Tailgate of the Volkswagen ID.3: Fiber-Reinforced PP Enables the Use of Plastics

Long Fibers, Smart Look

Until now, only metal has been used for the tailgates of VW cars. In its top of the line electric model, the ID.3, Volkswagen is now using a plastic-metal composite for the first time. One of the materials used for its production is a long glass fiber-reinforced polypropylene from Celanese. The material was required to not only satisfy the mechanical demands, but also enable an attractive appearance.

The ID.3 is Volkswagen's first car with a tailgate made partly of plastic. © Volkswagen

The car of the future should be energy-saving as well as low-emission, and at the same time dynamic, comfortable and safe. Consumer wishes such as less maintenance, greater durability and greater environmental friendliness, for example through more sustainable production processes and recyclable materials, round off the requirements profile. Such sophisticated vehicle concepts can only be achieved through further innovations in various areas of automotive engineering. Fiber-reinforced plastics (FRP) are making a particularly important contribution in this respect. They not only reduce the weight of components, but also offer designers great freedom of design.

The first vehicle in Volkswagen's new generation of electric cars, the ID.3, uses such FRPs from plastics producer, Celanese. The ID.3 is based on a newly developed MEB platform (MEB = modular e-drive system) and is designed purely for electric drive. To increase range and create more interior space without dramatically increasing costs, VW relies on affordable lightweight construction measures.

Plastic/Metal Hybrid instead of Steel

For example, the steel construction of the tailgate which has been the norm up to now is being replaced in this vehicle for the first time in the VW Group with a plastic/metal hybrid component with visible areas. To satisfy the high rigidity requirements, the main structural part was made from recyclable thermoplastic, long glass fiber-reinforced plastic with metal reinforcing elements. This construction method allows a high degree of design freedom and functional integration. Areas visible to the customer are produced directly with long glass fiber-reinforced polypropylene (PP) without an additional treatment step.

The structural component of the tailgate is a visible part in vehicle interior color. In addition to a good surface quality and the vehicle interior color, the material has to have a low gloss level and good scratch resistance.

Extensive Demands

The load-bearing structure had to meet crash requirements, as well as rigidity and strength specifications, and offer low distortion and low creep under continuous load and elevated temperatures. To ensure this, metal inserts were planned that had to be sheathed. This required low thermal expansion and a coefficient of expansion as similar as possible to that of metal. Furthermore, the load-bearing structure of the tailgate was to be bonded to the spoiler support. The components were to be tested, among other things, up to 90 °C and the material had to be resistant up to 150 °C. Since the visible area is located inside the vehicle, the odor and emission requirements had to be met for the vehicle interior. In addition, the necessary UV resistance had to be assured for the visible area of the component (**Fig. 1**).

Appearance
- Good surface with graining
- Color matching, gloss level, scratch resistance

Implemented by:
fully impregnated long glass fibers with special color formulation

Mechanics
- Impact behavior
- Strength and rigidity
- Low warpage

Implemented by:
PP-LGF40

Adhesive bonding & metal inserts
- Low dimensional variation over temperature range
- Coefficient of thermal expansion comparable with metal
- Thermal aging at 150 °C

Implemented by:
PP-LGF40 with specially developed thermal aging package

Interior
- Odor and emissions
- UV resistance

Implemented by:
formulation for interior applications and special UV package

Fig. 1. The demands on the structural and visible part of the tailgate of the ID.3 electric runabout are numerous. They were met with various material modifications.
Source: Volkswagen, Celanese; graphic: © Hanser

Bonded instead of Bolted

For the ID.3 tailgate, VW relies on a completely new design concept: the structural parts are now bonded and no longer bolted together. This allows costs to be saved through automation in production. To achieve this, the plastic and the bonding process also had to be coordinated during the material development.

New legal requirements are also increasing the pressure to select materials that can be manufactured in an energy-efficient way and recycled at the end of their life cycle. A correspondingly resource-saving material from Celanese is being used for the tailgate. It comes from the company's Celstran LFT product family (LFT = Long Fiber Thermoplastics) that comprises long fiber-reinforced PP and, on request, other reinforced polymers. The series also offers further savings potentials. For example, their surface quality is already so good that the polymers can be used without painting in the visible area (**Fig. 2**). The technology developed by VW and Celanese can be transferred to other lightweight structural components in the visible area.

Celanese has been successful on the market for more than two decades with the Celstran LFT material solution chosen for the tailgate. The desired production of components pigmented in the vehicle interior color, however, is an interesting new development in the field of long fiber reinforcement. With Celstran LFT, the pigment is already contained in the granules and does not have to be added later. That enables the production of visible parts with a very high surface quality. In addition, Celstran LFT is UV-stabilized to prevent color changes when exposed to sunlight. The material has also been emission-reduced for use in vehicle interiors. The complete impregnation of the long fibers plays a crucial role in achieving good surface finishes with long fiber-reinforced thermoplastics. That is achieved at Celanese using the pultrusion technology (**Fig. 3**) that enables complete fiber impregnation.

All Additives Incorporated in One Step

With this technology it is possible to incorporate all the additives, such as thermal stabilizers, UV stabilizers and also the pigment into the material in a single process step without damaging the fibers. Lightweight structural components with visible surfaces can be produced by injection molding using this material concept. For light colors, Celanese has also developed an anti-static Celstran LFT grade. This allows contamination due to electrostatic dust deposition to be prevented. »

Fig. 2. One part of the tailgate is a visible interior part. The FRP used have a very good surface quality and therefore do not have to be additionally painted. They are supplied as pre-pigmented pellets in the desired vehicle interior color. © Celanese

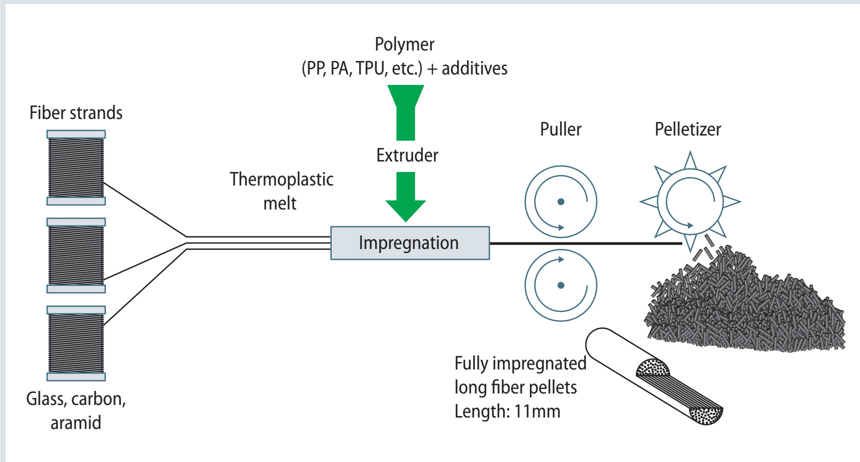

Fig. 3. Production of Celstran LFT: the pultrusion technology allows the fibers to be completely impregnated. Source: Celanese; graphic: © Hanser

Fig. 4. Since the demands on the tailgate and rear spoiler support differ, they were produced using different materials. Source: A2MAC1; graphic: © Hanser

In order to meet the mechanical requirements in terms of rigidity, strength and impact resistance, a PP with a glass fiber content of 40 % was required. The long glass fiber-reinforced Celstran LFT grades of PP, in particular, offer the combination of a low weight and at the same time very good mechanical properties at temperatures from –40 to 120 °C. The particular strength of the long-fiber skeleton is demonstrated under impact loads in the crash test.

UV Protection and Odor Requirements Met with Adapted Formulation

The requirement for a low coefficient of expansion close to that of metals was also satisfied with this choice of material. The thermal resistance in combination with UV protection and the necessary odor and emission requirements presented a particular challenge. For this, the existing formulations had to be revised and a modified new formulation created (**Fig. 1**). A PP Celstran LFT PP-GF40 in vehicle interior color is used for the tailgate. The rear spoiler support does not have to meet any visual and therefore also no UV requirements. For this reason, a high-performance product for structural parts in black from Celanese could be used for this part (**Fig. 4**).

Tapes Could Be Used as Substitutes for Metal Inserts

As already mentioned, the high demands in terms of rigidity and crash behavior necessitated the use of metal inserts. The next innovation step could be to replace the metal inserts. The pultrusion technology also provides an interesting option for this. By completely impregnating the fibers with plastic melt, it is possible to roll out the round strands by pultrusion that are subsequently cut into pellets or flat profiles known as

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References & Digital Version

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German Version

Read the German version of the article in our magazine ***Kunststoffe*** or at ***www.kunststoffe.de*** tapes (**Fig. 5**). These are typically produced in thicknesses of 0.25 mm or less and in widths of approx. 300 mm and wound endlessly onto spools.

The progression from a short fiber pellet, to a cable sheath, a fully impregnated long fiber pellet, and finally to a tape is shown schematically in **Figure 6**. These tapes can then be drawn off the coils at the injection-molding machine, cut to the required length and inserted into the injection-molding machine as "local reinforcements".

Celanese has extensive know-how in the production of Celstran CFR TP tapes. The tapes can be used in a single layer, for example, as local reinforcements, typically 0.25 mm thick, or in multiple layers, such as four layers with a typical thickness of 1 mm, as inserts. In these cases, they are made of a PP with 70 % unidirectional continuous glass fiber reinforcement. In multilayer processing, different lay angles (e.g. 0°/90° or 0°/45°) can be realized. Since the tapes have the same matrix polymer as the injection-molding material, a unit is formed with the injection-molding material, particularly in the case of local reinforcement without pretreatment. The tapes are then inseparably bonded to the injection-molding material.

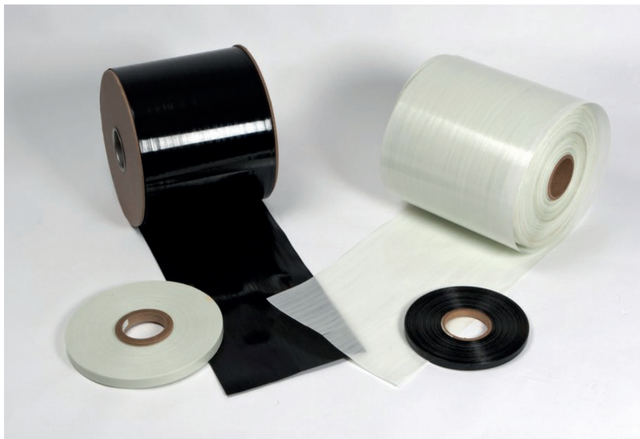

Fig. 5. The strands produced by pultrusion can be rolled out into 300 mm wide tapes.
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Tapes and Injection Molding Material Form a Solid Unit

Long fiber-reinforced thermoplastics such as Celstran LFT are typical materials for modern motor vehicle construction. Their typical matrix materials, PP and polyamide (PA), save weight while the fiber skeleton ensures stability even in molded parts subject to high stress. In addition, these materials exhibit high thermal resistance. This makes them ideal for battery mountings or the battery housing of electric vehicles, as well as for floor panels and instrument panels.

Celanese also offers an extensive product range of short fiber-reinforced materials for electromobility. Celanex PBT polybutylene terephthalate (PBT) has good sliding properties, high resistance to chemicals and weathering, and can be used at high service temperatures. It can therefore be used in connectors for electrical cables. The various Celanyl PA6 and PA66 grades are used for housings and connectors. They are available in the UL94-V0 setting as Frianyl.

The Fortron PPS polyphenylene sulfide (PPS) has long been a proven material in automotive construction and is also suitable for use in electric cars. It is used for pumps for cooling media or fans, but also in coil carriers for electric motors. Actuators are a suitable field of application for the liquid crystal polymer (LCP) Vectra LCP, as are connectors, functional parts for high-voltage applications and components for lighting. The Hostaform POM ECO-B polyoxymethylene (POM) is a sustainable drop-in solution for reducing the carbon footprint in automotive applications. The low-emission XAP grades of this material are suitable for automotive interior applications. ■

Fig. 6. Schematic illustration of the development of fully impregnated continuous fiber-reinforced tapes: the tapes can be wound onto spools and then processed by injection molding. Source: Celanese; graphic: © Hanser