

# Small Particles – Big Effect

**Profile Expansion.** Particularly easy-flow PBT grades refined with nanoparticles have proved successful for the injection molding of filigree, complex-structured moldings and are constantly acquiring new fields of application. New variants are now rounding off this growing product family. At the same time, a similar trend is also emerging in the polyamide product group.

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**P**olybutylene terephthalate (PBT) is one of the engineering plastics with above-average market growth, associated primarily with the increasing demand for comfort and electronics in automotive engineering – the chief area of application for PBT. Its annual growth of more than 5 % makes this an economically attractive class of materials. This is one of the reasons that prompted plastics producers to look into the further development of this material in technical terms and to harness its cost-efficiency potential for the customer. At the same time, optimized materials also permit improvements to be made to the processes employed.

The market launch, in summer 2004, of the first PBT (Ultradur High Speed) with particularly easy flow due to the introduction of nanoparticles, marked a major step in this direction. The organic particles, 50 to 300 nm in size, have a three-dimensional effect, contrary to the case for the familiar inorganic particles, which act only in two dimensions. This leads to a more or less twofold increase in flowability and hence considerably improves the processability of the PBT. Using a material of this type, it is possible to produce standard components, such as simple plugs and housings, at a lower cost, since the lower melt viscosity permits a reduction in the processing temperature, the holding pressure time, the cooling time and hence the cycle time, allowing a reduction of up to 30 % in the latter. At the same time, materials that have been optimized with nanoparticles open up the way to technically demanding, innovative

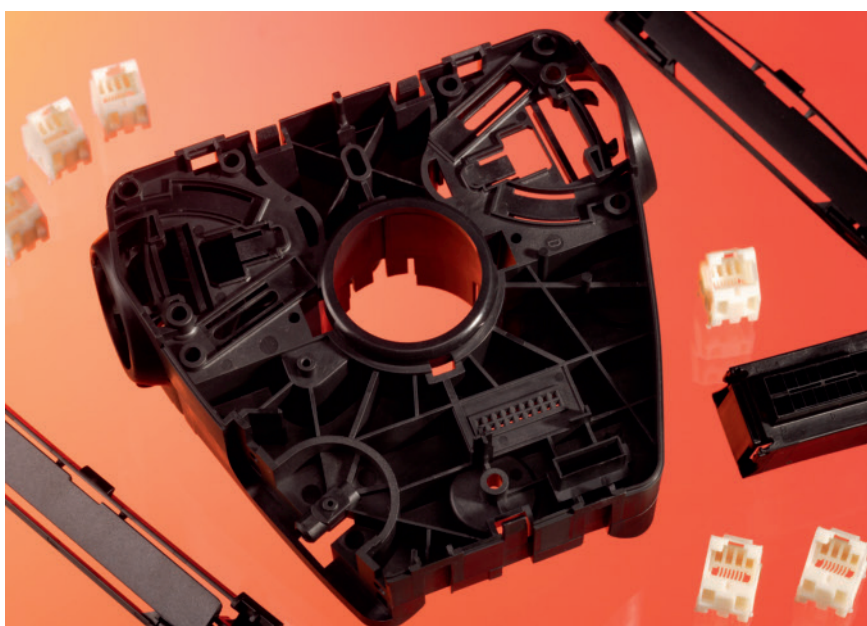


Fig. 1. Steering column switch in PBT with nano-additives for the Mini

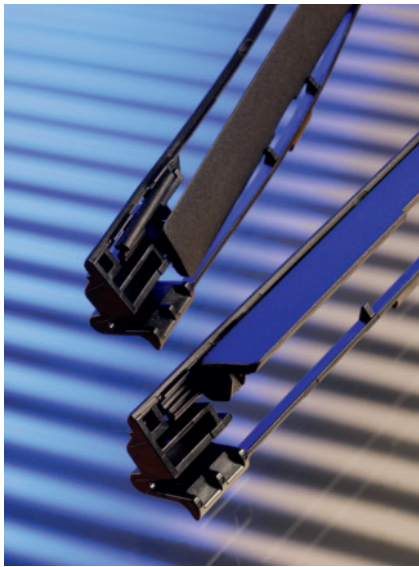
functional parts, such as mechatronic assemblies. These include complex structures, such as parts with low wall thicknesses, a demanding flow path to wall thickness ratio and more cavities – challenges that frequently cannot be met with general-purpose materials. This applies equally to mechanical and electronic/electrical engineering requirements. In the laboratory and in simulations, for example, it proved possible to show that metal inserts being encapsulated in plastic are displaced from their correct position to a lesser extent by the more readily-flowing material, coupled with the lower injection pressure that is required.

## PBT with Nanoparticles set for Expansion

The market success of the new product is evident from the large number of appli-

cations that have entered series production since 2004. After the first filigree plugs and plug housings, a large number of complex structures have already come onto the market: Bosch is working with a grade suitable for laser inscription in its development work on steering angle sensors. The latest variant of this sensor – a key vehicle-safety component – has to be very flat on account of the installation space available and thus places stringent requirements on the material's flowability.

The filigree structure of the steering column switch used by BMW for the Mini (Fig. 1) is similarly series-produced from this easy-flow PBT, as are the flaps for the car roof rails (Fig. 2). Apart from this, the process-optimized materials also allow completely new processes to be implemented. The Dolphin process developed by Engel, Georg Kaufmann,



**Fig. 2. Flaps for car roof rails or roof channel covers in Ultradur High Speed**

P-Group and BASF for the simple and low-cost production of soft-touch instrument panels benefits from a specially configured product variant which, as a (PBT+ASA) blend, has a particularly low warpage (Fig. 3).

It is not only in automotive engineering and electrical engineering (the traditional domains for PBT), however, that the new material has attracted attention. Following a dedicated workshop for industrial designers, a project was completed by eminent designer, Konstantin Grcic, and the BASF plastics experts in the record time of a year, leading to the Myto designer chair that was presented to the public for the first time at K 2007 (Fig. 4). The cantilevered chair is made in one piece and achieves its airy appearance

through the large number of geometrical holes in the back and seat. A particularly easy-flow engineering plastic was necessary in order to ensure that such a filigree structure was sufficiently stable. The chair is made up entirely of the new material.

Good flow behavior also helps with the door-control unit that Continental makes for Audi. Use is made here of a PBT variant that is based on a particularly low-warpage (PBT+ASA) blend. The contact pins of the plug connectors have to fit precisely into the openings made for them, which means that the dimensional stability of the plastic is particularly important here (Fig. 5). The good flowability helps the user achieve shorter cycle times and improves mold filling. The number of reject parts is reduced, as is the amount of wear on the injection mold, since it is possible to get by with a lower injection pressure.

### New PBT Grades Being Launched

The material's success has prompted the developers to offer a large number of materials from the PBT range as high-speed products too. Amongst the new developments, the thermally conducting variants and also the new fireproof products were of particular importance. The thermally conducting PBT (grade: Ultradur B4300 M12 High Speed) is noted for a thermal conductivity that is four to five times higher than that of general-purpose grades, coupled with good mechanical properties and good flowability. A grade with such a high mineral-filler content could not be readily processed without nanoparticles. It is suitable as a substitute for metals in the housing lids of control

units, or for the heat management of lamp sockets and door locks.

The new fireproof grades include both halogen-containing and halogen-free versions. Suitable products are thus available for a large number of application areas. The 16-terminal automotive plug made by Molex, where balanced mechanical properties are essential, is made of Ultradur B4300 High Speed (Fig. 6).

To ensure that customers can simulate the optimized flowability themselves on the computer on the basis of their own nano-PBT components, BASF supplies complete Moldflow datasets for all the different grades. And a specially-developed computer program permits the cost savings achieved with the switch from general-purpose PBT to high-speed PBT to be readily calculated.

A nano-PBT grade is also available for the water injection technique (WIT), which has been further developed in the meantime. This is suitable for structural parts, such as car roof railings, where not only a good external surface and paintability are important but also particularly favorable crystallization behavior and UV resistance. The material is called Ultradur B4040 G10 WIT High Speed and was developed following a comprehensive research project into the WIT at BASF. One of the key results of the investigation was that the advantages of the process are only really exploited to the full with the latest variant that works with a thermal buffer of air or nitrogen (GID-WIT).

The latest development (grade: Ultradur 4300 GM24 LDS High Speed) is a product for the still young process of laser direct structuring (LDS). In the same way



**Fig. 3. Part produced by the Dolphin process in Ultradur S4090 GXI High Speed**



**Fig. 4. Myto, the designer chair by Konstantin Grcic in Ultradur High Speed**



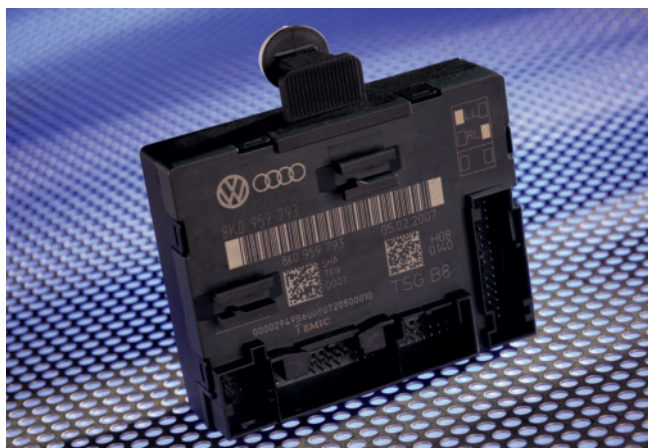


Fig. 5. Door control unit made for Audi by Continental, in Ultradur S4090 G4 LS High Speed

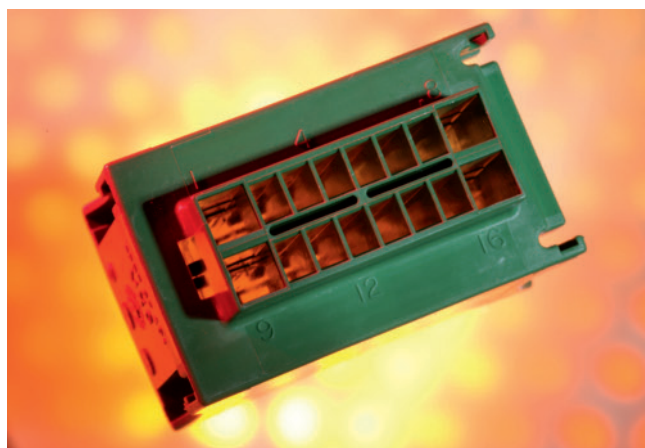


Fig. 6. Automotive electronics plug from the Molex company, in Ultradur B4300 High Speed

as for the LDS polyamides that have already been presented, this LDS polyamide can now be laser-structured and then electroplated, thus allowing conductor paths to be integrated directly in the 3-D surface of the substrates and making MID parts more accessible.

### Effects of the Nanoparticles

The interesting impact of specially-tailored nanoparticles on the polymer matrix in question is made clear by additional findings. On the nano-PBT, it was shown that the incorporation of pigments is improved through the presence of the nanoparticles. With the improved-flow PBT, a smaller quantity of color concentrate is required than with general-purpose PBT in order to give the same, homogeneous color impression. Nano PBT grades also display almost twice the adhesion to TPU elastomers than general-purpose grades.

If the elongation at break is observed as a function of the injection speed, it is seen that the special additives make their

mark here too. Since the high-speed product permits higher injection speeds than general-purpose grades, more glass fibers are oriented perpendicularly to the direction of flow in grades with glass fiber reinforcement, thus ensuring a higher elongation at break (Fig. 7). All other properties, such as the melting point, degree of crystallization, shrinkage, modulus of elasticity, tensile strength and impact strength, remain more or less the same.

### Now Polyamide with Nanoparticles Too

After the success of the nanoparticle concept for PBT, this approach was to be transposed to one of the key engineering plastics too, namely polyamide. Right on time for K 2007, three PA 66 grades containing nanoparticles (Ultramid High Speed) were presented. These are two highly filled grades with 40 and 50 % glass fibers respectively, plus a third variant that contains glass fibers and mineral filler. This was the product class that

was selected for the first nano-PA grades, since the advantage of an improved flowability is particularly evident in the case of highly-filled PA 66. Flow improvements of up to 100 % were achieved. Yet there is still something else that is of interest: the tailor-made parts that are integrated in the PA matrix not only improve flow but also increase heat ageing resistance. This means that parts which are subject to particularly high heat levels on a continuous basis – such as under the engine hood – are what the developers are looking at. These include cylinder head covers or intercooler end caps. The lower melt viscosity of the material means that these big parts can be designed more thinly, thus saving weight and costs. The three new plastics are available in sample quantities as of the start of 2008.

In state-of-the-art injection molding for engineering plastics, it is essential to pay a great deal of attention to the interplay of the material, machine, mold, part design and process control if further optimization and efficiency potential is to be tapped. Process-optimized materials, such as the improved-flow polybutylene terephthalates and polyamides incorporating nanotechnology, are a highly promising approach. ■

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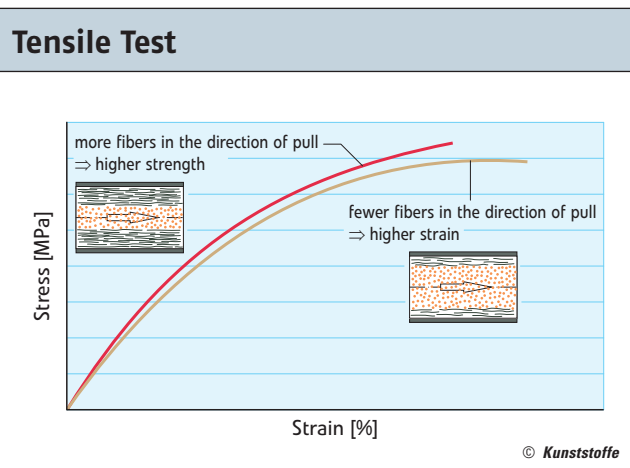


Fig. 7. The injection speed influences the orientation of the glass fibers and hence the mechanics of thin parts