just as stiff as the thick solid material without ribs, even with a lower material input. Very similar to a water-lily plant, on which an infant can sit without sinking, future TFIM com- »

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Ceramic Coating
A broad styling variety for injection molded parts: with **Cera-Shibo**, Eschmann Textures offers a coating process that allows different designs to be produced from the same mold. In conventional processing methods, the structure is determined by the mold. Cera-Shibo is different: with a heat-resistant, wear-resistant ceramic coating on the mold surface, plastic parts with a virtually unlimited bandwidth of individual surface structures can be produced – with Cera-Shibo, the structural information lies in the ceramic layer. This layer can be removed completely from the mold at any time and re-applied without additional polishing work, wall thickness changes or the like.
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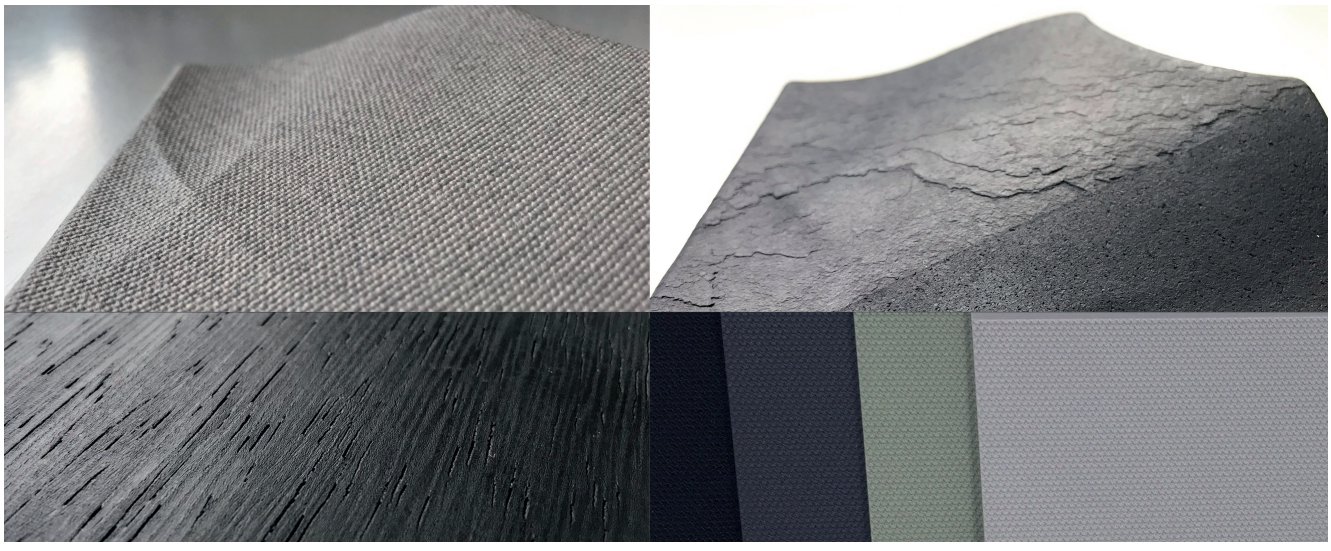

Fig. 2. Examples of textures (clockwise from top left): textile, slate and cork, textiles in various colors, wood. © Faurecia

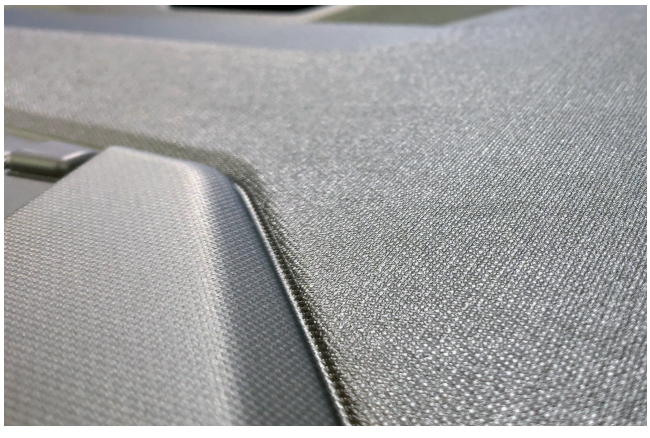

Fig 3. The door trim, which is about 25 % more lightweight than an unfoamed part, with a stable internal structure, is shown at the Engel booth. © Faurecia

ponents from Faurecia will consist of a thin skin with a sophisticated stiffening network at the back.

To avoid the risk of sink marks, ribs or B-side features (screw or weld bosses, clips or retainers) can generally be connected on the reverse of the component at right angles. This is particularly unfavorable for the force transmission because, due to the right-angled arrangement at the rib-base, there is increased stress here, which can lead to failure of the rib (notch effect). To minimize the notch effect, another example from nature was used. At this point, technology copies the architecture of a tree. Its trunk follows a geometrical principle that significantly reduces the notch effect. All the B-side features thus become more robust and can transmit larger forces. Such a functional part design cannot be applied in conventional injection molding. This is only possible due to the significantly greater design freedom in Microject Advanced.

The dissolved blowing agent improves the flowability of the melt significantly (plasticizing effect) and the non-localized foam pressure in addition permits significantly thicker ribs without sink marks. Both have the consequence that visible components can be made significantly thinner than before. In most cases a material saving of between 10 and 20 % is possible by altering the design to take account of foam. The foaming process itself permits a further weight saving of 5 to 7 % even for thin-walled components.

Sustainable and Lightweight

Besides a demonstrator with various textured surfaces that is produced at K 2022 by physical foaming (MuCell process), Faurecia also will show a demonstrator door trim part which is 23 % lighter than its unfoamed counterpart (**Fig. 3**). Of this saving, 17 % is accounted for by the above-described design change and 6 % by the foaming itself. Due to the significantly lower cavity pressure, the components can be realized with only 10,000 kN clamping force, while at least 18,000 kN is required for the unfoamed version.

Compared to unfoamed injection molding, significantly less energy is necessary for the foamed door trim. The reason for this is the lower required clamping force as well as the per se lower material consumption. A life cycle assessment (LCA) of the global warming potential (GWP) performed by Faurecia has shown that the carbon footprint of the production process is halved. The CO_2 emitted by obtaining and manufacturing the raw materials used is reduced by 23 %.

To make the product even more sustainable, the components are injected with a newly developed polypropylene type with a high recyclate content. The compound was developed especially for the new technology by experts of the Faurecia Sustainable Material Division (SMD). Besides good foamability, the material development also focused on matt, scratch-resistant surfaces. For the developers, it was important for the surfaces to have a soft, tactile feel, which, for textile surfaces, gives the component surface a pleasant appeal, even for different textures. If the innovative textures are combined with tailored color additives in the polymer, the grain character can be additionally emphasized and the visual experience made even more authentic. The validation of the new technology was successfully concluded some months ago. ■